
MERSİN UNIVERSITY 1992
MEUJMAF
Mersin University
Journal of Maritime Faculty
e-ISSN 2687-6612
December 2020 Volume: 2 Issue: 2

PUBLISHING BOARD

Prof.Dr. Özcan ARSLAN
Istanbul Technical University, Faculty of Maritime
Turkey

Prof.Dr. Serpil EROL
Gazi University, Faculty of Engineering
Turkey

Assoc.Prof.Dr. Nur Jale ECE
Mersin University, Faculty of Maritime
Turkey

MERSİN UNIVERSITY JOURNAL OF MARITIME FACULTY (MEUJMAF)

Mersin University Journal of Maritime Faculty (MEUJMAF) is an international, scientific, and multidisciplinary journal which covers all fields of maritime sector. MEUJMAF publishes the articles in English and is being published 2 times a year. The Journal involves both experimental and theoretical studies on the subject area of Maritime Business Administration, Marine Transportation Engineering, Logistics, Supply Chain Management, Logistics Engineering, Naval Architecture Engineering, Marine Operations, Operations Research, Foreign Trade, Maritime Economics, Maritime History, International Trade, Marine Pollution and Port Management. MEUJMAF aims to contribute to the literature by publishing manuscripts at the highest scientific level in each abovementioned field and to convey the latest development in the science and technology to the related scientists and the readers.

AIM AND SCOPE

Mersin University Journal of Maritime Faculty (MEUJMAF) is an international blind peer-reviewed open access journal, published twice a year. The Journal covers all fields of Maritime Business Administration, Marine Transportation Engineering, Logistics, Supply Chain Management, Logistics Engineering, Naval Architecture Engineering, Marine Operations, Operations Research, Foreign Trade, Maritime Economics, Maritime History, International Trade, Marine Pollution and Port Management.

PEER REVIEW PROCESS

All submissions will be scanned by iThenticate® to prevent plagiarism. Author(s) of the present study and the article about the ethical responsibilities that fit PUBLICATION ETHICS agree. Each author is responsible for the content of the article. Articles submitted for publication are priorly controlled via iThenticate® (Professional Plagiarism Prevention) program. If articles that are controlled by iThenticate® program identified as plagiarism or self-plagiarism with more than 25% manuscript will return to the author for appropriate citation and correction. All submitted manuscripts are read by the editorial staff. To save time for authors and peer-reviewers, only those papers that seem most likely to meet our editorial criteria are sent for formal review. Reviewer selection is critical to the publication process, and we base our choice on many factors, including expertise, reputation, specific recommendations and our own previous experience of a reviewer's characteristics. For instance, we avoid using people who are slow, careless or do not provide reasoning for their views, whether harsh or lenient. All submissions will be double blind peer reviewed. All papers are expected to have original content. They should not have been previously published and it should not be under review. Prior to the sending out to referees, editors check that the paper aim and scope of the journal. The journal seeks minimum three independent referees. All submissions are subject to a double blind peer review; if two of referees gives a negative feedback on a paper, the paper is being rejected. If two of referees gives a positive feedback on a paper and one referee negative, the editor can be decide whether accept or reject. All submitted papers and referee reports are archived by journal Submissions whether they are published or not are not returned. Authors who

want to give up publishing their paper in MEUJMAF after the submission have to apply to the editorial board in written. Authors are responsible from the writing quality of their papers. MEUJMAF journal will not pay any copyright fee to authors. A signed Copyright Assignment Form has to be submitted together with the paper.

PUBLICATION ETHICS

Our publication ethics and publication malpractice statement is mainly based on the Code of Conduct and Best-Practice Guidelines for Journal Editors Committee on Publication Ethics (COPE). (2011, March 7). Code of Conduct and Best-Practice Guidelines for Journal Editors. Retrieved from http://publicationethics.org/files/Code%20of%20Conduct_2.pdf

PUBLICATION FREQUENCY

The MEUJMAF accepts the articles in English and is being published 2 times (December and June) a year.

CORRESPONDENCE ADDRESS

Journal Contact: meujmaf@mersin.edu.tr

CONTENTS

Volume 2 – Issue 2

ARTICLES

Mersin University Journal of Maritime Faculty

Mersin University Journal of Maritime Faculty (MEUJMAF)
Vol. 2, Issue 2, pp. 38-43, December 2020
ISSN 2687-6612, Turkey
DOI:10.47512/meujmaf.744155
Research Article

AHP BASED SELECTION OF THIRD-PARTY LOGISTICS SERVICE PROVIDER

Nergis Özispa *[1], Oğuzhan Kava [2] and Volkan Çetinkaya [3]

[1] Dokuz Eylül University, Maritime Faculty, Maritime Business and Administration, İzmir, Turkey
ORCID ID 0000-0002-2467-5286
nergis.ozispa@deu.edu.tr

[2] Nordic Transport Group, Sea Freight Operation Specialist, İzmir, Turkey
ORCID ID 0000-0003-3631-5496
oguzhan.kava@outlook.com

[3] Dokuz Eylül University, Maritime Faculty, Logistics Management, İzmir, Turkey
ORCID ID 0000 – 0001 – 8921 – 1311
volkan.cetinkaya@deu.edu.tr

* Corresponding Author
Received: 28/05/2020 Accepted: 23/11/2020

ABSTRACT
Today, as in all other sectors, competition in the logistics sector is getting harder day by day. In order to be successful, firms should be able to take the right decisions and fast as they can to be able to catch changing competition conditions. The first stage of making the right decisions is to reach the correct and necessary data quickly. Although the concept of big data, which is one of the innovations brought by the Industry 4.0 revolution, has significantly facilitated access to information, it is still considered an important challenge to analyze this data obtained by companies during daily business processes in a meaningful way. Like many other sectors, the import / export sector has difficulties in the selection process of third party logistics companies in outsourcing activities. Hence, the purpose of this study is to decide the criteria that import export companies should pay attention while choosing a 3rd party logistics company and to determine the priority and importance of these criteria. Both qualitative and quantitative methods used in the study, in the criteria selection phase, one of the directors of Turkey's leading import / export company's was interviewed, in the second phase of the study, obtained criteria were prioritized using the AHP methodology. As a result of the study, a total of 16 criteria, 4 main and 12 sub-criteria were determined, and cost was determined as the most important main criterion in 3rd party logistics company selection process.

Keywords: *3rd Party Logistics Provider, Multi Criteria Decision Making, Import/Export Companies, Selection Process.*

1. INTRODUCTION

The concept of outsourcing, which means that companies are outsourcing some of their activities which is not their core activities, such as supply chain or logistics activities, in order to focus more on their main/core activities, has been used extensively in developed countries in recent years (Aktaş and Ulengin, 2005). With the increasing competition conditions, enterprises not only responsible of the quality of the products, but also products must be presented to the consumers at the desired place and desired time while providing cost advantages (Barlın, 2009). In the 1970s, companies which aim to increase their productivity, started to hire outside companies to manage less important processes. The experience of the companies has been successful, and many manufacturers now supply 70% to 80% of the finished product from external sources (Corbett, 2004). About 90% of companies see the outsourcing as an important growth strategy globally, even Peter Drucker, who is a famous management expert, defines the outsourcing as fastest-growing industry (Çakır, 2009). Developing countries, on the other hand, started to become attractive markets in the globally integrated world due to their geographical location, low wages and high market potentials, but when it is come to outsourcing mainly transportation comes to mind in developing countries (Ulengin and Ulengin, 2003). With the impact of globalization, companies whose powers are highly equalized in areas such as raw material supply and production methods have begun to look for different ways to gain advantage over their competitors, and logistics services at every stage of the supply chain cycle have come to the fore as the area where companies can make this difference successfully (Barlın, 2009).

Logistics services, which aim to improve the service of many steps from warehouse design to inventory management, mean not only to take the order from the manufacturer and deliver the products to the order point, but to add value to the product in this process with the help of outsourcing concept (Aktaş and Uluengin). In addition to be an important factor of customer satisfaction, logistics services are also an important cost factor for businesses, hence in today's market conditions it becomes an important item for outsourcing (Barlın, 2009). While gaining competitive advantage, logistics capabilities of companies becomes important, Razzaque and Sheng (1998) suggested three basic options that companies choose while handle their logistics activities;

- Providing the function in-house
- Setting up their own logistics subsidiary and buying a logistics firm
- Outsourcing the service from an external provider.

There are several advantages and disadvantages of logistics outsourcing, such as reduction of the cost, capital investments, workforce as advantages (Çakır, 2009), and loss of control (Wentworth, 2003) is mainly cited as disadvantage.

In the literature, it is possible to see multi-criteria decision making methods in studies on logistics service provider selection. Çakır *et al.,* (2018) mentioned the necessity of decision makers to evaluate multiple options such as quality, cost, and delivery time at the same time and to find the best option in the logistics service provider selection and suggested multi-criteria decision making methods for the solution.

2. LITERATURE REVIEW

Baltacıoğlu (2003) has defined third party logistics companies as external suppliers that perform all or part of the logistics functions of a company that produces products and / or services. 3PL companies work in harmony with the businesses they serve, and they provide a broad logistics services to coordinate the delivery of goods from one place to another (Karaman, 2014). Defined as an independent economic asset that creates value for his customer by Yıldız and Turan, (2015), 3rd PL is considered to be more economic and more efficient by many businesses today. Main differences between traditional transportation and 3rd PL Providers demonstrated in Table 1.

Table 1. Comparison of 3PL and Traditional Transportation

Traditional Transportation	**3rd Party Logistics Provider**
Standard Services	Customer-Specific Services
One-Way: Transportation and Storage	Versatile: Integrated System Approach and Logistics Services
Minimizing shipping cost	Service Quality - Flexibility
Short Term Simple Contracts (0–2 Year)	Intermediate and High Level Decisions, Strategic Contracts (2–5 Years)
Limited Expertise	Wide-ranging Expertise and Analytic Thinking
Weak Inter-Firm Bond	Strong Inter-Firm Bond

Source: Mersin, 2003; Hergüllü, 2009.

According to Hergüllü (2009), there are ten main service areas that can outsourced from 3PL companies, such as, shipping/ transportation, forwarding services, product tracking service and logistics information system, cross-docking terminal activities/ consolidation transactions, recycling logistics, inventory (stock) management, warehouse management, customer service and export and import documentation/customs transactions value-added transactions. 3rd party logistics (3PL) providers are one of the important types of logistics value chain related strategic alliances with the retailer-supplier partnerships and distributor integration (Çakır, 2009). The alliance between businesses and 3PL is important because, in this way, businesses use the resources and capacity of 3PL to reduce logistics costs per unit and reduce logistics facility investments, as well as increase overall operational efficiency and customer satisfaction. All these reasons enable them to establish an important advantage in gaining competitive advantage in today's conditions (Çakır, 2009).

The supplier selection has become one of the most important decision making problems for businesses as they contribute to the reduction of purchasing costs and the development of common talent capabilities (Hergüllü, 2009). For this reason, although it is considered as an important variable, only buyer and supplier relations

depending on price factor are not suitable for supply chain management. In the 3PL selection process, in addition to the price, quality, delivery, flexibility and other strategic and operational factors should be taken into account (Hergüllü, 2009).

In the current literature there are various studies that investigate 3PL service providers with different perspectives. In 2004, Akyıldız aimed to examine the current situation on outsourcing logistics activities od manufacturer companies in Turkey, he conducted questionnaire on 125 companies and analyzed obtained data with statistical methods. Most outsourced logistics services have been identified as transport and customs procedures as a result of the study. In addition, the fact that logistics outsourcing is 75% is one of the remarkable results of the study.

In the study conducted by Yıldız and Turan in 2015, data conducted from 14 steel pipe production company managers with face to face interview method, and obtained data analyzed by the content analysis. As a result of the study, the procurement and distribution functions determined as the logistics functions with the most outsourcing. In the study, the most important factors in the selection of logistics service providers were determined as service quality, reliability and price.

Sahay and Moran (2006), aimed to measure effect of using 3PL services on business outputs and analyzed the data collected in India by using survey method with statistical methods. As a result of the study, it has been determined that the use of 3PL has a significant and positive effect on the business performance of enterprises.

In 2004, Aguezzeul examined the 3PL selection decisions and the criteria used in the process by using academic articles published between 1994-2013. In the study, in which 67 articles were examined, 11 basic criteria were determined. Cost was the most adopted criterion for these 11 criteria, while relationship, services and quality followed it. In addition, the most used methods in the studies are determined as; MCDM techniques, statistical approaches, artificial intelligence, mathematical programming and hybrid methods respectively.

When current literature analyzed it is seen that various studies suggest 3PL supplier selection criteria such as; relationship, services, professionalism (Aguezzoul, 2014), geographical spread (Aguezzoul, 2014; Boyson et al., 1999; Maltz, 1994; Bradley, 1995), performance measurement (Bhatnagar et al., 1999; Lynch, 2000; Langley et al., 1999), quality (Aguezzoul, 2014; Andersson and Norman, 2002; Lynch, 2000; Boyson et al., 1999; Razzaque and Sheng, 1998; Thompson, 1996; Langley et al., 1999; Stock et al., 1998), flexibility (Aguezzoul, 2014; Bradley, 1995), cost, (Aguezzoul, 2014; Lynch, 2000; Langley et al., 1999; Boyson et al., 1999; Stock et al., 1998; Tam and Tummala, 2001), reputation (Aguezzoul, 2014; Lynch, 2000; Thompson, 1996; Boyson et al., 1999), Long-term relationships (Lynch, 2000; Boyson et al., 1999; Maltz, 1994; Stank and Daugherty, 1997), Information sharing (Lynch, 2000; Stock, 1990; Bagchi and Virum, 1996), information & equipment system (IT Capability) (Aguezzoul, 2014; Andersson and Norman, 2002); Lynch, 2000; Langley et al., 1999; Boyson et al., 1999; Langley et al., 2002; Rabinovich et al., 1999), financial position (financial performance) (Aguezzoul, 2014; Andersson and Norman, 2002; Boyson et al., 1999; Gattorna and Walters, 1996), market share (Thompson, 1996) and risk management (Boyson et al., 1999; *Gupta et al.,* 2011).

3. METHODOLOGY

The aim of this study is to, define the importance degree of 3PL service provider selection criteria for an import/export companies, and select the most appropriate 3PL company for one of the most important production, import/export company that serves in Turkey. To reach this specific aim, first face to face interview was conducted with an import specialist who worked in selected case company. As a result of this interview, the 3PL company selection criteria that gathered form the literature was analyzed and the importance degree of each main and sub-criteria decided with the binary comparisons of import specialist of the company. Then, with the AHP (Analytical Hierarchy Process) method, importance degree of the chosen criteria was determined via the Microsoft Office Excel program. In the third step, four different logistics company and the case company itself evaluated according to these criteria by 16 industry expert from different industries. The expertise area of the participants is given Table 2. In the last step, alternatives of the logistics companies analyzed via Super Decision Program to choose the best alternative.

Table 2. The Expertise Area of the Participants

Industry	Percent (%)
Freight Forwarders	75%
Liner Companies	12%
Port Operators	7%
Shippers	6%

3.1. Analytical Hierarchy Process (AHP)

The AHP method, which is used when there are more than one criteria to be evaluated when making a decision and the effects of these criteria not equal each other on the decision to be made, was developed by Thomas P. Saaty in 1977 (Dündar and Ecer, 2008). In this study, AHP method was preferred because of its advantages as, ease of use, scalable and hierarchical nature that can easily adjust its size to accommodate decision-making problems, and although it requires sufficient data to properly perform binary comparisons, alternatives with the ability to solve larger problems that do not require as much data as other multi-criteria decision-making methods (Velasquez and Hester, 2013). In the method based on binary comparisons, the scale developed by Saaty is completed by evaluating the decision options with a value between 1 and 9 for each decision criterion (Saaty, 1994). In the method, the data obtained through the matrices used to get CI (Consistency Index) value, by using the Eq (1);

$$CI = \frac{-\lambda ma}{\mathrm{n}-1} \quad (1)$$

then Random Index (RI) values, which is given in Table 3, used to calculate reliability of the results by using the Eq. (2) (Tzeng and Huang, 2011).

$$CR = \frac{CI}{RI} \quad (2)$$

Table 3. Random Value Index

n	1	2	3	4	5	6
RI	0	0	0,52	0,89	1,11	1,25

Source: Tzeng and Huang, 2011.

4. FINDINGS

In the AHP method, CR value should be smaller or equal to 10%, to accept that the results are consistent (Aykın, 2007). Table 4 demonstrates that the CR values of main and sub criteria, and according to the results our findings found consistent and reliable except sub-criteria of quality.

Table 4. Reliability of Results

	CR Value
Main Criteria	0,0644
Sub-criteria of Cost	0,0725
Sub-criteria of Quality	0,2128
Sub-criteria of Delivery	0,0725
Sub-criteria of Technical Capability	0,0537

According to results of the Analytical Hierarchy Process, cost determined as the most important 3PL selection criteria, and cost followed by quality, delivery and technical capability respectively.

Figure 1 demonstrates the hierarchy and the priority values of all decision criteria and sub-criteria. Accordingly, total cost, experience in production, reliability and information technology is determined as the most important sub-criteria in the 3PL selection process for the chosen company. Priority values of all other criteria can be seen in Figure 1.

After defining the importance of each criteria and sub-criteria, alternative logistics companies' performance in line with these criteria were analyzed via face to face interviews and e-mail responses. Experts form different expertise areas which summarized in Table 2, answered the questions according to their experiences in the sector and their personal networks. Obtained data analyzed with the help of Super Decision program and the results are given in Table 5.

Study results demonstrate that Alternative 1's performance is above average in all segments, while Alternative 2 is very good in technical capability also. Alternative 3 is above average in cost and technical capabilities but it found below average in quality and delivery dimensions. According to experts' opinions, Alternative 4 get the highest scores with two above average and 2 very good performances. Company itself, however, gets the worst results and it stayed below the average in all segments. This result also revealed the positive effect of outsourcing on business performance.

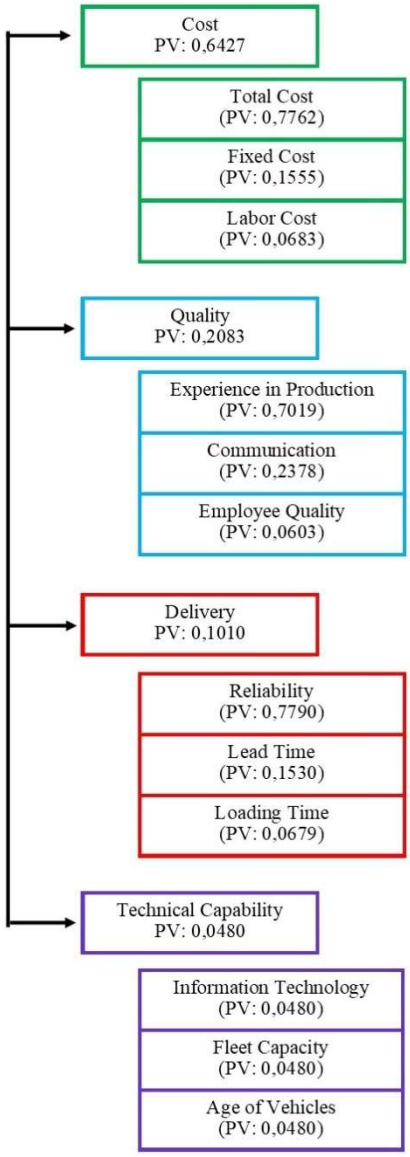

Fig. 1. Importance Degree of Criteria

Table 5. Evaluation of Alternatives

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Company Itself
Cost					
Transport Cost Labor Cost Fixed Cost	AA*	AA	AA	AA	BA
Quality					
Experience Communication Employee Quality	AA	AA	BA*	AA	BA
Delivery					
Lead time Loading Time Reliability	AA	AA	BA	VG	BA
Technical Capability					
Fleet Capacity It Age of Vehicles	AA	VG*	AA	VG	BA
Priority Ratings	0,20	0,22	0,17	**0,30**	0,09
Total Ratings	0,33	0,36	0,27	**0,49**	0,15

* AA= Above Average
BA= Below Average
VG= Very Good

5. CONCLUSION

This study aims to, define the importance degree of 3PL service provider selection criteria for an import/export companies, select the most appropriate one for a case company. With the impact of globalization, gaining a competitive power becoming harder and harder every day for the businesses, because of the limitless opportunities of technology, science, production improvement, supply raw materials, etc. All these innovations and improvements we encounter in the 21st century compel businesses to make difficult decisions to survive. The concept of outsourcing, which means that specializing in the areas where businesses are the best, uses outsourcing for tasks that are not very good, or purchases functions that it does not invest in, while providing its investments to certain areas, provides this competitive power to businesses. However, this process has become a decision-making challenge for businesses today. Namely, companies that decide to outsourcing after comparing all the advantages and disadvantages of outsourcing, have to make more decisions about the outsourcing process. One of the examples that we frequently encounter in the literature is that businesses tend to outsource especially for their logistics activities (Barlın, 2009; Aktaş and Uluengin, 2005; Razzaque and Sheng, 1998). Again in the literature, it is argued that 3PL companies that provide this service to businesses do this job more successfully than the companies themselves (Yıldız and Turan, 2015; Mersin, 2003; Hergüllü, 2009). In line with the literature this study also proved this argument with the results have shown in Table 5, which demonstrates the company itself has below average scores in all dimensions with the 0,09 priority ratings.

In the literature several study, suggests the cost as the most important criteria (Aguezzoul, 2014; Lynch, 2000; Langley et al., 1999; Boyson et al., 1999; Stock et al., 1998; Tam and Tummala, 2001) in the 3PL selection process of businesses. In this study, in parallel with the literature cost has been chosen as the most important 3PL selection criteria and followed by quality, delivery and technical capability of service providers. However, Alternative 4, the best option as a 3PL company, revealed the importance of other criteria such as delivery and technical capability, as chosen because of its performance in that fields.

REFERENCES

Aguezzoul, A. (2014). Third-party logistics selection problem: A literature review on criteria and methods. *Omega*, *49*, 69-78.

Aktas, E., and Ulengin, F. (2005). "Outsourcing logistics activities in Turkey". *Journal of Enterprise Information Management*.

Anderson, D., and Norman, A. (2002). "Procurement of logistics services-A minute's work or a multi-year project?" *European Journal of Purchasing and Supply Management*, 8(1), 3–14.

Aykin, N. (Ed.). (2007). Usability and Internationalization. HCI and Culture: Second International Conference on Usability and Internationalization, UI-HCII 2007, held as Part of HCI International 2007, Beijing, China, July 22-27, 2007, Proceedings (Vol. 4559). Springer.

Bagchi, P.K., Virum, H. (1996), "European logistics alliances: a management model", *International Journal of Logistics Management*, Vol. 7 No.1, pp.93-108.

Baltacıoğlu, T. Lojistik Yönetimine Genel Bakış. İzmir: *Ege Denizcilik ve Lojistik Kongresi*, 2003, s.27.

Barlın, A. (2009). Lojistikte dış kaynak kullanımı ve maliyetlerin kontrolü. *Unpublished PhD Thesis*. Marmara University, Institute of Social Sciences

Bhatnagar, R., Sohal, A.S. and Millen, R. (1999). "Third party logistics services: a Singapore perspective", *International Journal of Physical Distribution & Logistics Management*, 29(9), pp. 569-587.

Boyson, S., Corsi, T., Dresner, M., & Rabinovich, E. (1999). Managing effective third party logistics relationships: what does it take?. *Journal of Business Logistics*, 20(1), 73.

Bradley, P. (1995). Third parties gain slow, cautious buyer support. *Purchasing*, 118(8), 51-52.

Çakır, E. (2009). "Logistics outsourcing and selection of third party logistics service provider (3PL) via fuzzy AHP".*Unpublished Masters Thesis*, Bahçeşehir University, Institute of Science.

Çakir, E., Tozan, H., and Vayvay, O. (2009). "A method

for selecting third party logistic service provider using fuzzy AHP". *Journal of Naval Science and Engineering*, *5*(3), 38-54.

Corbett, M. F. (2004). The outsourcing revolution. Dearborn, Chicago, 39.

Dündar, S., & Fatih, E. (2008). Öğrencilerin GSM operatörü tercihinin analitik hiyerarşi süreci yöntemiyle belirlenmesi. *Yönetim ve Ekonomi: Celal Bayar Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 15(1), 195-205.

Gattorna, J. I., & Walters, D. W. (1996). Managing the Supply Chain: a strategic perspective. Macmillan Business.

Gupta, O. K., Ali, S. S., & Dubey, R. (2011). Third party logistics: key success factors and growth strategies. *International Journal of Strategic Decision Sciences* (*IJSDS*), 2(4), 29-60.

Hergüllü, İ. (2009). Lojistik Fonksiyonlarda Dış Kaynak Kullanımı 3PL Lojistik (*Doctoral Dissertation*, DEÜ Sosyal Bilimleri Enstitüsü).

Karaman, M. F. (2014). Lojistikte Dış Kaynak Kullanımı: Ege Bölgesi (*Master's thesis*, Maltepe Üniversitesi, Sosyal Bilimler Enstitüsü).

Langley C.J., Jr, Newton, B.F. and Tyndall, G.R. (1999). "Has the future of third-party logistics already arrived?" *Supply Chain Management Review*, Autumn, pp. 85-94.

Langley, C.J. Jr, Allen, G.R. and Tyndall, G.R. (2002). "Third-party logistics study results and findings of the 2002 seventh annual study", unpublished Report, Georgia Institute of Technology, Atlanta, GA.

Lynch, C. F. (2000). Logistics Outsourcing: A Management Guide. Oak Brook, IL: Council of Supply Chain Management Professionals.

Maltz, A.B. (1994). "The relative importance of cost and quality in the outsourcing of warehousing", *Journal of Business Logistics*, Vol. 15 No.2, pp.45-62.

Mersin, D.N. (2003). "Lojistikte Dış Kaynak Kullanımı Yararları ve Dikkat Edilmesi Gerekli Noktalar", *Uluslararası Lojistik Kongresi* 30 Haziran - 1 Temmuz 2003, İstanbul. Bahçeşehir Üniversitesi Yayınları

Rabinovich, E., Windle, R., Dresner, M. and Corsi, T. (1999). "Outsourcing of integrated logistics functions: an examination of industry practices", *International Journal of Physical Distribution & Logistics Management*, Vol. 29 No. 6, pp. 353-73.

Razzaque, M.A. and Sheng, C.C. (1998). "Outsourcing of logistics functions: a literature survey*", International Journal of Physical Distribution & Logistics Management*, Vol. 28 No. 2, pp. 89-107.

Saaty, T. L. (1994). How to make a decision: the analytic hierarchy process. *Interfaces*, 24(6), 19-43.

Stank, T. P., and Daugherty, P. J. (1997). "The impact of operating environment on the formation of cooperative logistics relationships" *Transportation Research, Part-E*, 33(1), 53–65.

Stock, G., Greis, N. and Kasarda, J. (1998). "Logistics, strategy and structure: a conceptual framework", *International Journal of Operations & Production Management*, Vol. 18 No. 1, pp. 37-52.

Tam, M. C., & Tummala, V. R. (2001). An application of the AHP in vendor selection of a telecommunications system. *Omega*, 29(2), 171-182.

Thompson, T. J. (1996). An Analysis of Third Party Logistics and Implications for USAF Logistics (No. AFIT/GTM/LAL/96S-15).

Tzeng, G. H., & Huang, J. J. (2011). Multiple attribute decision making: methods and applications. CRC press.

Ulengin, F., and Ulengin, B. (2003, June). "Impact of Internet on supply chain activities: the case of Turkey". *In The International Logistics Congress* (Vol. 30).

Velasquez, M., & Hester, P. T. (2013). An analysis of multi-criteria decision making methods. *International Journal of Operations Research*, 10(2), 56-66.

Wentworth, F. (2003). "Outsourcing services: The case against. *Journal of the Institute of Logistics & Transport,* 5(2): 57-59.

Mersin University
Journal of Maritime Faculty

Mersin University Journal of Maritime Faculty (MEUJMAF)
Vol. 2, Issue 2, pp. 44-49, December 2020
ISSN 2687-6612, Turkey
DOI: 10.47512/meujmaf.816402
Research Article

MULTI-PERIOD MIXED INTEGER PROGRAMMING MODEL FOR SUPPLY CHAIN PLANNING UNDER SAFETY STOCK

Ahmet Aktas *[1] and İzzettin Temiz [2]

[1] Gazi University, Faculty of Engineering, Department of Industrial Engineering, Ankara, Turkey
ORCID ID 0000-0002-4394-121X
aaktas@gazi.edu.tr

[2] Mersin University, Faculty of Maritime, Department of Maritime Business Administration, Mersin, Turkey
ORCID ID 0000-0001-8672-1340
itemiz@mersin.edu.tr

* Corresponding Author
Received: 26/10/2020 Accepted: 16/11/2020

ABSTRACT
Supply chain management philosophy has been adopted by enterprises due to the requirement of customer demand satisfaction in reasonable times under market competition. In case of rapid increase in product demands and/or occurrence of supply problems in materials, enterprises choose holding some amount of safety stock of several materials and products. In this study, a multi-period, multi-product supply chain with different suppliers, material storages, production plants, distribution centers and customers is modeled. To determine the optimal production, supply and storage plans at minimum cost, a mixed-integer programming model is proposed. Capacity, bill-of-materials structure of products and placement of safety stocks are taken into account within the proposed model. Solutions of a set of examples are also presented in order to test the model.

Keywords: *Supply chain, Safety stock, Integer programming, Bill-of-materials*

1. INTRODUCTION

As a result of changing economic conditions, enterprises need to develop new relations with their customers and suppliers. Furthermore, recently developed customer oriented marketing strategies force enterprises to communicate with their customers in a continuous and dynamic way.

Enterprises, which do not desire to be behind their rivals in market, have to manage their supply chain. Supply chain is defined as the aggregation of whole processes and organizations related to material supply, transformation of materials to products and distribution of products to customers, effectively. Effective management of supply chains reduce costs and increase profit of the enterprise significantly.

One of the popular subjects related to supply chain management and inventory management is to save money and storage area by communication and coordination over supply network. The most important problems being faced at this point are the uncertainty and variability. To overcome the uncertainty and variability problems faced here, companies may hold some amount of safety stock of materials and products.

In this study, a multi-period, multi-product supply chain with several suppliers, material storages, production plants, distribution centers and customers is modelled. To determine the optimal supply, distribution and storage plan at minimum cost, a mixed-integer programming model is proposed. A schematic representation of the supply chain is given in Figure 1.

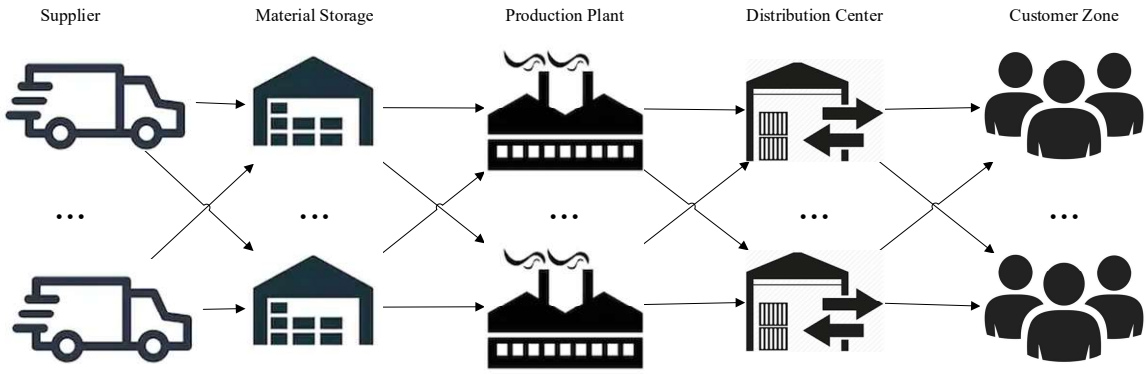

Figure 1. Schematic representation of supply chain network

Rest of the paper is organized as follows: In the second part, a literature review related to optimization of supply chains is presented. The proposed integer programming model is formulated in the third part by presenting the definitions of notations, parameters and decision variables of the model. Solution to a numerical example of the proposed model is given in the fourth part. The paper is concluded in the fifth part by giving further research suggestions.

2. LITERATURE REVIEW

Supply chain planning has taken attention of researchers in recent 20 years. Some of the studies related to this topic can be summarized as follows:

Value add of the activities and resources within the supply chain on overall performance is investigated under the demand and capacity considerations (Lakhal et al., 2001). An integrated solution approach based on Analytic Hierarchy Process and Integer Programming is developed in order to determine partner selection and production-distribution planning decisions in supply chains (Sha and Che, 2004). A two stage dynamic programming approach is used to find the optimal supply chain configuration for a new designed product (Graves and Willems, 2005). Uncertainty in supply chains is modelled by Santoso et al. (2005) by using stochastic programming approach. In another study taking uncertainty into consideration in supply chains (Aliev et al., 2007), fuzzy genetic programming approach is used to determine aggregate production-distribution planning.

A two-stage supply chain under stockout, capacity and safety stock considerations is modelled by Romeijn et al. (2007). Fuzzy multi-objective linear programming formulation is used by Liang (2008) to determine the multi-period production-distribution plan in a multi-product supply chain subject to demand, workforce and machine capacity constraints by minimizing cost and delivery time. A mixed-integer programming model considering quality constraints, tax and exchange rates is proposed to optimize production-distribution plans in supply chains (Tsiakis and Papageorgiou, 2008). A real case study of multi-stage supply chains with several production plants is solved by using fuzzy goal programming to determine aggregated plans of supply, production and distribution (Torabi and Hassini, 2009).

A mixed-integer programming model subject to supplier capacity constraints is proposed to optimize supply chain configuration in the agile manufacturing supply chains (Constantino et al., 2012). The trade-off between quality and profit is searched in a study that maximizes the profit on a supply chain (Paksoy et al., 2012).

A mixed-integer program is proposed to optimize cost and reliability objectives in a three echelon production distribution system (Khalifehzadeh et al., 2017). Miranda et al. (2018) propose an integrated production, distribution, routing and inventory planning model for the small furniture companies. A bi-objective production-distribution planning model is proposed by Rafiei et al. (2018) to optimize cost and service level objectives. A goal programming model taking lead times, bill-of-materials, capacity and demand issues into account is proposed by Aktas and Temiz (2020) to determine the trade-off point between profit and

emission caused of transportation activities over the supply chain.

Production, inventory and distribution decisions in a supply chain are optimized by using a column generation and MILP based two-stage approach to obtain maximum profit (Cóccola et al., 2020). A two – stage stochastic mixed integer programming formulation is proposed to determine integrated production-distribution decisions in dairy products supply chain (Guarnaschelli et al., 2020). Optimal production capacity and safety stock levels in a multi-product serial production-distribution network are determined under guaranteed service approach (Ghadimi and Aouam, 2021). The problem of the study is formulated as a non-convex program subject to budget limitation and solution is obtained by developing a nested Lagrangian relaxation algorithm.

In the light of reviewed studies, a mixed-integer programming model for the optimization of a multi-product supply chain is proposed in this study by considering material supply, production, distribution and inventory planning decisions in an integrated manner.

3. PROPOSED MODEL

The main aim of this study is to propose a mathematical model to support multi-period planning decisions in multi-product multi-stage supply chains with safety stock consideration. The supply chain defined with the mathematical model consists several suppliers, customers, material storage, production and distribution center plants. Each material storage must have inventory of each item at least safety stock level and cannot have more than storage capacity. Similarly, distribution centers must have products more than safety stock level and can have at most storage capacity of products. Moreover, production capacity and bill-of-materials structure are also taken into consideration in the proposed model. Distribution centers send products to customer locations to satisfy customer demands.

Indices, parameters and decision variables of the model are defined and mathematical formulation of the problem is presented as follows:

Indices

m	Materials
s	Suppliers
p	Material storage plants
i	Products
w	Production plants
d	Distribution centers
c	Customer zones
t	Planning periods

Parameters

c_{msp}	unit variable transportation cost of material m from supplier s to material storage p
c_{mpw}	unit variable transportation cost of material m from material storage p to product plant w
c_{iw}	unit variable production cost of product i at production plant w
c_{iwd}	unit variable transportation cost of product i from production plant w to distribution center d
c_{idc}	unit variable transportation cost product i from distribution center d customer zone c
h_{mp}	unit variable inventory holding cost of material m at material storage p
h_{id}	unit variable inventory holding cost of product i at distribution center d
cap_{mp}	storage capacity of material storage p for material m
ss_m	safety stock level for material m
b_{im}	required number of material m for product i
a_i	unit production time for product i
cap_w	production capacity of production plant w
D_{ict}	demand of customer c for product i in period t
cap_{id}	storage capacity of distribution center d for product i
ss_i	safety stock level of product i

Decision Variables

XS_{mspt}	transportation amount of material m from supplier s to material storage p in period t
IP_{mpt}	storage amount of material m in material storage p in period t
XW_{iwt}	production amount of product i at production plant w in period t
XP_{mpwt}	transportation amount of material m from material storage p to production plant w in period t
XD_{iwdt}	transportation amount of product i from production plant w to distribution center d in period t
XC_{idct}	transportation amount of product i from distribution center d to customer center c in period t
ID_{idt}	storage amount of product i at distribution center d in period t

Mathematical Formulation

$$\min TC = \sum_{t=1}^{T}\sum_{m=1}^{M}\sum_{s=1}^{S}\sum_{p=1}^{P} c_{msp} * XS_{mspt} + \sum_{t=1}^{T}\sum_{m=1}^{M}\sum_{p=1}^{P}\sum_{w=1}^{W} c_{mpw} * XP_{mpwt} + \sum_{t=1}^{T}\sum_{i=1}^{N}\sum_{w=1}^{W} c_{iw} * XW_{iwt} + \sum_{t=1}^{T}\sum_{i=1}^{N}\sum_{w=1}^{W}\sum_{d=1}^{D} c_{iwd} * XD_{iwdt} + \sum_{t=1}^{T}\sum_{i=1}^{N}\sum_{d=1}^{D}\sum_{c=1}^{C} c_{idc} * XC_{idct} + \sum_{t=1}^{T}\sum_{m=1}^{M}\sum_{p=1}^{P} h_{mp} * IP_{mpt} + \sum_{t=1}^{T}\sum_{i=1}^{N}\sum_{d=1}^{D} h_{id} * ID_{idt} \quad (1)$$

Subject to

$$\sum_{s=1}^{S} XS_{mspt} - \sum_{w=1}^{W} XP_{mpwt} + IP_{mp,t-1} = I_{mpt} \quad \forall m,p,t \quad (2)$$
$$IP_{mpt} \leq cap_{mp} \quad \forall m,p,t \quad (3)$$
$$\sum_{p=1}^{P} IP_{mpt} \geq ss_m \quad \forall m,t \quad (4)$$
$$\sum_{i=1}^{N} b_{im} * X_{iwt} - \sum_{p=1}^{P} XP_{mpwt} = 0 \quad \forall m,w,t \quad (5)$$
$$\sum_{i=1}^{N} a_i * XW_{iwt} \leq cap_w \quad \forall w,t \quad (6)$$
$$\sum_{d=1}^{D} XD_{iwdt} = XW_{iwt} \quad \forall i,w,t \quad (7)$$
$$\sum_{w=1}^{W} XD_{iwdt} - \sum_{c=1}^{C} XC_{icdt} + ID_{id,t-1} = I_{idt} \quad \forall i,d,t \quad (8)$$
$$ID_{idt} \leq cap_{id} \quad \forall i,d,t \quad (9)$$
$$\sum_{d=1}^{D} ID_{idt} \geq ss_i \quad \forall i,t \quad (10)$$
$$\sum_{d=1}^{D} XC_{icdt} = D_{ict} \quad \forall i,c,t \quad (11)$$
$$XS_{mspt} \geq 0 \text{ and integer} \quad \forall m,s,p,t \quad (12)$$
$$XW_{iwt} \geq 0 \text{ and integer} \quad \forall i,w,t \quad (13)$$
$$XP_{mpwt} \geq 0 \text{ and integer} \quad \forall m,p,w,t \quad (14)$$
$$XD_{iwdt} \geq 0 \text{ and integer} \quad \forall i,w,d,t \quad (15)$$
$$XC_{idct} \geq 0 \text{ and integer} \quad \forall i,d,c,t \quad (16)$$
$$IP_{mpt} \geq 0 \text{ and integer} \quad \forall m,p,t \quad (17)$$
$$ID_{idt} \geq 0 \text{ and integer} \quad \forall i,d,t \quad (18)$$

Eq. (1) shows the objective function of the model and minimizes the total cost of production, distribution and storage within the supply chain. The objective function consist costs of the material supply cost, the transportation costs of materials to production plants, production costs, transportation costs of products to distribution centers and customer locations and storage cost of materials and products, respectively. Eq. (2) expresses the balance constraint for materials. Eq. (3) and Eq. (4) states the lower (safety stock) and upper bounds (storage limitation) for material storage levels, respectively. Eq. (5) represents the equity of material amount from material storage plants to each production plant and material amount used in production in that plant. Eq. (6) shows the production capacity of production plants. Eq. (7) states that the production amount must be equal to the product amount transported to distribution centers. In other words, production plants cannot store any products. Eq. (8) shows the balance equation for products in distribution centers. Eq. (9) and Eq. (10) states the safety stock and storage capacity amounts for products, respectively. Eq. (11) expresses that customer demands are satisfied by product transportation to customer zones. Nonnegativity and integrity restrictions for the decision variables are given by Eq. (12) – Eq. (18).

4. NUMERICAL STUDIES

Solution of the proposed model is obtained for a set of examples on a supply chain with 2 suppliers, 2 material storage plants, 2 production plants, 2 distribution centers and 3 customer zones. Production-distribution plan for 12 months planning period is obtained for problems with several combinations of 3, 4 and 5 products and 5, 10 and 15 materials. Number of products and materials in each example problem is presented in Table 1.

Safety stock level for each material at each material storage plant is assumed to be 250 and each material storage can store 5000 materials. Distribution centers can store up to 500 products and safety stock of each product is 30. Production capacity of each plant is determined as 12000 minutes per planning period. Unit production time of products are generated randomly from uniform distribution between 5 and 15 minutes. Product demands are also randomly generated from uniform distribution between 100 and 200 units. Range value of other random parameters are presented in Table 2.

Table 1. Number of materials and products in example

Problem	# of Products	# of Materials
P1	3	5
P2	3	10
P3	3	15
P4	4	5
P5	4	10
P6	4	15
P7	5	5
P8	5	10
P9	5	15

Table 2. Parameter ranges

Parameter	Value Range
c_{msp}	(5,35)
c_{mpw}	(10,25)
c_{iw}	(7,32)
c_{iwd}	(9,40)
c_{idc}	(5,35)
c_{iwr}	(10,25)
h_{mp}	(10,30)
h_{id}	(8,30)

Proposed mathematical model is coded on GAMS software and randomly generated nine examples are solved by CPLEX 24.1.3 solver with a personnel computer with Intel i7 2.40 GHz processor and 8 GB RAM. Obtained solution results are given in Table 3.

Solution results show that the model can easily be solved by a commercial solver. Each of the example problems reached to the optimal solution in less than 1 second solution time. So, the model can be used as a multi-period production – distribution planning tool for multi – product supply chains.

Table 3. Solution results

Problem	Objective Value	Solution Time
P1	2392226	0.047 sec
P2	4675950	0.062 sec
P3	8166604	0.062 sec
P4	5347514	0.031 sec
P5	5606356	0.047 sec
P6	9576919	0.172 sec
P7	4106332	0.282 sec
P8	8135839	0.047 sec
P9	11369679	0.187 sec

According to the solution results, the increase of material and product numbers caused greater values of system cost. It seems sensible, because the more elements the supply chain contain brings extra cost of material purchase, transportation, also production and product transportation.

5. CONCLUSION

Effective management of the supply chain requires consideration of whole system entirely and making decisions according to this consideration. Besides, its negative effects on system costs, placement of safety stock in supply chains may be an appropriate solution to increase customer service level.

In this study a mixed-integer programming model for a supply chain with safety stocks is proposed. Within the proposed model, capacity constraints and bill-of-materials structure are considered. A set of numerical examples of the model is solved by a commercial solver software.

The novelty of the model consideration of bill-of-materials and safety stock placement in a supply chain with suppliers, material storages, production plants, distribution centers and customers. Researchers can extend this study by insertion of different aspects of supply chains. For practitioners, this model can be used to determine supply, production, distribution and storage decisions, since it reaches optimal solution in a very short time.

The main limitation of the study is that the decisions can be expressed by binary variables are ignored in this model. Operation decisions for plants, supplier selection decisions, linkage of products with production plants can be considered as extension paths of the study. Also, capacity and demand uncertainties can be taken into account by fuzzy or stochastic modelling.

REFERENCES

Aktas, A., Temiz, İ. (2020). "Goal Programming Model for Production-Distribution Planning by Considering Carbon Emission". *Gazi University Journal of Science*, Vol. 33, No. 1, pp. 135-150 .

Aliev, R. A., Fazlollahi, B., Guirimov, B. G., Aliev, R. R., (2007), "Fuzzy-genetic approach to aggregate production–distribution planning in supply chain management", *Information Sciences*, Vol. 177, pp. 4241-4255.

Cóccola M. O., Méndez, C. A., Dondo, R. G., (2020), "A two-stage procedure for efficiently solving the integrated problem of production, inventory, and distribution of industrial products", *Computers and Chemical Engineering*, 134, 106690

Costantino, N., Dotoli, M., Falagario, M., Fanti, M. P., Mangini, A. M., (2012), "A model for supply management of agile manufacturing supply chains". *International Journal of Production Economics*, Vol. 135, pp. 451-457.

Ghadimi F., Aouam, T., (2021), "Planning capacity and safety stocks in a serial production–distribution system with multiple products, *European Journal of Operational Research*, 289, pp. 533–552.

Graves, S. C., Willems, S. P., (2005), "Optimizing the Supply Chain Configuration for New Products", *Management Science*, Vol. 51, pp. 1165-1180.

Guarnaschelli, A., Salomone H. E., Méndez, C. A., (2020). "A stochastic approach for integrated production and distribution planning in dairy supply chains", *Computers & Chemical Engineering*, 140, 106966.

Khalifehzadeh, S., Seifbarghy, M., Naderi, B., (2017), "Solving a fuzzy multi objective model of a production–distribution system using meta-heuristic based approaches". *Journal of Intelligent Manufacturing*, Vol. 28, pp. 95-109.

Lakhal, S., Martel, A., Kettani, O., Oral, M., (2001), "On the optimization of supply chain networking decisions", *European Journal of Operational Research*, Vol. 129, pp. 259-270.

Liang, T.-F., (2008), "Fuzzy multi-objective production/distribution planning decisions with multi-product and multi-time period in a supply chain", *Computers & Industrial Engineering*, Vol. 55, pp. 676-694.

Miranda, P. L., Morabito, R., Ferreira, D., (2018). "Optimization model for a production, inventory, distribution and routing problem in small furniture companies". *TOP*, Vol. 26, pp. 30-67.

Paksoy, T., Özceylan, E., Weber, G.-W., (2012), "Profit oriented supply chain network optimization", *Central European Journal of Operations Research*, Vol. 21, pp. 455-478.

Rafiei, H., Safaei, F., Rabbani M., (2018)., "Integrated production-distribution planning problem in a competition-based four-echelon supply chain". *Computers & Industrial Engineering*, Vol. 119, pp. 85–99.

Romeijn, H. E., Shu, J., Teo, C.-P., (2007), "Designing two-echelon supply networks", *European Journal of Operational Research*, Vol. 178, pp. 449-462.

Santoso, T., Ahmed, S., Goetschalckx, M., Shapiro, A., (2005), "A stochastic programming approach for supply chain network design under uncertainty", *European Journal of Operational Research*, Vol. 167, pp. 96-115.

Sha, D. Y., Che, Z. H., (2004), "Virtual integration with a multi-criteria partner selection model for the multi-echelon manufacturing system", *The International Journal of Advanced Manufacturing Technology*, Vol. 25, pp. 793-802.

Torabi, S. A., Hassini, E., (2009), "Multi-site production planning integrating procurement and distribution plans in multi-echelon supply chains: an interactive fuzzy goal programming approach", *International Journal of Production Research*, Vol. 47, pp. 5475-5499.

Tsiakis, P., Papageorgiou, L. G., (2008), "Optimal production allocation and distribution supply chain networks", *International Journal of Production Economics*, Vol. 111, pp. 468-483.

Mersin University
Journal of Maritime Faculty

Mersin University Journal of Maritime Faculty (MEUJMAF)
Vol. 2, Issue 2, pp. 50-61, December 2020
ISSN 2687-6612, Turkey
DOI: 10.47512/meujmaf.815671
Research Article

SUPPLIER SELECTION WITH AHP AND 0-1 GOAL PROGRAMMING: AN APPLICATION IN HEALTHCARE INDUSTRY

Res. Ass. Sena Kumcu *[1], Asst. Prof. Dr. Bahar Özyörük [2]

[1] Gazi University, Faculty of Engineering, Department of Industrial Engineering, Ankara, Turkey
ORCID ID 0000-0002-9648-6281
senakumcu@gazi.edu.tr

[2] Gazi University, Faculty of Engineering, Department of Industrial Engineering, Ankara, Turkey
ORCID ID 0000-0001-5434-6697
bahar@gazi.edu.tr

* Corresponding Author
Received: 23/10/2020 Accepted: 26/11/2020

ABSTRACT
In order for health institutions to continue their activities, the goods and services they need must be supplied at the right time, in the right amount, at the right quality, at an affordable price and from the right source. This is possible with an effective supply chain management and selection of the right supplier. Supplier selection studies in the health sector are almost nonexistent, therefore, it was wanted to contribute to the literature by studying in this sector. In this study, it was aimed to work with the right suppliers to ensure that a dental health center provides critical medical supplies. First of all, the products of vital importance were determined by ABC (Always, Better Control)-VED (Vital, Essential, Desirable) matrix analysis and a supplier list was created. The best suppliers were selected with the Zero-One Goal Programming method based on AHP priorities, one of the multi-criteria decision making methods, by determining the criteria suitable for the sector.It is thought that this model will contribute significantly to the literature and will save time in supplier selection studies in the health sector.

Keywords: *Supplier Selection, Healthcare Industry, Multiple Criteria Decision Making (MCDM), Goal Programming*

1. INTRODUCTION

In order for health institutions to continue their activities, the goods and services they need must be supplied at the right time, in the right amount, at the right quality, at an affordable price and from the right source. This is possible with an effective supply chain management (SCM). For this reason, more emphasis is placed on supply chain management in today's healthcare industry. SCM in hospitals provides elimination of all activities, movements and processes, minimizing errors, and increasing the efficiency of the process between the inputs and outputs.

The procurement activities of the health institution, where human health and even life is in question, should be carried out without interruption, because there is no compensation for the fault of logistics activities in health institutions. Any disruption that may be experienced can cost human life. Therefore, suppliers should be selected very carefully in healthcare institutions (Aptel & Pourjalali 2001: 68).

One of the most important components in SCM is supplier selection (Tookey and Thiruchelvam, 2011). Because choosing an appropriate supplier reduces purchasing costs, improves profits, reduces product delivery time, increases customer satisfaction and strengthens competitiveness (Frej et al., 2017).

Various supplier selection methods as observed in the literature have been classified in main categories and sub-categories. Table 1 summarizes the supplier selection methods (Taherdoost and Brard, 2019). Among the supplier selection studies, which have a very wide area in the literature, only the literature review of Analytic Hierarchy Process (AHP) and Goal Programming (GP) method are used together are presented below;

Dağdeviren and Eren (2001) applied AHP and zero one goal programming (ZOGP) method together in order to perform supplier selection in their studies.

Wang et al. (2004) proposed an integrated AHP and preemptive goal programming (PGP) model in their studies.

Perçin (2006) applied an integrated AHP and GP model for supplier selection. The model was to determine the optimal order quantity from the most appropriate supplier while considering the capacities of potential suppliers.

Mızrak et al. (2008) applied a goal programming (GP) approach with AHP priorities was utilized to solve the problem of materials' supplier selection for a company operating in textile industry.

Sivrikaya et al. (2015) presented an integrated evaluation approach for decision support enabling effective supplier selection and ordering processes in textile industry. The integrated evaluation method in their studies includes two phases that consist of fuzzy AHP and goal programming approaches.

Ünal et al. (2019) proposed an approach for integrated Fuzzy Analytical Hierarchy Process (FAHP) and GP method for supplier selection in a hotel business in Antalya.

As a result of the literature research, it was seen that there are very few studies in which ZOGP and AHP were used together in supplier selection. Integrated AHP and ZOGP method has been proposed because it is thought to contribute to the literature.

In this study, an application has been made for the selection of suppliers of high value and vital medical supplies to be purchased by the oral health center. ABC (Always Better Control) and VED (Vital, Essential, Desirable) analysis methods were combined with the matrix created to determine the vital and high value product group. There are limited studies on ABC and VED matrix analysis in the health sector. Some of the recent studies are mentioned below;

Nigah et al. (2010), Yeşilyurt and Bayhan (2015), Karagöz and Yıldız (2015), Fitriana et al. (2017), Guimarães et al. (2019) applied the ABC-VED matrix analysis method for inventory management in the health sector recently.

Table 1. Classification of Supplier Selection Methods (source Taherdoost and Brard, 2019)

Supplier Selection Methods	
Statistical/Probabilistic (Cluster Analysis)	Fuzzy Set Theory
Multi Attribute Decision Making (Categorical Method)	AHP ANP (Analytic Network Process) TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) MAUT (Multi-Attribute Utility Theory) Outranking Methods: ELECTRE (Elimination and Choice Expressing Reality) PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations)
Methods Based on Costs	ABC (Activity Based Costing) TCO (Total Cost of Ownership)
Mathematical Programming	Linear Programming MOLP (Multi-Objective Linear Programming) Goal Programming
Artificial Intelligence	CBR (Case-Based Reasoning) ANN (Artificial Neural Network)

A model has been developed by integrating the priorities of AHP, one of the MCDM methods, into a zero-one goal programming model for selecting the best supplier to provide this product group. The zero-one goal programming model is a type of GP method, in which the decision variable values can either result in one or zero. The advantage of ZOGP is that the model can help the decision makers to select an optimal allocation solution for limited resources.

In Chapter 2, the literature review for supplier selection in the healthcare sector is examined. In Chapter 3, the methodology of the study is given and the methods used are explained in detail. Chapter 4 includes the application section. Finally, Chapter 5 includes the results of the study and the findings obtained.

2. SUPPLY CHAIN MANAGEMENT IN HEALTCARE INDUSTRY

Today, healthcare industry grows rapidly. Therefore healthcare delivery systems has become a major priority in the field. (Fashoto et al., 2016). The healthcare sector supply chain is characterized by its complexity, which results on the one hand from the multitude of different supplies used by the institutions.

A major characteristic of the healthcare sector supply chain is the simultaneous presence of two chains: one external and the other internal (Rivard-Royer et al.,2002). (see Figure 1).

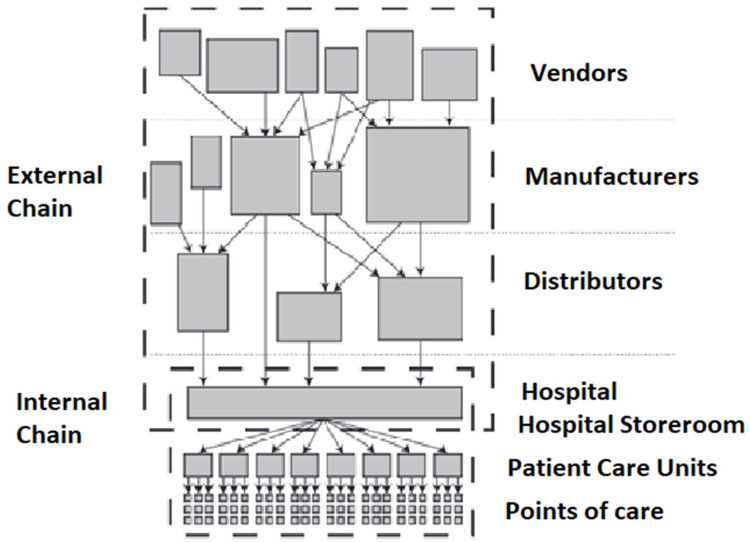

Figure 1. Supply Chain in Healtcare Sector (Source: Rivard-Royer, Landry and Beaulieu, 2002)

In the health sector supply chain structure, producers are divided into two as primary and secondary producers. Primary manufacture involves the creation of the active ingredient contained within the medication. Secondary Production converted the active ingredient into usable products. The final products are distributed to healthcare organizations by distributors, wholesalers and manufacturers and there is a backward flow from them. (Kritchanchai, 2014). Figure 2 summarizes the health sector supply chain structure.

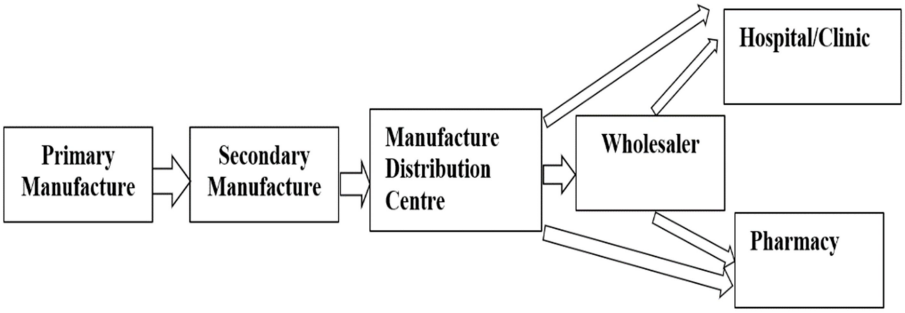

Figure 2. Healthcare Supply Chain Structure (Source: Mustaffa and Potter, 2009)

2.1. Literature Review Of Supplier Selection Studies And The Criteria Used In The Health Sector

Supplier selection problem is described as a complex multi-criteria decision problem that can contain many quantitative and qualitative variables together.

Therefore, the systematic evaluation of such a problem is important in terms of producing correct solutions. One of the first studies on supplier selection was conducted by Dickson (1966) in America. Dickson sent a questionnaire to 273 selected people from the purchasing agent and the executives of the National Association of Purchasing. Here, 23 criteria were used and the most important criteria were determined as product quality, on-time delivery and warranty policy (Dickson, 1966: 16-17).

It is seen that various criteria are used in the studies on the supplier selection problem in the literature. In this study, the criteria used in the health sector were examined. The literature review in this field is given in Table 2.

Kirytopoulos, Leopoulos, and Voulgaridou (2008) presented a comprehensive method for evaluating and selecting proposals in pharmaceutical industry clusters in their work. The best supplier was selected in line with the criteria determined by the analytical network process (ANP).

Enyinda, Dunu, and Bell-Hanyes (2010) made use of the analytical hierarchy process (AHP) model in their articles. They developed the Expert Selection Software by conducting a case study to solve the supplier selection process problem in a pharmaceutical company.

Vankatesh et al. (2015) addressed the problem of selecting suppliers for blood bag purchase, which is critical in the health sector. They made their supplier selection with TOPSIS method in line with the criteria determined by the literature review and expert opinions.

Fashoto, Akimuwesi, Owalabi, and Adelekan (2016) used analytical hierarchy process (AHP) and artificial neural network (ANN) in their studies. They developed a decision support model for evaluating and selecting the healthcare providers of tertiary institutions.

Bahadori et al. (2017) used a combination of ANN and fuzzy VIKOR in their study. They have developed a model for selecting the best supplier in the hospital. The results obtained from the model showed that the most effective factor in supplier selection is 'quality'.

Forghani et al. (2018) worked in a multi-supplier pharmaceutical company.In order to improve supplier selection, they first used the principal component analysis (PCA) method to reduce the number of supplier selection criteria. Then, they obtained the importance value of each supplier for each product using the method based on the concept of Z-numbers called Z-TOPSIS. Finally, they used these values as input in mixed integer linear programming (MILP). With the developed model, they determined the suppliers and the amount of products supplied from the relevant suppliers.

Manivel and Ranganathan (2019) analyzed the Supplier Selection process in line with the interviews with the pharmacy manager. They have applied the combination of Fuzzy Analytical Hierarchy Process (FAHP) and Fuzzy Ideal Solution methods (FTOPSIS) for the selection of suppliers.

Table 2. Supplier Selection Criteria in Healthcare Industry

Supplier Selection Criteria	
Authors	**Criteria**
Kirytopoulos, Leopoulos and Voulgaridou (2008)	Price, Quality, Service, Supplier's Profile, Risk
Enyinda,Dunu ve Bell-Hanyes (2010)	Quality, Cost, Compliance with Legislation, Service, Supplier Reliability, Risk Management, Supplier's Profile, Green Purchasing
Venkatesh and diğ. (2015)	Purchasing Cost, Production Quality, Financial Status
Fashoto, Akimuwesi, Owalabi and Adelekan (2016)	Cost, Service, Risk, Quality, Delivery
Bahadori and et al. (2017)	Price, Quality, Delivery Time, Payment Terms, The Suppliers Background, Packaging and Transport Quality
Forghani, Sadjadi, Farhang ve Morhadam (2018)	Cost, Quality, Service, Delivery, Supplier Profile
Manivel and Ranganathan (2019)	Cost, Delivery, Service, Flexibility, Supplier Reliability
Doğan and Akbal (2019)	Price, Technical Competence, Service Quality, Repair Service and Guarantee Policy
Yazdani et al. (2020)	Offer Price, Supplier's Stock Capacity, Batch Volume, Flexibility, Technology and Quality

Doğan and Akbal (2019) discussed the selection of a medical company for a university hospital in their study and used the AHP method, which is one of the multi criteria decision making methods, to determine the most suitable supplier for both the patient and the hospital.

Yazdani, Torkayesh, Chatterjee (2020) conducted their studies in order to realize the sustainable supplier selection in a hospital in Spain. They determined the importance weights of alternative suppliers using the DEMATEL and BWM (Best Worst Method) method. The best supplier; They determined it using the EDAS (Evaluation According to Average Solution Distance) method.

3. METODOLOGY

In this study, ABC-VED matrix analysis method was used to determine critical product groups. Then these products are grouped according to their application areas. Later, alternative suppliers were determined for these product groups. Later, in order to determine the priority values of the suppliers, the AHP method was preferred because the interactions of the criteria with each other are not taken into account in the decision-making process and because it can compare more than one quantitative and qualitative criteria at the same time. In solving the problem, 0-1 Goal Programming method was preferred because it realizes many goals at the same time and offers an effective solution method.

Figures or Tables should be sized the whole width of a column, as shown in Table 1 or Fig. 1 (Figs. 1 and/to n) in the present example, or the whole width over two columns. Do not place any text besides the figures or tables. Do not place them altogether at the end of manuscripts.

3.1. ABC Analysis

ABC analysis is defined to the inventory control model that separates the products in inventory according to the number of use and cost value in a year. The principle that forms the basis of the analysis was first put forward by H. Ford Dickie, one of the employees of General Electric. This method, which was developed in 1896 by an Italian economist named Vilfredo Pareto, is also known as the pareto rule (Demiral 2013: 48).

The following steps are followed in classifying the stocks according to the ABC principle:

1. All inventory items are listed.
2. The investment made in these elements; It is calculated as (Unit price / cost) x Annual Demand.
3. Annual investment values are put in order from large to small.
4. The investment made to each element is calculated as what% of the total investment is.
5. The cumulative sums of the ratios in (4) are found.
6. By examining the cumulative percentages,

The elements that make up 70-80% of the investment are defined as A group, 20-25% as B group, and the remainder as C group (Yenersoy, 2011).

3.2. VED Analysis

Errors and lack of materials in hospital facilities can cause patient losses or disabilities. Therefore, sometimes the lack of a low cost material in hospitals can be of vital importance. Although the cost of the medical equipment used for vascular access is very low, its value for the patient is much greater. Lack of such materials may cause disruption or failure of treatments. Therefore, inventory control methods of hospital enterprises take into account not only cost but also vital importance (Karagöz and Yıldız 2015: 319).

While ABC method classifies inventories according to their cost; VED classifies medical supplies, especially drugs and consumables, according to the vital needs of the patient. (Kaptanoğlu, 2013: 32).

VED analysis classifies the inventory items in the pharmaceutical and medical supplies inventory list of hospital enterprises as vital (V) essential (E) and desirable (D). İnventory with critical importance for survival of patients are defined as V, inventory materials with lower critical importance than V are defined as E and inventory materials with the lowest usage requirement are defined as D group (Vaz, et al. 2008: 120).

3.3. ABC-VED Matrix Analysis

The ABC-VED matrix is a method that considers both the critical values and the economic and importance levels of drugs and medical supplies. It also categorizes the control of inventories according to priority (Pund et al., 2016: 469-470).

The ABC-VED matrix is formulated by cross-tabulating ABC and VED analysis. The combination obtained is classified into three groups (Vaz, et al., 2008: 120).After determining the groups to be checked and evaluated in the ABC-VED matrix, the materials in the V, E, D groups are ABC classified.

First, in the first group, all vital (V) inventory materials and A group inventory materials are handled. This group includes AV, BV, CV, AE and AD subclasses. Second, among the remaining inventory materials, all subclasses of essential (E) and B group are gathered into a group. Accordingly, in this second group there will be BE, BD and CE subclasses. Finally, the third category consists of the CD group (Gupta et al., 2010: 201-205).

Table 3 shows the ABC-VED matrix analysis.

Table 3.ABC-VED Matris

Category	V	E	D
A	AV	AE	AD
B	BV	BE	BD
C	CV	CE	CD

3.4. AHP

AHP, which is one of the multi-criteria decision making methods in selecting the right supplier and was introduced by Thomas Saaty in the second half of the 1900s, is an effective tool to deal with complex decision making and helps the decision maker to set priorities and make the best decision. In addition, AHP is a useful

technique to check the consistency of the decision maker's evaluations and thus reduce bias in the decision-making process (Saaty, 1980).

The steps of AHP are shown in Table 4.

Table 4. Steps of AHP

1.Step: Decision making problem is defined.
2.Step: The hierarchy of the problem is created.
3.Step: The Criteria Are Compared Between Each Other. $\begin{bmatrix} a_{11} & \cdots & a_{1m} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nm} \end{bmatrix}$ (1)
4.Step: Assigning Weights and Priorities $b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$ (2) $W = \frac{\sum_{j=1}^{n} b_{ij}}{n}$ (3)
5.Step: Calculation of Consistency Ratio $CR = \frac{CI}{RI}$ (4) $CI = \frac{\pi_{max} - n}{n-1}$ (5)
6.Step: Evaluation of Consistency Rate

π_{max} – computed average from values of divided weighed sum vector elements by associated priority value.

n – the number of criteria.

RI-the value for the corresponding size of matrix proposed by Saaty (1980) can be found in Table 5.

Table 5. Randomness Index

Matrix size	Random Consistency index (RI)
1	0,0
2	0,0
3	0,58
4	0,90
5	1,12
6	1,24
7	1,32
8	1,41
9	1,45
10	1,49

In the AHP method, after the problem definition and target are determined, alternatives and criteria are determined. Saaty (2008) developed a scale to compare the determined criteria and determine the advantages. If one criterion is more important than another, the scale acts with the logic of giving importance to a value from 1 to 9 (Equation 1).

A paired comparison matrix is created between the criteria determined in line with this scale. After the comparison matrix is created, the eigenvector showing the importance of each item relative to the other items is created (Equation 2 and 3). The "Consistency Index (CI)", which is an indicator of consistency, is calculated and divided by the Randomness index (Equation 4). If CR> 0.1, the decision matrix is considered inconsistent, if CR≤0.1, the decision matrix is considered consistent (Equation 5).

3.5 0-1 Goal Programming

GP tries to come up with a compromise solution that takes into account the importance of multiple conflicting objectives.

Unwanted deviation variables are minimized by target programming. In goal programming, each goal requested from the decision maker is formulated to achieve a certain numerical goal, minimizing the total penalty arising from missing these goals, that is, the weighted sum of the deviations of each of the goal functions from their goals (Öztürk, 2009: 273). Its main purpose is to transform a multi-purpose problem into a single-purpose problem. The result of the model is generally called effective solution (Taha, 2007: 343).

Charnes and Cooper (1961) were the first researchers to introduce the goal programming (GP) method. Later, scientists such as Lee (1972), Flavell (1976) Ignizio (1985), Tamiz (1998), Vitoriano and Romero (2001), Chang (2002) developed the goal programming method (Karaatlı and Davras, 2014).

4. APPLICATION

In this study was carried out in an oral and dental health center operating in Ankara. It is aimed to provide the materials needed by the enterprise in order to provide a quality health service on time and on site. For this purpose, materials with critical importance that must be included in the inventory of medical products to be purchased were determined using the ABC-VED Matrix method. Later, the suppliers of tooth extraction tools grouped by the application area among these materials have been determined.

In order to determine the priority values of the suppliers, the AHP method was preferred because the interactions of the criteria with each other are not taken into account in the decision-making process and because it can compare more than one quantitative and qualitative criteria at the same time. The solution was implemented with the program Super Decision (2.10.0). In solving the problem, 0-1 Goal Programming method was preferred because it realizes many goals at the same time and provides an effective solution method. The 0-1 Goal Programming model was developed by transforming the determined goals into constraints and adding the priority values obtained from AHP as constraints. The model was solved with Lindo 6.1 program and the right suppliers were selected for critical product groups.

4.1. Finding Critical Product Groups with ABC-VED Matrix Analysis

It is planned to purchase 104 products of dental consumables in the oral and dental health center where the application is performed. ABC-VED analysis method was used to determine the critical materials that must be

kept in the center among 104 items to be ordered.

ABC-VED Matrix analysis was created by combining 104 items of materials according to whether they are critical or not. The results of the analysis are shown in Table 6. According to these results, the products in category I, which must be kept in the oral and dental health center, correspond to 71.15% of the total materials and 91.26% of the total material value.

The materials in the category II correspond to 21.15% of the total materials and 8.34% of the total value. So, materials in category I are lesser importance than the materials in category II in terms of both amount and value.

The least important of the materials in the category III correspond to 7.7% of the total materials and 0.4% of the total value.

According to the result of ABC-VED Matrix analysis, 74 items of materials in Category I were identified as critical materials. For this reason, these materials should be provided with priority.

In this study, among 74 critical products, the products used in tooth extraction, created according to the application area, were taken into consideration.

In the next stage, the priorities of the suppliers in this group with AHP will be determined.

Table 6. ABC-VED Matrix

Group	Products	Products Ratio	Value (TL)	Value Ratio
I.Category (AV+AE+AD+BV+CV)	74	%71,15	31.722.422	%91,26
II.Category (BE+CE+BD)	22	%21,15	2.899.915	%8,34
III.Category (CD)	8	%7.7	138.529	%0,40
TOTAL	104	%100	34.760,87	%100

4.2. Determining the weights of criteria and ranking of suppliers with AHP

As a result of the ABC-VED Matrix analysis, criteria were determined by the experts to select the right suppliers to supply the tooth extraction tools in Category I.

Criteria;

Price; It is aimed to find the supplier with the most suitable offer.

Delivery; The supplier's ability to deliver the right amount of products at the desired time has been taken into account.

Quality; An evaluation was made by taking into account the improper product percentages of the suppliers.

Supplier Reliability; The past performance of the suppliers has been taken into account.

The Analytical Hierarchical structure created for tooth extraction tools is shown in Figure 3.

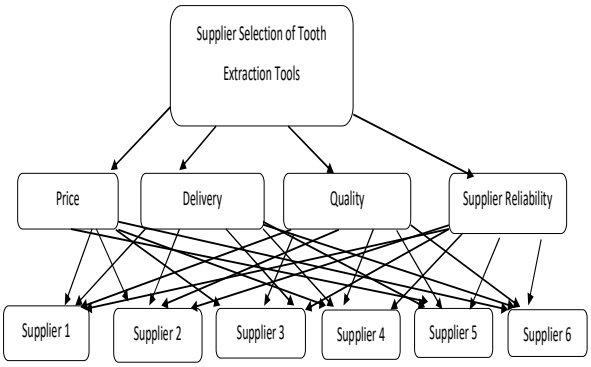

Figure 3. AHP Structure

4.2.1. Comparison of Criteria with AHP

Criteria were evaluated by experts using Saaty's 1-9 point preference scale, and the geometric mean of the results is shown in Table 7.

Table 7. Compration Matrix

Criteria	Price	Quality	Supplier Reliability	Delivery
Price	1	0.215	0.203	0.382
Quality	4.64	1	2.3	3.3
Supplier Reliability	4.93	0.438	1	2.28
Delivery	2.62	0.30	0.438	1

The comparison matrix of the criteria has been solved by Super Decision (2.10). The consistency ratio of the criteria was calculated as 0.03348. A consistency ratio of less than 0.1 indicates that the criteria were evaluated consistently.

The weights of the criteria are included in Table 8.

Table 8. Weights of Criteria

Criteria	Weights of Criteria
Price	0.072
Quality	0.484
Supplier Reliability	0.293
Delivery	0.150

According to the results obtained by the evaluations of experts, it has been observed that the quality criterion is the most important in the selection of the supplier for the product group that has critical importance in the health sector, and the price criterion is the least important.

4.2.2. Comparison of Suppliers by Criteria

Comparison of suppliers by each criterion is included in Table 9-12. As a result of the comparisons, weights of the suppliers were calculated according to the criteria.

4.2.3. Sorting Alternatives with AHP

As the last step in AHP, the priorities of suppliers are obtained by multiplying the criteria weights of the suppliers and the weight of each criterion. The sorting of suppliers by AHP are shown in Table 13. According to the AHP result, the first priority was Supplier 3, followed by suppliers with number 6,1,5,4,2, respectively.

Table 9. Comparison of Suppliers by Criteria of Price and Priority Values

Suppliers	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5	Supplier 6	Priority Values	Consistency Rate
Supplier 1	1	0.333	0.20	0.16	0.143	0.11	0.0265	
Supplier 2	3	1	0.33	0.16	0.143	0.11	0.0410	
Supplier 3	5	3	1	0.33	0.25	0.20	0.0860	
Supplier 4	5.9	5.9	3	1	0.5	0.33	0.1735	**0.05650<0.1**
Supplier 5	7	7	4	2	1	0.33	0.2443	
Supplier 6	9	9	5	3	3	1	0.4283	

Table 10. Comparison of Suppliers by Criteria of Quality and Priority Values

Suppliers	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5	Supplier 6	Priority Values	Consistency Rate
Supplier 1	1	0.5	0.11	0.33	0.143	0.2	0.032	
Supplier 2	2	1	0.143	0.33	0.2	0.25	0.047	
Supplier 3	9	7	1	7	2	3	0.421	
Supplier 4	3	3	0.143	1	0.25	0.33	0.080	**0.02970<0.1**
Supplier 5	7	5	0.5	4	1	2	0.255	
Supplier 6	5	4	0.3	3	0.5	1	0.165	

Table 11. Comparison of Suppliers by Criteria of Supplier Reliability and Priority Values

Suppliers	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5	Supplier 6	Priority Values	Consistency Rate
Supplier 1	1	0.33	0.25	0.25	0.33	0.143	0.039	
Supplier 2	3	1	0.33	0.33	1.28	0.33	0.090	
Supplier 3	4	3	1	1.28	3	0.33	0.198	
Supplier 4	4	3	0.781	1	0.5	0.25	0.144	**0.07038<0.1**
Supplier 5	3	0.781	0.33	2	1	0.25	0.122	
Supplier 6	7	3	3	4	4	1	0.406	

Table 12. Comparison of Suppliers by Criteria of Delivery and Priority Values

Suppliers	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5	Supplier 6	Priority Values	Consistency Rate
Supplier 1	1	9	0.33	9	7	3	0.310	
Supplier 2	0.11	1	0.143	3	0.33	0.25	0.042	
Supplier 3	3	7	1	9	5	3	0.413	
Supplier 4	0.11	0.33	0.11	1	0.25	0.16	0.025	**0.06604<0.1**
Supplier 5	0.143	3	0.2	4	1	0.5	0.077	
Supplier 6	0.33	4	0.33	6	2	1	0.132	

Table 13. The Sorting of Suppliers by AHP

Suppliers	Price	Quality	Supplier Reliability	Delivery	Priority Value	Sorting of Suppliers
Supplier 1	0.0265	0.310	0.032	0.039	0.168	3
Supplier 2	0.0410	0.0420	0.047	0.090	0.051	6
Supplier 3	0.0860	0.413	0.421	0.198	0.360	1
Supplier 4	0.1735	0.025	0.080	0.144	0.069	5
Supplier 5	0.2443	0.077	0.255	0.122	0.147	4
Supplier 6	0.4283	0.132	0.165	0.406	0.204	2

4.3. AHP Priorities Integrated 0-1 Goal Programming Model

In this section, the targets are determined by the oral and dental health center about the material cost and supply times. Then these constraints are formulated in model. Later, the priority values of the suppliers obtained from AHP were added as a constraint in the 0-1 Goal Programming model.

The targets determined in 0-1 Goal Programming are as follows;

Goal 1: The prices do not exceed the average approximate cost.

Goal 2: Not exceeding the appropriate delivery time for the product.

Goal 3: To protect the priority values obtained from AHP.

The proposed model for 0-1 Programming, which provides an effective solution method by meeting these three targets at the same time, is as follows;

Min Z = $(\boldsymbol{d1^+})$ + $(\boldsymbol{d2^+})$+($\boldsymbol{d3^-}$) + $(\boldsymbol{d3^+})$ (6)

Constrains:

$\sum_{i=1}^{n} \boldsymbol{A_i x_i} + \boldsymbol{d1^-} - \boldsymbol{d1^+}$ = C (7)

$\sum_{i=1}^{n} \boldsymbol{t_i x_i} + \boldsymbol{d2^-} - \boldsymbol{d2^+}$=T (8)

$\sum_{i=1}^{n} \boldsymbol{w_i x_i} + \boldsymbol{d3^-} - \boldsymbol{d3^+}$ =1 (9)

$\sum_{i=1}^{n} \boldsymbol{x_i}$=1 (10)

$\boldsymbol{x_i}$= 0 or 1 $\forall_i$ (11)

$\boldsymbol{dj^-, dj^+ \geq 0}$ $\forall_j$ (12)

Decision Variables:

$\boldsymbol{x_i}$= if the order is to be given to the supplier i, takes the value "1", if not, "0".

Deviation Variables:

$\boldsymbol{d1^-}$: negative deviation from approximate cost,
$\boldsymbol{d1^+}$: positive deviation from approximate cost,
$\boldsymbol{d2^-}$: negative deviation from delivery time,
$\boldsymbol{d2^+}$: positive deviation from delivery time,
$\boldsymbol{d3^-}$: negative deviation from priority values obtained from AHP
$\boldsymbol{d3^+}$: pozitif deviation from priority values obtained from AHP.

Model related parameters are shown in the Table 14.

Z= Sum of deviation variables,
$\boldsymbol{A_i}$=The amount of offered price by the supplier i,
C=Approximate cost amount determined by the enterprise for the tools used in tooth extraction,
$\boldsymbol{t_i}$=Delivery time of supplier i,
T=Delivery time
$\boldsymbol{w_i}$=Priority value of supplier i obtained from AHP

Objective Function:

It is aimed to minimize the sum of deviations from the determined targets.

Table 14. Parameters

Suppliers	**Prices** $(\boldsymbol{A_i})$	**Delivery Time** $(\boldsymbol{t_i})$	**Priority Values of AHP**
Supplier 1	53.134TL	7	0,16
Supplier 2	19.238 TL	5	0,05
Supplier 3	12.710 TL	4	0,36
Supplier 4	11.221 TL	4	0,071
Supplier 5	9.762 TL	5	0,152
Supplier 6	8.338 TL	3	0,204

Constrains:

Equation 7 is a approximate cost amount constrains.

Equation 8 is a delivery time constrains.

Equation 9 is a priority value of supplier obtained from AHP constrains.

Equation 10 is a restriction of selecting only one supplier constrains.

Equation 11 is a deviation variables take a value of 0 or 1 constrains.

The formulation of the 0-1 goal programming model with integrated AHP priorities with this information is as follows,

Min Z = $(\boldsymbol{d1^+})$ + $(\boldsymbol{d2^+})$+($\boldsymbol{d3^-}$) + $(\boldsymbol{d3^+})$ (12)

Equation 12 is aimed to minimize the sum of deviations from the determined targets.

53.134$\boldsymbol{x_1}$+19.238 $\boldsymbol{x_2}$+12.710 $\boldsymbol{x_3}$+11.22 $\boldsymbol{x_4}$+9.762 $\boldsymbol{x_5}$+ 8.338 $\boldsymbol{x_6}$+ $\boldsymbol{d1^-} - \boldsymbol{d1^+}$ =26.625 (13)

Equation 13 is a approximate cost amount constrains.

7 $\boldsymbol{x_1}$+5 $\boldsymbol{x_2}$+4 $\boldsymbol{x_3}$+4 $\boldsymbol{x_4}$+5 $\boldsymbol{x_5}$+3 $\boldsymbol{x_6}$+$\boldsymbol{d2^-} - \boldsymbol{d2^+}$=10 (14)

Equation 14 is a delivery time constrains.

0,16 $\boldsymbol{x_1}$+ 0,05 $\boldsymbol{x_2}$+ 0,36 $\boldsymbol{x_3}$+ 0,071 $\boldsymbol{x_4}$+ 0,152 $\boldsymbol{x_5}$+ 0,204 $\boldsymbol{x_6}$+ $\boldsymbol{d3^-} - \boldsymbol{d3^+}$ =1 (15)

Equation 15 is a priority value of supplier obtained from AHP constrains.

$\sum_{1}^{6} \boldsymbol{x_i}$=1 (16)

Equation 16 is a restriction of selecting only one supplier constrains.

$\boldsymbol{x_i}$=0 or 1 i=1,2,3,4,5,6 (17)

Equation 17 is a decision variable. İf the order is to be given to the supplier i, takes the value "1", if not, "0".

$\boldsymbol{dj^-}$ ≥0 , $\boldsymbol{dj^+}$≥0 j=1,2,3 (18)

Equation 18 is a deviation variables take a value of 0 or 1 constrains.

4.4. Results of 0-1 Goal Programing

The model was solved in Lindo 6.1 program on a 64 bit operating system computer with Intel Core ™ i7-7500U @ 2.70 GHz-2.90 GHz processor. The results obtained from the program are shown in the Table 15.

Table 15. Results of The Model

Decision Variable	Value	Deviation Variable	Value
x_1	0	$d1^-$	13 915
x_2	0	$d1^+$	0
x_3	1	$d2^-$	6
x_4	0	$d2^+$	0
x_5	0	$d3^-$	0,64
x_6	0	$d3^+$	0

According to the results obtained from the program, it was found that the desired targets were achieved and an order should be provided from Supplier 3. The effects of deviation variables on constraints are as follows;

A gain of 13 915 TL was obtained from the cost amount.

A saving of 6 days from the delivery time.

It seems that in order to reach the AHP priorities goal, the enterprise must make a purchasing decision.

5. CONCLUSION

Medical materials used in diagnosis, treatment and examination procedures of patients in health institutions are of vital importance. Correct decisions should be made in the procurement of these materials needed in service provision. Since the number of suppliers of health institutions is high, making a decision becomes more difficult.

The aim of this study is to select the most appropriate supplier among the medical equipment suppliers of an oral dental health center operating in Ankara by using the AHP method, one of the multi-criteria decision making methods, and the 0-1 goal programming method in an integrated manner.

In this context, in order to decide on the most suitable supplier, the procurement department manager and employees of the hospital were interviewed and their experiences were used.

While determining the medical company suppliers, price, supplier reliability, quality and delivery criteria were taken as basis. The criterion quality criterion with the highest priority value at the end of the study; The criterion with the lowest priority was the price criterion. According to this result, it was revealed that the hospital made a quality-oriented decision while choosing its medical supplier. Considering the weight of the alternatives in terms of criteria, it was decided that supplier 3 should be selected as the most suitable supplier. Created using data obtained from AHP and other constraints

The zero one goal programming model created using the data obtained from AHP and other constraints was solved with Lindo (6.1). As a result of the solution, it was found that order from Supplier 3 should be consistent with AHP.

Supplier selection studies in the health sector are almost nonexistent, so this study emphasized the importance of working with the right suppliers to find the products that are critical in the health sector at the right quality at the right time. With this study, an enterprise operating in the health sector has determined its suppliers, which are determined according to critical product groups, using effective stock control methods, with an AHP priority integrated 0-1 goal programming model. It is thought that this model will contribute significantly to the literature and will save time in supplier selection studies in the health sector. In this respect, the study differs from other studies because it deals with a real life problem.

In the future studies, different criteria are used in the supplier selection and evaluations in the health sector and different multi criteria decision making methods by modeling with goal programming and the results can be compared.

REFERENCES

Aptel, O., & Pourjalali, H. (2001). Improving activities and decreasing costs of logistics in hospitals: a comparison of US and French hospitals. *The international journal of accounting*, Vol.36, No.1, pp. 65-90.

Bahadori, M., Hosseini, S. M., Teymourzadeh, E., Ravangard, R., Raadabadi, M., & Alimohammadzadeh, K. (2017). A supplier selection model for hospitals using a combination of artificial neural network and fuzzy VIKOR. *International Journal of Healthcare Management*, Vol. 5, pp. 1-9.

Dağdeviren, M., & Eren, T. (2001). Tedarikçi firma seçiminde analitik hiyerarşi prosesi ve 0-1 hedef programlama yöntemlerinin kullanılması. *Gazi Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi*, Vol. 16, No. 2, pp. 41-52.

Demiral, P. (2013). Hastanelerde Malzeme Yönetimi ve İki Hastanenin Malzeme Yönetim Sistemlerinin Karşılaştırılmasına Yönelik Bir Uygulama. *Ms Thesis*, *TC Gazi Üniversitesi, Sosyal Bilimler Enstitüsü*, Ankara.

Dickson, G. W. (1966). An analysis of vendor selection systems and decisions. *Journal of purchasing*, Vol.2, No.1, pp. 5-17.

Doğan, N. Ö., & Akbal, H. (2019). Sağlık Sektöründe Tedarikçi Seçim Kararının AHP Yöntemi ile İncelenmesi: Bir Üniversite Hastanesi Örneği. *Celal Bayar University Journal of Social Sciences*, Vol.17, No.4, pp. 440-456.

Enyinda, C., Dunu, Bell Haynes, J. (2010). A model for quantifying strategic supplier selection: Evidence from a generic pharmaceutical firm supply chain. *International Journal of Business, Marketing, and Decision Science*. Vol.3, No.2, pp.23-44.

Fashoto, S. G., Akinnuwesi, B., Owolabi, O., & Adelekan, D. (2016). Decision support model for supplier selection in healthcare service delivery using analytical hierarchy process and artificial neural network. *African journal of business Management*, Vol. 10, No.9, pp.209-232.

Fitriana, I., Satria, R. G. D., & Setiawan, D. C. B. (2018). Medicine Inventory Management by ABC-VED Analysis in the Pharmacy Store of Veterinary Hospital, Yogyakarta, Indonesia. *Asian Journal of Animal and Veterinary Advances*, Vol.13, No.1, pp. 85-90.

Forghani, A., Sadjadi, S. J., & Farhang Moghadam, B. (2018). A supplier selection model in pharmaceutical supply chain using PCA, Z-TOPSIS and MILP: A case study. *PloS one*, Vol.13, No.8, Article ID: e0201604.

Frej, E. A., Roselli, L. R. P., Araújo de Almeida, J., & de Almeida, A. T. (2017). A multicriteria decision model for supplier selection in a food industry based on FITradeoff method. *International Series in Operations Research & Management Science*, Vol. 274, pp. 257-280.

Guimarães, F. S., dos Santos, C. B., Gonçalves, L. B., Thurow, L. L., & Silveira, M. P. T. (2019). Tools For İnventory Control Of Dental Supplies Of A Municipal Health Department: A Case Study. *Brazilian Journal Of Oral Sciences*, Vol. 18, pp. 1-8.

Kaptanoğlu, A. (2013). Sağlık İşletmelerinde Maliyet Depo Stok ve Envanter Yönetimi. 1. Baskı, İstanbul: Beşir Kitabevi.

Karaatlı, M., & Davras, G. (2014). Tedarikçi seçiminde analitik hiyerarşi prosesi ve hedef programlama yöntemlerinin kombinasyonu: otel işletmelerinde bir uygulama. *Yönetim ve Ekonomi Araştırmaları Dergisi*, Vol.12, No. 24, pp.182-196.

Karagöz, F., & Yıldız, M. S. (2015). Hastane İşletmelerinde Stok Yönetimi İçin ABC ve VED Analizlerinin Uygulanması. *Yönetim ve Ekonomi Araştırmaları Dergisi*, Vol.13, No.2, pp. 375-396.

Kirytopoulos, K., Leopoulos, V., & Voulgaridou, D. (2008). Supplier selection in pharmaceutical industry: An analytic network process approach. *Benchmarking: An International Journal*. Vol. 15 No. 4, pp. 494-516

Kritchanchai, D. (2014). A framework for healthcare supply chain improvement in Thailand. *Operations and Supply Chain Management: An International Journal*, Vol.5, No.2, pp. 103-113.

Mızrak Özfırat, P., & Öğüt, C. (2008). Application of Analytic Hierarchy Process and Goal Programming in Supplier Selection Problem. *DEÜ Mühendislik Fakültesi Fen ve Mühendislik Dergisi*, Vol.10, No 1, pp. 39-48

Mustaffa, N. H., & Potter, A. (2009). Healthcare supply chain management in Malaysia: a case study. *Supply Chain Management: An International Journal*, Vol. 14, No. 3, pp. 234 –243.

Nigah, R., Devnani, M., & Gupta, A. K. (2010). ABC and VED analysis of the pharmacy store of a tertiary care teaching, research and referral healthcare institute of India. *Journal of young pharmacists*, Vol. 2, No. 2, pp. 201-205.

Öztürk, A. (2009). Yöneylem Araştırması, Ekin Yayınevi.

Manivel, P., & Ranganathan, R. (2019). An Efficient supplier selection Model for Hospital Pharmacy through Fuzzy AHP and Fuzzy TOPSIS. *International Journal of Services and Operations Management*, Vol.33, No.4, pp.468–493.

Percin, S. (2006). An application of the integrated AHP-PGP model in supplier selection. *Measuring Business Excellence*, Vol. 10, No. 4, pp. 34-49.

Pund, S. B., Kuril, B. M., Hashmi, S. J., Doibale, M. K., & Doifode, S. M. (2016). ABC-VED matrix analysis of Government Medical College, Aurangabad drug store. *Int J Community Med Public Health*, Vol.3, No.2, pp. 469-472.

Rivard-Royer, H., Landry, S., & Beaulieu, M. (2002). Hybrid stockless: a case study. *International Journal of Operations & Production Management*, Vol. 22 No. 4, pp. 412-424.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal Of Services Sciences*, Vol.1, No. 1,pp. 83-98.

Saaty,T.L.(1980). The Analytic Hierarchy Process: Planning, Priority Setting and Resource Allocation, New York: McGraw-Hill.

Sivrikaya, B. T., Kaya, A., Dursun, M., & Çebi, F. (2015). Fuzzy AHP–goal programming approach for a supplier selection problem. *Research in Logistics & Production*, Vol. 5, No. 3,pp. 271-285.

Taha, H. A. (2007). Yöneylem Araştırması, 4. basım. Literatür Yayıncılık, İstanbul.

Taherdoost, H., & Brard, A. (2019). Analyzing the process of supplier selection criteria and methods. *Procedia Manufacturing*, Vol.32, pp.1024-1034.

Thiruchelvam, S., & Tookey, J. E. (2011). Evolving trends of supplier selection criteria and methods. *International Journal of Automotive and Mechanical Engineering*, Vol.4, No.1, pp. 437-454.

Tooranloo, H. S., & Iranpour, A. (2017). Supplier selection and evaluation using interval-valued intuitionistic fuzzy AHP method. *International Journal of Procurement Management*, Vol.10, No.5, pp. 539-554.

Ünal, Z., Güven, S. & Çetin, E. İ. (2019). Otel İşletmelerinin Tedarikçi Seçiminde Bulanık AHP ile

Ağırlıklandırılmış Hedef Programlama Uygulaması. *Hitit Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, Vol.12, No.1, pp. 188-204.

Vaz, F. S., Ferreira, A. M., Kulkarni, M. S., Motghare, D. D., & Pereira-Antao, I. (2008). A study of drug expenditure at a tertiary care hospital: An ABC-VED analysis. *Journal of Health Management*, Vol.10, No.1,pp. 119-127.

Venkatesh, V.G. & Dubey, Rameshwar. (2015). Supplier selection in blood bags manufacturing industry using TOPSIS model. *International Journal of Operational Research*. Vol.24, pp. 461-488.

Wang, G., Huang, S. H., & Dismukes, J. P. (2004). Product-driven supply chain selection using integrated multi-criteria decision-making methodology. *International journal of production economics*, Vol. 91 No. 1, pp. 1-15.

Yazdani, M., Torkayesh, A. E., & Chatterjee, P. (2020). An integrated decision-making model for supplier evaluation in public healthcare system: the case study of a Spanish hospital. *Journal of Enterprise Information Management*. Vol. 33 No. 5, pp. 965-989

Yenersoy, G. (2011). Üretim Planlama ve Kontrol. Papatya Yayıncılık.

Yeşilyurt, Ö., Sulak, H., & Bayhan, M. (2015). Sağlık Sektöründe Stok Kontrol Faaliyetlerinin ABC ve VED Analizleriyle Değerlendirilmesi: Isparta Devlet Hastanesi Örneği. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*. Vol. 20 No.1, pp.365-376.

Mersin University Journal of Maritime Faculty

Mersin University Journal of Maritime Faculty (MEUJMAF)
Vol. 2, Issue 2, pp. 62-76, December 2020
ISSN 2687-6612, Turkey
DOI: 10.47512/meujmaf.808323
Research Article

ANALYZING COMPETITIVE ADVANTAGE FACTORS OF LOGISTICS SERVICE PROVIDERS: A CASE STUDY OF IZMIR REGION

Gökçe Tuğdemir Kök*[1], İlke Sezin Ayaz[2] and Esra Baran Kasapoğlu [3]

[1] Dokuz Eylul University, Maritime Faculty, Maritime Business Management Department, Izmir, Turkey
ORCID ID 0000–0002–9642–3985
gokce.tugdemir@deu.edu.tr

[2] Dokuz Eylul University, Maritime Faculty, Maritime Business Management Department, Izmir, Turkey
ORCID ID 0000–0002–7053–3940
ilke.ayaz@deu.edu.tr

[3] Dokuz Eylul University, Maritime Faculty, Maritime Business Management Department, Izmir, Turkey
ORCID ID 0000–0002–2235–5617
esra.baran@deu.edu.tr

* Corresponding Author
Received: 09/10/2020 Accepted: 02/12/2020

ABSTRACT

Competition starts with existence of life itself. In order to survive in the globalizing world, it is a great necessity for companies to provide sustainable competitive advantage. In this sense, in order to achieve a sustainable competitive advantage, factors affecting competition should be deeply perceived and implemented. In recent years, logistics sector has had a complex structure as global competition has been increasing and logistics capabilities are getting more and more critical for the success of logistics service providers. For this reason, it is aimed to determine the attitudes of senior managers who are working in the logistics service provider companies in Izmir towards the factors affecting competition. For this purpose, Delphi method, which is a qualitative research method, has been applied in this research. In the first round of Delphi research, 29 factors affecting competition obtained from the literature review have been asked to experts under six groups and a consensus has been tried to be reached. As a result of the first round, for 6 factors a consensus could not be reached, and then the statements have been re-evaluated and detailed, and another Delphi form for second round has been prepared and implemented. According to the findings, t the valuable, sense of market opportunities and sensitivity to the market, the ability to integrate employees' knowledge and skills with the routines of their operations, after-sales service and reliability which are the factors affecting competition for logistics service providers have been fully agreed upon by logistics service providers. All factors related to dynamic capabilities approach associated with competition in the literature have been considered important by logistics service providers. There has no consensus on the factors related to threats / barriers faced by new entrants in the logistics sector and bargaining power of service buyers.

Keywords: *Competition, Logistics Service Provider, Delphi, Competitive advantage*

1. CONCEPTUAL FRAMEWORK: COMPETITION

According to Henderson (1989: 139), competition begins with life itself and the concept of competition in business science (strategic) and biological competition (natural) are not fundamentally different (Henderson, 1983: 8). One of the basic elements of strategic competition is the ability to understand competitive behavior as a system in which competitors, customers and resources interact continuously (Henderson, 1989: 142).

Understanding the sources of sustainable competitive advantage for companies has been an important research area in the field of strategic management (Barney, 1991: 99). According to the modernist strategic management point of view, what is important and necessary for companies to sustain their long-term life is to gain competitive advantage (Ülgen and Mirze, 2013: 32).

Porter (1980) has approached the concept of competition from an industry-based perspective, by presenting a comprehensive framework gathered under "Five forces" to understand the forces behind competition in sector. This framework aims to help companies to gain a unique position in sector. With the industry structure embodied by five force of competition (existing competitors, new entrants, suppliers, customers and substitutes) offering a way of thinking about how value is created and how it is distributed among current and potential sector participants, the attention is drawn to the fact that competition is more than just competing with existing competitors (Porter, 1980). Porter also classified competitive strategies that can be successful in dealing with these five forces in the sector as cost leadership, differentiation and focus (Porter, 1980: 35).

Wernelfelt (1984), one of the important pioneers of the resource-based approach, associated the competitive advantage with the resources and capabilities of the firms and he defined the resource as anything that could be considered strong or weak for the firm. Barney (1991), who has important contributions to the resource-based approach, has taken into account both the internal (strengths and weaknesses) and external (opportunities and threats) factors of the firm while dealing with the concept of competitive advantage. In addition, not every company resource has the potential for sustainable competitive advantage. In order to have this potential, the resource must have the following four important characteristics; "Valuable", "rare", "inimitable" and " non-substitutable".

According to Barney (1991:102), if the company implements a strategy that creates value, it can have a competitive advantage. But sustainable competitive advantage is implementing a value-creating strategy that other competitors cannot imitate the benefits of this strategy. Unlike Porter, the definition of sustainable competitive advantage adopted by Barney depends on the probability of being imitated by its competitors, not the period in which the company gains competitive advantage.

2. COMPETITION AND LOGISTICS

International logistics service creates an important cost (Hise, 1995). Global competition has been increasing and logistics capabilities getting more and more critical for the success of logistics service providers (Mentzer *et al*., 2004).

Freight forwarders and logistics service providers are intermediary companies that provide services in the global logistics industry that connect shipper and maritime operators / lines and facilitate cross-border trade (Murphy and Daley 2001, as cited in Lee and Song, 2015). Freight forwarder businesses provide important supportive, complementary and facilitating services to businesses that provide logistics, transportation and maritime transport services in international trade (Deveci and Çetin, 2013). Due to the wide variety of and highly complex customer demands, competition among forwarder organizations is getting more and more difficult. In this highly competitive environment, while large organizations that can meet customer needs are growing day by day, smaller organizations are struggling to survive (Lee and Song, 2015).

Logistics service providers should show their customers that they can offer much more value for logistics services than their competitors in the market, and according to Paché and Medina (2007) it is the only way to offer a sustainable competitive advantage. Customers' reliance to logistics service providers will become stronger as the value created by logistics service provider's increases.

Sandberg and Abrahamsson (2011) investigated how two leading Swedish retail stores, which successfully use logistics to gain competitive advantage over their competitors, achieve sustainable competitive advantage, via a resource-based theoretical framework. Their study concluded that sustainable competitive advantage is based on an integration of efficient and effective logistics operations with the information technology systems.

Founou (2002), who examined the contribution of the Internet and related technologies to the value chain of logistics service providers, concluded that information technologies must meet essential requirements in order to create a competitive advantage, and in fact information technologies tend to be a "strategic necessity" in practice.

Hise (1995) stated that *"competition based on time"* is a strategic tool that will enable companies to create competitive advantage in both national and international markets. Time-based competition is then followed by competition on a cost basis and competition by value (providing the highest value at the lowest cost). According to this approach, it is assumed that the most successful companies will be those that provide the highest value at the lowest cost in the shortest time. Seven important logistics management principles have been revealed to strengthen the international time-based competition of companies. These are; (a) focusing on customers' service needs, (b) reducing the emphasis on cost reduction target, (c) emphasizing flexibility (to achieve time goals), (d) coordinating all logistics functions, (e) coordinating logistics and non-logistics functions, (f) improving the rapid flow of information and (g) making decisions faster (Hise, 1995).

By emphasizing the role of logistics in increasing the competitiveness of companies operating in the global supply chain, Bhatnagar and Teo (2009) used Porter's value chain-based framework in their study. A key element of the value chain framework is to take advantage of the links among various business activities. Considering the focus of the study, issues related to

procurement and shipping logistics (inbound & outbound) were discussed principally.

Kramer and Kramer (2010) analyzed the strategic impact of price and flexible delivery frequency on the competition among logistics service providers in the supply chain. They performed their studies according to time-based competition literature that deals with customers' selection of logistics service providers based on price and delivery times. The main result of the research is that flexible delivery frequency is a strategic advantage for logistics service providers when customers' inventory costs are relatively high compared to transportation costs. The service provider with higher delivery frequency will be more advantageous for customers as inventory costs will decrease.

In their studies aiming to carry out competitive analysis of air cargo logistics providers, Wen *et al*. (2011) investigated which factors are taken into consideration while the third party logistics service providers are chosen by high technology manufacturers in Taiwan. According to their findings, delivery performance (speed, reliability, door-to-door service, security, service frequency) is perceived as the most important factor affecting the outsourcing selection decisions of high technology manufacturers.

Babacan (2003) conducted interviews with the managers of logistics companies in Turkey about what can be done to gain competitive power in the national and international global logistics sector. According to her findings, the objectives focused by logistics sector are right customer, determination of needs, customer service level, wide product range, profit targets, customer satisfaction, strategic control, special reansportation, interactive and automation supported storage, project transportation and management, knowledge production and successful human resource management.

Çekerol and Kurnaz (2011) stated that logistics sector is highly affected by the negativity in terms of competitiveness due to various reasons such as lack of experience and infrastructure together with the negative effects of the economic crisis. They conducted the SWOT (strengths, weaknesses, opportunities and threats) analysis of the sector by applying survey to logistics industry stakeholders in Turkey. The findings of their research revealed the necessity of establishing a balance between survival strategies and progress strategies in the axis of cost and efficiency in order to keep the competitiveness of the logistics sector at a sustainable and high level. At the same time, in order to gain competitiveness in the logistics sector, importance should be given to physical infrastructure adequacy, facilitation of customs procedures, regulations on transport legislation and cooperation between stakeholders (business, government, chambers, and trade unions).

3. FACTORS AFFECTING COMPETITIVE ADVANTAGE

Competitive advantage of business over competitors depends on a number of factors. In this study, factors affecting the competition are divided into resource dependency approach, dynamic capabilities approach, structural approach, operational factors, marketing factors and quality factors (Table 1).

Resource Dependency refers to combine the firm's resources resulting into generation of high order and heterogeneous resources. These high order and heterogeneous resources possess the potential of sustainable competitive advantage (Barney 1991; 1995; Hamel & Prahalad 1994; Michalisin *et al*., 1997; Porter 1996; Teece *et al*., 1997). Resource Dependency theory include four factors. First, they are valuable, in the sense that they exploit opportunities and/or neutralize threats in a firm's environment. Resources are valuable when they enable a firm to conceive of or implement strategies that improve its efficiency and effectiveness. Second, they are rare, or if possible unique, among a firm's current and potential competition. Third, they are imperfectly imitable, in the sense that these resources and capabilities are costly to copy or hard to imitate (Bhuyan and Padhy, 2015). Gaining resources which are needed for imitating the rival's competitive advantage will shorten the life time of that competitive advantage (Grant, 1991). The final attribute is non-substitutability. There are two forms which are important to explain substitutability. The first one emphasizes that one company may apply the same strategies by substituting a similar resource. The second one emphasizes that the possibilities of different resources of a company become strategic substitutes (Barney, 1991).

Dynamic Capabilities can be defined as the firm's ability to integrate, build and restructure internal and external competencies to address the rapidly changing environment. Dynamic competencies reflect the success of creating new and innovative competitiveness with certain market positions (Teece *et al.,* 1997). The concept of sensing (market sensitivity) is about identifying and evaluating opportunities and threats in technology and the market. According to components of the dynamic capabilities, if the enterprises lack the ability to perceive or their ability is insufficient, it is not possible to talk about dynamic capabilities for those enterprises. Organizational learning is *"the process of change in individual and shared thought and action which is affected and embedded in the institutions of the organization"* (Crossan *et al*., 1999). Lopez *et al.* (2005)' study supports that organizational learning is an important and developing subject in creating strategy policies that improve competitiveness. The capability to integration is defined as the ability to process individual information into new organizational information (Teece, 1982). Coordination capability is defined as the ability to organize and activate tasks, resources and activities in organizational skills (Helfat and Peteraf, 2003).

The five force model show a systematic way to understand and learn about competition in an industry, making it necessary to evaluate the strength of each of the five competitive forces. The integrated effect of these forces reveals the nature of competition in that sector (Porter, 2000; Porter 2010; Barutçugil, 2013). The five forces consist threats of new entrants, bargaining power of suppliers, bargaining power of buyers, threat of substitute products/services, and rivalry among existing competitors. Threats of new entrants will affect their resources and with this impact sectoral changes will occur. The suppliers in the sector show their bargaining power on the sector by increasing the prices or decreasing the quality of the products / services purchased, and accordingly, they increase the costs of the enterprises in the sector and decrease the level of sectoral profitability. Strong customers can gain more value and reduce the profitability of the sector by pressing for lowering prices

like strong suppliers, demanding higher quality and more differentiating services, and thereby intensifying competition among enterprises in the sector. Substitutes set the prices that businesses in the sector can set high profitability and reduce the potential returns of that sector. Firms compete with each other with similar strategies such as discounts, developing services, offering new products (Porter, 2008). If there are many strong competitors, if the growth of the industry is slow and the obstacles are high, the competition will be intense (Proctor, 2000). It has a great impact on industry profitability and competitive advantage whether competitors choose to compete on the same dimensions or not (Porter, 2008).

Table 1: Factors Affecting Competitive Advantage

		Porter, 1980	Barney, 1991	Hamel & Prahalad, 1994	Teece *et al.*, 1997	Ghemawat, 2002	Wattanapruttipaisan, 2002	Gonzalez *et al.*, 2004	Dikyol, 2007	Gal, 2010	Vinayan *et al.*, 2012	Wanjiku, 2012	Ağgez, 2013	Kocaoğlu, 2013	Yılmaz, 2014	Bhuyan, 2015	Global competitveness, 2017
Resource-based view	Valuable		✓	✓	✓						✓		✓	✓		✓	
	Rare		✓	✓	✓						✓		✓	✓		✓	
	Inimitable		✓	✓	✓						✓		✓	✓		✓	
	Non-Substitutable		✓	✓	✓						✓		✓	✓		✓	
Dynamic capability view	Market responsiveness				✓						✓		✓	✓			
	Organizational learning				✓						✓			✓		✓	
	Integration				✓						✓			✓			
	Coordination				✓			✓			✓			✓			
Five forces model	Threats of new entrants	✓				✓		✓	✓		✓	✓	✓		✓		
	Bargaining power of suppliers	✓				✓		✓	✓		✓	✓	✓		✓		
	Bargaining power of buyers	✓				✓		✓	✓		✓	✓	✓		✓		
	Threats of substitute products/services	✓				✓		✓	✓		✓	✓	✓		✓		
	Rivalry among existing competitors	✓				✓		✓	✓		✓	✓	✓		✓		
Operational factors	Cost reduction	✓	✓			✓		✓	✓		✓	✓	✓	✓	✓		
	Time											✓	✓				
	Technology						✓			✓	✓	✓	✓	✓	✓		✓
	Research and Development						✓			✓				✓	✓		
	Innovation						✓	✓	✓	✓	✓	✓	✓			✓	
	Qualified workforce						✓	✓	✓	✓				✓	✓		✓
	Manage and take risks						✓							✓			
Factors related to marketing	Value creation / Customer satisfaction							✓	✓		✓		✓				
	Customer orientation						✓	✓		✓		✓	✓	✓			✓
	Market share						✓	✓					✓	✓	✓		
	Services/Value Added Services											✓			✓		
	University-industry cooperation																✓
Factors related to quality	Corporate image and brand					✓			✓					✓	✓	✓	
	Quality and conforming to standards					✓	✓		✓	✓		✓	✓	✓	✓		
	Reliability											✓		✓			
	Ethical behavior of firms									✓							✓

In addition to theories, there are some operational factors that affecting the competitive advantage. One of the most important factors in improving competitiveness is cost reduction. Decreasing costs make businesses strong in the market with their price advantage (Dikyol, 2007). *"Today, time is on the cutting edge ".* Ways to manage time offer the most powerful new resources that provide competitive advantage (Stalk, 1988). Technology is an important factor affecting the competitive advantage. The concept of knowledge management is concerned with the creation of structures that combine the most advanced elements of technology resources and the indispensable input of human response and decision making (Raisinghani, 2000). With the effect of globalization, technological innovations can become old or imitate quickly. In order to compete, businesses have to constantly develop new products / services and implement innovative market strategies in an intensive research and development and scientific study process (Karamustafa *et al.,* 2010). Innovation is the key to competitive advantage in a highly turbulent environment. It is an important driving force for the growth of the organization. Values created by innovations often reveal themselves with the emergence of new things or new products and processes that contribute to wealth (Bhuyan and Padhy, 2015). Businesses that want to survive and succeed in a competitive environment must take advantage of strategic entrepreneurship principles and manage their knowledge effectively (Türkmen and Yılmaz, 2019). Qualified workforce is crucial for both the country and the business image and competitiveness. It is not possible to survive in today's global competition for businesses that do not have a skilled, efficient and educated workforce (Yılmaz, 2014). In today's intense competitive environment, the success of businesses depends largely on their ability to manage and take risks they face (Özer, 2012).

The needs of businesses for marketing and sales activities are increasing day by day in order to survive in global competitive conditions. Because today's competitive conditions make it necessary to foresee market trends and meet customer needs rapidly (Kotler and Armstrong, 2004). The company with the highest competitive advantage is that creates value for the customer and makes it sustainable over time (Kotler, 2000). Because competition means advantage as long as it is sustainable (Bahar and Kozak, 2012). Customer orientation, which is one of the basic components of market orientation, leads businesses in gaining competitive advantage and expresses continuing to create value for customers (Kohli and Jaworski, 1990). If a competitive strategy aiming to increase its existing market share is not supported by strategies aiming to create brand new markets, it is inevitable that other competitors will gain competitive advantage (Kırım, 2004). When the services provided to the customer are various, they can be used to gain competitive advantage. If a firm provides better service, customers may prefer that firm even though its cost is higher (Wanjiku, 2012). Surviving in competition and maintaining a competitive advantage depend on the continuous development of businesses' products, processes, structures and management approaches. In this framework, university-industry cooperation continues to gain vital importance in increasing and sustaining competitiveness (Tanış, 2020).

The quality factors which are corporate image and brand, quality goods and services, conforming to standards, reliability and ethics code affect competitive advantage. The ability of businesses to gain strength and gain competitive advantage in an intense competitive environment depends on having a strong corporate image in the eyes of the customer and providing corporate brand loyalty (Yalçın and Ene, 2013). Businesses have to be able to respond quickly to the increasing demands of consumers on the variety of quality goods and services. In today's world, where competition is at a high level, businesses that produce and serve in line with technological know-how and can adapt to the change in the market can achieve high competitive advantage against competitors by offering higher quality, conforming to standards goods and services. Establishing reliability is one of the main issues that directly affect the competitive advantage, future and therefore the existence of organizations (Asunakutlu, 2002). In a competitive world, an updated and well-defined code of ethics reflects the core values of an organization. This can protect against harassment or dictum, fines and sanctions (Kain and Sharma, 2014).

4. METHODOLOGY OF THE RESEARCH

The factors affecting competition and their degrees of importance differ according to the sectors. In previous studies, any study has been found that determined the factors affecting competition as a whole in logistics sector. It is aimed to contribute to the scientific gap in the literature by determining at the factors affecting competition in a holistic manner in logistics sector. The aim of this study is to determine the attitudes of senior managers working in the logistics service provider companies in Izmir towards the factors affecting competition in the logistics sector which has complex environment in recent years. In order to achieve this purpose, Delphi method, which is a qualitative research method, has been applied.

The reasons for using the Delphi method in this study is its suitability to the subject and its advantages. The most important advantage of the Delphi method is the provided convenience when participants cannot come together frequently due to distance, cost, time and place (Turoff and Hiltz, 2001: 60). Also thanks to the Delphi method; opinions and thoughts are documented and evaluated (Stewart et al., 2007:155), new ideas on the subject are provided (Franklin and Hart, 2007:238), common knowledge shared by experts are captured that previously unspoken or undiscovered (Stewart et al., 2007:155) effective decisions can be made when insufficient and conflicting information is found (Hasson et al., 2000:1008). Besides its advantages, Delphi method also has some disadvantages. For example, difficulty in finding enough experts for questions is one of the most important disadvantage of Delphi method (Gordon, 1994: 11). In addition, Delphi method can be time-consuming and laborious for both researchers and participants. Participants of the Delphi method might also drop out due to the long temporal commitment, distraction between rounds, or disappointment with the process (Donohoe and Needham, 2009).

The origin of the word Delphi is based on an oracle named *"Delphic"* who lived on the island of Delphi and prophesied about the future in Ancient Greek mythology.

As can be understood from the origin of the word, Delphi means to predict some future developments (Clayton, 1997: 376). As a scientific research method, it is considered as a technique that allows each individual of the group to contribute to the solution of complex problems as a process of group communication (Linstone and Turoff, 2002: 3). This method, which was introduced in the 1950s by researchers named Norman Dalkey and Olf Helmer working at RAND (research corporation) in the United States to conduct research on military issues, is based on a structured process to collect and decompose the information of a particular group of experts with the help of a series of questionnaires together with controlled feedback (Dalkey and Helmer, 1963; Ziglio, 1996: 3).

Delphi technique is a widely used and accepted method in which information is collected according to the expertise of the participants. This technique is designed to reach consensus on a particular issue within a group. In Delphi technique, a written form is sent to the experts in the related subject, which includes questions about their point of view and solution suggestions. After the forms are completed by experts, they are sent back to the researcher. Then the opinions and suggestions of all group members or experts are classified and sent back to them again. This process continues until a decision is made and a consensus is reached (Aktan, 2008: 8).

Delphi technique can be seen in marketing, education, information systems, strategic management, tourism, operations and production management, program planning, needs determination, policy making, developing the use of resources to evaluate alternatives and estimation, are confidentiality in the identities of the participants, repetition feature, controlled feedback, statistical analysis of answers and consensus of experts (Sandford and Hsu, 2007: 1). In recent years, it has been observed that the Delphi method is frequently used in the fields of maritime and logistics in both domestic and international literature.

For example, Saldanha and Gray (2002) investigated the expert opinions about the integration of cabotage transportation with multimodal transportation and the potential of British cabotage transportation with Delphi method. Lu *et al*. (2006) used the Delphi method to investigate possible disadvantages, success factors, and ideas for future development of alliances in the liner shippig industry. Emiroğlu and Ozer Çaylan (2014) evaluated the strategic leadership perceptions of the senior port managers in Turkey by Delphi method. Gomez Paz *et al*. (2015) investigated the constraints that may affect the future size of mega container ships by Delphi method. Gülmez and Karataş Çetin (2016) used the Delphi method in their study to consult experts and proposed a model for the ownership and management of logistics centers. Chen and Pak (2017) determined green performance evaluation indicators for Chinese ports by using the Delphi method. In their study, Ayaz and Çetin (2018) evaluated the attitudes of managers working in Turkish ship-owner companies towards green shipping practices using the Delphi method. The Delphi method was used in this study due to its suitability to the subject, its expected advantages to the study and its widespread use in the literature.

Dephi form has been used by Porter, 1980; Barney, 1991; Hamel & Prahalad, 1994; Teece *et a*l., 1997; Ghemawat, 2002; Wattanapruttipaisan, 2002; Gonzalez *et al*., 2004; Dikyol, 2007; Gal, 2010; Vinayan *et al.,* 2012; Wanjiku, 2012; Ağgez, 2013; Kocaoğlu, 2013; Yılmaz, 2014; Bhuyan, 2015 and Global competitiveness, 2017. This study consists of two rounds and two questionnaire forms. The first round consists of a questionnaire compiled from the relevant literature, aiming to measure the attitudes of managers towards the factors affecting competition in the logistics sector. Later, for the questions that could not be agreed at the first round, the second round questionnaire form was used. The information obtained during the research was used for statistical purposes only; the names and private information of the participants were not disclosed.

4.1. Sampling and Data Collection Process

The selection of the participants is on the basis of a successful Delphi research. In order to get the conclusion of the research successfully, the knowledge and cooperation of the people who participated in the study with valuable ideas are very important (Gordon, 1994: 6). There is no definite judgment in the literature about determining the participants to take part in the Delphi research (Hsu and Sandford, 2007: 3). However, in Delphi method, participants are not chosen randomly. People who have certain criteria, whose knowledge and experience can be consulted, are selected and attention is paid to ensure that the participants are people who can participate in all rounds carried out in the study (Hasson *et al*., 2000: 1010; Stitt-Gohdes and Crews, 2004: 61). Participants, who can vary according to the subject, can be in the range of 10-30 people (Rayens and Hahn, 2000: 309).

The sample of the research is composed of senior managers of logistics service providers operating in İzmir province. For the first round of the Delphi method, a Delphi form has sent to the senior executives of 30 companies operating in İzmir province via e-mail and the first round has completed between the dates of 16-22 October 2019. It is observed that the majority of the participants are working with the position of team leader (14 participants), department manager (12 participants) and specialist (4 participants) in their company. The second round questionnaire form has prepared for the questions that could not reached a consensus in the first round, and the second round has completed between the dates of 24-31 October 2019 with the participation of 18 managers.

5. FINDINGS

The findings have been analyzed under 2 headings. These are the findings regarding the logistics companies and the analysis of Delphi results. These results divided into the s the results of the 1st and 2nd Round.

5.1. Profile of the Companies Included in the Study

The participants have been asked three questions (field of activity, total service time of the institution, number of employees of the institution) regarding the logistics companies they worked with. The findings have been obtained within the scope of descriptive statistics and information about the institutions where the participants work are shown in Table 2.

Table 2: Findings Related to Logistics Service Providers

	n	%
Field of Operation		
Maritime Transportion	30	100
Airway Transportion	27	90
Road Transportion	20	66,7
Project Transportation	2	6,7
Railway Transport	1	3,3
Warehousing	1	3,3
Total	30	100
Operation Year		
0-10	10	37
11-20	11	40,8
21-30	1	3,7
41-50	5	18,5
Total	27	100
Number of Employees		
0-50	7	25
51-100	13	46,5
101-150	7	25
151+	1	3,5
Total	28	100

According to the results, all of the companies operate in the field of maritime transport, 90% of them operate in the field of air transport and 66.6% of them in the field of road transport. The logistics companies in the sample also provide project transportation, rail transportation and warehousing services. It is seen that 40.8% of the companies operate in the sector between 11-20 years, while 37% of them operate under 5 years. In the light of the data obtained, it can be concluded that the logistics sector has increased rapidly in recent years and the number of companies operating is increasing day by day. Most logistics companies in the sample employ between 51 and 100 people. Considering the number of departments and the size of the firms, it can be concluded that the İzmir Office employees of the companies in the sample are sufficient.

5.2. Analysis of the Delphi Results

In this study, APMO (The Average Percentage of Majority Opinion) technique used as a consensus measurement. In the calculation process of the first round of Delphi survey, the number of majority agreements and disagreements are calculated by expressing the participants 'comments "agree", "disagree" and "no comment" in percentages per statement. It was defined by Kapoor (1987) as:

$$\text{APMO} = \frac{\text{Majority Agreements} + \text{Majority Disagreements}}{\sum \text{Opinions Expressed}}$$

According to the Brett and Roe (2010: 8); a statement achieved consensus when it reached 70% or more. Authors stated that, a results of 70–79% was categorized as low consensus, consensus between 80 and 89% was categorized as medium consensus and consensus that fell between 90 and 100% was categorized as a high consensus. In this study, the Delphi survey prepared with the data obtained from the literature review has sent to 30 expert participants, the results have been analyzed with the APMO method and the agreement rates have been calculated for each statement. After, the statements that could not be reached a consensus in the first round have been detailed and a second round Delphi survey has been created. 17 participants attended in the second round of Delphi research. At the end of the second round, 2 questions could not be reached a consensus but the research has decided to be terminated both because the consensus rates have above 70% and it has seen that saturation has achieved in the obtained results.

5.2.1. Results of the First Round of the Delphi Survey

In the first round of Delphi research Delphi form consisting of 29 questions have prepared with the data obtained from the literature review and answered by 30 expert participants working in the logistics sector. The agreement rate of each statement in the form has calculated by APMO method.

According to first round of the Delphi survey results, majority of agreements includes 704 statements, majority of disagreements includes 34 statements and total opinions expressed with 868 statements including 78 non-comment responses. APMO cut-off percentage rate for the first round Delphi survey has been found 91% according to this results. When the results have been examined, it has seen that there is a total of 23 statements that over the APMO cut-off percentage rate and reached high consensus rate. It has determined that there is no consensus in 6 statements. Summary results of first round of the Delphi research presented in the Table 3. The statements in order of numbers used to evaluate the findings of the first stage of the Delphi research, the frequency and distribution of the responses of the experts to each statement, and the agreement rates are shown in Table 4.

Table 3: Brief Results of the First Round of the Delphi Research

Majority Agreements	704
Majority Disagreements	86
Total Opinion stating Agree and Disagree	790
Total Opinion announced by Panel Members	868
Average Percent of Majority Opinions	%91
Number of Statements Reaching Consensus	23
Number of Uncompromising Statements	6
Number of Total Statements	29
High Consensus (>90)	23
Medium Consensus (>80 - <89)	-
Low Consensus (>70 <79)	-
Number of Statements over 70 % Consensus	23

When the results of the first round of the Delphi study are examined, it is seen that the participants agree that the valuable and rare of the service provided by logistics service providers, which is one of the factors related to the resource dependency approach, affects the competition in the sector. However, 69% of the participants thought that the inimitability of the services provided by the logistics service providers affected the competition in the logistics sector, only 62% of the participants stated that the non-substitutable of the services has one of the factors affecting the competition

in the logistics sector and there is no consensus for these two statements.

Table 4: Results of the First Round of the Delphi Research (1/1)

STATEMENTS **A. Factors related to Resource Based View**	**NUMBER OF ANSWERS**					**RESULTS**
	Agree		**Disagree**		**Unable to Comment**	
	N	**%**	**N**	**%**	**N**	
1. **Value** of the service given by logistics service providers is one of the factors that affect the competition in the logistics sector.	28	100	0	0	2	%100 AGREED CONSENSUS
2. **Rarity** of the service given by logistics service providers is one of the factors that affect the competition in the logistics sector.	27	93	2	7	1	%93 AGREED CONSENSUS
3.**Inimitability** of the service given by logistics service providers is one of the factors that affect the competition in the logistics sector.	20	69	9	31	1	*%69* AGREED
4. **Non-substituted** service given by logistics service providers is one of the factors that affect the competition in the logistics sector.	16	62	10	38	4	*%62* AGREED
B. Factors related to Dynamic Capabilities						
1. The ability of logistics service providers to **sense** opportunities in the market and to be **responsiveness** to the market is one of the factors that affect the competition in the logistics sector.	28	100	0	0	2	%100 AGREED CONSENSUS
2. Logistics service providers' ability to find new solutions, create new knowledge and learn to take advantage of market opportunities (**organizational learning**) in the changing environment is one of the factors that affect the competition in the logistics sector.	28	97	1	3	1	%97 AGREED CONSENSUS
3. The ability of logistics service providers to **integrate the knowledge and skills** of their employees with the routines of their operations is one of the factors that affect the competition in the logistics sector.	28	100	0	0	2	%100 AGREED CONSENSUS
4. The ability of logistics service providers to effectively **coordinate** their resources and activities is one of the factors affecting the competition in the logistics sector.	26	96	1	4	3	%96 AGREED CONSENSUS
C. Factors related to Structural Approach						
1. **Threats and obstacles for new entrants** to the market in the logistics sector are one of the factors affecting the competition.	13	62	8	38	9	*%62* AGREED
2. **Bargaining power of suppliers** is one of the factors affecting the competition in the logistics sectors.	26	96	1	4	3	%96 AGREED CONSENSUS
3. **Competition strategies** implemented by logistics service providers and **rivalry among existing competitors** are one of the factors affecting the competition in the sector.	26	93	2	7	2	%93 AGREED CONSENSUS
4. **Bargaining power of buyers (customers)** is one of the factors affecting the competition in the logistics sectors.	17	63	10	37	3	*%63* AGREED
5. **Threats of substitute services** are one of the factors affecting the competition in the logistics sectors.	14	61	9	39S	7	*%61* AGREED

Table 4: Results of the First Round of the Delphi Research (1/2)

STATEMENTS	**NUMBER OF ANSWERS**					**RESULTS**
D. Operational Factors	**Agree**		**Disagree**		**Unable to Comment**	
	N	**%**	**N**	**%**	**N**	
1. The **cost** of operations is one of the factors that affect the competition in the logistics sector.	28	97	1	3	1	%97 AGREED CONSENSUS
2. The **speed of operations (time)** is one of the factors affecting the competition in the logistics sector.	29	97	1	3	0	%97 AGREED CONSENSUS
3. The **technological** infrastructure used by logistics service providers is one of the factors affecting the competition in the logistics sector.	29	97	1	3	0	%97 AGREED CONSENSUS
4. **Research and development (R&D)** activities implemented by logistics service providers are one of the factors affecting the competition in the logistics sector.	25	93	2	7	3	%93 AGREED CONSENSUS
5. **Innovation** activities implemented by logistics service providers are one of the factors affecting the competition in the logistics sector.	27	93	2	7	1	%93 AGREED CONSENSUS
6. The **qualified workforce** of logistics service providers is one of the factors affecting the competition in the logistics sector.	27	96	1	4	2	%96 AGREED CONSENSUS
7. **Risk taking** tendency of logistics service providers is one of the factors affecting the competition in the logistics sector.	18	69	8	31	4	*%69* AGREED
E. Factors related to Marketing						
1. **Customer satisfaction and value creation** is one of the factors affecting the competition in the logistics sector.	27	93	2	7	1	%93 AGREED CONSENSUS
2. **Customer orientation** is one of the factors that affect competition in the logistics sector.	24	92	2	8	4	%92 AGREED CONSENSUS
3. The **market share** of logistics service providers is one of the factors affecting the competition in the logistics sector.	27	96	1	4	2	%96 AGREED CONSENSUS
4. **After-sales (value-added) services** offered by logistics service providers to their customers is one of the factors affecting the competition in the logistics sector.	29	100	0	0	1	%100 AGREED CONSENSUS
5. The **cooperation between university and industry** is one of the factors affecting the competition in the logistics sector.	21	91	2	9	7	%91 AGREED CONSENSUS
F. Factors related to Quality						
1. The **brand and image** of logistics service providers is one of the factors affecting the competition in the logistics sector.	24	96	1	4	5	%96 AGREED CONSENSUS
2. Compliance of logistics service providers with **quality standards** is one of the factors affecting the competition in the logistics sector.	26	93	2	7	2	%93 AGREED CONSENSUS
3. The **reliability** of logistics service providers is one of the factors affecting the competition in the logistics sector.	27	100	0	0	3	%100 AGREED CONSENSUS
4. The **ethical behavior** displayed by logistics service providers is one of the factors affecting the competition in logistics the sector.	24	92	2	8	2	%92 AGREED CONSENSUS

According to the first round results of the Delphi survey, it can be said that the participants reached a consensus on all factors related to the dynamic capabilities. In other words, the participants agree that the ability to sense opportunities in the market and to be responsiveness to the market, find new solutions and learn, integrate knowledge and skills with the routines of their operations, and the ability to effectively coordinate their resources and activities are factors that affect the competition in the logistics industry. The obtained results emphasize that the logistics sector has become one of the largest and most dynamic sectors in parallel with the increase in international trade volume, the removal of borders between countries and the development of the concept of globalization.

When the factors related to the structural approach are examined, results are showed that the participants agreed that only the market dominance of the logistics sector suppliers and the competitive strategies implemented by the logistics service providers affect the competition in the sector. The lowest consensus rate in the first round of Delphi research has experienced on the impact of the threat of substitution services in the logistics sector on the competition with a consensus rate of 61%. In addition, the participants reached a consensus on all marketing and quality related factors.

At the end of the first round of Delphi research, there are no consensus on a total of 6 statements. The statements that could not be reached a consensus have been re-evaluated, some of the statements are detailed for easier understanding by the participants, and the two statements which are not reached a consensus about the substitution of services provided in the logistics sector are combined in a single question. The second round Delphi form created in the light of these developments has sent to the experts who participated in the first round of the Delphi research.

5.2.2. Results of the Second Round of the Delphi Survey

In the second round of the Delphi survey, the Delphi form consisting of 5 questions and prepared with the data obtained from the first round has answered by 18 expert participants working in the logistics sector who also participated in the first round of the research. Due to time constraints and workloads, 12 participants who participated in the first round could not participate in the second round of the study by informing to the authors about their situation. The consensus rate of each statement in the second round questionnaire has calculated with the APMO method as in the first round.

According to second round of the Delphi research, majority of agreements includes 65 statements, majority of disagreements includes 11 statements and total opinions expressed with 85statements including 9 non-comment responses. APMO cut-off percentage rate for the second round Delphi survey has been found 85,5% according to this results. According to second round of the Delphi survey results, there are 3 statements that over the APMO cut-off percentage rate. Although 2 statements that over the 70%, they could not reach a consensus because they are below to 85,5% APMO cut-off percentage rate for the second round Delphi survey. In the second round of the Delphi study, different from the first round, participants have been asked to state with their reasons whether they agree or disagree with the statements for a more detailed analysis of the results. Summary results of the second round of the Delphi research presented in the Table 5. The statements in order of numbers used to evaluate the findings of the second stage of the Delphi research, the frequency and distribution of the responses of the experts to each statement, and the agreement rates are shown in Table 6.

Table 5: Brief Results of the Second Round of the Delphi Research

Majority Agreements	65
Majority Disagreements	11
Total Opinion stating Agree and Disagree	76
Total Opinion announced by Panel Members	85
Average Percent of Majority Opinions	%85,5
Number of Statements Reaching Consensus	3
Number of Uncompromising Statements	2
Number of Total Statements	5
High Consensus (>90)	2
Medium Consensus (>80 - <89)	1
Low Consensus (>70 <79)	2
Number of Statements over 70 % Consensus	5

When the results of the second round of Delphi research have been examined, it is seen that there is a consensus of 88% in the first question about imitation of logistics services. Only 2 participants are not agreed with this statement. As it can be understood from the comments added by the participants to the Delphi survey form, by imitating a unique service offered for the first time, the company providing this service is no longer in a monopoly position, the service provided becomes cheaper and accessible, and this situation increases the general competition in the logistics sector. In the second question about the substitution of logistics services, it has seen that the highest consensus rate in the second round is reached with a rate of 94%. Participants emphasize that as similar services increase, new options that provide positive results for customers will increase and as a result of this situation.

Logistics service provider will try to create different added value logistics services and also the competitive environment in the sector will increase. Only one participant who expressed a negative opinion stated that the important thing is not to produce similar services, but to make a difference in communication channels and technical issues, and this will affect the whole competitive environment in the logistics sector.

In the third question about the threats and obstacles that new entrants to the market will encounter in the logistics sector, the consensus rate has determined as 71%, and this statement remained the second round APMO cut-off percentage rate of 85.5%. While some participants emphasized that in parallel with the increase in the number of businesses in the sector, the market share will be divided; however, some of them stated that the logistics sector is not a sector that is very open to new businesses. The important thing is to create a perception of trust in the sector and for these reasons new entrants to the market cannot be a threat to the old and well-established companies in the sector.

Table 6: Results of the Second Round of the Delphi Research

STATEMENTS	RESULTS					
	Agree		Disagree		Unable to Comment	
	N	%	N	%	N	
1. Imitating a unique logistics service offered to customers by a company for the first time by competitors in the industry and offering the same service is one of the factors affecting the competition in the logistics sector.	15	88	2	12	0	%88 AGREED CONSENSUS
2. The provision of similar services by competitors that create the same value for customers is one of the factors affecting the competition in the logistics sector.	15	94	1	6	1	%94 AGREED CONSENSUS
3. The inclusion of new businesses in the logistics sector is a threat (division of market share, loss of customers, etc.) to existing logistics businesses in the market. The threats to be created by these new entrants are one of the factors affecting the competition in the logistics sector.	10	71	4	29	3	%71 AGREED
4. Customers' demand for higher quality and additional services by trying to lower prices for the service they will purchase is one of the factors affecting the competition in the logistics sector.	11	79	3	21	3	%71 AGREED
5. The risks (new investments, R&D expenditures, etc.) taken by logistics service providers to achieve a sustainable competitive advantage are one of the factors affecting the competition in the sector.	14	93	1	7	2	%93 AGREED CONSENSUS

In the fourth question about the bargaining power of service buyers in the logistics sector, the agreement rate has again 71%, which was below the second round APMO cut-off percentage rate of 85.5 %.

While many participants emphasized in their comments that customers put a great pressure on logistics businesses to lower their prices and this situation increased the competition in the sector. Some participants stated that the bargaining power of customers has not a factor that affects competition in the sector alone, but a result of this competition.

In the last question about the risks taken by logistics service providers, it has seen that there is a consensus with 93%. Most of the participants has stated that the risks achieve success with new investments and R&D expenditures. It can bring new customers, decrease the work intensity, increase the quality of the service and consequently bring a significant competitive advantage against the competitors. Only one participant has expressed the opposite opinion, and 2 participants has remained without comment.

At the end of the second round of the Delphi research, the results of the study have found to be sufficient because the agreement rates of the 2 statements below the second round APMO cut-off percentage rate are not very low (over 70%) and it is thought that sufficient saturation is achieved in the results and the research is terminated without a third round.

6. CONCLUSION

According to Henderson (1983), competition is universal and applied to biological or business competition. Understanding the factors which affect competitive advantage is an important research topic in the strategic management field. The important and necessary thing for companies to sustain their long term life is to gain competitive advantage in the literature.

Logistics capabilities are considerably critical for the success of companies with the effect of global competition in the logistics sector, which has displayed a very complex appearance in recent years. For this reason, it is aimed to determine the attitudes of senior managers working in logistics service companies towards the factors affecting competition. It is aimed to determine the attitudes of senior managers working in logistics service companies towards the factors affecting competition. To achieve this purpose, Delphi method, which is a qualitative research method, has applied. The first stage of the study consists of a questionnaire that aims to measure the attitudes of the managers towards the factors affecting competition in the logistics industry, compiled from the relevant literature. Later, for the statements that could not reached a consensus at the first stage, the second round of the Delphi study has implemented.

In the first round of Delphi research, most of the factors obtained from the literature are consensus. When the results of the first round are examined, it is seen that the participants agree that the value and rare of the service provided by the logistics service providers, which is one of the factors related to the resource dependency approach, affects the competition in the sector. It is seen that the participants agree on all of the factors related to the dynamic skills approach. In other words, the participants agree that the ability to sense opportunities in the market, find new solutions and learn, integrate knowledge and skills with the routines of their operations, and the ability to effectively coordinate their resources and activities are factors that affect the competition in the logistics industry. When the factors related to the structural approach are examined, the participants agreed that only the market dominance of the logistics sector suppliers and the competitive strategies implemented by the logistics service providers affect the competition in the sector. Two of the 5 variables belonging to the approach known as the Porter's five forces model, which is of great importance and associated with competition in the literature, have not been considered as highly significant and compromised by logistics service provider experts as a factor affecting competition. This situation suggests that there is a perception difference between the academy and the industry in terms of the logistics industry. In addition, the participants agreed on all of the factors related to marketing such as value creation, customer orientation, and market share, value added services and university-industry cooperation and factors related to quality such as corporate image and brand, quality and conforming standards, confidence and ethical behavior of firms

As a result of the first round of the Delphi study, a total of statements could not reached a consensus, for this reason the statements have been re-evaluated and detailed, and a second round Delphi form has prepared. When the factor related to imitation of logistical services that could not be reached a consensus in the first round has detailed, it has seen that the experts agreed with this high consensus rate. Likewise, the participants agreed with high consensus rate on the statements regarding the substitution of logistics services and the risks taken by logistics service providers. There has no consensus regarding the threats / barriers faced by new entrants to the market and the bargaining power of the service buyers in the logistics sector. At the end of the second round of the Delphi research, the results of the study have been found to be sufficient because the agreement rates of the 2 statements below the second round APMO cut-off percentage rate are not very low and it is thought that the results are reached sufficient saturation, and the research is terminated without a third round.

The obtained results emphasize that the logistics sector has become one of the largest and most dynamic sectors in parallel with the increase in international trade volume, the removal of borders between countries and the development of the concept of globalization. By imitating a unique service offered for the first time, the company offering this service is no longer in a monopoly position. Therefore, provided service becomes cheaper and accessible, and this condition increases the general competition in the logistics sector. Results of the study indicated that as similar services increase, new options that provide positive results for customers will increase and as a result of this situation, it is thought that logistics service providers will try to create different added value services and the competitive environment in the sector will increase. Some participants emphasized that as the number of businesses in the sector increases, the market share will be divided, while others stated that the logistics sector is not a sector that is very open to new businesses, the important thing is to create reliability in the sector, and for these reasons, new entrants to the market cannot be a threat for old and well-established companies in the sector. In addition, it was stated that the customers put a great pressure on the logistics service providers to lower their prices and this situation increased the competition in the sector. Participants specified that the risks to be taken with new investments and R&D expenditures can bring new customers, reduce the work intensity, increase the quality of the service and, as a result, bring a significant competitive advantage against competitors.

As a result; valuable, sense of market opportunities and sensitivity to the market, the ability to combine the knowledge and skills of employees with the routines of their operations, after-sales service and reliability are factors that reached a 100% consensus rate. All factors related to dynamic capabilities approach associated with competition in the literature have been considered important by logistics service providers. There was no consensus regarding the threats and obstacles faced by new entrants to the market and the bargaining power of the service buyers in the logistics industry.

When the results of the study are examined, it can be seen that high consensus rates in the operational factors' statements such as costs, speed of operations, technological infrastructure and qualified workforce are compatible with the relevant literature. For example, Çekerol and Kurnaz (2011) identified high importance of infrastructure for the gaining competitiveness in the logistics sector. Also, Hise (1995) defended competition related to time is a strategic tool for creating competitive advantage in the logistics sector. Kramer and Kramer (2010) also highlighted the flexible delivery frequency and price in their study. In addition to operational factors, high consensus rates in the quality and marketing factors' statements obtained in the study. Importance of quality in terms of competitiveness of logistics sector has also been emphasized in the literature. For instance, Babacan (2003) stated that choosing the right customer and ensuring accuracy in needs determination, increasing the customer service level and ensuring the balance of customer satisfaction and firm value are important factors for gaining competitive power in the logistics sector. According to the literature review, there haven't been found many studies containing the factors related to resource based view and structural approach in terms competitiveness of the logistics sector.

Limitations and Recommendations of the Study

Due to limited time of the study, a certain number of experts working in logistics provider companies have been reached. For this reason, the research of the study only covers logistics service providers in the İzmir region.

In the following studies, researches can be conducted including overall competition factors based on Turkey. Comparative analyzes can also be performed by increasing the number of studies and expanding the sample groups.

REFERENCES

Aktan, C. C. (2008). "Stratejik yönetim ve stratejik planlama." *Çimento İşveren Dergisi*, Vol. 4, No. 22, pp. 4-21.

Asunakutlu, T. (2002). "Örgütsel güvenin oluşturulmasına ilişkin unsurlar ve bir değerlendirme." *Muğla Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, No. 9, pp. 1-13.

Ayaz, İ.S. and Çetin, İ.B. (2018). "Analyzing the attitudes of turkish shipowning companies towards green shipping application aiming sustainable transportation." *Journal of Business Researh-Turk*, Vol. 10, No. 4, pp. 229-245.

Babacan, M. (2003). "Lojistik sektörünün ülkemizdeki gelişimi ve rekabet vizyonu." *Ege Akademik Bakış Dergisi*, Vol. 3, No.1, pp. 8-15.

Bahar, O. and Kozak, M. (2012). *Turizm ve rekabet,* Detay Yayıncılık, Ankara, Turkey.

Barney, J. (1991). "Firm resources and sustained competitive advantage." *Journal of Management*, Vol. 17, No. 1, pp. 99-120.

Barney J. (1995). "Looking ınside for competitive advantage." *Academy of Management Perspectives,* Vol. 9, No. 4, pp. 49-61.

Barney, J. B. (1996). *Gaining and sustaining competitive advantage*, Addison Wesley Publishing Company Reading, Massachusetts, USA.

Barutçugil, İ. (2013). *Stratejik Yönetim*, Kariyer Yayıncılık, İstanbul, TURKEY.

Bhatnagar, R. and Teo, C. C. (2009). "Role of logistics in enhancing competitive advantage: A value chain framework for global supply chains." *International Journal of Physical Distribution & Logistics Management*, Vol. 39, No. 3, pp. 202-226.

Bhuyan, J. and Padhy, P. K. (2015). "Key success factors of achieving sustainable competitive advantage: An empirical study." *SPC ERA IJBM*, Vol.3, No.7, pp.41-53.

Brett, V. and Roe, M. (2010). "The potential for the clustering of the maritime transport sector in the greater dublin region." *Maritime Policy and Management*, Vol. 37, No.1, pp. 1-16.

Chen, Z. and Pak, M. (2017). "A delphi analysis on green performance evaluation indices for ports in china." *Maritime Policy & Management*, Vol.44, No.5, pp.537-550.

Clayton, M. J. (1997). "Delphi: a technique to harness expert opinion for critical decision-making tasks in education." *Educational Psychology*, Vol.17, No.4, pp. 373-386.

Crossan, M. M., Lane, H. W. and White, R. E. (1999). "An organizational learning framework: From intuition to institution." *Academy of Management Review*, Vol. 24, No.3, pp. 522-537.

Çekerol, G. S. and Kurnaz, N. (2011). "Küresel kriz ekseninde lojistik sektörü ve rekabet analizi." *Selçuk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi,* No. 25, pp. 47-59.

Dalkey, N. and Helmer, O. (1963). "An experimental application of the delphi method to the use of experts." *Management Science*, Vol. 9. No. 3, pp. 458-467.

Deveci ve Çetin (2013). "Gemi acenteleri ve forvarder işletmeleri: işlevler ve hizmetler." *Denizcilik İşletmeleri Yönetimi* A. Güldem Cerit, D. Ali Deveci and Soner Esmer, Eds., Beta Yayıncılık, İstanbul, pp. 471-501.

Dikyol, S. (2007). The analysis of Michael Porter's competition strategy factor's in civil aviation sector: comparison of atlasjet and pegasus airlines, Master Thesis, Marmara University, İstanbul, Turkey.

Donohoe, H. M. and Needham, R. D. (2009). "Moving best practice forward: Delphi characteristics, advantages, potential problems, and solutions". *International Journal of Tourism Research*, 11(5), 415–437.

Emiroğlu, Ç. and Çaylan, D. Ö. (2014). "The ımportance of strategic leadership for port management: A delphi research on top managers of Turkish private ports." *Journal of Global Strategic Management*, Vol. 8, No.2, pp. 5-16.

Founou, R. (2002). "The role of IT in logistics competitive advantage or strategic necessity." *Proc., 2nd Swiss Transport Research Conference*, Switzerland, pp. 1-21.

Franklin, K.K. and Hart, J.K. (2007). "Idea Generation and Exploration: Benefits and Limitations of the Policy Delphi Research Method", *Innovative Higher Education,* 31(4): 237–246.

Gál, A. N. (2010). "Competitiveness of small and medium sized enterprises-a possible analytical framework." *Hungarian Electronic Journal of Science*, pp. 1-14.

Ghemawat, P. (2002). "Competition and Business Strategy In Historical Perspective." *Business History Review*, Vol. 76, No.1, Pp. 37-74.

Gomez Paz, M. A., Camarero Orive, A. and González Cancelas, N. (2015). "Use of the Delphi method to determine the constraints that affect the future size of large container ships." *Maritime Policy & Management*, Vol.42, No.3, pp. 263-277.

Gonzalez, M. E., Quesada, G., Mueller, R. and Mora-Monge, C. A. (2004). "QFD strategy house: an innovative tool for linking marketing and manufacturing strategies." *Marketing Intelligence & Planning,* Vol. 22, No.3, pp. 335-348.

Gordon, T. J. (1994). The Delphi method. *Futures Research Methodology,* AC/UNU Millenium Project,

http://www.gerenciamento.ufba.br/downloads/delphi_method.pdf [Accessed 08 Oct 2020].

Grant, R. M. (1991). "The resource-based theory of competitive advantage: Implications for strategy." *California Management Review*, Vol. 3, No.33, pp. 114-135.

Gülmez, S. and Çetin, Ç. K. (2016). "An ownershıp and management model proposal for logıstıcs centers ın Turkey." *Proc., The Second Global Conference on Innovation in Marine Technology and the Future of Maritime Transportation*, Bodrum, Muğla, TURKEY, pp. 543-559.

Hamel, G. and Prahalad, C.K. (1994). *Competing for the future*, Harvard Business School Press, Massachusetts, USA.

Hasson, F., Keeney, S. vand Mckenna, H. (2000). "Research guidelines for delphi survey technique." *Journal of Advanced Nursing*, Vol. 32, No.4, pp. 1008-1015

Helfat, C. E. and Peteraf, M. A. (2003). "The dynamic resource-based view: Capability lifecycles." *Strategic Management Journal*, Vol. 24, No. 10, pp.997-1010.

Henderson, B. D. (1983). "The anatomy of competition." *Journal of Marketing,* Vol. 47, No.2, pp. 7-11.

Henderson, B. D. (1989). "The origin of strategy." *Harvard Business Review*, Vol. 67, No. 6, pp. 139-143.

Hise, R. T. (1995). "The implications of time-based competition on international logistics strategies." *Business Horizons*, Vol. 38, No. 5, pp. 39-46.

Kain, P. and Sharma, S. (2014). "Business ethics as competitive advantage for companies in the globalized era." *Journal of Management Sciences and Technology*, Vol.3, No. 1, pp. 39-46.

Karamustafa, K., Güllü, K., Acar, N. ve Ulama, Ş. (2010). *Konaklama İşletmelerinde Pazar Odaklılık*, Detay Yayıncılık, Ankara, Turkey.

Kırım, A. (2004). *Yeni Dünyada Strateji ve Yönetim,* Sistem Yayıncılık, İstanbul, Turkey.

Kocaoğlu, İ. U. (2013). Firma rekabet gücünü artıran faktörler ve kümelenme yaklaşımı: Türkiye doğal taş kümelenmelerinin rekabet gücü açısından incelenmesi, PhD Thesis, Ege University, İzmir, Turkey.

Kohli, A. K. and Jaworski, B.J. (1990). "Market orientation: the construct, research propositions, and managerial ımplications." *Journal of Marketing*, Vol. 54, No.2, pp.1-18.

Kotler, P. (2000). *Marketing management*, The Millennium Edition, Person Prentice Hall, New Jersey, USA.

Kotler, P. and Armstrong, G. (2004). *Principles of m*arketing, 10th Edition, Pearson-Prentice Hall, New Jersey, USA.

Kramer, A. and Kramer, J. (2010). Flexibility of delivery frequency in logistic competition. Working paper, University of Karlsruhe, Germany.

Lee, E. S., and Song, D. W. (2015). "Competition and co-operation in maritime logistics operations." *Handbook of Ocean Container Transport Logistics*, Springer, Cham, pp. 477-496.

Linstone, H. A. and Turoff, M. (2002). *The Delphi method techniques and applications,* Addison-Wesley, London, UK.

Lu, H. A., Cheng, J. and Lee, T. S. (2006). "An evaluation of strategic alliances in liner shipping-an empirical study of CKYH." *Journal of Marine Science and Technology*, Vol. 14, No. 4, pp. 202-212.

Lopez, S. V. (2005). "Competitive advantage and strategy formulation: The key role of dynamic capabilities." *Management Decision*, Vol. 43, No. 5, pp. 661–669.

Mentzer, J. T., Min, S., and Michelle Bobbitt, L. (2004). "Toward a unified theory of logistics." *International Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 8, pp. 606-627.

Michalisin*, M.D.,* Smith*, R.D. and* Kline*, D.M.* (*1997*). "In search of strategic assets." *The International Journal of Organizational Analysis*, Vol. 5. No. 4, pp. 360-387.

Paché, G., and Medina, P. (2007). "The entrenchment strategy of logistics service providers: Towards a sequential cooperation-competition process?" *Journal of Transport and Supply Chain Management*, Vol. 1, No. 1, pp. 65-78.

Porter, M. E. (1980). *Competitive strategy: techniques for analyzing industries and competitors*. The Free Press, New York, USA.

Porter, M. E. (2000). *Competitive strategy: techniques for Analyzing Industries and Competitors*, New York, USA.

Porter, M.E. (2008). "The five competitive forces that shape strategy." *Harvard Business Review*, No.86, No. 1, pp. 78-93.

Proctor, T. (2000). *Strategic marketing: An introduction*, Routledge, London, UK.

Raisinghani, M.S. (2000). "Adapting data modeling techniques for data warehouse design." *Journal of Computer Information Systems*, Vol. 4, No. 3, pp. 73-77.

Rayens, M. K. and Hahn, E. J. (2000). "Building consensus using the policy delphi method." *Policy, Politics and Nursing Practice*, Vol. 1, No. 4, pp. 308-315

Saldanha, J. and Gray, R. (2002). "The potential for british coastal shipping in a multimodal chain." *Maritime Policy and Management*, Vol. 29, No. 1, pp. 77-92.

Sandberg, E., and Abrahamsson, M. (2011). "Logistics capabilities for sustainable competitive advantage." *International Journal of Logistics Research and Applications*, Vol. 14, No. 1, pp. 61-75.

Stanford, B. A. and Hsu, C. C. (2007). "The Delphi technique: Making sense of consensus." *Practical Assessment, Research and Evaluation*, Vol. 12, No. 10, pp. 1-8.

Stalk, G. (1988). "Time-the next source of competitive advantage." *Harvard Business Review*, Vol. 66, No. 4, pp. 41-51.

Stewart, D.W., Shamdasani, P.N. and Rook, D.W. (2007). *Focus Groups: Theory and Practice,* Applied Social Research Methods Series, 20, ABD: Sage Publications.

Stitt-Gohdes, W. L. and Crews, T. B. (2004). "Delphi technique: A research strategy for career and technical education." *Journal of Career and Technical Education*, Vol. 20, No. 2, pp. 55-67.

Tanış, F. (2020). Üniversite - Sanayi İşbirliği. http://www.emo.org.tr/genel/bizden_detay.php?kod=46183&tipi=21&sube=0 [Accessed 22 June 2020].

Teece, D. J. (1982). "Towards an economic theory of the multi-product firm." *Journal of Economic Behavior and Organization,* Vol. 3, No. 1, pp. 39-63.

Teece, D. J., Pisano, G., and Shuen, A. (1997). "Dynamic capabilities and strategic management." *Strategic Management Journal*, Vol. 18, No. 7, pp. 509-533.

Turoff, M. and Hiltz, S. R. (2001). *Computer Based Delphi Processes. Gazing into the Oracle The Delphi Method and its Application to Social Policy and Public Health*. London: Jessica Kingsley Publishers.

Türkmen, İ. and Yilmaz, H. (2019). "Stratejik girişimcilik ve bilgi yönetimi performansı arasındaki ilişki: Bilişim 500 şirketlerinde bir araştırma." *Journal of Yaşar University*, Vol. 14, No. 53, pp.1-12.

Ülgen, H. and Mirze, S. K. (2013). *İşletmelerde Stratejik Yönetim (8. Baskı)*, Beta Basım Yayım Dağıtım, İstanbul, Türkiye.

Vinayani G., Jayashree, S. and Marthandan, G. (2012). "Critical success factors of sustainable competitive advantage: A study in Malaysian manufacturing industries." *International Journal of Business and Management*, Vol. 7, No. 22, pp. 29-45.

Wanjiku, W. A. (2012). Factors influencing competitive advantage of firms in the micro finance industry in Kenya, Master thesis, Business University of Nairobi, Nairobi, Kenya.

Wattanapruttipaisan, T. (2002). "SME subcontracting as a bridgehead to competitiveness: An assessment of supply-side capabilities and demand-side requirements." *Asia-Pacific Development Journal*, Vol. 9, No. 1, pp. 65-87.

Wen, C. H., Tsai, M. C. and Lin, C. H. (2011). "Classification and competition analysis of air cargo logistics providers: The case of Taiwan's high-technology industry." *Journal of Air Transport Management*, Vol. 17, No. 2, pp. 106-109.

Wernerfelt, B. (1984). "A resource-based view of the firm." *Strategic Management Journal*, Vol. 5, No. 2, pp. 171-180.

World Economic Forum (2017). The Global Competitiveness Report (2016-2017), Geneva, Switzerland

Yalçin, A. and Ene, S. (2013). "Online Ortamda Kurumsal Marka Imajinin Marka Sadakati Ile Ilişkisi Üzerine Bir Araştirma." *Marmara Üniversitesi Iktisadi ve Idari Bilimler Dergisi*, Vol. 34, No. 1, Pp. 113-134.

Yılmaz V. (2014). Konaklama işletmelerinin rekabet gücünü belirleyen faktörler üzerine Nevşehir ilinde bir uygulama, Master Thesis, Nevşehir Hacı Bektaş University, Nevşehir, Turkey.

Ziglio, E. (1996). "The Delphi method and its contribution to decision making." *Gazing Into the Oracle: The Delphi Method and Its Application to Social Policy and Public Health*, Ziglio, E. and Adler, M. Eds., Jessica Kingsley Publishers, London, pp.3-29.

Mersin University Journal of Maritime Faculty

Mersin University Journal of Maritime Faculty (MEUJMAF)
Vol. 2, Issue 2, pp. 77-88, December 2020
ISSN 2687-6612, Turkey
DOI: 10.47512/meujmaf.821687
Review Article

A SURVEY OF DATA ENVELOPMENT ANALYSIS IN CONTAINER TERMINALS

Volkan Efecan*[1], İzzettinTemiz[2]

[1]Mersin University, Vocational School of Maritime, Department of Transportation Services, Mersin, Turkey
ORCID ID: 0000-0002-8450-0445
volkanefecan@mersin.edu.tr

[2]Mersin University, Faculty of Maritime, Department of Maritime Business Administration, Mersin, Turkey
ORCID ID: 0000-0001-8672-1340
itemiz@mersin.edu.tr

*Corresponding Author
Received: 05/11/2020 Accepted: 09/12/2020

ABSTRACT
In recent years, Data Envelopment Analysis (DEA) technique has been used quite frequently in determining container terminal efficiency. When the studies reviewed, conducted on the subject in the recent past, it is seen that the details such as the parameter on which the activity model focuses, sample selection, sample size and input-output selection have not yet been clarified enough, additionally, problems and confusion are encountered in practice. In this study, a critical analysis was carried out regarding the determinations in the use of the DEA technique, which is frequently used in the measurement of container terminal efficiency, and on which issues should be considered in order to establish the model better. In the consequences of the study, it was seen that data accessibility was an obstacle to reaching more robust results in efficiency analysis. It is very important to make evaluations between ports that are close to each other in terms of regional or infrastructure, demand and technological development in order to obtain more reliable and consistent results. Moreover, future studies should consider reliable inputs such as the number of equipment in the terminal that divided by two group, the terminal area, maximum depth, pier length.

Keywords: *Container Terminal, Productivity, Efficiency, DEA, Data Envelopment Analysis*

1. INTRODUCTION

Facilities where transportation modes can be changed between sea and land and / or rail, transfer between ship and ship or between ship and inland watercraft are called container terminal. Container terminals may be parts of their ports that are specially designed for container handling, or they can also be terminals established only for container handling. The goals of container terminal operations include maximization of the total handling amount on a yearly basis, obtaining more output with less handling equipment, labor or capital, more ship frequency and lower anchoring or drift periods and operational flexibility.

Since port management is about a country's gateways to other countries, it is an area that needs to be addressed, as well as complex and global. If ports want to be successful in global competitive conditions, they should perform performance analyzes in all aspects in order to pre-evaluate their opportunities and handicaps. (Mahmoudi *et al*., 2020). Therefore, especially container terminal efficiency and performance evaluation on terminal basis has attracted great attention. The number of articles published on this subject has also been increasing rapidly in recent years.

When the studies on efficiency analysis are examined, it is stated that the container terminal operators not only provide a strong management tool, but also are crucial for the development of terminal planning and operations (Notteboom and Verhoeven, 2010). Therefore, container port efficiency analysis is very important for competitiveness in the industry (Cullinane and Wang, 2006). So, the need for a more stable, consistent and good modeling of the technical activity, which is tried to be determined by different methods by establishing different models, shows the importance of the research.

2. AIM AND SCOPE OF THE RESEARCH

The Data Envelopment Analysis (DEA) is frequently used in the efficiency analysis of seaports and especially container terminals as in many areas. In this study, it is aimed to examine the sample, technique and input-output parameters used in the researches in the literature and to synthesize the theory and practice. The research question is whether the researchers choose the determinants of efficiency for container terminals properly or not. The results of the study are expected to shed light on future studies of efficiency analysis. This study demonstrates the value of such research for both academic knowledge and practitioners, as it will help to clear some confusion about the determinants of performance measurement.

When the studies of the researchers who use DEA in the efficiency measurement of the ports are reviewed, it is inferred that they have many limitations and hesitations especially about the input selection and output quantity. It is thought that this situation is mainly caused by the unique and complex structure of the terminal. As a matter of fact, DEA attracts attention as the most common method in container terminal efficiency measurement.

3. METHODOLOGY

In the study, Science Direct, Google Scholar, Scopus, Web of Knowledge databases were used in the search made by considering the articles published in international journals and published in English. Firstly, the primary articles list was created with the PRISMA flow chart (The Preferred Reporting Items for Systematic Reviews and Meta-Analyses) used in systematic screening and meta-analysis, and then the articles directly related to the subject were defined and filtered with the detailed evaluation.

In the study, a preliminary evaluation was made of 111 articles published in international refereed journals on the technical efficiency analysis of container terminals between 2009 and 2020, where DEA method was applied.

Subsequently, 26 articles were selected for detailed analysis. Inputs and outputs used to evaluate the efficiency of container terminals used in DEA are presented in Fig. 1.

Common features of the investigated studies are that it is related to container terminal efficiency and the use of DEA method. In the following sections of the study, it will be dwelled on which assumptions are accepted for container terminal efficiency analyzes including DEA method, which parameters are taken into the model as input, which parameters are used as output, and critical analysis will be made by making recommendations. Based on the study, limitations and contradictions will be addressed, taking into account the technological infrastructure of today's terminals and competition conditions.

4. PERFORMANCE MEASUREMENT

Although performance is a relative concept, it is defined as the degree of success in achieving specified goals (Devine and Ostrom, 1985). Performance can also be explained by the production function. Production processes transform specific inputs into specific outputs. The production function also explains the relationship between changes in the amount of input and the amount of output in this process. Nicholson (1995), by making the basic definition of the production function for a product, tried to determine the maximum amount of product that can be produced with alternative input combinations (frontier models) such as labor, capital, warehouse space.

As with other businesses, evaluating port performance or measuring terminal efficiency is very important from an economic, functional and strategic perspective. The methods used for performance measurement vary according to the assumptions about the data, production technology, economic behavior of decision-making units, and the type of measures applied.

Although productivity and efficiency, which are concepts related to performance, are often used interchangeably in the literature, they are defined differently by many researchers. Productivity is defined as producing the output with the least cost or obtaining the optimum output with the resources available, while efficiency is defined as reaching the maximum output by utilizing the resources in the best possible way (Yükcü and Atağan, 2009). Productivity and efficiency are also different in terms of process. While the efficiency period

is short, the productivity process is usually longer. For example, while the process of becoming more effective as a result of a manufacturer company using all inputs at the optimal level is short, the process of increased productivity by minimizing the residues of resources is generally longer (Çağlar and Oral, 2011).

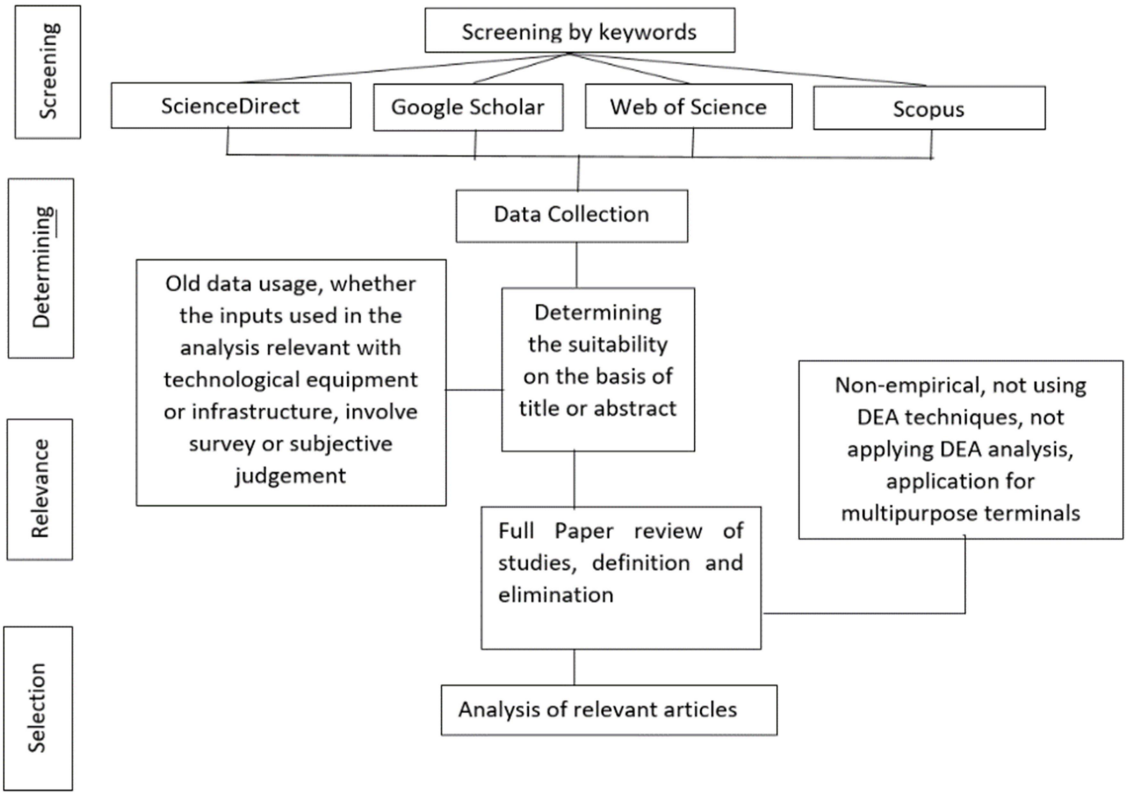

Fig. 1. Flowchart (PRISMA diagram) applied for article screening

The most common approach used to analyze the development of both efficiency and productivity over time is the Malmquist Productivity Index (MPI) (Malmquist, 1953; Caves *et al*., 1982; Fare *et al*., 1994; Cuccia, 2017). Malmquist (1953) and then Fare *et al*. (1994) first described MPI as a DEA-based method that measures the change in productivity over time. Measures of efficiency need to take into account multiple outputs and inputs together. One of the major disadvantage of DEA is that observation points can only measure their relative efficiency. To circumvent this disadvantage, researchers use DEA-Malmquist to evaluate changes in productivity over time in addition to predicting efficiency. (Wilmsmeier *et al*., 2013). The Malmquist index has some advantages that it does not require any input or output prices or any behavioral assumptions. This feature makes the Malmquist index very suitable for analyzing productivity changes in both public and other sectors. This index measures the "total factor productivity" changes between the DMU's (Decision Making Units) by calculating the ratio of the distances of each DMU to a frontier or maximum output level.

The concept of efficiency, which is the subject of our study, is aimed at the goals and determines the realization levels of the goals by establishing a relationship with the results obtained by the firm (Erturan and Uysal, 2013; Rouyendegh, 2011). Efficiency is generally classified as technical efficiency, allocation efficiency and scale efficiency. Technical efficiency indicates whether the input is producing output as much as its capacity to produce. Thus, it reveals that outputs can be developed in proportion to the production limit. For example; while a container terminal is capable of handling 1000 units of 20-foot-length equal units (Twenty Foot Equivalent Unit (TEU) per unit time, but can handle 900 TEU, it is considered 10 percent ineffective or 90 percent efficient. Allocation efficiency refers to how low-cost a combination of input costs consists of producing the same amount of output. In terms of production, the unit of production that achieves higher output with equal or less input is more efficient. The unit of production that achieves equal or greater output with lower input values in terms of cost is more efficient. Scale efficiency determines an efficiency score based on this value by targeting the highest output values that can be obtained with available inputs. Calculating both scale efficiency and technical efficiency together enables the calculation of overall efficiency.

While emphasizing the efficiency, it should be known that the model presents from outputs and results. Getting the results is much more difficult to measure the results (Gülcü *et al*., 2004).

The techniques used in efficiency measurement can be classified as parametric and non-parametric methods, radial and non-radial methods, as well as deterministic and stochastic methods. Stochastic methods allow a random measurement error, unlike deterministic

methods. While radial efficiency measurements predicted by using equally proportional reduction of outputs and inputs above the best practice limit (or frontier), non-radial efficiency measures were also developed (Panayides *et al*., 2009; Fare and Lovell, 1978). DEA, one of the nonparametric methods, is the leading technique used in container terminal activity.

4.1. Frontier Models

Farrell, (1957) first introduced frontier models in the analysis of economic efficiency. Farrell has created a widely accepted framework on this subject with his frontier models. There are some fundamental differences between the methods used to obtain the specification of the frontier model. The first difference; some are statistical and some are non-statistical methods. The first of the important differences is the statistical method assuming the data's stochastic property while non-statistical methods do not make any assumptions regarding this issue. Second important difference; is whether the frontier model is parametric. The non-parametric approach consists of a mathematical programming technique called DEA and different versions of this technique while the parametric approaches use econometric methods in which efficiency is measured according to the statistically estimated limit production function by putting a certain form (Cullinane and Gray, 2002). While the econometric approach comes to the forefront in the analysis of the efficiency of competing industrial organizations and public institutions, mathematical programming approaches are used more in managerial decisions (Aigner and Schmidt, 1977; Fare *et al*., 1994).

4.2. Data Envelopment Analysis

DEA is a nonparametric technique used in operations research and econometrics that can include more than one input and output variable and sequences observation points. (Ye *et al*, 2020). Charnes *et al*. first used DEA technique; they introduced it in 1978. Efficiency differences between businesses serving in the same sector can be calculated using this technique. With DEA, it becomes possible for decision-makers to control the production process at various levels, including daily operations, medium and long-term strategies, and make more effective decisions (Charnes *et al*., 1978). DEA uses the engineering approach, which is the ratio of the weighted sum of outputs to the weighted sum of inputs in efficiency evaluation. While calculating this ratio, it is not always possible to determine the input and output weights. Using the data set with DEA, different weights are determined for all decision units with linear programming. Thus, decision units are evaluated with weighting that will maximize their efficiency relative to other decision units.

The efficiency value obtained by DEA based on the fixed return to scale assumption represents the overall technical efficiency, which is the sum of pure technical efficiency and scale efficiency (Constant Returns to Scale-CRS). Banker, Charnes and Cooper introduced variable Returns to Scale-VRS (Variable Returns to Scale-VRS) technique, which is based on this handicap and thus enables the calculation of both efficiency values, in 1984. While fixed return to scale is taken as basis in CRS model, variable return to scale is used in VRS model. The VRS model assumes that scale differences may affect the overall efficiency of the decision-making unit and excludes the scale effect from the evaluation (Güner, 2015). DEA- Super Efficiency technique is; it was introduced by Charnes *et al*. to apply a rating method between units. This technique; It consists of a linear programming application that compares the same type of service units such as terminal, airport, school, drug store and puts them in hierarchical order. Solution indicators of the created model; some units are effective, less efficient or ineffective than some other units. For example; Cullinane and Wang (2006) were able to compare the technical efficiency of container terminals with DEA-Super efficiency and SFA (Stochastic Frontier Analysis methods, and they were able to rank the terminals with an equal and "1" efficiency score among themselves.

In addition, DEA is included in the literature as hybrid techniques for performance measurements, along with other multi-criteria decision making methods such as AHP or Fuzzy Ahp technique (Rouyendegh et al, 2019).

5. LITERATURE

Studies in which the most frequently used DEA among the efficiency measurements of container terminals in the literature is preferred are summarized in Table 1, chronologically, together with the data type, method used, input and output parameters. When the literature was reviewed, three reviews were found on the efficiency analysis of container terminals (Odeck and Bråthen, 2012; Panayides *et al*., 2009; Trujillo, 2009). Since the compilation studies were between 2009 and 2012, the empirical studies conducted between 2009 and 2020 were focused. The study of Odeck and Brathen (2013), which is detailed below, was in the form of meta-analysis. In this study, critical analysis will be made.

Panayides *et al*., (2009), examined the studies using DEA method in the efficiency analysis of ports after 1993 (The first terminal efficiency analysis was done by Roll and Hayuth (1993)). The study, which covers the articles published before 2009, focused on the suitability of inputs and outputs to technical efficiency analysis, sample selection, model and variable definition, alternative model suggestions, political effects and research gaps. In addition, the details of the studies were included and the findings of the effectiveness analyzes were examined in detail.

Trujillo, (2009) comprehensively evaluated parametric and non-parametric approaches to productivity analysis as applied to the port sector in their study. In addition, they examined the relationship between the event and whether the terminal is a private or public enterprise, port capacity, improvements and reform. As a general conclusion drawn from the 28 studies compiled, they stated that the efficiency analysis had positive effects on port performance. In addition, in terms of the method used, although it is known that the terminal creates multiple outputs, it is seen as a deficiency that many potential outputs are not included in the model, while the dynamic analyzes using panel data reach more consistent results than cross-sectional data, and they point out the importance of data

accessibility. In operational and strategic terms, it was pointed out that technological equipment has a positive effect on efficiency and that the operation of port enterprises by the private sector increases the efficiency score.

Table 1: Details of articles using the DEA method

	Author/s	Year	Method	Type of data	Period	DMU	Port /Terminal	Input	Output
1	Jiang and Li	2009	Radial and Non-Radial DEA	Cross-sectional	2007	12	Port Level	Sum of Export/import, regional national income, pier length, cranes	Handled TEU
2	Cullinane and Wang	2010	DEA, Window Analysis.	Panel	1992-1999	25	Port Level	Shore cranes, yard cranes, straddles	Handled TEU, Terminal area, Pier Length
3	Wu and Goh	2010	DEA	Cross-sectional	2007	21	Port Level	Terminal area Pier Length Total equipment	Handled TEU
4	Hung *et al.*	2010	DEA	Cross-sectional	2006	31	Port Level	Pier length Terminal area Shore crane Pier quantity	Handled TEU
5	Cheon *et al*.	2010	DEA, Malmquist	Panel	1991-2004-2005	98	Port and Terminal Level	Pier length Terminal area Shore crane	Handled TEU
6	Bottasso *et al*.	2011	DEA	Panel	2001-2008	5	Terminal Level	Non-Labor expenditure Terminal area Shore crane Labor	Handled TEU
7	Wanke	2013	DEA, Regression analysis	Cross-sectional	2011	27	Port Level	Piers, Storage area, Terminal area	Handled TEU
8	Wilmsmeier *et al*.	2013	DEA	Panel	2005-2011	20	Terminal Level	Labor, Terminal area and Ship to Shore crane	Handled TEU
9	Schoyen and Odeck	2013	DEA	Panel	2002-2008	24	Terminal Level	Pier length Terminal area Yard crane Straddle carrier	Handled TEU Trucks
10	Polyzos and Niavis	2013	DEA-Super Efficiency, Tobit Regression	Cross-sectional	2008	30	Port Level	Pier length, Shore crane	Handled TEU
11	Yuen, *et al*.	2013	DEA-Malmquist	Panel	2003-2007	21	Terminal Level	Piers, Pier length, Terminal Area, Shore Crane, Yard Crane	Handled TEU
12	Munisamy and Jun	2013	DEA	Panel	2000-2008	30	Terminal Level	Pier length, Terminal area, Handling equipment, yard equipment, Truck	Handled TEU
13	Song and Cui	2014	DEA-Malmquist	Panel	2006-2011	26	Terminal Level	Labor, Shore crane, Pier length	Handled TEU
14	Tae-Won	2015	DEA, Total Factor Productivity	Panel	2003-2007	50	Port Level	Terminal area, pier, pier length, equipment, reefer capacity, cranes, CFS equipment	Handled TEU
15	Carine	2015	DEA-BCC, DEA-CCR and Super Efficiency	Cross-sectional	2012	16	Terminal Level	Handling equipment, Terminal area, Pier length	Handled TEU
16	Güner	2015	DEA	Cross-sectional	2010	13	Port Level	Terminal area, Pier length, Piers, Cranes, Tugs, Forklift, Labor	Handled cargo (mt), Ship Call
17	Baran and Górecka	2015	DEA-Malmquist	Cross-sectional	2012	18	Port Level	Piers, Terminal area, Storage capacity, Pier Length	Handled TEU

Table 1: Details of articles using the DEA method – *Continue*

	Author/s	Year	Method	Type of data	Period	DMU	Port /Terminal	Input	Output
18	Almawsheki and Shah	2015	DEA	Cross-sectional	2012	19	Terminal Level	Terminal area, Pier length, Shore Crane, Yard equipment, Maximum Draught	Handled TEU
19	Jin and Ding	2015	DEA - Malmquist	Panel	2008-2012	21	Terminal Level	Pier length, Handling Equipment, Labor	Handled TEU
20	Acerand Timor	2017	DEA	Cross-sectional	2005-2009	20	Terminal Level	Labor, Pier Length, Yard + CFS equipment (RTG, RMG, LCH, CRS, SC, ECS, Forklift)	Handled TEU and Annual ship frequency
21	Wiegmans and Witte	2017	SFA, DEA	Cross-sectional	2016	127	Terminal Level	Working hours h/weekly, Terminal area, Storage capacity, Pier length, Draught, Shore crane, Stacker, Container Handling (TEU)	Handled TEU, Handling Capacity,
22	Kutin *et al*.	2017	DEA	Cross-sectional	2014	50	Port and Terminal Level	Maximum draught at Pier, Terminal area, Pier Length, Piers, RTG, YC(RMG+SC+RTG), Forklifts, Trucks	Handled TEU
23	Kammoun	2018	DEA, SFA	Panel	2007-2017	77	Port Level	Handling Equipment, Storage area, Labor	Handled TEU
24	Hlali	2018	DEA, SFA	Cross-sectional	2015	26	Port Level	Pier Length, Depth, Terminal area, Storage Capacity	Handled TEU
25	Kalgora*et al*.	2019	SFA, DEA-Window Analysis	Panel, Cross-sectional	2000-2005	22	Port Level	Pier length, Terminal area, Shore crane, stacker, Draft, Handling Capacity	Handled TEU
26	Birafane and Abdi	2019	DEA	Panel	2014-2017	8	Port Level	Pier Length, Terminal area, Equipment	Handled TEU

The studies of Odeck and Bråthen (2012), on the other hand, consist of meta-analysis of average technical efficiency changes obtained by examining 40 studies in peer-reviewed journals. In the conclusions of this meta-analysis, they tried to determine the parameters on which the differences of mean scores depend. These parameters; analysis method, port location, data type, number of observations and variables. In addition, in this study, they obtained very interesting results, especially with the random effects regression model. In recent studies, lower average efficiency scores compared to previous studies, higher average efficiency scores compared to SFA method in studies using non-parametric DEA method, panel data having cross-sectional data. The conclusions have been reached European ports have lower efficiency scores compared to other world ports. Apart from these review articles, some of the studies that include applications; Polyzos and Niavis (2013) followed a 2-stage DEA efficiency analysis, than; they examined the regional ports close to each other in terms of proximity to the main routes with Tobit regression analysis. Wilmsmeier *et al*. (2013) applied the DEA to analyze the level of technical efficiency in 20 container terminals in Latin America and Spain between 2005 and 2011. In addition, using the Malmquist Total Factor Productivity Index, they tried to evaluate the impact of the financial crisis on the efficiency and productivity of the difficulties experienced in responding effectively to the unexpected increase and sudden changes in demand.

Jin and Ding (2015) analyzed the efficiency scores of 21 small and medium-sized container terminals in China using DEA method. Then, they used the Malmquist Productivity index value, which they obtained by using the technical efficiency change index and technical efficiency score of each port, as the dependent variable in Tobit regression analysis. Although the dependent variable is continuous, in the case of constraint, the "ordinary least squares" (OLS) method calculates consistent estimates. On the other hand, Tobit regression models generally assumes "discrete normal distribution" instead of normal distribution and prefers to using "Maximum Likelihood estimation" (MLE) method. Since Malmquist Productivity Index scores have lower and upper limits, the least squares (OLS) regression model can be discrete. Therefore, using the Tobit regression model rather than the least squares model, they determined the

Malmquist Productivity Index by factors such as the number of workers, terminal setup capital, line affiliates as well as terminal operator and ship route number(Tobin, 1958). As a result of the empirical application of the model, it has been concluded that there is a positive relationship between route, number of workers, capital, line participation status, while there is a negative relationship between the number of terminal operators and efficiency. Having more than one cargo handling contractor in the same terminal may cause conflict of interest and lead to a decrease in efficiency. For this reason, as much as possible, one organization chart should prevail within the terminal.

Almawsheki and Shah (2015) analyzed the technical efficiency of 19 Middle East container terminals in geographically critical regions. In addition to preferring DEA as a method, they also has benefited from slack variable analysis to assess the inefficiency values and how terminals can improve themselves and better use of inputs. Among the inputs used in the study, the draft, that is, the highest water depth level of the dock draws attention. As it is known, in the traditional production function, worker, capital and facility constitute inputs. Therefore, if the dock length and terminal area are considered as capital, it is thought that it would be quite appropriate to include dredging and deepening studies as inputs in the model in case of increasing competitiveness.

Song and Cui (2014), in their study where the Chinese government examined the results of the improvements related to container terminals in recent years, using the DEA-Malmquist Productivity Index with the data of 2006-2011. The increase in productivity is due to technological developments rather than the increase in technical efficiency and the development of technical efficiency is the main they concluded that the source was the increase in scale efficiency. Apart from that, the relationship of productivity changes with geographical location, using the number of cranes, the number of workers and the length of the dock as inputs and ownership has been examined. It was concluded that there was no positive, significant and strong relationship between the terminal ownership and the efficiency in the study using the total amount of cargo handled per TEU as output.

Acer and Timor (2017), the working port in Turkey using DEA and Clustering Analysis of operational efficiency analysis, they sort out the most efficient ports. The number of workers, the length of the dock and the number of equipment were chosen as input variables, and the annual amount of cargo handled (throughput) and the number of ship calls on TEU basis as output. The terminal area, maximum depth, theoretical handling capacity, the number of in-port transfer vehicles and the number of dock cranes were removed from the DEA model by applying the canonical correlation statistics test.

Kammoun (2018) used Stochastic Frontier Analysis including Cobb-Douglas production function and traditional DEA (CCR and BCC) techniques in a comparative study in which seven container terminals located on the coast of Tunisia were evaluated. The conclusion reached in the study generally consists of determining the most efficient port that has achieved the best score with all three techniques.

Hlali (2018) conducted a comparative efficiency analysis using the cross-sectional data of 2015 of 26 large container terminals around the world and using SFA and DEA techniques. While the inputs used were draught, berth length, storage capacity, the annual total amount of cargo handled on TEU basis was preferred as output. Study results are in the form of a comparative presentation of efficiency scores.

6. DISCUSSION

6.1. Sample Selection

The size, geographical location and hinterland accessibility of the selected terminals should be close to each other. Otherwise, the efficiency analysis will not give healthy results. This is because each container terminal has its own unique character. When the literature on the dimensions of the amount of cargo handled and competitiveness was examined, terminal efficiency was seen as one of the five dimensions explained (Tongzon and Heng, 2005). Other dimensions; ship call frequency, economic activity, location, terminal fees. In this case, it can be inferred that the increase in terminal efficiency has a positive effect on the amount of cargo handled. Assuming that terminal efficiency is inversely proportional to competitiveness, we can conclude that competitiveness negatively affects the amount of container handling. The number of samples used in the studies are shown in Fig. 2 as below.

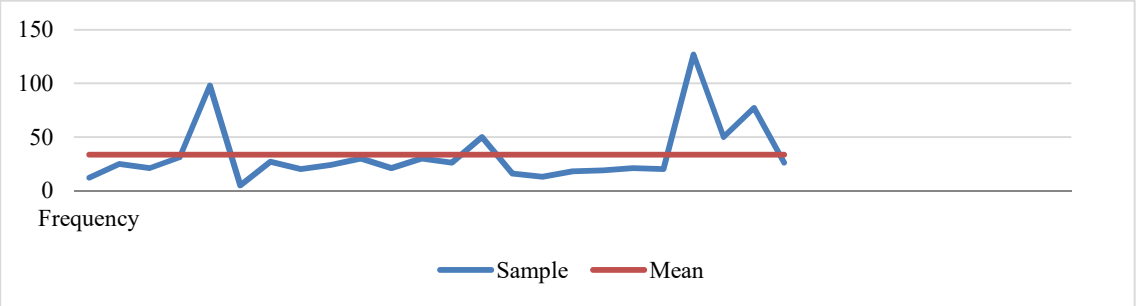

Fig. 2. Sample numbers of studies in the literature

6.2. Input Variables

When we consider the general structure of the container terminals, it is seen that it can be matched with a production facility consisting of inputs such as capital, labor, and facility. Under the title of facilities; apron, dock and / or pier, container yard, container freight station, gates, under the technology title; under the heading of human resources, automation, information technologies, equipment; Dock crane, mobile crane, field crane (rubber wheel, rail), field carriers (stacker, empty container handler) and trailer can be collected. Apart from these, time and sales / marketing can also be considered as other inputs.

All the inputs mentioned above, regardless of whether they are included in the model or not, are realized through a financial investment. In this case, it is thought that the right thing is to include all inputs in the model somehow. In general, as seen in Fig. 3, the number of equipment, the length of the dock, and the terminal area constitute the majority of the inputs preferred in the efficiency model.

Ship cranes are still used in undeveloped country ports. Therefore, it should be close to each other in terms of development level in efficiency analysis. For example, it would be more accurate to evaluate two terminals with similar numbers of dock cranes. Otherwise, it should be ensured that the terminal, which has much less cranes, does not receive support from ship cranes and ship personnel. Sarriera and Briceño-garmendía (2013), in their study where they conducted technical efficiency analysis of Latin American and Caribbean ports, took into account that ship cranes were used based on the annual maximum capacities of shore gantry cranes and mobile cranes.

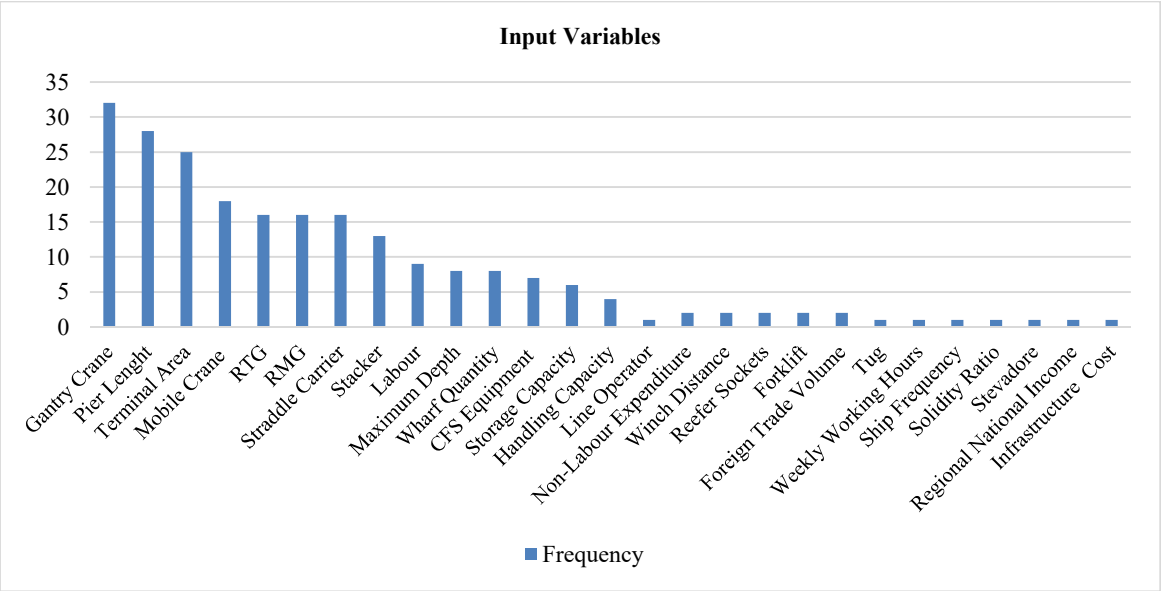

Fig. 3. Input variables used in studies

Shore gantry crane is one of most important elements of the theoretical handling capacity at the container terminal. Therefore, it draws attention as the most common input used in efficiency analysis in the literature. In the terminal design, the number of moves of the gantry crane in the expected 1-hour period is calculated. The optimum number of cranes is determined together with other parameters such as vessel's hatchcover moves, gang change and annual expected handling amount. As mentioned above, the number of moves per hour varies according to the crane size, as the increase in the dimensions of the shore gantry crane will increase the average distance of the "spreader".

It is observed in the studies that gantry cranes and mobile cranes are separated from each other and create two different inputs. When these two equipment safety factors are taken into consideration, they have the same handling capability in the hourly period. Therefore, it may be more correct to create an input in the form of "total number of cranes handling ships".

Especially the yard equipment systems used in container terminals also present some differences. For example; Such as "straddle carrier system", "rubber tyred or rail mounted system" or "forklift" system. These systems are used interchangeably, not together. Therefore, considering the number of equipment, it can be said that it is not correct to use interchangeable equipment, which have some advantages and disadvantages compared to each other, as inputs by considering them as identical to each other. Therefore, the efficiency model should be created using the equipment costs input will give healthier results such as Malmquist DEA technique. In this context, while creating the inputs, taking three different input values into the model in three categories such as ship handling equipment, terminal-handling equipment, and trailer in the terminals using the same field handling system can give better results.

In an activity model where handling equipment creates input, it may be more appropriate to include the handling capacity as output instead of input. As in Hu *et al*. (2010); Kutin *et al*. (2017), it can be grouped

according to the size of the dock crane to see whether there is a statistically significant difference between the efficiency scores of the group.

6.3. Output Variables

In the efficiency analysis in the literature, the output variable is generally considered as annual container handling amount on TEU basis. However, the annual total handled TEU value, in other words, when the output amount is considered as the number of each container, it will decrease approximately between 0,4 to 0,6 times depending on the port-to-port and cargo potential. It should be evaluated whether the acceptance of this assumption, which is considered as a constraint in the literature.

Cullinane and Song (2006) regarding the need for data sources to be complete, accurate and reliable, has a significant effect on efficiency scores. Since the total handling amount is actually the sum of the containers loaded, discharged and relocated, if the annual cargo handled will constitute the output value, the best choice should be taken as total handling, i.e. loading, unloading and shifting, on the basis of pieces, instead of TEU, depending on data availability. Output variables used in studies are shown in Fig. 4 as below.

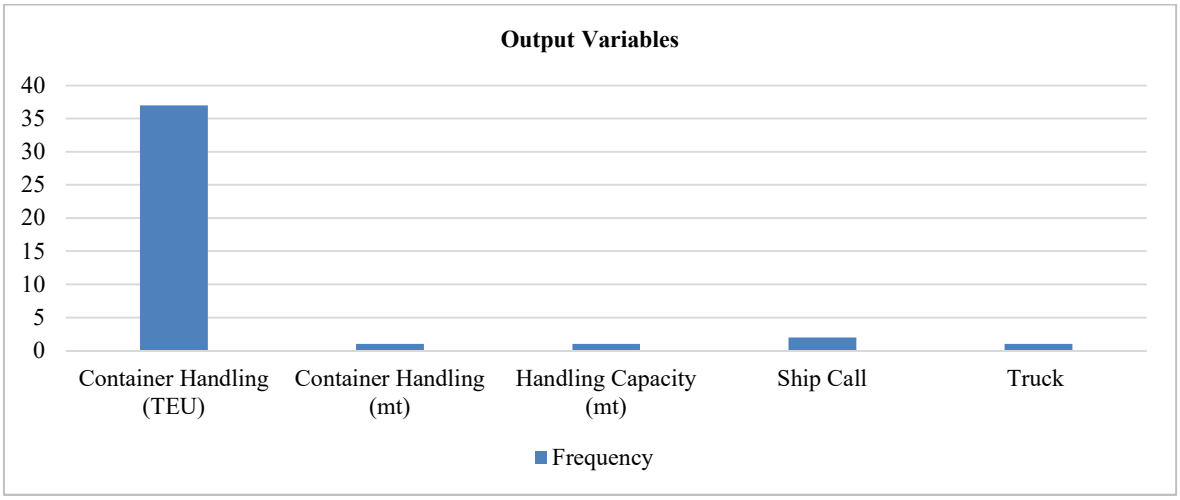

Fig. 4. Output variables used in studies

7. CONCLUSION

Although DEA is frequently used in container terminal efficiency measurement (Odeck and Brathen, 2012; Almawhseki and Shah, 2013), it has never been adopted as the sole efficiency measurement method. When the studies using the DEA technique, which is the subject of our study, are reviewed, it is seen that the same authors in different studies frequently change the inputs and outputs that form the activity model. The confusion experienced ends with the work done and the determination of efficiency scores and the reasons for ineffectiveness cannot be examined well enough. It is thought that this situation will adversely affect the course of the future studies. Although most of the studies reviewed recognize the multi-output nature of container terminal operations, they do not reflect this bundle of output to their performance evaluations. This is due to data availability. Authors tend to use primary data, preferring to stay in the safe haven. Obtaining data from secondary sources due to accessibility problems is another matter of discussion. Especially in studies, using panel data, the amount of containers (TEU) handled annually is clearly recorded, while it is very difficult to access data of input values by years from primary sources, and it is not encountered in secondary sources. For example; while the maximum berth depth increases by 2 meters with the scanning process, this increase may be valid for only one berth of the terminal. Alternatively, the number of equipment or workers in the container freight station may vary even within the same year. Trucks used for transporting containers may leave their places to mobsters. The post count can be increased or decreased. These or other similar possible situations are inherent to terminal operation. Moreover, it should not be ignored. Therefore, it is thought that using cross-sectional data and evaluating the current situation in container terminal efficiency analysis will give results that are more reliable. In case the data are obtained in a healthy way, of course, as Kumbhakar *et al.* (2000) stated in their studies, the use of panel data provides a better interpretation of efficiency scores that change over the years. Cullinane and Song (2006) investigated the technical efficiency of the ports in their study using the SFA method. In their study using Cross-Sectional data, they determined the difference in efficiency between private sector terminal enterprises and state ports. This situation can be examined more carefully, since the use of cross-sectional data may cause a temporary inefficiency immediately after new investments are made in ports (Cullinane *et al*., 2004). In another study on this issue (Wang and Cullinane, 2015), it is mentioned that container terminal applications of DEA in the literature are largely limited by standard DEA models using cross-sectional data. Panel data for container port production conducted a medium to long-term efficiency analysis for 25 container terminals, confirming the necessity of using panel data and revealing that significant waste is involved in trying to reach the maximum number of container handling. It is

understandable that past studies are carried out with reliable inputs such as the number of equipment in the terminal, the terminal area or the number of workers. However, in order to obtain more reliable and consistent results, it is very important to make evaluations between ports close to each other in terms of regional or infrastructure, demand and technological development. Especially the practical recommendations of this study show the novelty. In future studies, researchers consider mentioned issues while determining the variables in order to design efficiency model.

REFERENCES

Acer, A., Timor, M. (2017). The Evaluation of Turkish Container Terminal Efficiency Using by Data Envelopment Analysis (DEA), *Alphanumeric Journal*, 5:2, 340–352.

Aigner, D., Lovell, C. A. K., Schmidt, P. (1977), Formulation and Estimation of Stochastic Frontier Production Function Models, *Journal of Econometrics*, 6, 21–37, 1977.

Almawsheki, E. S., & Shah, M. Z. (2013). Technical Efficiency Analysis of Container Terminals in the Middle Eastern Region, *The Asian Journal of Shipping and Logistics*, 31(4), 477-486.

Banker, R.D., Charnes, A. and Cooper, W.W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science* 30(9), 1078-1092.

Baran, J., and Górecka, A. (2015). Seaport efficiency and productivity based on Data Envelopment Analysis and Malmquist Productivity Index, *Logistics &Sustainable Transport*, 6(1), 25–33.

Birafane, M., and Abdi, M. El. (2019). Efficiency of Moroccan Seaports : Application of DEA Using Window Analysis, *Engineering*, 11(02), 107–118.

Bottasso, A., Conti, M., Ferrari, C. (2011), Efficiency and Productivity Growth in a Sample of Italian Containers Terminals, *International Journal of Transport Economics*, 38, 2, pp. 107–122.

Çağlar, V., Oral, E., 2011, Türk Özel Limanlarının Etkinlik Verimlilik Analizi, Dokuz Eylül Üniversitesi Yayınları

Carine, F. (2015). Analyzing the Operational Efficiency of Container Ports in Sub-Saharan Africa, *Open Journal of Social Sciences*, 3(10):10-17.

Caves, D., Christensen, L. and Diewert, W.E. (1982) the Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity. *Econometrica*, 50, 1393-1414.

Charnes, A, Cooper, W.W. and Rhodes, E. (1978), Measuring the Efficiency of Decision Making Units, *European Journal of Operational Research*, 2, 429-444.

Chengpeng, W., Di, Z., Xinping, Y., &Zaili, Y. (2018). A Novel Model for the Quantitative Evaluation of Green Port Development – A Case Study of Major Ports in China. *Transportation Research Part D*, 61, 431–443.

Cheon, S., Dowall, D. E., & Song, D. (2010). Evaluating impacts of institutional reforms on port efficiency changes : Ownership, corporate structure, and total factor productivity changes of world container ports. *Transportation Research Part E*, 46(4), 546–561.

Cuccia, T. (2017). UNESCO sites and performance trend of Italian regional tourism destinations : A two-stage DEA window analysis with spatial interaction, *Tourism Economics*, 23(2), 316–342.

Cullinane, K. and Song, D. (2006), Estimating the Relative Efficiency of European Container Ports: A Stochastic Frontier Analysis, *Research in Transportation Economics*,16(06), 85–115.

Cullinane, K. and Song, D. W. (2003). A stochastic frontier model of the productive efficiency of Korean container terminals, *Applied Economics*, 35(3), 251-267

Cullinane, K., and Gray, R. (2002). A stochastic frontier model of the efficiency of major container terminals in Asia : Assessing the Influence of Administrative and Ownership Structures, *Transportation Research Part A: Policy and Practice*, 36, 743–762.

Cullinane, K., and Wang, T. (2006). The technical efficiency of container ports : Comparing data envelopment analysis and stochastic frontier analysis, *Transportation Research Part A: Policy and Practice*, 40(4), 354–374.

Cullinane, K., and Wang, T. (2010). The efficiency analysis of container port production using DEA panel data approaches, *OR Spectrum*, 32, 717–738.

Devine, P. G., and Ostrom, T. M. (1985). Cognitive mediation of inconsistency discounting. *Journal of Personality and Social Psychology*, 49(1), 5–21.

Erturan, B., Uysal, F. (2013). Türkiyede Demiryolu Taşımacılığı'nın Etkinliği üzerineVeri Zarflama Analizi ve Network Veri Zarflama Analizinin Karşılaştırılması. Cumhuriyet Üniversitesi, *İktisadi Bilimler Dergisi*, 14(1), 419–437.

Fare, R., and Lovell, C. K. (1978). Measuring the Technical Efficiency of Production. *Journal of Economic Theory*, 19(1), 150-162.

Fare, R., Grosskopf, S., Norris, M., Zhang, Z. (1994), Productivity Growth, Technical Progress and Efficiency Changes in Industrialized Countries. *American Economic Review*, 84, 66-83.

Farrell, R. S. (1957). The Measurement of Productive Efficiency, *Journal of the Royal Statistical Society, Series A (General*), 120(3), 253-281.

Gülcü, A., Coşkun, A., Yeşilyurt, C., Coşkun, S. Esener, T. (2004), Cumhuriyet Üniversitesi Diş Hekimliği

Fakültesi'nin Veri Zarflama Analizi Yöntemiyle Göreceli Etkinlik Analizi, *C.Ü. İktisadi ve İdari Bilimler Dergisi*, Cilt.5, Sayı. 2, 87-104.

Güner, S. (2015). Investigating Infrastructure, Superstructure, Operating and Financial Efficiency in the Management of Turkish Seaports Using Data Envelopment Analysis. *Transport Policy*, 40, 36–48.

Hlali, A. (2018). Efficiency Analysis with Different Models : The Case of Container Ports, *Journal of Marine Science : Research & Development*, 8:250, Vol 8(2).

Hung, S., Lu, W., and Wang, T. (2010). Benchmarking the operating efficiency of Asia container ports. *European Journal of Operational Research*, 203(3), 706–713.

Jiang, B., Li, J. (2009). DEA-based Performance Measurement of Seaports in Northeast Asia : Radial and Non-radial Approach, *The Asian Journal of Shipping and Logistics*, 25(2), 219–236.

Jo, Z. D. Ř. G., and Wang, Ř. Y. (2015). The Relative Efficiency of Container Terminals in Small and Medium-Sized Ports in China. *The Asian Journal of Shipping and Logistics*, 31(2), 231–251.

Kalgora, B., Goli, S. Y., Damigou, B., and Abdoulkarim, H. T. (2019). Measuring West-Africa Ports Efficiency Using Data Envelopment Analysis, *The Journal of Transportation Technologies*, 9, 287–308.

Kammoun, R. (2018). The Technical Efficiency of Tunisian Ports : Comparing Data Envelopment Analysis and Stochastic Frontier Analysis Scores, *Journal of Marine Science : Research & Development*, 8:261, Vol 8(6).

Kang, Tae-Won. (2015). Seaport Efficiency in China; From the Perspective of Malmquist Total Factor Productivity. *Journal of Distribution and Management Research*. 18. 45-52.

Kumbhakar, S.C. and Lovell, C.A.K. (2000). *Stochastic Frontier Analysis : An Econometric Approach*, Cambridge University Press

Kutin, N., Nguyen, T. T., Vallee, T., (2017). Relative Efficiencies of ASEAN Container Ports based on Data Envelopment Analysis. *The Asian Journal of Shipping and Logistics*, 33(2), 67-77.

Mahmoudi, R., Emrouznejad, A., Shetab-boushehri, S., & Reza, S. (2020). The origins, development and future directions of data envelopment analysis approach in transportation systems. *Socio-Economic Planning Sciences*, 69, 100672.

Malmquist, S. (1953) Index Numbers and Indifference Surfaces. *Trabajos de Estadistica*, 4, 209-242.

Munisamy, S., and Jun, O. B. (2013). Efficiency of Latin American Container Seaports using DEA, *Proceedings of 3rd Asia-Pacific Business Research Conference* 25 - 26 February 2013, Kuala Lumpur, Malaysia.

Nicholson, W., (1995), *Microeconomic Theory: Basic Principles and Extensions*. Canada: Thomson South Western. Ninth Edition.

Notteboom, T., and Verhoeven, P. (2010). The awarding of seaport terminals to private operators : European practices and policy implications, *European Transport\TrasportiEuropei*, 45, 83-101

Odeck, J., and Bråthen, S. (2012). A meta-analysis of DEA and SFA studies of the technical efficiency of seaports : A comparison of fixed and random-effects regression models. *Transportation Research Part A*, 46(10), 1574–1585.

Photis, M. Panayides, Christos N. Maxoulis, Teng - Fei Wang & Koi Yu Adolf Ng (2009) A Critical Analysis of DEA Applications to Seaport Economic Efficiency Measurement, *Transport Reviews*, 29:2, 183-206.

Polyzos, S., and Niavis, S. (2013). Evaluating port efficiency in the Mediterranean, *International Journal of Data Analysis Techniques and Strategies*, 5:1, 85-99

Roll, Y. and Hayuth, Y. (1993) Port Performance Comparison Applying Data Envelopment Analysis (DEA). *Maritime Policy and Management*, 20, 153-161.

Rouyendegh B. D. (2011), Selecting the high-performing departments within universities applying the fuzzy MADM methods, *Scientific Research and Essays*, 6 (13), 2646-2654.

Rouyendegh D. E. B., Oztekin, A., Ekong, J., Dag, A. (2019). Measuring the efficiency of hospitals: a fully-ranking DEA–FAHP approach. *Annals of Operations Research*. 278(1-2), 361-378.

Sarriera, J. M., Araya, G.,Serebrisky, T., Briceno-Garmendia, C.& Schwartz, J., (2013). "Benchmarking container port technical efficiency in Latin America and the Caribbean: a stochastic frontier analysis," Policy Research Working Paper Series 6680, The World Bank.

Schmidt, P., Lovell, A. K. (1979), Estimating technical and allocative inefficiency relative to stochastic Production and Cost Frontiers. *Journal of Econometrics*, 9(3), 343-366.

Schøyen, H. and Odeck, J. (2013), The Technical Efficiency of Norwegian container ports: A Comparison to some Nordic and UK container ports using Data Envelopment Analysis (DEA), *Maritime Economics and Logistics*, 15, (2), 197-221

Song, B., and Cui, Y. (2014). Productivity changes in Chinese Container Terminals 2006 – 2011. *Transport Policy*, 35, 377–384.

Tobin, J. (1958), Estimation of Relationships for Limited Dependent Variables, *Econometrica*, 26(1), 24-36.

Tongzon, J., and Heng, W. (2005). Port Privatization,

Efficiency and Competitiveness : Some Empirical Evidence from Container Ports (Terminals), *Transportation Research Part A: Policy and Practice*, 39(5), 405–424.

Trujillo, L. (2009). Efficiency Measurement in the Port Industry : A Survey of the Empirical Evidence Efficiency Measurement in the Port Industry : A Survey of the Empirical Evidence, *Journal of Transport Economics and Policy*, 43(2):157-192.

Wang T., Cullinane K. (2015) *The Efficiency of European Container Terminals and Implications for Supply Chain Management*. In: Haralambides H.E. (eds) Port Management. Palgrave Readers in Economics. Palgrave Macmillan, London.

Wanke, P. F. (2013). Physical infrastructure and shipment consolidation, efficiency drivers in Brazilian ports : A two-stage network-DEA approach. *Transport Policy*, 29, 145–153.

Wiegmans, B., and Witte, P. (2017). Efficiency of Inland Waterway Container Terminals : Stochastic Frontier and Data Envelopment Analysis to Analyze the Capacity Design and Throughput Efficiency, *Transportation Research Part A Policy and Practice*, 106, 12–21.

Wilmsmeier, G., Tovar, B., and Sanchez, R. J. (2013). Research in Transportation Business and Management, The Evolution of Container Terminal Productivity and Efficiency Under Changing Economic Environments, *Research in Transportation Business & Management*, 8, 50–66.

Wu, Y. J., and Goh, M. (2010). Container port efficiency in emerging and more advanced markets. *Transportation Research Part E*, 46(6), 1030–1042.

Ye, S., Qi, X., and Xu, Y. (2020). Analyzing the relative efficiency of China's Yangtze River port system. *Maritime Economics & Logistics*, (0123456789).

Yuen, A. C., Zhang, A., and Cheung, W. (2013). Foreign participation and competition : A way to improve the container port efficiency in China, *Transportation Research Part A*, 49, 220–231.

Yükcü, S. and Atağan, G. (2009). Etkinlik, Etkililik ve Verimlilik Kavramlarının Yarattığı Karışıklık. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi*, 23(4), 1–13.

MEUJMAF

Mersin University Journal of Maritime Faculty

CONTENTS
Volume 2 – Issue 2

ARTICLES

December 2020 Volume: 2 Issue: 2