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MASTER'S THESIS

IDENTIFICATION OF HINTERLAND LOGISTICS SUCCESS FACTORS: A STUDY ON ALIAGA CONTAINER PORT REGION

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İZMİR-2023

THESIS APPROVAL PAGE

DECLARATION

I hereby declare that this master's thesis titled as "Identification of Hinterland Logistics Success Factors: A Study on Aliaga Container Port Region" has been written by myself in accordance with the academic rules and ethical conduct. I also declare that all materials benefited in this thesis consist of the mentioned resources in the reference list. I verify all these with my honor.

01/07/2023

Melike CANDAN

ABSTRACT

Master's Thesis

Identification of Hinterland Logistics Success Factors: A Study on Aliaga Container Port Region

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The purpose of this research is to identify the hinterland logistics success factors in the Aliaga container port region. It is critical to assess hinterland logistics in this region with high export volumes. At the same time, this region-specific research investigates themes such as maritime logistics and hinterland logistics, which are getting more attention in the literature. Hinterland logistics, which is currently being researched and studied, will be extremely valuable in the literature and in the region.

In this study, Fuzzy AHP and Fuzzy DEMATEL are used. To fulfill the study's goal, experts from Aliaga container ports were requested to evaluate the success factors using the techniques, and the findings acquired, as well as the relevance and effect degrees of the hinterland logistics success elements, were identified.

Keywords: Maritime Logistics, Hinterland Logistics, Container Port, MCDM, Fuzzy AHP, Fuzzy DEMATEL.

ÖZET

Yüksek Lisans Tezi

Hinterland Lojistik Başarı Faktörlerinin Belirlenmesi: Aliağa Konteyner Liman Bölgesi Üzerine Bir Çalışma

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Bu araştırmanın amacı, Aliağa konteyner limanları bölgesindeki hinterland lojistik başarı faktörlerini belirlemektir. İhracat hacmi yüksek olan bu bölgede hinterland lojistiğinin değerlendirilmesi kritik önem taşımaktadır. Aynı zamanda bölgeye özgü bu araştırma, literatürde daha fazla ilgi görmeye başlayan deniz lojistiği ve hinterland lojistiği gibi kavramları da incelemektedir. Hâlihazırda araştırılmakta ve çalışılmakta olan hinterland lojistiği literatürde ve bölgede son derece değerli olacaktır.

Bu çalışmada Çok Kriterli Karar Verme yöntemlerinden AHP ve DEMATEL, bulanık sayılar ile hesaplanmıştır. Çalışmanın amacına ulaşabilmek için Aliağa konteyner limanlarında görev yapan uzmanlardan başarı faktörlerini değerlendirmeleri istenmiş ve elde edilen sonuçlar ile hinterland lojistik başarı faktörlerinin önem ve etki dereceleri belirlenmiştir.

Anahtar kelimeler: Denizcilik Lojistiği, Hinterland Lojistiği, Konteyner Limanı, Çok Kriterli Karar Verme, Bulanık AHP, Bulanık DEMATEL.

IDENTIFICATION OF HINTERLAND LOGISTICS SUCCESS FACTORS: A STUDY ON ALIAGA CONTAINER PORT REGION

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ABBREVIATIONS

AHP	Analytical Hierarchy Process
DEMATEL	The Decision-Making Trial and Evaluation Laboratory
FAHP	Fuzzy Analytical Hierarchy Process
FDEMATEL	Fuzzy the Decision-Making Trial and Evaluation Laboratory
HL	Hinterland Logistics
MADM	Multi Attribute Decision Making
MCDM	Multi Criteria Decision Making
ML	Maritime Logistics
MODM	Multi Objective Decision Making

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INTRODUCTION

This research aims to identify hinterland logistics factors in the Aliaga container port region, which is the first study in this field. Notteboom and Rodrigue (2018) define maritime logistics as the organization and coordination of sea transportation, intermodal connections, and logistical services to ensure the efficient and effective movement of goods and resources. At that point, even though there is much research on sea transportation, intermodal connections, and logistical services, there are very few studies on hinterland logistics, which has a different perspective from other terms. In order to explain this specific term in detail, maritime logistics, which has recently been studied in the literature of Türkiye, is explained in the first chapter. In the second part of the first chapter, hinterland logistics is explained in terms of its design, actors, and service components. According to literature, there is no study about Aliaga container port region related with maritime logistics and hinterland logistics directly. In existing studies, these concepts have guided the studies only as perspectives. On the other hand, in studies conducted in Türkiye, there are studies especially for hinterland logistics, and these studies were carried out specifically for Mersin, Antalya and Marmara regions.

Chapter 2, Container Ports, begins with the evaluation of container ports during the last decades. An important point of this whole process, the last generation of container ports, sheds light on how maritime logistics is described in literature. Relation between the last generation and result of the study explain in the conclusion. The last part of Chapter 2 explains the regional components of the Aliaga.

Methodology is thoroughly examined in Chapter 3. This study uses Fuzzy AHP and Fuzzy DEMATEL methods, which belong to Multi-Criteria Decision Making (MCDM). Aiming to sensitively identify success factors, both methods use fuzzy set theory. In keeping with the nature of fuzzy study, slight numerical differences in some of the results played an impressive role in the evaluation of importance and impact among factors. Lastly, as a result of both methods, leading and following factors are dedicated, and the importance of each factor is shown in the ending part of this research. (E) Digital technology integration came first in three of the four calculations. Especially, both fuzzy DEMATEL results give significant results which are (E) Digital

technology integration and (E2) Technology usage and developments. Both factors have strong leading features due to their location in the graphs. (E) Digital technology integration, which is the most important and influential factor found in this study, also gave a parallel result with the port generations described in the second chapter of the study. Due to DEMATEL's completion of the missing aspects of AHP, this study gives detailed information about the hinterland factors of the Aliaga container port region to professionals and academicians in terms of results.

CHAPTER ONE
MARITIME LOGISTICS

Some basic definitions have been affected by port evolution and have been redefined by many academics over the years, as ports have ceased to be freight transfer nodes and strengthened the features of ports on the land side as much as the services, they provide on the seaside. Maritime trade, which handles a significant part of world trade, has evolved into the concept of today's accepted Maritime Logistics with the help of technology and globalization in order to give clearer and more accurate answers to the expectations of its stakeholders. The six stages of Notteboom and Rodrigue (2005) progress of port generations described in Chapter 2 show that maritime trade is not just about maritime transport and reveal the development of port activities over time. Apart from the expansion of the port area and overseas, with the significant increase in container transportation, the inclusion of the land area of the port in a fused form into the port system has brought the concept of maritime logistics pioneered by Song and Panayides to literature.

1.1.DEFINITION OF MARITIME LOGISTICS

The maritime logistics concept was introduced in the early 2000s, and Maritime logistics represents a modern and comprehensive method for shipping that is relatively recent in its development. Scholars explain their contributions from different points of view.

Song et al. (2012:55) provide a definition of maritime logistics: “Maritime logistics is referred to as the process of planning, implementing, and managing the movement of goods and information that is involved in ocean carriage.”

In order to be effectively integrated into the logistics system, maritime logistics is in charge of handling the oceanic movement of products and information in a systematic, efficient, and effective manner (Lee, 2010:33). Maritime logistics is the application of logistics and supply chain management principles to the maritime transportation system (Panayides and Song, 2013:295). According to Christopher (2016), maritime logistics refers to the management and coordination of the flow of

goods, information, and resources from the point of origin to the point of consumption through the use of sea transportation. It is an essential part of the supply chain and involves various activities such as shipping, warehousing, inventory management, and transportation planning. The focus of maritime logistics is on distinct shipping (or sea transport) operations and effective logistics flows as an essential part of the logistics integration system (Song et al.2012:62). Langen and Vis (2013) In order to guarantee the swift and economical flow of resources and commodities, maritime logistics entails the design, implementation, and control of a variety of logistical tasks. Notteboom and Rodrigue (2018) define maritime logistics as the organization and coordination of sea transportation, intermodal connections, and logistical services to ensure the efficient and effective movement of goods and resources. It involves the integration of various activities, such as shipping, terminal operations, warehousing, and transportation planning.

Table 1: Maritime Logistics vs Maritime Transportation Comparison

	Maritime Logistics	Maritime Transportation
Concept	The process of planning, implementing and managing the movement of goods and information which is involved in the ocean carriage.	The process of carrying and handling cargoes across the ocean.
Focusing Point	Maritime logistics is concerned with not only individual functions relating to sea transportation, but also an effective logistics flow as a systematic entity of the logistics integration system.	Maritime transportation emphasises individual functions relating to sea transportation. Each function pursues its own aims or competitiveness.
Managerial Scope	Sea transportation activities: e.g. contracting, shipping, sea voyage, moving cargo, and loading/unloading Additional logistics services: e.g. stripping/stuffing, storage, warehousing, offering a distribution centre, quality control, testing, assembly, packaging, repacking, repairing, inland connection, and re-use	Sea transportation activities: e.g. contracting, shipping, sea voyage, moving cargo, and loading/unloading
References	World Bank (2006); Panayides (2006); Lu (2000); Robinson (2002); Notteboom and Winkelmans (2001); Carbone and De Martino (2003); Bichou and Gray (2005); Long (2003)	

Source: Lee and Song, (2012)

Consequently, as shown in Table 1, the concept of maritime logistics refers to the management and coordination of the flow of goods, information, and resources from the point of origin to the point of consumption through the use of sea transportation. It is a complex and integrated system that involves various activities such as shipping, warehousing, inventory management, and transportation planning. Maritime transportation, on the other hand, refers to the physical movement of goods and people by sea, and it focuses solely on the transportation function itself.

Considering focus points of both concepts, the main difference between maritime logistics and maritime transportation is that the former is concerned with the entire logistical flow, whereas the latter is focused solely on transportation. Maritime logistics operators aim to ensure that the flow of goods and information is efficient and effective by coordinating and managing various activities along the logistics chain. By fulfilling the integrated logistical demands, maritime logistics operators can minimize business costs and improve customer satisfaction. This, in turn, enhances their own competitiveness in the market. Ultimately, maritime logistics is crucial to ensuring the efficient and effective movement of goods and resources through the sea transportation network.

Lastly, the managerial scope of maritime logistics is wider than maritime transportation. Maritime logistics covers before and after services that are given to cargoes beside their transportation. Warehousing services such as stuffing, stripping, quality control, assembling, and repairing are given to shippers. So, this scope differs from maritime transportation. Generally, maritime transportation places importance on the movement of cargo between the loading and discharging points.

1.2. COMPONENTS OF MARITIME LOGISTICS

1.2.1. Key Activities of Maritime Logistics

The maritime logistics system is made up of the following three major maritime transportation players: shipping, port/terminal operating, and freight forwarding. Maritime logistics is a concept that was derived from the study of maritime

transportation within the framework of logistics. The table lists the primary and auxiliary logistical services that maritime operators must offer (Song et al. 2012:55).

Table 2: Primary and Auxiliary Activities of Maritime Logistics

	Shipping	Port Operation	Freight Forwarding
Main Function	Moving cargoes between ports.	Shipping reception; Loading/unloading cargoes; Stevedoring; and Connecting to inland transportation.	Booking vessels; and Preparing for requisite documents for ocean carriage and trade, on behalf of shippers.
Supportive Logistics Activities	Documentation relating sea trade; Container tracking and information; and Intermodal service.	Warehousing Offering a distribution centre; Testing; Assembly; Repairing; and Inland connection.	Inventory management; Packaging; and Warehousing.
References	Lu (2000); Heaver et al. (2000) Robinson (2002); and Notteboom and Winkelmans (2001).	Carbone and De Martino (2003); Bichou and Gray (2005); and Roh et al., (2007).	Murphy et al. (1992); Murphy and Daley (2001); Bernal et al. (2002); and Long (2003).

Source: Lee and Song, (2012)

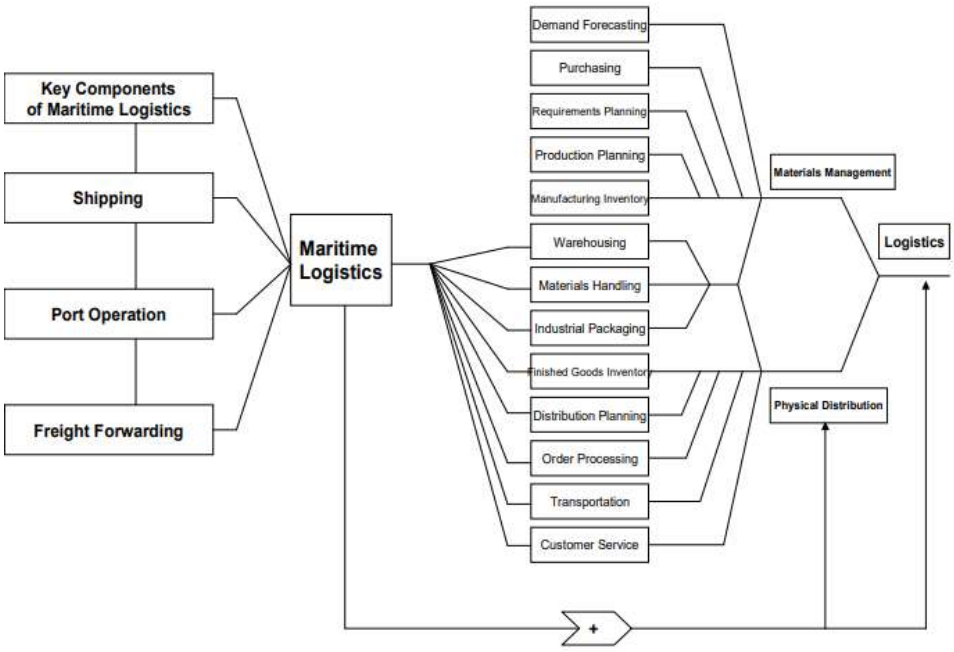
The major function of shipping is to transport goods and cargo from one location to another, typically by sea. Shipping helps facilitate global trade by connecting markets and enabling the exchange of goods and services across the world. In addition to its primary function of transporting goods and cargo, shipping also serves a number of supportive functions that are essential to global trade and the overall functioning of the world economy. Documentation is a crucial aspect of sea trade as it ensures that all parties involved in the transaction have a clear understanding of their responsibilities and obligations. Container tracking is an important function in the shipping industry that allows for the monitoring and tracking of containers as they move through the supply chain. This system allows for improved inventory management by providing accurate and up-to-date information on the location and status of containers and helps to develop security by providing information on the location and status of containers at all times. Intermodal service is another supportive function. When moving goods from one location to another, an intermodal service uses a variety of modes of transportation, including trucks, trains, airplanes, and shipping

containers. A smooth and effective transportation solution that makes use of the advantages of each mode of transportation is what intermodal service aims to deliver.

Secondly, the principal duties of a port or terminal operation are loading and unloading commodities from or onto a vessel and organizing the cargoes for inland transportation to the final destination of the consumer. Modern logistics systems involve port and terminal operations that include not only loading and unloading cargo to and from a vessel but also a variety of value-added services like warehousing, storage, packing, and coordinating inland transportation modes to ensure that the cargoes move smoothly and quickly to the next phase of the logistics system.

The last function, freight forwarding that arranges the transportation of goods on behalf of shippers. They act as intermediaries between shippers and carriers, coordinating the movement of goods across different modes of transportation, such as air, sea, road, and rail. The freight forwarder is responsible for ensuring that the goods are properly packaged and loaded onto the ship. They also handle all the necessary paperwork, such as customs clearance and insurance.

Figure 1: Maritime Logistics in Logistics System



Source: Lee, (2010)

Figure 1 demonstrates how maritime logistics interacts with other activities along the entire logistics chain. These additional logistics services, such as warehousing, material handling, packaging, product inventory, distribution planning, order processing, transportation, and customer service, are integral parts of physical distribution activities. Consequently, the efficiency of maritime logistics activities affects the efficacy of physical distribution management as a whole. As physical distribution is one of the two pillars of the entire logistics chain, effective maritime logistics management has an immediate effect on the overall management and activities of physical distribution and logistics management (Song et al.2012).

1.2.2. The Process of Maritime Logistics

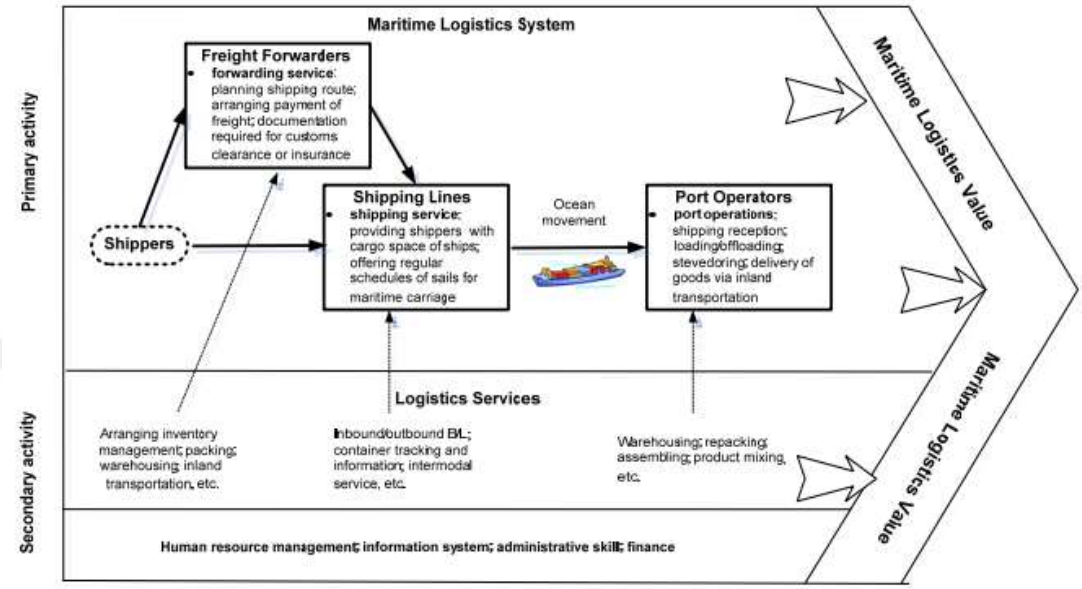
The process of maritime logistics is based on Porter's (1985) value chain model. The concept separates core and auxiliary tasks in a maritime logistics system. The main tasks performed by maritime operators (which include shipping lines, port and terminal operators, and freight forwarders) make up the key operations. The secondary activities are those that bolster the primary ones by facilitating their smoother operation. In order to support the core operations, additional logistical services provided by maritime operators and their organizational capacity, such as human resource management, information systems, administrative skills, and financial assistance, are crucial. In logistics systems, cargo is loaded and unloaded from a ship as well as other value-added services, including packing, storing, and organizing inland transit modes (Song et al. 2012:58).

The organization, management, and supervision of the transportation of products and commodities by water constitute the complicated process known as maritime logistics. The procedure starts with the planning phase, during which the kind and amount of the items to be carried, together with the final destination and shipping path, are chosen. This phase also entails determining any potential dangers or difficulties that can emerge throughout the shipping procedure and assessing the cost of transportation.

The logistics of the cargo must then be handled by a freight forwarder, which is the next stage. The freight forwarder is in charge of completing the required

documentation, such as customs clearance and insurance, and making sure the items are correctly packaged and loaded aboard the ship.

Figure 2: Process of Maritime Logistics



Source: Lee, (2010)

The shipping procedure starts when the products are put aboard the ship. To make sure the cargo is adequately secured, and the ship is traveling in the most effective way, the products are continuously checked. The products are unloaded at the port when the ship arrives at its destination, and port activities start. This entails removing the cargo from the ship, storing it at the port, and making sure it is securely fastened.

Once the cargo has been unloaded, it must go through the customs clearance process before it can be moved to its destination. Verifying that the products adhere to all legal standards and paying the appropriate customs charges are both part of the customs clearance process. Last but not least, the commodities are moved from the port to their ultimate location via trucks, railways, or other transportation methods.

To ensure the seamless and successful transfer of products by sea, proper communication and coordination among parties are crucial throughout the whole process. Included in this are shippers, freight forwarders, port administrations, and transportation firms. Goods may be carried securely and effectively by carefully

planning and carrying out each step of the maritime logistics process, which helps to advance international trade and commerce.

1.2.3. Importance of Maritime Logistics Value

Service value is a concept that focuses on the value proposition offered by a service provider to its customers. It represents the overall benefits and advantages that customers receive when utilizing a particular service. This value is subjective and can vary from one customer to another based on their individual needs, preferences, and expectations in the fields of economic, technical, service, and social benefits. Thus, the maritime logistics value needs to be a true representation of how effectively the system satisfies user requirements. The maritime logistics value is defined as the degree to which the system successfully manages the movement of products, services, and information in maritime logistics to meet customer needs (Song et al. 2012: 60). When clients of maritime operators believe the service is valuable enough to voluntarily acquire it, that is when the maritime logistics system's value (Anderson and Narus, 1991:60). Maritime logistics value is higher when customers are satisfied with the maritime logistics activities that are happening. A maritime logistics value may be defined as the value produced by the maritime logistics system. The value of maritime logistics is correlated to the degree to which the maritime logistics system successfully manages the movement of products, services, and information over the maritime logistics (Lee and Song, 2010: 38). When maritime logistics operators provide their services in the most effective and efficient way possible, the value of maritime logistics, or the value produced by the maritime logistics system, may be maximized. Maximizing the value of maritime logistics has evolved into one of the most important strategic objectives that maritime operators want to accomplish since it may help to improve the performance of both individual maritime operators and the overall logistics system (Song et al. 2012).

After all processes about maritime logistics, hinterland logistics began to attract attention. The paradigm of globalization / maritime transportation / freight distribution is becoming increasingly dependent on inland distribution. Changes in the structure of logistics have generated new freight distribution patterns and required

inventive solutions to port hierarchy. Customers are determining the overall logistic cost of transporting containerized products, implying that the present efficiency gains in logistics, specifically for container transportation, are largely derived from inland distribution (Notteboom and Rodrique, 2005:1). Globalization, the expansion of maritime transportation, and the increase in vessel size are exerting tremendous stress on seaports and their associated hinterland transport networks. The importance of inland nodes in furthering port-hinterland connectivity cannot be overstated (Nguyen and Notteboom, 2109:24). In the next, section hinterland logistics is explained in detail.

1.3. HINTERLAND LOGISTICS

Transportation, distribution, and administration of products and services in an area's inland or hinterland are referred to as "hinterland logistics." In most cases, the phrase "hinterland" refers to interior or rural regions that are located outside or behind the seaports. In the context of logistics, hinterland logistics refers to the flow of products from ports or other significant transportation hubs into inland regions as well as the reverse flow of products from the hinterland regions. It consists of a variety of tasks like logistics, inventory control, transportation, and storage. Many scholars have contributed to hinterland logistics. Leading authors Rodrique and Notteboom (2006) explain the hinterland. The port and maritime shipping sectors continue to depend heavily on the hinterland. Inland freight distribution and port operations are influenced by the density and size of the hinterland. Regionalization marks a new stage in port system development, which has historically concentrated on the port itself. In this stage, inland distribution overtakes port rivalry as the most important factor, supporting the development of transportation corridors and logistical hubs (Rodrique and Notteboom, 2006). There are two primary operations in export trade logistics: seaport activities on the coast and hinterland activities on the land. Beginning with the exporter's or shipper's contract with the consignee overseas, hinterland operations continue until the container arrives in the container yard of the seaport by the deadline (Bahagia et al. 2018: 777). Hinterlands are served by ports. The hinterland can be reached through a number of inland routes, including pipeline, inland waterways, rail,

and road (De Langen and Chouly, 2004: 361). The hinterland transportation network permits the transshipment of load units between inland locations and seaports. Load units with interior destinations and transshipments for other seaports both arrive at seaports (Bergqvist, 2012: 38).

Figure 3: Port Foreland and Hinterland

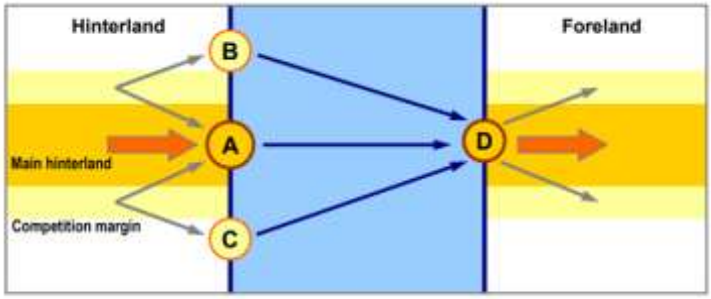


Figure 2 Port Foreland and Hinterland

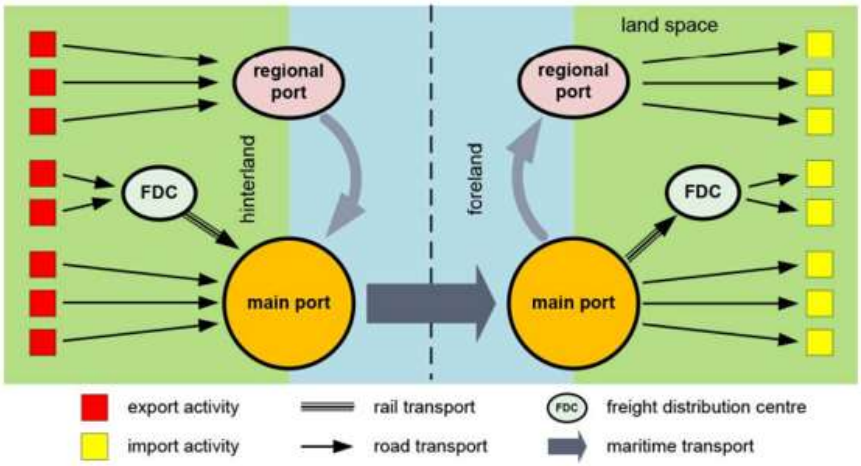
Source: Rodrique and Notteboom, (2006)

A hinterland's primary function is commercial, and the significance of this function is correlated with both the degree of economic activity and the level of competition from other modes not connected to the terminal. Outbound hinterland traffic is a result of extraction or production, whereas inbound hinterland traffic is often based on consumption, with the exception of situations when commodities and parts are used in the manufacture of a product. Since each type of product is a part of a distinct supply chain with its own set of geographical links, hinterlands may also be differentiated based on the type of commodity (Rodrique and Notteboom, 2006:5) . For the logistics pertaining to the hinterland to function properly and efficiently, there are several actors and actions involved. Consequently, hinterland transportation and logistics have emerged as a critical component in ensuring a successful supply chain (Bergqvist, 2012).

1.3.1. Hinterland Transport System Design

Port hinterlands are significantly affected by port dynamics and location since ports represent the intersection of maritime and land transportation networks (Rodrique and Notteboom, 2006) . Capital Investment in terminal facilities or infrastructure that is associated with ports, including hinterland corridors, is a common way that countries get involved in ports (Merk and Notteboom, 2015: 8). The actions of several parties, including terminal operators, freight forwarders, container operators, and the port authorities, will determine how well a port's hinterland access functions. In order to better comprehend the inter-organizational coordination, a theoretical method is needed for the evaluation of cooperation in inland container shipping (Horst and Langen, 2008). Because the quality of the hinterland access depends on the behavior of a wide range of players, including terminal operators, freight forwarders, transport operators, and port authorities, improving the hinterland access of seaports is, at least in part, an inter-organizational problem. These various businesses profit from improved hinterland access, but because no single business can fully reap the rewards of improved hinterland access, interorganizational coalitions are required to spend money on enhancing hinterland transport services (or transport infrastructure) (De Langen and Chouly, 2004: 361).

Figure 4: Hinterland Transportation Network



Source: Sholihah et. al. (2018)

The hinterland transportation system seeks to balance essential logistical excellence with accessibility and overall cost-efficiency. The transportation network consists of several means of transportation, either alone or in combination. In addition to the fundamental features of each kind of transportation, it is crucial to comprehend from the perspective of hinterland transportation that various geographic locations have quite distinct requirements for each type of transportation. As a result, there are significant variations in how the various means of transportation are used between areas and nations. Geographical factors can account for some of the variations, but other crucial details include legislative considerations, the health of the infrastructure, and even technology (Bergqvist, 2012: 77).

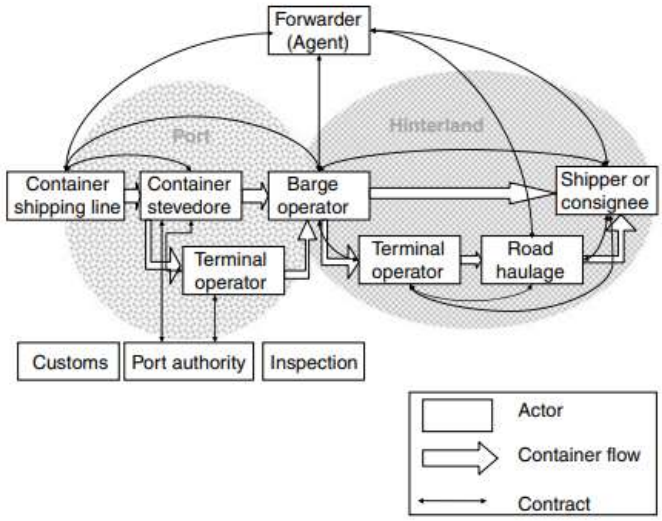
1.3.2. Hinterland Transport Chains and Involved Actors

The interport model can be used by shipping lines and freight forwarders to assess the potential and risks associated with their port-hinterland distribution systems. Companies that operate airports and railways should assess the systemic implications of economic and logistical decisions made by them and/or by their rivals. Finally, public actors might assess the geographical and infrastructure effects of changes in traffic patterns, as well as the effects of decisions made on infrastructure investment, regulation, and service award policies (Iannone, 2012: 36).

Figures 5, 6, and 7 show the parties involved in the hinterland chain and the connections they have. Several public players, including customs, a port authority, inspection services, and infrastructure providers, are involved in addition to the commercial actors who offer transportation and terminal services. As a provider of logistics services, your whole network and product offering now include the hinterland transport system, which is no longer an independent link in the supply chain. An appealing logistics service provider must be able to handle supply chain collaboration and coordination on both a horizontal and vertical level. Vertical coordination is accomplished by integrating various supply chain players, such as haulers, shipping lines, ports, terminals, infrastructure managers, etc., whereas horizontal coordination is accomplished by providing a single, multiple, or combination of transport modes (Bergqvist, 2012). Figure 5 shows the wide range of operations in the hinterland chain

that result in the engagement of several businesses and government agencies (Horst and Langen, 2008).

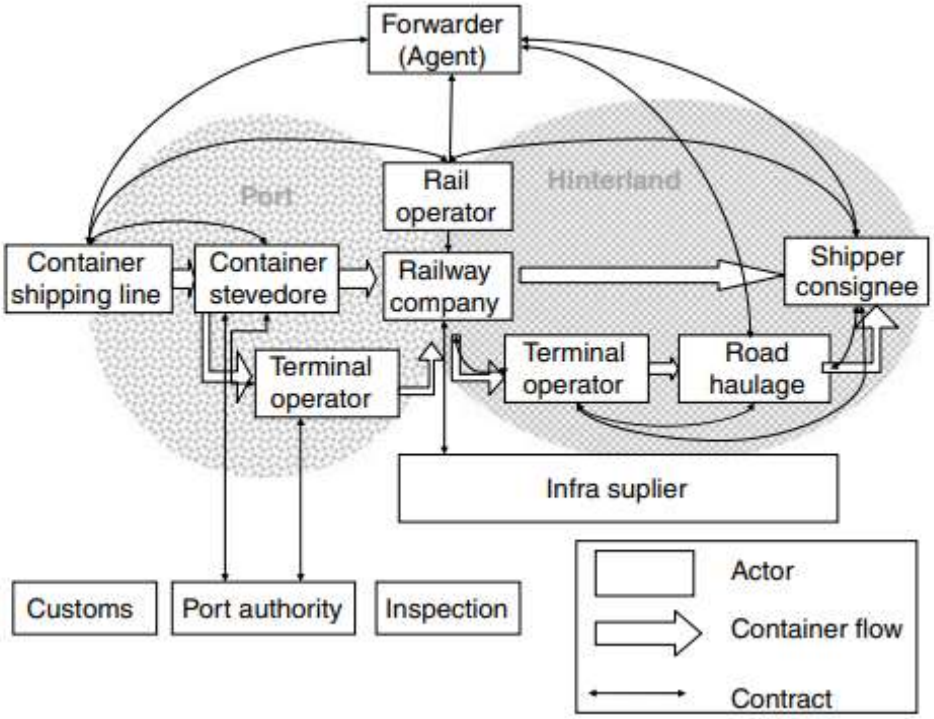
Figure 5: Hinterland Connection of Barge



Source: Horst and Langen, (2008)

Because of the function of a rail infrastructure supplier who has contractual agreements with railway firms, the railway hinterland chain differs from inland shipping. High fixed expenses and low variable expenses. The locomotives, containers, and handling apparatus have high fixed costs. The majority of variable costs are labor, petroleum, and maintenance. General operational characteristics include excellent velocity, frequency, and capacity. Typically, intermodal combinations are required to reach distributors and recipients (Bergqvist, 2012). The components of railway connectivity are shown in the figure below.

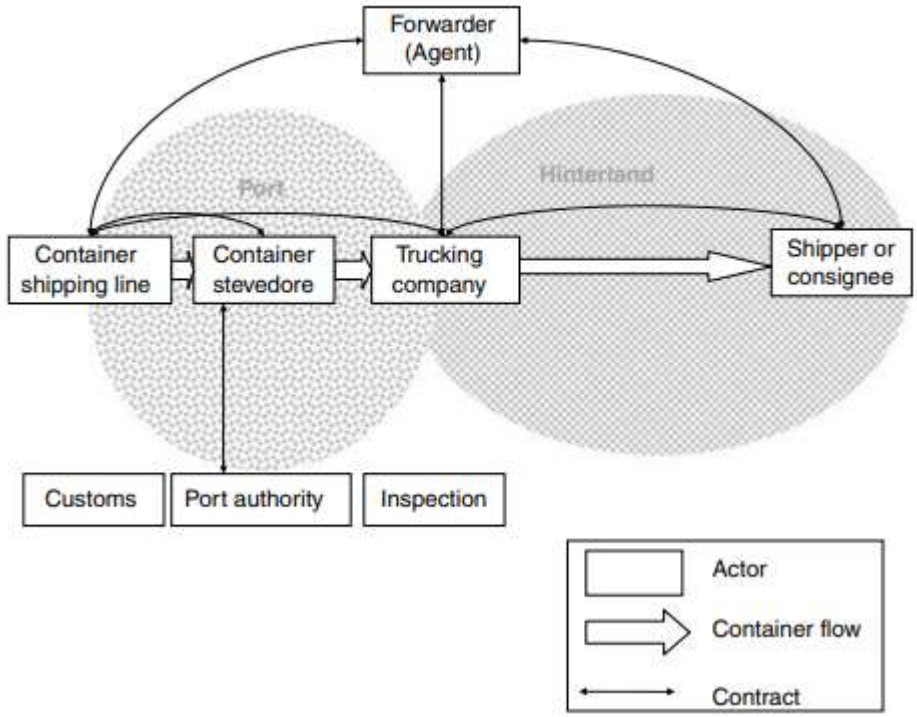
Figure 6: Hinterland Connection of Railway



Source: Horst and Langen, (2008)

The truck hinterland chain is shown below. According to all transport chains, Intermodal transportation chains are formed by merging several modes of transportation. The argument for linking multiple means of transportation is to preserve the inherited benefits of the modes while minimizing the downsides. Intermodal transportation networks, for example, can provide cost-effective and ecologically friendly transport across long distances, yet road transport allows for greater flexibility in routing and ultimate delivery to the end-customer. The architecture of the multimodal transport chain is considerably more complicated in other cases. Given the identical example of the road-rail intermodal transport chain, an additional direct road-based door-to-door transport chain for conveying appropriate amounts of door-to-door goods can exist. Following the conclusion of the direct door-to-door mission, the supplies are employed for terminal pick-up and delivery to the final clients. As a result, a sophisticated transport system design is built that employs the most appropriate mode of travel based on the features of the transport connection (Bergqvist, 2012: 211).

Figure 7: Hinterland Connection of Road Transportation



Source: Horst and Langen, (2008)

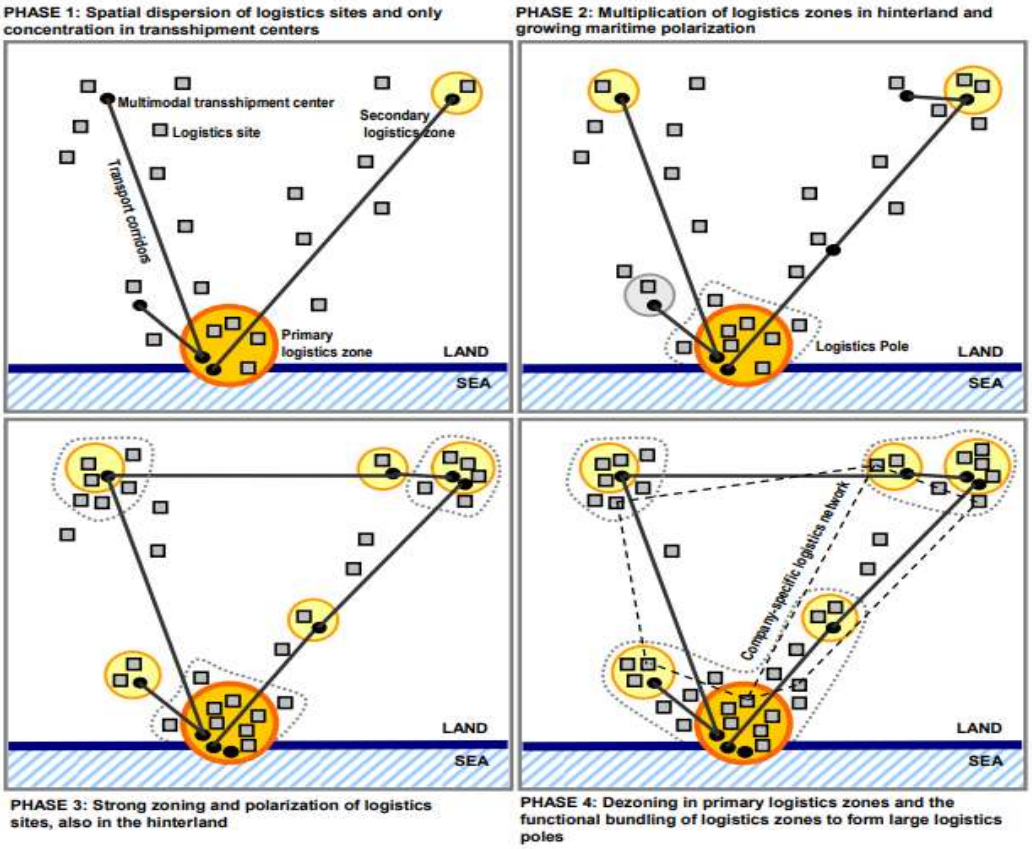
1.3.3. Service Components of Hinterland Transport Systems

The Economic analysis of port-hinterland container logistics is primarily driven by the potential to reduce dwell time at intermodal nodes. This indicates that the terminal buffer function should be optimized to make the most of the free storage time provided by inland and maritime terminal operators. In contrast, the pricing structure for container operations at the various intermodal node types is the same, but the circumstances at the interport nodes are typically better than at seaports in terms of free time, storage fees, and additional direct costs for some customs examination types (Iannone, 2012: 35). The potential for improved interaction and cooperation among supply chain participants, as well as the expansion of ports' hinterlands, offer hinterland logistics a clear role in developing and maintaining global supply chains (Bergqvist, 2012: 67).

Three primary purposes are served by dry ports. The first satellite terminal is the one that is close to a port facility. It supports more traffic and fulfills tasks that are

either less reliant on being close to a deep-sea quay or that have grown too expensive to do at the port, such as storage and empty container depots (Rodrique and Notteboom, 2011: 21). If the economic density is significant, satellite terminals can also act as load hubs for nearby or regional markets. In terms of modal and multimodal transportation supply, the physical hinterland is a concern. It takes into account the network of modes, terminals, and transport infrastructure connecting the port to its hinterland as a way to improve regional accessibility in freight distribution. Intermodal transportation now plays a crucial role in increasing the effectiveness and accessibility of hinterlands because it connects the port's worldwide access (via its intermodal capabilities) with local clients (ECMT 2001). In this instance, they create a multi-term network with the main port to which they are connected through frequent rail or barge shuttle services. In terms of modal and multimodal transportation supply, the physical hinterland is a concern. In order to achieve regional accessibility in freight distribution, it takes into account the network of modes and terminals connecting the port to its hinterland. Intermodal transportation now plays a crucial role in increasing the effectiveness and accessibility of hinterlands because it connects the port's worldwide access (via its intermodal capabilities) with local clients (Rodrique and Notteboom, 2006). A satellite terminal can also perform a large trans-loading role for gateways with a significant import component, converting the contents of maritime containers into domestic containers or truckloads. The second role played by dry ports is that of a significant intermodal facility, or load center, providing access to distinct regional markets with production and consumption functions. It only refers to a metro region where several terminals perform simultaneous intermodal, warehousing, distribution, and logistics tasks. These frequently occur in free trade zones and logistics parks.

Figure 8: A Spatial Model on Logistics Sites in the Port Hinterland



Source: Rodrique and Notteboom, (2006)

Therefore, the loading hub of a local market is the dry port. There will be freight distribution operations serving a wider market if the load center has a suitable intermediate position, like being near a busy rail line. A dry port's third purpose is that of a transshipment hub, connecting vast networks of freight movement along the same mode (such as rail-to-rail) or through intermodality (such as rail-to-truck or even rail-t-barge). In the second scenario, the inland terminal serves as a load center. A comparable role to that of transshipment hubs in maritime transport networks, the origin and destination of the freight handled are outside the terminal's market region. In order to combine administrative operations related to cross-border traffic with value-added logistical activities, such transshipment facilities are frequently located close to national boundaries. Even though this role is still mostly insignificant in much of the globe, continuous changes in inland freight distribution, where intermodal services' scale and breadth are expanding, are a sign that transshipment services are

inevitably going to gain in importance. These roles are not mutually exclusive, indicating that dry ports can perform many roles simultaneously. The dry port is the first tier of a functional hierarchy that identifies its primary (activities it directly supports) and secondary (activities it indirectly services) hinterlands for inbound or outbound freight flows (Rodrique and Notteboom, 2011: 21). Determine the functional classification of dry ports using the following criteria: (1) the number of modes served at the terminal (unimodal, bimodal, and trimodal); (2) the primary function, such as depot, warehousing, distribution, and value-added services; (3) terminal size; (4) the type of cargo handled; and (5) the openness of the node (i.e. multi-user vs. single user facilities) (Notteboom and Rodrique, 2009: 6).

CHAPTER TWO
CONTAINER PORTS

2.1. MARITIME TRANSPORTATION DEVELOPMENT

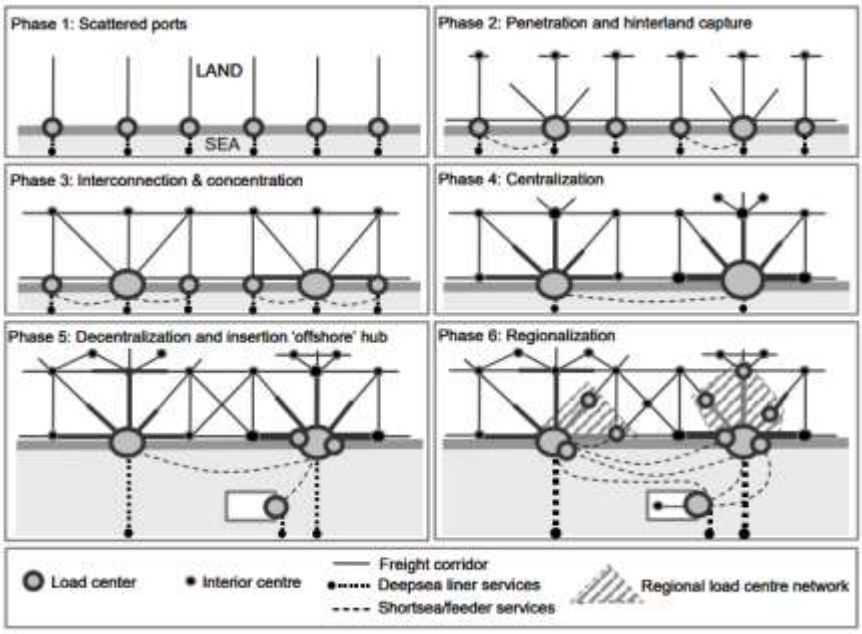
The movement of products and/or persons by water between two seaports is explicitly referred to as maritime transport (Panayides, 2006: 4). The rivers and seaports, respectively, are the linkages and nodes in these networks. Intermodal transportation networks, which convey freight between the hinterlands and the harbor, supplement maritime transportation networks. In other words, Maritime transportation is made up of two components: maritime shipping and port dimensions (Rodrique, 2010). Maritime shipping, also known as sea transportation or ocean freight, is the transportation of goods or people by water, primarily via ships or boats, across oceans, seas, or other bodies of water. This mode of transportation is essential to global trade, as it allows for the movement of large volumes of goods and commodities between countries and continents. Maritime shipping involves a complex network of ports, shipping lanes, and logistical systems, and plays a vital role in the world economy. On the other hand, port dimension refers to the physical characteristics and specifications of a port facility, including the size, depth, and layout of the harbor and its supporting infrastructure. These foundational elements of port were quite enough to provide services to their customers at the very beginning of port history. Due to the reasons that will be explained in the next section, the dimensions of the port have evolved, and the concept of the port has changed considerably since then.

2.1.1. Progress of Port Generations

Apart from their internal operations, ports are adding new dimensions to hinterland transportation to support the complexities of traffic and freight distribution outside the port (Rodrique, 2010: 11). In the end, each new dimension results in an updated generation of ports, and recently, general concepts of trade have been shaped into brand-new concepts. The methods of maritime transport, which proceeded unidirectionally in the primitive times of the ports, reached multidimensional

dimensions over time. Thus, maritime logistics, which has started to be more accepted today, has taken its place in the literature and already discussed in previous parts. The merging of logistics concepts with maritime transportation is known as maritime logistics, and it has lately received the attention of professionals and academicians (Panayides and Song, 2013: 295). This statement was made after years of development. The maritime business has evolved as a result of globalization and technical advancements like containerization and multimodality in the transportation sector. As a result, the crucial role of shipping and ports in global supply chains has undergone a significant transformation. Demand for integrated and value-added logistics services is growing as an outcome of changes in maritime transport. In order to provide high-quality logistics services via integrated transport and logistics systems in global supply chains, shipping firms and port operators start to build their own strategies as a result of their responses to changes in market demand (Hussein and Song, 2022: 151). This entire evaluation process will be examined in the next section. Figure 9 shows the port generation process.

Figure 9: Port Regionalization Phases



Source: Notteboom and Rodrigue (2005)

2.1.1.1. The First-Generation Port

At the beginning of the port generation journey, ports can be considered freight transfer points. Without any derived demand and without servicing any supply to port users, ports were only interchange locations for ships and deliverer-receivers. When distinguishing a new generation port from an older one, port development policy, strategy, and attitude are crucial factors. Prior to the 1960s, ports were essentially locations where cargo transferred between land and marine transport. Traditions and customs of those years have influenced the way of thinking of many port workers. Other than cargo loading/unloading and storage, no other activities were typically conducted in the port area (UNCTAD, 1992:13). Initially, ports were mainly utilized for the transportation of raw materials and finished goods in and out of an area. Typically, ports were modestly sized and situated close to natural harbors or the mouths of rivers. The port is separated from commercial operations and is not a key link in the logistical network, which only provides ship anchorage, mooring services, loading, unloading, and storing cargo with limited features. Due to their size and limited capabilities, first-generation ports were generally only able to serve local or regional trade. Notwithstanding, they were also crucial to the development of industrialization since they provided the infrastructure required for the movement of products and the expansion of the manufacturing sector. At the time, it was considered that merely making investments in port infrastructure was adequate, as the most essential functions of ports were loading and unloading, storage services, and navigational guidance. For these reasons, it is acceptable to state that investment in transportation technology in first-generation ports is underutilized (Alderton, 2008: 80).

2.1.1.2. The Second-Generation Port

As new technology enabled for the mass manufacture of commodities, ports started to expand in size and complexity with the start of the Industrial Revolution. As penetration phase, specific commodities were handled within this time of period, such iron ore, coal. Second-generation ports engage in commercial activities such as packaging, labeling, and physical distribution, which add value to the cargoes.

Industrial zones have been established in the hinterland regions (Alderton, 2008: 83) The scope of port activities is expanded to include any relevant commercial or industrial service, such as cargo packaging, marking, and cargo transformation. Within the port area, industrial facilities are built. Consequently, the port develops and expands into its hinterland with industries such as iron and steel, heavy metallurgy, refineries, and fundamental petrochemicals, aluminum, paper pulp production, fertilizers, sugar and starch, flour, and various agrofood activities. The ports of the second generation are not only transportation hubs, but also industrial and commercial hubs. They emerged in the 1960s as the quantity of basic materials imported into industrialized nations increased. In maritime transport, this was accompanied by the use of large tankers and dry bulk carriers (UNCTAD, 1992:14). Due to technological development and changing port services port production started to get better. Heavy industrial industries ask for large loading capacity, direct connections, and loads of various sizes and variations. Various fields, including steel, petrochemical, and electricity, have contributed to the advancement of second-generation ports. Some of the technological distinctions are large yards near the quays, oil terminals with high-tech security systems, and the beginnings of oil pipelines and electrical lines. The geographical point of view has transformed; at first, a production facility was built, which was followed by a port to service the industrial region. The boats that dock in ports are already more proficient. From the beginning, oil tankers come up, and as their hulls and technology alter, they shift to LNG ships (Russo and Musolino, 2020: 105).

2.1.1.3. The Third-Generation Port

In 1956, US truck owner Malcolm McLean developed the concept of employing standardized steel boxes to speed up the loading and unloading of ships. This idea was influenced by consumerism, mass manufacturing, and use (Adolf et al. 2014). When taking into account the increase in containerization and intermodality, the substantial interdependency between a port's foreland and hinterland becomes quite clear (Rodrigue, Notteboom 2010). People in terminals used to believe that "the cargo will follow the vessels" for centuries. However, they now recognize that cargo flows are significantly more volatile than in the past. There have been efforts to acquire

and retain them. These efforts are necessarily geared toward promoting trade and transport activities, which generate new revenue-generating and value-adding enterprises. As a consequence of these efforts, ports are becoming integrated transport hubs and logistical platforms for international commerce (UNCTAD, 1992:15). The new demands that emerged with containerization created new competitive elements in maritime trade. Port's foreland and hinterland interconnection added new nodes to the whole system. In addition, primer nodes became bigger, and supportive nodes started to be located around them. Interconnections between these two main nodes and supportive nodes face the brand-new demands of maritime transport participants. Since the 1970s, containerization has happened at a startlingly rapid rate due to faith in containers as well as, if not more so, the fear of divisive competition. Global shipping speculation has fundamentally changed the industry's environment. This meant that investments in shipping had to maintain the delicate balance between producing enough capacity to satisfy consumer demand and overcapacity (Ng, 2014: 18). To the satisfaction of the customers, value-added services were brought into use by the port.

2.1.1.4. The Fourth-Generation Port

Similar to distribution centers, ports can play a crucial role in the development of international logistics. Exceptional care should be given to these logistics interfaces because a significant opportunity to increase productivity is emerging (Paixao and Marlow, 2003:357). Port documentation was made more efficient through lowering vital processes and obtaining technology platforms to carry out effective information exchange, which was one of the biggest obstacles in previous port generations. The advent of EDI (Electronic Data Interchange) was absolutely essential in converting the system and gaining high efficiency for port records. Technology and competence were important disruptive forces in the period of third-generation ports (Bichou and Gray, 2004). In light of the explosive growth of computer science during the 1980s, the EDI data exchange systems launched during this time appear improper in the twenty-first century for two reasons. First, the Internet, which had become a common, international medium for bolstering international trade and banking, was not usable. Second, online

information security systems and processes must be boosted to improve the resilience of port turnover participants to hacker assaults that might result in a temporary or permanent withdrawal of stevedoring procedures at the port (Kaliszewski, 2018: 6). EDI is a technology that allows multiple parties engaged in the shipping process to exchange data electronically. It allows for the effective exchange of information such as shipment instructions, invoices, and other documents and can assist in optimizing the shipping process while reducing mistakes and delays. The globalization process has brought with it a number of propelling forces that have caused and are causing numerous economic transformations worldwide. The repercussions of these forces extend to all commercial and industrial sectors, including the port environment. Uncertainty is unquestionably the consequence that causes the most concern in the port industry, forcing ports to become more competitive. Port operators must implement new management strategies to become proactive as opposed to reactive. One such strategy that will help ports adapt to the new economy is agility, that is a knowledge-based strategy that enables any business to move swiftly in the new economy and is responsible for strengthening the connections between the internal and external business environments (Paixao and Marlow, 2003:361).

2.1.1.5. The Fifth-Generation Port

As the unconnected ports began to fall out of competition, these ports made attempts to establish connections with the service providers around them over the years. Moreover, these established connections stopped the ports from being solely ports that organize transshipment flows and made these ports the main centers. These main centers, which are affected by the fluctuating business environment, attach importance to strong supportive centers. Because each demand needs its own attention, ports as main centers should face these demands as a whole. At that point, this desire caters to each demand, bringing about phase 5: decentralization and insertion of the offshore hub. Value-added services are initiated not only in the ports but also in the hinterland of the ports, whether located just near them or not. Larger ships and fewer ports of call characterize high-order service networks compared to lower-order networks. Considering these developments, shipping firms have engaged in horizontal

and vertical integrations with other organizations as well as among themselves in order to supply global logistics services and spread their operations on a larger scale. In order to maintain a competitive edge, they are also making an effort to set their services apart (Yeni and Tuna, 2003: 738). As a result, growing volumes may cause hubs to become more complex and liner service networks to become more fragmented (Notteboom and Rodrigue, 2005).

2.1.1.6. The Sixth-Generation Port

Growing volumes have highly impacted mass customer-based production from all over the world. Each division of demand varies the cost of production and supplying this service to customers. This changing cost triggers the shape of connecting nodes once, and thus, regionalization phase 6 has happened. In other words, a new sort of maritime-land interface is created by the "synergy" between the port and the inland terminal of such a concept, thus creating a regionalized port (Rodrigue, 2010). The changes in supply chains and logistics models force market participants like shipping lines, stevedoring firms, inland transport operators, and forwarders to reevaluate their roles in the logistics process. They also present significant challenges for ports' roles as useful nodes in logistics networks (Notteboom and Rodrigue, 2005). The integration and optimization of a company's operations and processes for the dual goals of overall cost reduction and customer satisfaction form the foundation of logistics management. Logistics aims to provide the appropriate good or service in the appropriate amount and quality, at the appropriate price, at the appropriate location, and for the appropriate client (Bichou, 2014: 22). Port hinterlands are significantly affected by port dynamics and location since ports represent the intersection of maritime and land transportation networks (Rodrigue and Notteboom, 2006). Land transport is widely recognized as an essential objective for lowering logistics costs during the regionalization phase. In terms of increasing efficiency, expanding logistics integration, and lowering distribution costs, regionalization as such offers a strategic response to the demands of the supply chain's inland distribution sector. Land transport is widely recognized as an essential objective for lowering logistics costs during the regionalization phase. In terms of increasing efficiency, expanding logistics integration, and lowering

distribution costs, regionalization as such offers a strategic response to the demands of the supply chain's inland distribution sector (Ng, 2014, p. 24).

2.1.2. Contemporary Container Port Roles and Functions

After years of phases, scholars give more attention to the port hinterlands due to logistical services. It was seen during these development processes that the contribution of logistics services to the overall service quality played an important role in the development of port functions that involve a range of activities such as transportation, warehousing, distribution, and information management, among others. The association of sea and land transportation operations creates a Maritime transportation perspective, which is lately named Maritime logistics, and causes the creation of a brand-new port development aspect. This updated aspect gives attention to the back-end side of the port region, the hinterland, which directly adds value to port operations. Because the improvement of hinterland facilities, which is deeply explained in Section 2.3 Hinterland Logistics, is as influential as a port's inside capabilities, The regionalization phase explained the rise of well-qualified inland connections. This emergence is not only triggered by port-inside service providers but also by all other maritime actors' demands. To achieve this, ports must focus on developing their logistics capabilities and improving their connectivity with other nodes in the supply chain, including rail and road networks as well as air and water transportation systems. This involves investing in modern port infrastructure and ensuring that processes and systems are in place for efficient cargo handling, storage, and distribution, as well as effective supply chain management.

The number of container ships has increased concurrently with the flow of containerized goods, meaning higher call sizes, which adds to the burden on logistical infrastructure (road and rail networks) (Santos and Soares, 2019). A thorough analysis is necessary to determine how a port system is evolving structurally since other port locations may see a similar development if global container traffic keeps growing (Lui et al.,2013).

In the very beginning, the hinterland was located outside of the port region. Then, due to an increase in dematerialization, globalization, and changing production

aspects, it became associated with port operations. Additionally, there is growing interest in the port-hinterland link because the majority of bottlenecks occur in the hinterland and inland transportation expenses make up a sizeable portion of logistics costs (van Der Horst and De Langen, 2008). In order to increase their competitiveness and draw in new clients, port operators must also embrace innovation and new technology. This involves implementing digital solutions that may expand productivity, cut costs, and offer real-time insights into supply chain operations, such as automated port management systems, data analytics, and artificial intelligence.

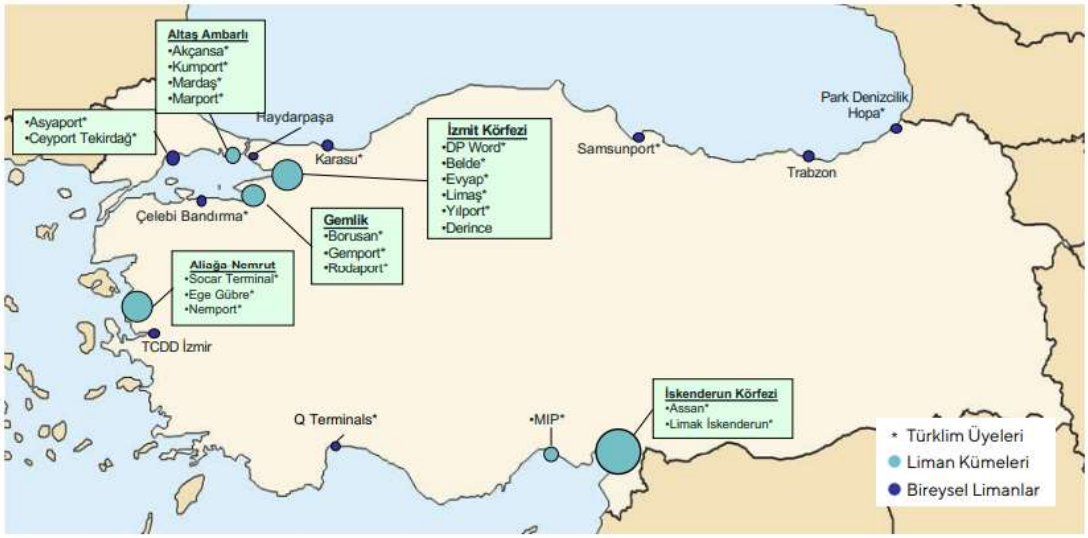
The development of an inland port in the hinterland connected to a port with a high-capacity link can achieve the goals of both port and inland players, enhancing trade access for an area with poor port accessibility and giving the port in question a competitive edge. Streamlining flows to achieve scale economies, the port benefits from increased traffic flows along this corridor as well as reduced congestion and increased administrative efficiency at the port gate (Wilmsmeier et al., 2015). Additionally, services given outside of the port directly affect port choice, and dedicated services, given at an appropriate price, result in good service performance at the port. Thus, it is a very important point in the choices made by the actors. Additionally, initiatives to increase the dependability of port services may be very profitable and hence lessen the incentives for shipping lines to invest in dedicated terminal capacity. Ports may boost their allure by taking advantage of complementarities with other supply chain components, such as tighter linkages with inland distribution centers, as well as by using capacity between the port and the hinterland as effectively as possible (De Langen, 2008).

2.1.3. Container ports in Türkiye

Because the maritime industry transports 85% of all cargo in global trade, it has reached a tipping point. Sea transportation necessitates the presence of three factors. These are the goods transported by sea, the ships that transport these cargoes, and the ports from which these ships operate. With the expanding globalization trend in the 1990s, the maritime sector as a network business achieved worldwide coverage in both ship management and port management. Türkiye's part in world commerce is

growing year after year as a newly industrialized country with significant growth rates. With increased global commerce, the functions of ports are becoming more important, which raises the interest of both domestic and international investors in Turkish ports. Indeed, since the beginning of privatization processes in 1997, the public sector has largely abandoned its port management identity in favor of a rule-making and regulatory identity. In Türkiye nowadays, there are around 180 port facilities, 80 of which are large-scale and mostly run by the private sector (Yeni and Esmer, 2021). The ongoing privatization process in Türkiye has coincided with a rise in containerization in the country as a result of both privatization and private port developments (Varan and Cerit, 2014: 91).

Figure 10: Container Ports in Türkiye



Source: Turkish Port Sector Report, 2022:87

The ports in the Marmara Region were in first place for total container volume handled, handling 60.3% of all containers handled in Türkiye. Ports in the Mediterranean Region and the Aegean Region follow the Marmara Region, with 23.3% and 15.4%, respectively. Black Sea Region ports account for 0.9% of all container handling volume (Turkish Port Sector 2022 Report:87).

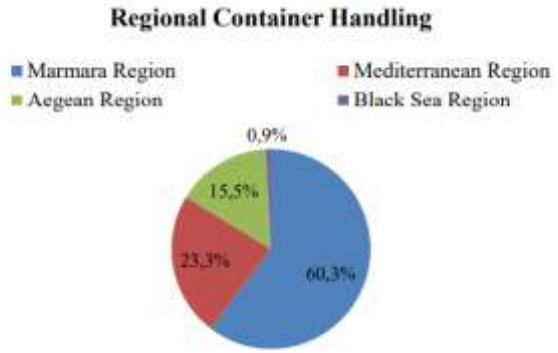
Figure 11: Development of Container Throughput in Türkiye



Source: Turkish Port Sector Report, 2022:88

12,442,449 TEUs worth of containers have been handled in total at our ports as of 2021. There are 3,441,872 TEU in transit containers and 8,294,003 TEU in international commerce and cabotage containers. The overall number of container loads handled at our ports, which are open to cabotage and foreign commerce, declined by 4.7%. The overall container handling at our ports increased by 6.1% over the prior year as a result of the 14.1% rise in transit container handling (Turkish Port Sector Report, 2022:88).

Figure 12: Regional Container Handling in Türkiye



Source: Turkish Port Sector Report, 2022:90

Türkiye ports, which make up the most crucial component of the maritime transportation infrastructure, handled an average of 85% of Türkiye's export commerce by sea in 2021. The Marmara Region has grown to be a significant transportation hub, particularly for cargo headed for the Black Sea. 84.8% of the transit freight handled passes via the ports of the Marmara Region. With a 14.2% share, the East Mediterranean region, which includes the ports of MIP Mersin, Limak Iskenderun, and Assan, comes in second. Asyaport, Marport, Kumport, and MIP Mersin International Port had the most transit container traffic in 2021 (Turkish Port Sector Report, 2022:90).

2.1.3.1. Container ports in Aliaga Region

Aliaga Port Region consists of Nemport, SOCAR Terminal, and TCE EGE ports.

2.1.3.1.1. Nemport

Nemport, the very first private container port in the Aegean, has seen an increase in the number of containers handled since 2010. Turkish Port Sector Report, (2022) claims that Nemport finished 2021 with a throughput of 544,568 TEUs, making it the port in the Aegean Region that handles the most containers. They also plan to purchase five RTGs in 2022 as part of their ongoing equipment investment. According to reports, money will be spent on a new gantry crane in the following year. Nemport is the first terminal with a railroad link in the Aliaga region and one of the few ports qualified to acquire the Green Port/Eco Port certification.

Table 3: Port of Nemport Features

PORT FEATURES	
Administrator	Nemport Liman İşletmeleri ve Özel Antrepo Nakl.Tic.A.Ş.
Coordinates	38º 46” 07’ N & 26º 55” 51’ E
Handled Cargo	Container, General Cargo, Project Cargo
Handling Capacity	
Container (TEU/ year)	750.000
General Cargo (Ton/year)	1,000.000

Total port area	160.000 m²	
Closed warehouse	100.000 m²	
Customs warehouse (open)	5.000 m²	
Parking area		
Length	1.080 m	
Width	40 m	
Maximum Draft	-21,5 m	
Equipment	**Number**	**Capacity (ton)**
SSG	2	65 TON
MHC	5	4x100T – 1x140T
E-RTG	5	6+1– 7
CRS	9	5 High 45 T
ECS	2	6 High 10 T
ECH	4	8 High 9 T
Truck	45	60 T
CONTACT DETAILS		
Related persons	Hakan TURUNÇ	
Address	Siteler Mah. Kardeşlik Cad. No:12 Nemrut Körfezi Aliağa 35800-IZMIR	
Telephone	0 232 618 3001	
Fax	0 232 618 3020	
E-mail	hturunc@nemport.com	
Web site	www.nemport.com	

Source: Turkish Port Sector Report, 2022:212

2.1.3.1.2 SOCAR Terminal

On November 22, 2010, Petlim Limancilik Ticaret A.S. (Petlim) was established. As part of the strategic cooperation with APM Terminals in the operation of container ports, the port's first phase, consisting of 800 000 TEU, was finished on December 6, 2016, and APM Terminalleri Liman Isletmeciligi A.S. started operating it. The port's second phase was inaugurated on July 4, 2018, and it started using all of its available capacity. The Company's trade name was changed to "SOCAR Aliaga Liman Isletmeciligi A.S." on December 27, 2018, as a consequence of SOCAR Türkiye Enerji A.S. purchasing all of APM Terminalleri Liman Isletmeciligi A.S.'s shares. The port (SOCAR Aliaga Terminal) is currently run by SOCAR Aliaga Liman Isletmeciligi A.S. SOCAR Aliaga Terminal is the first port management in the Aegean Region to accommodate ships with a capacity of 18.000 TEU. It has a 700-meter integrated dock structure with a minimum sea level of 16 meters. With a 1.5 million

TEU processing capacity, the terminal is the biggest in the Aegean Region. Additionally, the terminal contains a general cargo dock that is 150 meters long and 10 meters deep, as well as logistical areas for container storage that are 42 hectares and 6 hectares in size on the port reach and support services area, respectively (https://www.socarterminal.com).

Table 4: SOCAR Terminals Features

PORT FEATURES		
Administrator	SOCAR Aliağa Liman İşl. A.Ş.	
Coordinates	38º 46” 44’ N & 26º 55” 51’ E	
Handled Cargo	Container, General Cargo	
Handling Capacity		
Container (TEU/ year)	1.500.000 TEU	
General Cargo (Ton/year)	420.000 m² (20.000 m² unbonded area)	
Total port area	225 m²	
Closed warehouse	400.000 m²	
Customs warehouse (open)	30.000 m²	
Parking area		
Length	7700 m (Container) / 150 m (General Cargo)	
Maximum Draft	-16 m (Container) / -10 m (General Cargo)	
Equipment	**Number**	**Capacity (ton)**
STS	3	70
RTG	10	45
Reach Stacker	3	45
Empty Container Handler	3	8
Terminal Tractor	26	50
CONTACT DETAILS		
Related persons	Arcan Fayatorbay	
Address	Siteler Mahallesi Kardeşlik Caddesi No:16 35800 Aliağa-İZMİR	
Telephone	90 (0) 232 455 65 55	
E-mail	izmir@socarterminal.com	
Web site	www.socarterminal.com	

Source: Turkish Port Sector Report, 2022:222

2.1.3.1.3 TCE EGE

Along with container services, TCE EGE also offers general cargo and bulk freight services. According to container throughput in 2021, TC EGE places third in the Aegean Region and 11th overall in Türkiye with 488,507 TEU (Turkish Port Sector

Report, 2022:182). Since 2009, TCE EGE Container Terminals has offered its services at the Ege Gubre Sanayi plant. 55 kilometers separate TCE EGE from Izmir's downtown. Ege Gubre Sanayi A.S. wholly owns the subsidiary TCEEGE Container Terminals (http://www.tceege.com.tr).

Table 5: TCEEGE Container Port Features

PORT FEATURES		
Administrator	Ege Gübre Sanayi A.Ş	
Coordinates	38º 45’ 65”N & 026º 55’ 68” E	
Handled Cargo	Container, General Cargo, Bulk Cargo, Liquid Bulk; IMDG Cargo	
Handling Capacity		
Container (TEU/ year)	1.000.000	
General Cargo (Ton/year)	2.500.000	
Bulk Cargo (Ton/ year)	5.000.000	
Total port area	485.000m²	
Closed warehouse	37.415m²	
Customs warehouse (open)	4.615m²	
Custom Area	350.000m²	
Steel Silos	20.000 Tons	
Parking area	25.000m²	
Berth-Pier Dimensions		
Length	EAST JETTY: 417mx30m WEST JETTY: 367mx40m	
Maximum Draft	28m	
Equipment	**Number**	**Capacity (ton)**
STS (Single Boom)	1	75
STS (Double Boom)	2	140
MHC	2	160
LHM	3	228
Sennebogen 870EQ	1	30
RTG	10	400
STACKER	5	225
ECH	4	36
Terminal Truck	48	60
CONTACT DETAILS		
Related persons	Bülent Çiçek – Murat IRMAK	
Address	25. Cadde No:2 Çakmaklı, Aliağa/İZMİR	
Telephone	0.232.625 1250	
E-mail	murat.irmak@egegubre.com.tr bulent.cicek@egegubre.com.tr	
Web site	www.egegubre.com.tr	

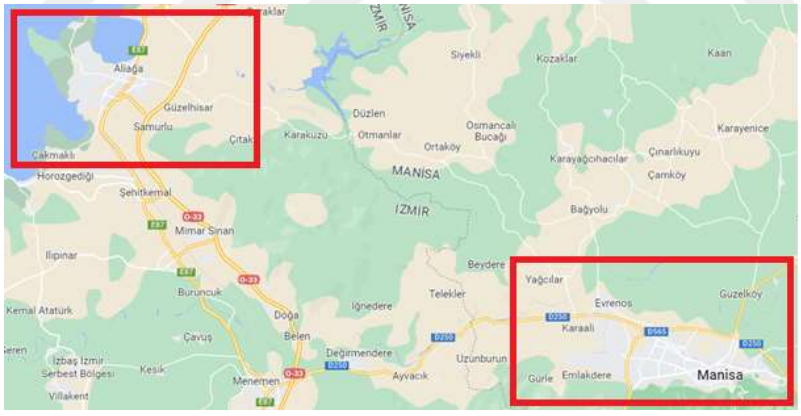
Source: Turkish Port Sector Report, 2022:182

2.1.3.2 Aliaga Container Port Hinterland components

Ports have lately evolved from being basic transshipment hubs to integrated logistics centers in the continuous transport chain, and these developments are strongly dependent on the supply chain strategies of major port users. Although these advancements have a favorable impact on terminal handling volume, the increased volume has increased terminal work burden, as well as congestion and dwell durations in terminal areas (Sağlam et. al. 2015: 1). Ports that hold a prominent place in coastal demand have a social and economic impact not only on the coastal area in which they are located, but also on a large area formed in their hinterland. Ports are logistical hubs where cargo transportation modes are switched for critical transport infrastructure and transshipment occurs (Şengönül and Esmer, 2016: 133).

Aliaga Container Port hinterland, in addition to its own region, also covers the Organized Industrial Zone in Manisa. Between these two locations, there is a railway connection through Menemen. In the map, the railway follows the yellow road line.

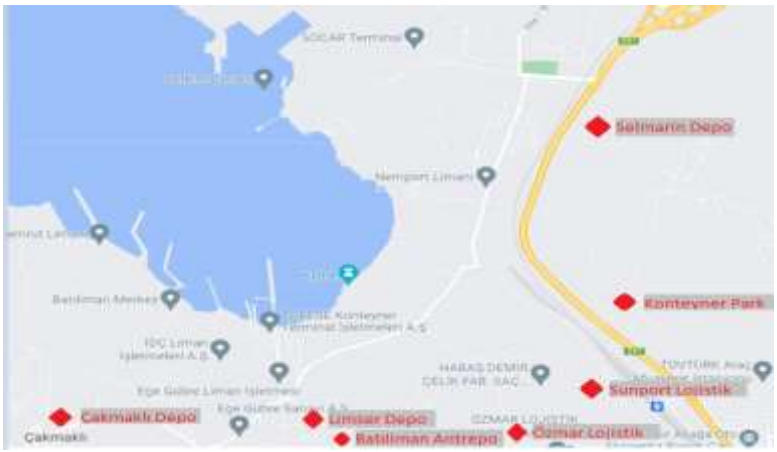
Figure 13: Aliaga Container Port Hinterland



Source: Author

Some of Aliaga hinterland service providers are shown in Figure 16. SOCAR terminal, Nemport, and TCE EGE Container Terminal are located one after another in Nemrut Bay. Except for the SOCAR terminal, other two container ports have significantly smaller container yards, as shown in figures 12, 13, and 14. For the handling of containers for the different types of services, depots are located near the ports. In this area, road and railway connections exist.

Figure 14: Aliaga container Port Hinterland in detail



Source: Author

CHAPTER THREE
IDENTIFICATION OF HINTERLAND LOGISTICS SUCCESS FACTORS: A STUDY ON ALIAGA CONTAINER PORT REGION

3.1. THE AIM OF THE RESEARCH

The main purpose of the research is to define, classify, and analyze the hinterland logistic success indicators in perspective of Aliaga container ports. Also, there are few studies in the literature about maritime logistics and hinterland logistics, especially in Türkiye.

Hinterland logistics factors covering this region and affecting the relevant stakeholders, especially in the Aliaga container port hinterland, which is the export region, were desired to be evaluated.

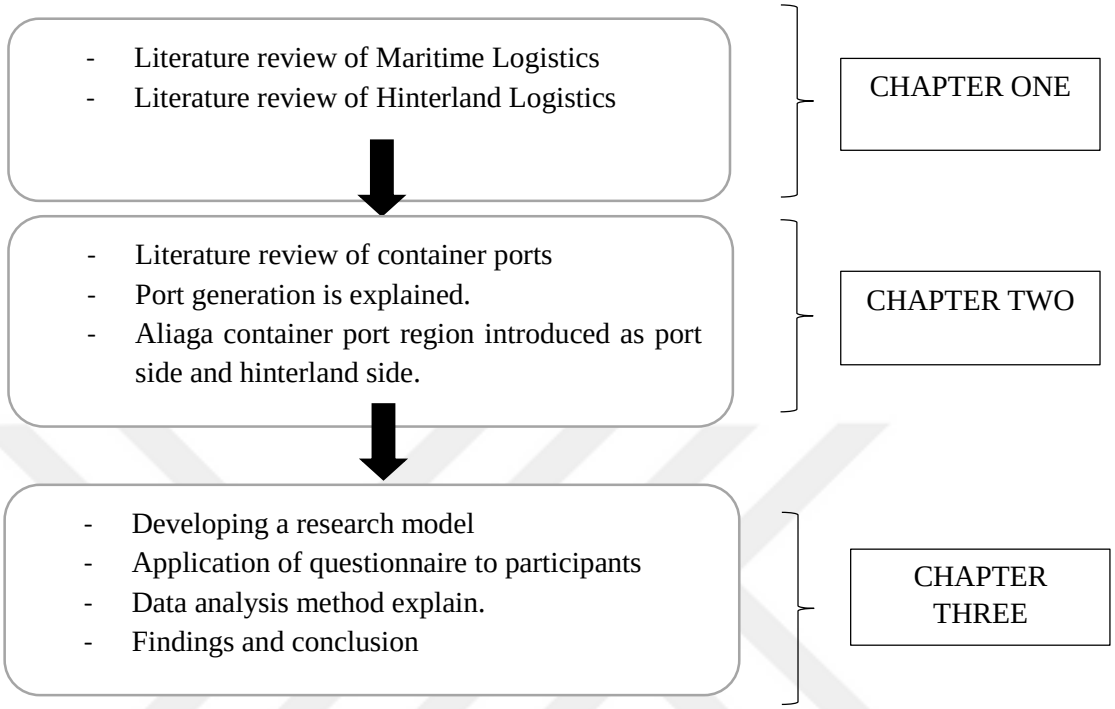
The objectives of the study are determined as follows:

- To define and understand the terms maritime logistics and hinterland logistics.
- To study the generation of container ports and make connections to maritime logistics and hinterland logistics.
- To evaluate qualitative results and understand factors clearly.
- To provide the results of both methods and share information about the importance and influence of the situation with the scholars and experts.

As a result, the data obtained in this study will reveal what constitutes the links between container ports and their hinterlands. The importance of these success factors against each other and how much they affect each other were examined with fuzzy AHP and fuzzy DEMATEL.

3.2. THE PROCESS OF THE RESEARCH

Figure 15: Process of the Research



The research process design is shown in Figure 15 above. In Chapter 1, the literature of maritime logistics and hinterland logistics are examined. Definitions are mentioned, components, actors, and design approaches are reviewed. In Chapter 2, container ports are examined. Container port generations are identified. Then, container ports in the Türkiye and Aliaga region are handled. Additionally, the hinterland of the Aliaga container port region is mentioned. In Chapter 3, the methodology of the study is explained with the application of research evaluation and data analysis. In the last part of the chapter, three findings are developed and explained.

3.3. METHODOLOGY OF THE STUDY

3.3.1. Sampling and Data Collection

In this research, Aliaga region Container port employees are the sample group. Total of 13 respondents. Between the dates of 20.06.2023 and 29.06.2023 evaluation form was sent to participants via e-mail. Because of the time-consuming nature of the

evaluation form, experts were briefed about the major objectives of the research, essential concepts, and criteria abstracted from the literature to be assessed prior to the evaluation process, both face-to-face and by telephone. The general profiles of the participants are summarized in the table below.

Table 6: General Profile of Experts

Expert	Profession	Job description	Experience in the industry	Experience in the port	Education
E1	Ship Operations Manager	To plan ship operations and control crane working process.	6 years	5 years	Bachelor's degree
E2	Planning Assistant Specialist	To handle yard operations such as positioning of containers, planning of handling activities	4 years	2 years	Bachelor's degree
E3	Data Reporting Specialist	To do reports about port operations to analyze performance, effectiveness of the port and make forecasts.	8 years	8 years	Master' degree
E4	Customer Services Assistant Specialist	To control and organize container operations with the line and hinterland service providers communication	3 years	1 years	Bachelor's degree
E5	Customer Services Specialist	To control and organize container operations with the line and hinterland service providers communication	5 years	4 years	Bachelor's degree
E6	Customer Services Specialist	To control and organize container operations with the line and hinterland service providers communication	8 years	6 years	Bachelor's degree

E7	Data Control Specialist	To organize and control data flow with the stakeholders.	10 years	8 years	Bachelor's degree
E8	Data Control Specialist	To organize and control data flow with the stakeholders.	5 years	2 years	Bachelor's degree
E9	Sales Specialist	To making contracts with lines and hinterland service providers. Aggregating pricing strategies	5 years	5 years	Bachelor's degree
E10	Internal Audit and Claims Manager	To handle the crisis in the port. To make damage detection and reporting to related parties	4 years	4 years	Bachelor's degree
E11	Ship Operations Manager	To plan ship operations in the arriving and departing	7 years	4 years	Bachelor's degree
E12	Equipment Planning Specialist	To plan and organize the stuffing, positioning, loading and discharging activities of yard equipment.	8 years	6 years	Bachelor's degree
E13	Customs Relation Specialist	To organize customs affairs	13 years	9 years	Bachelor's degree

Source: Author

3.3.2. Data Analysis Method

3.3.2.1. Multi-Criteria Decision-Making (MCDM)

One of the primary issues in decision-making is multi-criteria decision-making (MCDM), which seeks to identify the optimal choice by taking into account many factors (Taherdoost and Madanchian, 2023:78). Scholars may utilize MCDM to solve common problems. However, the evaluation of criteria is a significant issue when the issue is focused on the more significant issues, such as capital levels. Decision-making in these circumstances must thus be based on good organization and a detailed examination of all the factors using appropriate software and tools. When the domain

has several criteria to arrive at an ideal solution based on the deciders' preferences, MCDM is utilized to deal with structure, decision-making, and planning procedures practically (Shahsavarani and Abadi, 2015: 215). A typical MCDM problem implies a number of decision-makers (DMs) to offer qualitative and quantitative indicators to evaluate the performance of each potential solution in terms of criteria and the corresponding significance of the assessment criteria in terms of overall determinations. The purpose of the MCDM technique is to assist decision makers in merging objective data with value judgments that are based on collective group ideas rather than individual opinions. Furthermore, there are cases where information is partial or inaccurate, or where opinions are subjective or endowed with linguistic features, resulting in a "fuzzy" decision-making environment. The FMCDM strategy is intended to reduce such unfavorable factors while also strengthening the partnership selection process (Chou, 2007: 186).

A group of DMs judges or evaluates several MCDM challenges in the real world. So far, various MCDM techniques have been presented. To mention a few, there is the analytic hierarchy process (AHP), the analytic network process (ANP), the decision-making trial and evaluation laboratory (DEMATEL), and the technique for determining preference for order by similarity to the ideal solution (TOPSIS) (Abdullah and Zulkifli, 2015).

One of the methods for making multi-criteria decisions that makes use of pair-wise comparison is the Analytic Hierarchy Process (AHP). Later, the approach is broadened to accommodate and address the ambiguity and imprecise information problem known as fuzzy AHP. The problem of inadequate information has emerged frequently in the review process and may result in inaccurate and skewed outcomes. The lack of knowledge for certain cases and situations as well as inefficiency or neglect in processing the information are major causes of inadequate information. This work proposes a fuzzy DEMATEL-based approach for estimating missing values in fuzzy AHP. The suggested solution employs an imputation approach, replacing the missing data in the fuzzy AHP decision matrix with realistic and logical fuzzy values. Through the use of a numerical example, the process of estimating the partial information will be demonstrated step-by-step. It was discovered that the consistency of assessment, a crucial validity instrument for the fuzzy AHP, was retained when the missing

information in the fuzzy AHP was estimated using fuzzy DEMATEL (Mohamad and Zanuddin, 2021).

3.3.2.2. Fuzzy Set Theory

The fuzzy set hypothesis argued that people's ideas, reasoning, and perceptions of their surroundings are rather imprecise. Because of the difficulties in assigning a specific percentage or number to these notions due to uniqueness and subjectivity, it was argued that typical very accurate quantification methods could not be employed to properly answer people-centered or complicated situations. Fuzzy set theory principles are required to account for the unpredictability and fuzziness of genuine situations (Zadeh, 1965). To signify their fuzzy degree, research respondents are assigned a value between 0 and 1. Crisp sets relate to binary logic [0,1] and are a partial truth (Huarng and Yu, 2006). People's subjective assessments are quantified. By leveraging binary logic, this conversion solves the flaw of ordinary sets in representing events. This strategy allows study findings to closely match human cognitive processes (Tsai et. al. 2015: 7).

The study goal of fuzzy theory, which is based on the fuzzy set, is to detect the phenomenon of vagueness in order to deal with imprecise and uncertain circumstances. Artificial intelligence, automated control, image identification, medical diagnosis, psychology, decision support, management science, weather forecasting, and environmental assessment have all benefited from the fuzzy theory (Tsaur and Kuo, 2011: 9164). Each number between 0 and 1 is considered partially valid in the framework of fuzzy logic. Crisp set notions, on the other hand, need solutions to be either 1 or 0. As a result, fuzzy logic enables academics to interpret unclear, imprecise, and fuzzy mathematical judgments. Triangular fuzzy numbers, trapezoidal fuzzy numbers, and Gaussian fuzzy numbers are the most commonly used fuzzy numbers (Tsaur and Kuo, 2011: 9164).

Many companies have used group decision-making to solve real-world decision-making difficulties. However, in decision-making problems involving complex systems, experts' or decision-makers' evaluations of qualitative criteria of a specific item are always represented in language phrases rather than clear values, based

on experience and expertise. Such verbal judgments are ambiguous, making additional analysis difficult to quantify. As a result, fuzzy set theory may be used to quantify confusing ideas connected with human subjective judgments. Each integer between 0 and 1 represents a partial truth in fuzzy logic, whereas crisp sets correspond to binary logic [0,1] (Lin, 2013).

The fuzzy linguistic function converts linguistic language into fuzzy integers, which are subsequently defuzzified to produce explicit values (Tsaur and Kuo, 2011: 9166).

The defuzzification solution used in this study determines the left and right threshold values by using the lowest and greatest fuzzy numbers. The weighted average of the membership function is used to get the overall integral value. The four stages that follow are then carried out (Tsaur and Kuo, 2011: 9166). The importance of collective decision making in attaining a good result cannot be overstated. Because the process of reaching a consensus is based on the reactions of several people, an acceptable judgment can be reached. To deal with the research's uncertainty, fuzzy aggregation is necessary, which includes a defuzzification procedure, because human judgments with fuzzy linguistic variables are fuzzy numbers. Defuzzification is the process of selecting a certain crisp element based on the output fuzzy set and converting fuzzy numbers into crisp scores (Lin, 2013: 35).

3.3.2.3. Fuzzy AHP Method

Thomas L. Saaty presented the AHP for the first time in 1980. The AHP weighting is mostly set by the decision makers who do pair-wise comparisons to reflect the relative value of two criteria (Shahraki and Paghaleh, 2011). AHP is an effective strategy for dealing with difficult choice issues. AHP may deconstruct any complicated problem into numerous sub-problems in terms of hierarchical levels, where each level represents a set of criteria or qualities relating to each sub-problem. The AHP technique is a multi-criteria analysis approach that uses an additive weighting procedure to represent various significant qualities via the relative significance process (Shahraki and Paghaleh, 2011). The fuzzy AHP was used to determine the relative weights of the criteria in the first phase of the integration approach, and fuzzy multi-

objective linear programming was utilized to find the best solution to the issue (Abdullah and Zulkifli, 2015). In order to handle problems with a hierarchical structure, the fuzzy AHP employs fuzzy arithmetic and fuzzy aggregation operators. The fuzzy AHP is calculated using the standard AHP approach for weighing the criteria of decision problems (Bozbura et.al. 2007: 1100).

1- Constructing the Pair Wise Comparison Matrix. A comparison matrix is set up from the pairwise comparison evaluation between the criteria, sub-criteria, and alternatives that can be considered as the degree of preference between two objects. The matrix will be first normalized before the vector of priorities is calculated.

2- Calculate the Value of Fuzzy Synthetic Extent.

$$\sum_{j=1}^{m} M_{gi}^{j}$$

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right)$$

3- Inverse of Fuzzy Synthetic Extent.

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right)$$

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$$

4- Calculate the Degree of Possibility. To find the criteria/sub-criteria weight and the weight of the rating for alternatives, the elements in each row of the matrix will be aggregated.

$$V\left(\tilde{M}_2 \geq \tilde{M}_1\right) = \sup_{y \geq x} \left[\min\left(\mu_{\tilde{M}_1}(x), \mu_{\tilde{M}_2}(y) \right) \right]$$

$$V\left(\tilde{M}_2 \geq \tilde{M}_1\right) = hgt(\tilde{M}_1 \cap \tilde{M}_2) = \mu_{M_2}(d)$$

$$= \begin{cases} 1, & \text{if} \quad m_2 \geq m_1 \\ 0, & \text{if} \quad l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \end{cases}$$

$$V(M \geq M_1, M_2, ...M_k) = V[(M \geq M_1) \ \ ve \ \ (M \geq M_2) \ \ ve....(M \geq M_k)]$$
$$= \min \ \ V(M \geq M_i), \ \ i = 1,2,3,....,k \qquad (12)$$

3.3.2.4. Fuzzy DEMATEL Method

To examine and work on the complex issue group, the DEMATEL approach was applied. DEMATEL was created with the premise that pioneering and correct use of scientific research methodologies may improve knowledge of specific problematic situations, clusters of linked difficulties, and help to the development of practical solutions through hierarchical structure.

The fuzzy-DEMATEL model incorporates the fuzzy linguistic part of fuzzy theory as well as the DEMATEL (Wu and Lee, 2007). When used in a fuzzy setting, the DEMATEL allows researchers to examine the causal links of fuzzy variables and evaluate the extent of interaction effect between variables (Tsai et. al. 2015). Likewise, fuzzy AHP, fuzzy DEMATEL method is also one of the MCDM approaches. However, the two MCDM methods serve different purposes. Determining the relative weights of criteria through pair-wise comparison judgment is the end result of fuzzy AHP. Unlike fuzzy AHP, fuzzy DEMATEL is a method that is specifically tailored for causal relationships between criteria and dimensions. Fuzzy DEMATEL and DEMATEL methods have been developed initially to visualize the causal relationship of sub-systems through a causal diagram (Abdullah and Zulkifli, 2015).

DEMATEL is based on graph theory and can assess and solve issues through visualization. To depict the interdependence links and the values of influencing impact between elements, this structural modeling technique takes the shape of a directed graph, a causal effect diagram. All elements are classified as causative or affected based on an investigation of the visual connection of levels among system factors. And

this can help researchers comprehend the structural link between system parts and discover solutions to complex system issues (Lin, 2013: 35).

Fuzzy DEMATEL is a pairwise comparison approach that demonstrates causal relationships between elements. The following are the method's general steps:

• Establish the target, scale, and assessment criteria list.

• Using appropriate language measures, do a pairwise comparison to examine the influence of variables. No Influence, Very Low Influence, Low Influence, High Influence, and Very High Influence are the most commonly used scales.

• Using linguistic information to transform fuzzy numbers into a crisp score, the fuzzy evaluations are applied, de-fuzzified, and aggregated as a crisp value.

1- Normalization

$$xa_{1ij}^{k} = \left(a_{1ij}^{k} - \min a_{1ij}^{k}\right) / \Delta_{\min}^{\max}$$
$$xa_{2ij}^{k} = \left(a_{2ij}^{k} - \min a_{2ij}^{k}\right) / \Delta_{\min}^{\max}$$
$$xa_{3ij}^{k} = \left(a_{3ij}^{k} - \min a_{3ij}^{k}\right) / \Delta_{\min}^{\max}$$
$$\text{Where } \Delta_{\min}^{\max} = \max r_{ij}^{n} - \min l_{ij}^{n}$$

2- Compute Right (Rs) And Left (Ls) Normalized Values

$$xls_{ij}^{k} = xa_{2ij}^{k} / \left(1 + xa_{2ij}^{k} - xa_{1ij}^{k}\right)$$
$$xrs_{ij}^{k} = xa_{3ij}^{k} / \left(1 + xa_{3ij}^{n} - xal_{2ij}^{k}\right)$$

3- Compute Total Normalized Crisp Values

$$x_{ij}^{k} = \left[xls_{ij}^{k}\left(1 - xls_{ij}^{k}\right) + xrs_{ij}^{k} \times xrs_{ij}^{n}\right] / \left(1 - xls_{ij}^{k} + xrs_{ij}^{k}\right)$$

4- Compute Total Normalized Crisp Values

$$\tilde{\omega}_{ij}^{k} = \min a_{ij}^{n} + x_{ij}^{n} \Delta_{\min}^{\max}$$

5- Integrate Crisp Values from Different Opinions of K Respondents

$$\tilde{\omega}_{ij}^{k} = 1/\mathrm{k}\left(\tilde{\omega}_{ij}^{1} + \tilde{\omega}_{ij}^{2} + \ldots + \tilde{\omega}_{ij}^{k}\right)$$

6- Generating the direct relation matrix

$$T = [t_{ij}]_{n \times n}$$

7- Normalizing the direct relation matrix. The normalized direct relation matrix I may be constructed by solving the equation on the basis of the direct relation matrix A.

$$S = k \times A$$

$$k = \frac{1}{\max\limits_{1 \le i \le n} \sum_{j=1}^{n} aij}$$

8- Total relation matrix. After obtaining the normalized direct relation matrix S, the total relation matrix I is designated as the identity matrix.

$$T = X(I - X) - 1$$

9- Making a causal diagram. Within the total relation matrix M, the sum of rows and sum of columns are denoted individually as vectors D and R. By mapping the dataset of (D+R, D-R), a cause and effect graph may be obtained. The horizontal axis vector (D+R) called "Prominence" is formed by adding D to R, revealing how important the criterion is. Similarly, the vertical axis (D-R) labeled "Relation" is created by subtracting D from R, which may be used to organize criteria into a cause group. Alternatively, if the (D-R) is negative, the criteria is assigned to the impact group.

$$T = [t_{ij}]_{n \times n}, \quad i,j = 1,2,\ldots,n$$

$$D = \left[\sum_{i=1}^{n} t_{ij}\right]_{1 \times n} = [t_j]_{n \times 1}$$

$$R = \left[\sum_{j=1}^{n} t_{ij}\right]_{1 \times n} = [t_j]_{n \times 1}$$

3.3.3. Findings

3.3.3.1. Identification of Variables

In the preliminary study, 5 out of 13 experts evaluated criteria and indicators from the literature with the aim of more appropriate and consistent study results. The experts, who commented on each factor one by one, added new perspectives to some concepts in the literature with their industry experience. Considering the characteristics of the Aliaga container port region, the experts made detailed examinations especially about the indicators in the B criterion and did not make any changes and they approved them. For the separation of physical and virtual technologies in the E criterion, the technology criteria was divided into two groups as

(E1) System connection with 3rd parties and (E2) Technology usage and developments. As in group E, the concept of security in (G) Security criteria was divided into two groups as internal and external risks. Previously, this article was under a general title as just being prepared for risks. In sustainability part of (F) Value added services, experts agreed that focusing only on environmental sustainability would be more appropriate to the overall structure of the study.

Finally, total 8 criteria and 18 indicators have been brought together to be used in this study with the contributions of the literature and experts, as seen in Table 7. Afterwards, these revised factors were evaluated by 13 experts.

Table 7: Hinterland Logistics Success Factors

Service Criteria	**Indicators**	**Description**	**References**
(A) Capacity	**(A1)** Shipping time depending on the number of customers	The amount of freight for different customers that can be shipped within a given time period.	Hazendock & Verbeke (2014) , Notteboom (2008) ,
	(A2) Empty container operation agreements with hinterland service providers	Empty container storage/forwarding facility and storage time capacity with contracted service providers (e.g. Warehouses)	Behdani et al. , Shintani et. al. (2021) , Song & Dong (2011) , Olivo et. al. (2005)
(B) Capability	**(B1)** Pricing agreements	Pricing strategies due to carriage, handling, storage etc.	Vanelslander et. al. (2016) , Hazendock & Verbeke (2014) ,
	(B2) Inland transport alternatives: Road / Rail	Connection availability with any transportation alternative	Woodburn (2017) , Jafari & Khosheghbal (2013) , Parola et. al. (2011) Rodrique (2022)

	(B3) To organize governmental process	Governmental regulation applications, Customs clearance activities, X-ray, VGM etc.	Beresford et. al. (2012)
	(B4) Cooperation with the port's hinterland service providers	Port has horizontal relationship with 3rd party hinterland depot / dry port beside its own storage/service area	Nguyen & Notteboom (2019) , De langen & Sharypova (2013)
	(B5) Distance of the port to hinterland Service providers	Location of aggregate parties	Deveci et. al. (2016), Lu & Yan (2015) , Garcia et. a. (2017)
	(B6) Third party services based on goods	Stacking of refrigerated goods or handling of breakbulk and OOG cargoes	Ambrosino et.al. (2013)
(C) Transit time	**(C1)** Time range of transit time between customers' place and depot which is given hinterland services of all the necessities of one booking	When an order is placed, it is decided, and it remains such until the transit activity is finished in delivery place.	Berg & Langen (2015), Feng et. al. (2015), Notteboom (2008) ,
(D) Reliability	**(D1)** Given reliable hinterland services	Services are given in the same range of quality in each shipment.	Notteboom (2008) , Zhao & Goodchild (2011) , Vernimmen et. al. (2007)
	(D2) Shows the attitude to be in the face of problems	In case of any problem will solve appropriate way.	Zhao & Goodchild (2011), Zomer et.al. (2019)
(E) Digital Technology Integration	**(E1)** System connection with 3rd parties	EDI based information flow with hinterland service providers	Wiegmans et. al. (2018)

	(E2) Technology usage and developments	Updated technological services are given during hinterland services such as updated infrastructure etc.	Jeevan et. al. (2018)
(F) Value added services	**(F1)** Adding and specializing new and updated service features to existing services	Stacking of reefer containers in a special racking system Special services of the warehouse; Specializing in special equipment services such as reefer container services, Flats and Tanks	Padilha & Ng (2012) , Vernimmen et. al. (2007) Franc & Horst (2010)
	(F3) Environmental Sustainability activities	Supplying hinterland service that reduces carbon footprint, emission control, green logistics applications	Iannone (2012), Tran e. al. (2017),, Rahimi et. al. (2008) , Roso & Lumsden (2010)
(G) Security	**(G1)** Being prepared for external risks	Existence of an action plan against external threats: disasters, terrorist attack, etc.	Chen et. al. (2018)
	(G2) Being prepared for internal risks	Security of the working environment while providing hinterland Services: tracking devices, cameras, etc.	Chen et. al. (2018)
(H) Reverse Logistics	**(H1)** Delivery of canceled shipments to exporters	Stopping the proper execution of the services provided until the cancellation stage and delivering them to the customer	Lee et. al. (2009), Min and Ko (2008)

Source: Author

3.3.3.2. Application of Fuzzy AHP Method

3.3.3.2.1. Application of Fuzzy AHP Method for Criteria

Hinterland Logistics services have many aspects to identify and analyze. The natural behavior of hinterland logistics success indicators has linguistic dimensions. To understand deeply, first of all, fuzzy set theory is used, and then Fuzzy AHP is used for the importance calculation of both criteria and indicators. Lastly, to calculate the causal and effected sides of the hinterland logistic services, fuzzy DEMATEL is studied.

Aiming to identify important criteria and indicators, the following sections are stated below.

1- Constructing the Pair Wise Comparison Matrix. This study uses Saaty's 1-9 Triangular Fuzzy numbers. Fuzzy AHP needs TFNs and Inverse TFNs due to comparison of mutual criteria or indicator evaluation.

Table 8: Triangular Fuzzy numbers 1-9 Scale

	TFNs			Inverse TFNs		
Linguistic Scale	**l**	**m**	**u**	**l**	**m**	**u**
Equal Importance (EI)	1	1	1	1	1	1
Modarate Importance (MI)	1	3	5	0,2	0,33	1
Strong Importance (SI)	3	5	7	0,14	0,2	0,33
Very Strong Importance (VSI)	5	7	9	0,11	0,142	0,2
Extreme Importance (EXI)	7	9	11	0,09	0,11	0,142

Source: Author

Each experts' responses are entered into the Pair Wise Comparison Matrix separately. One of them is shown below. After that, the average of all 13 experts' responses was taken.

Table 9: Example of Pair Comparison Matrix of Criteria

		A			B			C			D			E			F			G			H	
A	1	1	1	1	3	5	0,14	0,2	0,33	3	5	7	0,11	0,142	0,2	5	7	9	5	7	9	7	9	11
B	0,2	0,33	1	1	1	1	5	7	9	1	3	5	1	3	5	3	5	7	3	5	7	7	9	11
C	3	5	7	0,14	0,2	0,33	1	1	1	3	5	7	1	3	5	0,14	0,2	0,33	5	7	9	5	7	9
D	0,14	0,2	0,33	0,2	0,33	1	0,14	0,2	0,33	1	1	1	0,11	0,142	0,2	0,14	0,2	0,33	3	5	7	5	7	9
E	5	7	9	0,2	0,33	1	0,2	0,33	1	5	7	9	1	1	1	7	9	11	5	7	9	7	9	11
F	0,11	0,142	0,2	0,14	0,2	0,33	3	5	7	3	5	7	0,09	0,11	0,142	1	1	1	5	7	9	5	7	9
G	0,11	0,142	0,2	0,14	0,2	0,33	0,11	0,142	0,2	0,14	0,2	0,33	0,11	0,142	0,2	0,11	0,142	0,2	1	1	1	3	5	7
H	0,09	0,11	0,142	0,09	0,11	0,142	0,11	0,142	0,2	0,11	0,142	0,2	0,09	0,11	0,142	0,11	0,142	0,2	0,11	0,142	0,2	1	1	1

Source: Author

Table 10: Average Pair Comparison Matrix of Criteria

		A			B			C			D			E			F			G			H	
A	1,00	1,00	1,00	3,15	4,54	5,92	2,58	3,68	4,79	2,00	3,12	4,37	0,42	0,63	1,02	3,18	4,73	6,32	2,59	3,53	4,48	5,00	7,00	9,00
B	0,40	0,45	0,63	1,00	1,00	1,00	1,80	2,28	2,85	3,15	5,92	7,92	1,17	2,87	4,57	1,20	1,98	2,79	1,46	3,46	5,46	2,51	3,15	3,92
C	1,14	1,78	2,44	0,80	1,11	1,44	1,00	1,00	1,00	0,95	1,47	2,21	0,55	1,36	2,35	0,29	0,52	0,95	1,69	2,48	3,30	1,47	2,12	2,79
D	1,15	2,10	3,12	0,14	0,21	0,43	1,57	2,82	4,08	1,00	1,00	1,00	0,18	0,37	0,63	0,56	1,23	2,13	1,46	3,15	4,85	1,57	2,04	2,52
E	3,55	5,25	6,95	1,36	1,91	2,78	1,77	2,90	4,23	4,63	6,49	8,38	1,00	1,00	1,00	1,51	2,31	3,20	1,69	2,82	4,11	2,86	3,94	5,03
F	0,63	0,98	1,36	1,30	1,95	2,74	2,17	4,03	5,92	1,06	2,18	3,46	0,98	1,03	2,37	1,00	1,00	1,00	1,71	2,84	4,23	1,63	2,30	3,13
G	2,43	3,37	4,32	0,19	0,30	0,85	2,82	4,07	5,37	0,31	0,40	0,85	1,16	2,12	3,23	0,54	1,51	2,61	1,00	1,00	1,00	0,87	1,38	2,00
H	0,12	0,17	0,29	1,88	2,97	4,07	2,27	3,66	5,07	3,10	3,88	4,66	1,14	1,47	1,83	3,03	4,43	5,83	2,25	3,65	5,09	1,00	1,00	1,00

Source: Author

2- Calculate the Value of Fuzzy Synthetic Extent. Each fuzzy number as l, m and u are summed and listed. After, each l, m and u values' total summation is calculated.

$$\sum_{j=1}^{m} M_{gi}^{j}$$

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j \right)$$

Table 11: Value of Fuzzy Synthetic Extent of Criteria

	Fuzzy Sum of Each Column		
Criteria Variables	l	m	u
A	3,10	3,48	3,91
B	3,14	2,40	2,03
C	1,57	1,36	1,51
D	1,64	1,39	2,04
E	3,07	3,50	3,43
F	1,98	2,11	2,45
G	1,81	1,57	2,23
H	2,99	2,54	2,81
Column Sum	19,290	18,352	20,406

Source: Author

3- Inverse of Fuzzy Synthetic Extent. After the last step, matrix is getting invest with the help of sum of l, m and u values.

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i} , \frac{1}{\sum_{i=1}^{n} m_i} , \frac{1}{\sum_{i=1}^{n} l_i} \right)$$

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$$

Table 12: Inverse of Fuzzy Synthetic Extent of Criteria

	Fuzzy Synthetic Extent (S)		
Criteria Variables	l	m	u
A	0,152	0,190	0,203
B	0,154	0,131	0,105
C	0,077	0,074	0,078
D	0,080	0,076	0,106
E	0,150	0,191	0,178
F	0,097	0,115	0,127
G	0,089	0,086	0,115
H	0,146	0,138	0,146

Source: Author

4- Calculate the Degree of Possibility. To find the criteria/sub-criteria weight and the weight of the rating for alternatives, the elements in each row of the matrix will be aggregated. And lastly, calculation of the importance weight of criteria is done.

$$V\left(\tilde{M}_2 \geq \tilde{M}_1\right) = \sup_{y \geq x} \left[\min\left(\mu_{\tilde{M}_1}(x), \mu_{\tilde{M}_2}(y)\right)\right]$$

$$V\left(\tilde{M}_2 \geq \tilde{M}_1\right) = hgt(\tilde{M}_1 \cap \tilde{M}_2) = \mu_{M_2}(d)$$

$$= \begin{cases} 1, & \text{if} \quad m_2 \geq m_1 \\ 0, & \text{if} \quad l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \end{cases}$$

$$V(M \geq M_1, M_2, \ldots M_k) = V\left[(M \geq M_1) \ \ ve \ \ (M \geq M_2) \ \ ve \ldots (M \geq M_k)\right]$$
$$= \min \ \ V(M \geq M_i), \ \ i = 1,2,3,\ldots,k \qquad (12)$$

Table 13: Degree of Possibility of Criteria

	Degree of Possibility								Normalization	
	A	B	C	D	E	F	G	H	minimum	weight
A		1,00	1,00	1,00	0,98	1,00	1,00	1,00	0,98	0,55
B	0,00		1,00	1,00	0,00	1,00	1,00	0,00	0,00	0,00
C	0,00	0,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
D	0,00	0,00	1,00		0,00	-0,20	1,00	0,00	-0,20	0,00
E	1,00	1,00	1,00	1,00		1,00	1,00	1,00	1,00	0,50
F	0,00	0,00	1,00	1,00	0,00		1,00	0,00	0,00	0,00
G	0,00	0,00	1,00	1,00	0,00	0,01		0,00	0,00	0,00
H	0,00	1,00	1,00	1,00	0,00	1,00	1,00		0,00	0,00
								sum of mins:	1,78	

Source: Author

As a result of fuzzy AHP calculation for the criteria (A) Capacity is the most important criteria. Hazendock and Verbeke (2014) emphasized in their work, the capacity utilization of the actual intermodal terminals and logistical operations like warehouses, employment per hectare, added value per hectare, and the spatial productivity of inland container terminals and logistics activities in the port network. Also, according to Notteboom (2008), supply chain managers are increasingly basing their port and mode choice decisions on dependability and capacity considerations in addition to pure cost considerations due to growing worries about capacity bottlenecks in ports and inland infrastructures. In exchange for reliable guarantees from network partners in the hinterland that they will fulfill obligations regarding port capacity utilization criteria, a port authority will give priority to a certain seaport investment (Hazendock and Verbeke, 2014:238). Seaports that are situated along ineffective or constrained capacity corridors are undoubtedly at a disadvantage (Notteboom, 2008:7). Both studies also supported A1 and A2 indicators.

According to experts' answers (E) Digital Technology Integration comes second. Wiegmens et.al. (2008) explain the technology importance, a transportation system involves a large number of players and necessitates extensive communication and coordination between them.

3.3.3.2.2. Application of Fuzzy AHP Method for Indicator

In the continuation of the study, Fuzzy AHP was studied within the indicators to examine the details in more detail.

1- Constructing the Pair Wise Comparison Matrix.

Each experts' responses are entered into the Pair Wise Comparison Matrix separately. One of them is shown below. After that, the average of all 13 experts' responses was taken.

Table 14: Average Pair Comparison Matrix of Indicators

	A1			A2			B1			B2			B3			B4			B5			B6			C1	
A1	1,00	1,00	1,00	1,29	2,24	3,26	1,16	1,81	2,60	0,53	1,32	2,15	1,02	1,18	1,36	0,56	0,76	1,15	0,21	0,28	0,60	0,00	0,78	0,88	0,12	0,17	0,32
A2	1,23	2,05	3,03	1,00	1,00	1,00	0,62	0,81	1,04	1,14	1,65	2,14	2,14	2,95	3,92	0,89	1,43	2,26	0,40	0,91	1,55	0,68	1,07	1,77	0,99	1,53	2,38
B1	2,12	3,22	4,33	2,32	3,55	4,79	1,00	1,00	1,00	0,50	1,34	2,48	1,31	2,85	4,38	1,23	2,19	3,26	1,22	2,18	3,20	1,29	2,55	3,87	0,80	2,35	3,91
B2	2,38	3,51	4,85	2,50	3,59	4,74	1,00	2,28	3,77	1,00	1,00	1,00	1,39	2,78	4,16	0,86	0,87	0,88	0,53	0,55	0,60	0,41	0,78	1,52	0,17	0,26	0,67
B3	0,96	1,12	1,31	0,66	1,29	1,94	0,38	0,46	0,90	0,96	1,17	1,61	1,00	1,00	1,00	0,51	0,71	1,00	0,66	0,86	1,15	0,66	0,86	1,14	0,66	0,85	1,10
B4	1,40	2,49	3,62	1,42	2,82	4,23	1,25	2,19	3,26	1,62	1,92	2,23	3,39	5,24	7,09	1,00	1,00	1,00	0,80	1,12	1,45	1,18	1,67	2,23	0,88	1,20	1,62
B5	3,77	5,62	7,46	2,66	4,08	5,62	1,38	2,34	3,41	2,69	3,77	4,85	3,24	5,09	6,93	1,49	1,97	2,54	1,00	1,00	1,00	0,38	0,47	0,95	2,22	3,04	4,02
B6	2,17	3,10	4,08	1,33	2,88	4,44	1,10	1,93	2,95	2,26	3,67	5,15	3,55	5,39	7,24	0,81	1,14	1,55	1,46	3,00	4,54	1,00	1,00	1,00	1,92	2,38	2,85
C1	4,85	6,85	8,85	1,36	2,82	4,42	1,00	1,56	2,54	2,23	4,23	6,23	3,55	5,39	7,24	0,88	1,20	1,62	0,78	1,40	2,07	0,80	0,81	0,87	1,00	1,00	1,00
D1	0,79	0,98	1,21	0,81	0,83	0,90	0,56	0,83	1,56	0,91	1,09	1,34	2,47	4,16	5,88	0,38	0,46	0,90	1,10	1,76	2,54	0,62	0,66	0,88	1,31	1,97	2,80
D2	0,81	0,98	1,15	0,88	1,05	1,31	1,85	2,98	4,28	0,71	0,97	1,61	4,01	5,55	7,09	0,50	0,58	0,95	1,71	2,69	3,92	0,63	1,05	1,92	1,31	1,97	2,80
E1	2,69	3,77	4,85	2,40	3,63	4,87	1,65	3,05	4,46	1,44	1,92	2,43	4,47	6,16	7,86	1,06	1,40	1,87	3,58	5,13	6,74	1,20	1,52	1,87	2,38	4,08	5,77
E2	1,58	2,26	3,20	2,87	4,26	5,66	1,52	2,46	3,43	1,18	1,72	2,54	2,93	3,86	4,79	1,05	1,55	2,17	1,37	2,02	2,69	1,20	1,52	1,87	1,92	3,92	5,92
F1	2,32	4,18	6,08	1,79	3,48	5,18	0,30	0,70	1,44	0,60	0,84	1,46	2,23	3,18	4,18	1,21	2,63	4,18	3,77	5,77	7,77	1,04	2,29	3,56	1,15	2,54	3,92
F2	0,81	1,44	2,13	0,71	0,91	1,30	0,30	0,55	1,13	0,43	0,67	1,19	2,17	2,79	3,46	0,93	1,14	1,56	1,03	1,72	2,69	0,60	0,63	0,72	0,56	0,76	1,15
G1	0,78	1,26	1,77	1,45	2,39	3,36	0,74	1,06	1,44	0,66	1,75	2,86	1,93	2,89	3,92	2,51	3,43	4,69	0,41	0,92	1,57	2,83	3,94	5,18	0,49	1,16	2,01
G2	0,78	1,27	1,78	1,29	2,24	3,20	0,67	0,84	1,07	0,60	1,70	2,86	1,93	2,89	3,92	1,85	2,97	4,23	0,48	1,14	1,94	2,83	4,10	5,49	0,49	1,16	2,01
H1	0,17	0,27	0,71	0,59	0,60	0,63	0,73	1,09	1,54	0,60	0,63	0,68	2,38	3,15	3,92	0,83	1,02	1,34	0,47	0,52	0,69	0,84	1,03	1,36	0,68	0,71	0,85

	D1			D2			E1			E2			F1			F2			G1			G2			H1	
3,08	4,62	6,16	2,47	3,25	4,03	0,53	0,56	0,64	0,82	1,20	1,84	0,61	1,00	1,70	1,22	1,72	2,38	3,88	5,43	7,00	3,88	5,43	7,00	2,23	4,23	6,23
1,31	1,77	2,23	0,94	1,26	1,62	1,39	1,73	2,11	0,70	1,04	1,42	0,91	1,30	1,92	1,40	2,48	3,56	2,30	3,40	4,54	2,30	3,41	4,59	2,85	3,77	4,69
1,09	2,93	4,78	2,16	4,01	5,86	2,20	3,15	4,23	3,31	5,15	7,00	2,57	4,28	6,08	1,71	3,41	5,15	2,57	4,13	5,77	3,09	4,79	6,54	2,71	4,42	6,16
1,74	2,69	3,66	1,13	2,38	3,65	0,99	1,49	2,01	0,80	1,89	2,99	0,93	2,32	3,72	1,40	2,79	4,23	1,95	2,79	3,92	1,95	2,95	4,23	2,08	3,00	3,92
0,75	0,98	1,46	0,62	0,80	1,00	0,55	0,73	0,93	0,74	0,91	1,09	0,35	0,55	0,80	0,73	0,89	1,06	0,20	0,41	0,70	0,20	0,41	0,70	0,66	0,67	0,70
1,31	2,85	4,38	1,15	2,38	3,62	1,02	1,65	2,28	1,11	1,75	2,44	0,59	1,28	2,23	1,09	2,01	2,94	0,99	1,94	2,91	1,00	1,95	2,94	1,55	2,32	3,10
1,75	2,85	3,97	0,67	1,78	2,95	0,18	0,37	0,59	1,66	2,60	3,55	0,13	0,19	0,36	0,74	1,84	3,00	2,35	3,77	5,31	1,98	3,26	4,69	2,48	3,72	5,00
1,62	2,54	3,46	0,87	2,57	4,32	1,48	2,10	2,73	1,48	2,10	2,73	1,12	1,80	2,78	2,08	3,00	3,92	1,15	1,95	2,79	1,09	1,90	2,79	1,24	2,02	2,79
2,12	3,21	4,32	2,12	3,21	4,32	0,28	0,35	0,58	0,17	0,28	0,73	0,44	0,53	0,95	1,40	2,49	3,62	1,52	2,79	4,23	1,52	2,79	4,23	1,46	2,23	3,00
1,00	1,00	1,00	0,81	0,83	0,90	0,37	0,92	1,77	0,37	0,91	1,76	0,40	1,06	1,77	0,87	1,50	2,18	0,39	1,04	1,72	0,70	1,35	2,03	0,93	2,02	3,10
1,15	1,46	1,77	1,00	1,00	1,00	1,12	1,29	1,48	3,31	4,27	5,33	3,84	4,95	6,16	3,02	4,11	5,20	0,47	0,65	0,85	0,25	0,43	0,63	0,74	0,76	0,84
1,28	2,85	4,54	2,31	3,09	3,86	1,00	1,00	1,00	0,79	0,79	0,80	1,10	2,03	2,96	4,08	5,92	7,77	4,02	5,87	7,77	3,40	4,64	5,92	2,51	3,36	4,54
1,28	2,85	4,54	2,31	4,16	6,01	2,38	2,85	3,31	1,00	1,00	1,00	0,81	1,03	1,46	2,54	4,34	6,54	1,92	3,20	4,69	1,86	3,00	4,38	2,17	4,03	5,92
2,51	4,08	5,77	1,43	2,37	3,31	2,01	2,52	3,20	2,93	4,47	6,01	1,00	1,00	1,00	2,18	3,26	4,34	2,03	2,87	3,95	2,03	2,86	3,90	2,65	4,20	5,80
0,91	1,26	1,77	0,82	1,14	1,47	0,19	0,23	0,30	0,16	0,25	0,65	1,76	2,25	2,77	1,00	1,00	1,00	3,15	4,69	6,23	3,17	4,87	6,57	1,46	3,00	4,54
3,06	4,49	6,08	1,75	2,39	3,04	0,19	0,38	0,61	0,48	1,29	2,25	1,27	2,52	3,77	0,34	0,38	0,57	1,00	1,00	1,00	1,46	1,92	2,38	1,52	2,62	3,74
3,05	4,47	6,02	3,40	5,10	6,85	0,45	0,63	0,82	0,54	1,50	2,56	1,43	2,67	3,92	0,89	1,24	1,75	0,80	0,82	0,85	1,00	1,00	1,00	0,56	1,22	1,99
0,72	0,95	1,46	1,62	2,23	2,85	0,65	1,89	3,14	0,23	0,47	1,02	0,95	1,45	2,00	0,37	0,46	0,89	1,93	2,90	4,05	2,29	3,71	5,26	1,00	1,00	1,00

Source: Author

2- Calculate the Value of Fuzzy Synthetic Extent. Each fuzzy number as l, m and u are summed and listed. After, each l, m and u values' total summation is calculated.

$$\sum_{j=1}^{m} M_{gi}^{j}$$

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right)$$

Table 15: Value of Fuzzy Synthetic Extent of Indicators

Criteria Variables	Fuzzy Sum of Each Row		
	l	m	u
A1	25,20	36,98	50,40
A2	23,19	33,53	45,77
B1	33,19	57,51	82,81
B2	23,23	37,92	54,32
B3	11,24	14,69	19,60
B4	22,72	37,77	53,56
B5	30,78	47,73	66,19
B6	27,73	44,49	62,13
C1	27,37	43,15	60,80
D1	14,79	23,38	34,21
D2	27,31	36,73	48,30
E1	41,34	60,21	79,87
E2	31,91	50,22	70,13
F1	33,18	53,24	75,07
F2	20,17	29,30	40,64
G1	22,66	35,80	50,25
G2	23,03	36,95	52,26
H1	17,07	24,09	33,38
Column Sum	456,100	703,674	979,717

Source: Author

3- Inverse of Fuzzy Synthetic Extent. After the last step, matrix is getting invest with the help of sum of l, m and u values.

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right)$$

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$$

Table 16: Inverse of Fuzzy Synthetic Extent of Indicators

Criteria Variables	Fuzzy Synthetic Extent (S)		
	l	m	u
A1	0,026	0,053	0,111
A2	0,024	0,048	0,100
B1	0,034	0,082	0,182
B2	0,024	0,054	0,119
B3	0,011	0,021	0,043
B4	0,023	0,054	0,117
B5	0,031	0,068	0,145
B6	0,028	0,063	0,136
C1	0,028	0,061	0,133
D1	0,015	0,033	0,075
D2	0,028	0,052	0,106
E1	0,042	0,086	0,175
E2	0,033	0,071	0,154
F1	0,034	0,076	0,165
F2	0,021	0,042	0,089
G1	0,023	0,051	0,110
G2	0,024	0,053	0,115
H1	0,017	0,034	0,073

Source: Author

4- Calculate the Degree of Possibility. To find the criteria/sub-criteria weight and the weight of the rating for alternatives, the elements in each row of the matrix will be aggregated.

$$V\left(\widetilde{M}_2 \geq \widetilde{M}_1\right) = {}_{y \geq x} \sup\left[\min\left(\mu_{\widetilde{M}_1}(x), \mu_{\widetilde{M}_2}(y)\right)\right]$$

$$V\left(\widetilde{M}_2 \geq \widetilde{M}_1\right) = hgt(\widetilde{M}_1 \cap \widetilde{M}_2) = \mu_{M_2}(d)$$

$$= \begin{cases} 1, & \text{if} \quad m_2 \geq m_1 \\ 0, & \text{if} \quad l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \end{cases}$$

$$V(M \geq M_1, M_2, ...M_k) = V\left[(M \geq M_1) \;\; ve \;\; (M \geq M_2) \;\; ve....(M \geq M_k)\right]$$
$$= \min \;\; V(M \geq M_i), \;\; i = 1,2,3,....,k \qquad (12)$$

Table 17: Degree of Possibility of Indicators

	Degree of Possibility																	Normalization	
	A1	A2	B1	B2	B3	B4	B5	B6	C1	D1	D2	E1	E2	F1	F2	G1	G2	H1	Minimum	Weight
A1		1	0.724	0.985	1.000	0.987	1.000	0.889	0.904	1.000	1.000	0.674	0.866	0.788	1.000	1.000	1.000	1.000	0.674	0.058
A2	0.917		0.681	0.925	1.000	0.928	0.838	0.822	0.841	1.000	1.004	0.609	0.743	0.794	1.000	1.020	0.940	1.000	0.609	0.052
B1	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.973	1.000	1.000	1.000	1.000	1.000	1.000	0.973	0.084
B2	1.000	1.000	0.754		1.000	1.000	1.000	0.907	0.925	1.000	1.000	0.708	0.832	0.797	1.000	1.000	1.000	1.000	0.708	0.061
B3	0.353	1.888	0.130	0.399		0.370	0.863	0.257	0.271	1.256	1.019	0.012	0.171	0.143	1.198	1.032	0.381	1.245	0.012	0.001
B4	1.000	1.000	0.740	0.998	1.000		0.198	0.903	0.921	1.000	1.000	0.702	0.827	0.792	1.000	1.000	1.000	1.000	0.198	0.017
B5	1.000	1.000	0.889	1.000	1.000	1.000		1.000	1.000	1.000	1.000	0.893	0.970	0.934	1.000	1.000	1.000	1.000	0.893	0.075
B6	1.000	1.000	0.847	1.000	1.000	1.000	1.000		1.000	1.000	1.000	0.808	0.927	0.892	1.000	1.000	1.000	1.000	0.808	0.070
C1	1.000	1.000	0.830	1.000	1.000	1.000	0.098	0.092		1.000	1.000	0.700	0.000	0.874	1.000	1.000	1.000	1.000	0.700	0.060
D1	0.717	0.788	0.459	0.715	1.000	0.717	0.940	0.809	0.626		1.095	0.385	0.527	0.492	1.142	1.020	0.727	1.241	0.385	0.033
D2	0.011	1.000	0.709	0.980	1.000	0.982	0.557	0.876	0.895	1.000		0.656	0.791	0.754	1.260	1.000	0.990	1.000	0.557	0.048
E1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.086
E2	1.000	1.000	0.920	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.887		0.965	1.000	1.000	1.000	1.000	0.887	0.076
F1	1.000	1.000	0.956	1.183	1.000	1.000	1.000	1.100	1.000	1.000	1.000	0.025	1.000		1.000	1.000	1.000	1.000	0.025	0.000
F2	0.852	0.919	0.979	0.842	1.000	0.846	1.062	0.738	0.797	1.000	1.207	0.516	0.659	0.819		1.212	0.858	1.000	0.516	0.044
G1	0.980	1.000	0.712	0.966	1.000	0.969	0.888	0.869	0.887	1.000	0.851	0.662	0.791	0.755	1.000		0.901	1.000	0.662	0.057
G2	0.998	1.000	0.734	0.995	1.000	0.998	0.823	0.899	0.918	1.000	1.000	0.687	0.813	0.777	1.000	1.000		1.000	0.687	0.059
H1	0.720	0.788	0.451	0.716	1.000	0.720	0.844	0.688	0.626	1.000	1.004	0.378	0.522	0.487	1.309	1.018	0.731		0.378	0.032
																		Sum of min	11.617	1.000

Source: Author

Differently from the fuzzy AHP of criteria (E1) System connection with 3rd parties is the most important criteria. Subgroups of group (A) Capacity did not come first in the assessment of AHP. Then, (B1) Pricing agreements get into the second. Third and fourth are (F1) Adding and specializing new and updated service features to existing services and (E2) Technology usage and developments, respectively.

The first criteria (E1) System connection with 3rd parties, is the most important criteria supported in the literature. Lee and Lee (2016) find that, the economies of the flow of container cargoes in a supply-driven chain system, as well as the accompanying demand for transparency and less bureaucracy in customs, are strongly tied to the port management information system and EDI, which contribute to lowering a ship's time expenses and boosting a port user's utility. One of the important results of Lee et.al. (2010) is that the adoption of a worldwide message standard, such as EDI, is required to improve communication between business partners and the transportation industry.

(B1) Pricing agreements are of secondary importance to stakeholders in the current economic environment. Dry ports have emerged as a crucial component of multimodal supply chains, providing carriers with reduced transaction costs (Padilha and Ng, 2012:121). In a logistics environment where costs are high, the stakeholders state that prices are an important determinant when making their decisions. Footloose cargo movements are a reflection of a well-functioning, competitive port system, in which efficiency considerations or reduced transport costs influence logistics chain structure and port selection. A well-functioning, competitive port system drives logistics chain structure and port choice based on efficiency or reduced transport costs, resulting in footloose cargo movements (Hazendock and Verbeke, 2014:241)

Thirdly, (F1) Adding and specializing new and updated service features to existing services. Ports can no longer rely solely on their status as natural gateways to hinterlands to attract cargoes. Thus, dry ports have progressively acquired prominence as a means of capturing hinterland markets in this process (Padilha and Ng, 2012:100).

(E2) Technology usage and developments have a fourth degree of importance. Adoption of technology permits abundant information exchange, rapid and dependable data availability, and simple access to business associates (Iskandar and Ibrahim, 2010:497).

3.3.3.3. Application of Fuzzy DEMATEL Method

3.3.3.3.1. Application of Fuzzy DEMATEL Method for Criteria

In the second part of the hinterland logistics variable table, there are listed 8 criteria in detail. Aiming to understand of each indicators' importance among them, this method was used.

The following steps are followed in order:

• Establish the 8 different criteria which are mainly used in hinterland operations and studied in the literature.

• In this study, to do pairwise comparison, Chang's Triangular fuzzy numbers (TFNs) are used. Very high, high influence, low influence, very low and no influence values are shown in the bellow table.

Table 18: Saaty's Triangular Fuzzy Numbers (TFNs)

	TFNs			Inverse TFNs		
Linguistic Scale	**l**	**m**	**u**	**l**	**m**	**u**
Equal Importance (EI)	1	1	1	1	1	1
Modarate Importance (MI)	1	3	5	0,2	0,33	1
Strong Importance (SI)	3	5	7	0,14	0,2	0,33
Very Strong Importance (VSI)	5	7	9	0,11	0,142	0,2
Extreme Importance (EXI)	7	9	11	0,09	0,11	0,142

Source: Author

Following steps are belongs to one of experts' response.

• Experts' linguistic information turn into TFN as below.

Table 19: Linguistic Terms with TFNs

	A			B			C			D			E			F			G			H		
A	0	0,1	0,3	0,1	0,3	0,5	0,3	0,5	0,7	0,5	0,7	0,9	0,1	0,3	0,5	0,3	0,5	0,7	0,7	0,9	1	0,7	0,9	1
B	0,5	0,7	0,9	0	0,1	0,3	0,3	0,5	0,7	0,3	0,5	0,7	0,1	0,3	0,5	0,5	0,7	0,9	0,5	0,7	0,9	0,5	0,7	0,9
C	0,1	0,3	0,5	0,1	0,3	0,5	0	0,1	0,3	0,5	0,7	0,9	0,1	0,3	0,5	0,5	0,7	0,9	0,7	0,9	1	0,7	0,9	1
D	0,1	0,3	0,5	0,1	0,3	0,5	0,1	0,3	0,5	0	0,1	0,3	0,1	0,3	0,5	0,1	0,3	0,5	0,1	0,3	0,5	0,1	0,3	0,5
E	0,5	0,7	0,9	0,5	0,7	0,9	0,7	0,9	1	0,7	0,9	1	0	0,1	0,3	0,5	0,7	0,9	0,5	0,7	0,9	0,5	0,7	0,9
F	0,3	0,5	0,7	0,1	0,3	0,5	0,3	0,5	0,7	0,3	0,5	0,7	0,3	0,5	0,7	0	0,1	0,3	0,3	0,5	0,7	0,5	0,7	0,9
G	0,1	0,3	0,5	0,1	0,3	0,5	0,1	0,3	0,5	0,1	0,3	0,5	0,1	0,3	0,5	0,1	0,3	0,5	0	0,1	0,3	0,1	0,3	0,5
H	0,1	0,3	0,5	0,1	0,3	0,5	0,1	0,3	0,5	0	0,1	0,3	0	0,1	0,3	0	0,1	0,3	0	0,1	0,3	0	0,1	0,3

Source: Author

• Using linguistic information to transform fuzzy numbers into a crisp score, the fuzzy evaluations are applied, de-fuzzified, and aggregated as a crisp value. For each of the 13 experts, this whole calculation of crisp value is done separately. Then, all the crisps values' average is calculated for the DEMATEL calculation. First expert's crips value calculation is shown below.

1- Normalization of TFN valued response table:

$$xa_{1ij}^{k} = \left(a_{1ij}^{k} - \min a_{1ij}^{k}\right) \Big/ \Delta_{\min}^{\max}$$
$$xa_{2ij}^{k} = \left(a_{2ij}^{k} - \min a_{2ij}^{k}\right) \Big/ \Delta_{\min}^{\max}$$
$$xa_{3ij}^{k} = \left(a_{3ij}^{k} - \min a_{3ij}^{k}\right) \Big/ \Delta_{\min}^{\max}$$
$$\text{Where } \Delta_{\min}^{\max} = \max r_{ij}^{n} - \min l_{ij}^{m}$$

Table 20: Normalized TFNs

	A			B			C			D			E			F			G			H		
A	0,10	0,00	0,00	0,10	0,20	0,20	0,30	0,40	0,40	0,50	0,60	0,60	0,10	0,20	0,20	0,30	0,40	0,40	0,70	0,80	0,70	0,70	0,80	0,70
B	0,40	0,60	0,60	0,00	0,00	0,00	0,30	0,40	0,40	0,30	0,40	0,40	0,10	0,20	0,20	0,50	0,60	0,60	0,50	0,60	0,60	0,50	0,60	0,60
C	0,00	0,20	0,20	0,10	0,20	0,20	0,00	0,00	0,00	0,50	0,60	0,60	0,10	0,20	0,20	0,50	0,60	0,60	0,70	0,80	0,70	0,70	0,80	0,70
D	0,00	0,20	0,20	0,10	0,20	0,20	0,10	0,20	0,20	0,00	0,00	0,00	0,10	0,20	0,20	0,10	0,20	0,20	0,10	0,20	0,20	0,10	0,20	0,20
E	0,40	0,60	0,60	0,50	0,60	0,60	0,70	0,80	0,70	0,70	0,80	0,70	0,00	0,00	0,00	0,50	0,60	0,60	0,50	0,60	0,60	0,50	0,60	0,60
F	0,20	0,40	0,40	0,10	0,20	0,20	0,30	0,40	0,40	0,30	0,40	0,40	0,30	0,40	0,40	0,00	0,00	0,00	0,50	0,60	0,60	0,50	0,60	0,60
G	0,00	0,20	0,20	0,10	0,20	0,20	0,10	0,20	0,20	0,10	0,20	0,20	0,10	0,20	0,20	0,10	0,20	0,20	0,00	0,00	0,00	0,10	0,20	0,20
H	0,00	0,20	0,20	0,10	0,20	0,20	0,10	0,20	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Source: Author

2- Compute Right (Rs) And Left (Ls) Normalized Values

$$xls_{ij}^{k} = xa_{2ij}^{k} \Big/ \left(1 + xa_{2ij}^{k} - xa_{1ij}^{k}\right)$$
$$xrs_{ij}^{k} = xa_{3ij}^{k} \Big/ \left(1 + xa_{3ij}^{n} - xal_{2ij}^{k}\right)$$

Table 21: Compute result of Right (Rs) And Left (Ls) Normalized Values

	xls	xrs	xls	xrs	xls	xrs	xls	xrs	xls	xrs	xls	xrs	xls	xrs	xls	xrs
A	0,000	0,000	0,182	0,200	0,364	0,400	0,545	0,600	0,182	0,200	0,364	0,400	0,727	0,778	0,727	0,778
B	0,500	0,600	0,000	0,000	0,364	0,400	0,364	0,400	0,182	0,200	0,545	0,600	0,545	0,600	0,545	0,600
C	0,167	0,200	0,182	0,200	0,000	0,000	0,545	0,600	0,182	0,200	0,545	0,600	0,727	0,778	0,727	0,778
D	0,167	0,200	0,182	0,200	0,182	0,200	0,000	0,000	0,182	0,200	0,182	0,200	0,182	0,200	0,182	0,200
E	0,500	0,600	0,545	0,600	0,727	0,778	0,727	0,778	0,000	0,000	0,545	0,600	0,545	0,600	0,545	0,600
F	0,333	0,400	0,182	0,200	0,364	0,400	0,364	0,400	0,364	0,400	0,000	0,000	0,545	0,600	0,545	0,600
G	0,167	0,200	0,182	0,200	0,182	0,200	0,182	0,200	0,182	0,200	0,182	0,200	0,000	0,000	0,182	0,200
H	0,167	0,200	0,182	0,200	0,182	0,200	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Source: Author

3- Compute Total Normalized Crisp Values

$$x_{ij}^{k} = \left[xls_{ij}^{k}\left(1 - xls_{ij}^{k}\right) + xrs_{ij}^{k} \times xrs_{ij}^{n}\right] \Big/ \left(1 - xls_{ij}^{k} + xrs_{ij}^{k}\right)$$

Table 22: Total Normalized Crisp Values of Criteria

	xij	xij	xij	xij	xij	xij	xij	xij
A	0,000	0,185	0,378	0,576	0,185	0,378	0,765	0,765
B	0,555	0,000	0,378	0,378	0,185	0,576	0,576	0,576
C	0,173	0,185	0,000	0,576	0,185	0,576	0,765	0,765
D	0,173	0,185	0,185	0,000	0,185	0,185	0,185	0,185
E	0,555	0,576	0,765	0,765	0,000	0,576	0,576	0,576
F	0,358	0,185	0,378	0,378	0,378	0,000	0,576	0,576
G	0,173	0,185	0,185	0,185	0,185	0,185	0,000	0,185
H	0,173	0,185	0,185	0,000	0,000	0,000	0,000	0,000

Source: Author

$$\tilde{\omega}_{ij}^{k} = \min a_{ij}^{n} + x_{ij}^{n}\Delta_{\min}^{\max}$$

4- Integrate Crisp Values from Different Opinions of 13 Respondents

$$\tilde{\omega}_{ij}^{k} = 1/\mathrm{k}\left(\tilde{\omega}_{ij}^{1} + \tilde{\omega}_{ij}^{2} + \ldots + \tilde{\omega}_{ij}^{k}\right)$$

Table 23: Average Normalized Crisp Values of Criteria

	zij	zij	zij	zij	zij	zij	zij	zij
A	0,000	0,408	0,546	0,646	0,320	0,349	0,304	0,602
B	0,465	0,000	0,603	0,409	0,320	0,454	0,366	0,438
C	0,509	0,513	0,000	0,617	0,333	0,379	0,290	0,411
D	0,360	0,349	0,260	0,000	0,289	0,542	0,366	0,171
E	0,406	0,589	0,572	0,575	0,000	0,516	0,471	0,573
F	0,435	0,439	0,527	0,543	0,364	0,000	0,483	0,470
G	0,335	0,320	0,555	0,461	0,424	0,201	0,000	0,409
H	0,303	0,557	0,501	0,558	0,216	0,291	0,337	0,000

Source: Author

Then, calculation of the average crisps value table of all experts, DEMATEL methods are applied.

5- Generating the direct relation matrix. The values of each row are summed and the maximum total is determined.

$$T = [t_{ij}]_{n\times n}$$

Table 24: Direct Relation Matrix of Criteria

	A	B	C	D	E	F	G	H	Row
A	0,00	0,41	0,55	0,65	0,32	0,35	0,30	0,60	3,18
B	0,46	0,00	0,60	0,41	0,32	0,45	0,37	0,44	3,05
C	0,51	0,51	0,00	0,62	0,33	0,38	0,29	0,41	3,05
D	0,36	0,35	0,26	0,00	0,29	0,54	0,37	0,17	2,34
E	0,41	0,59	0,57	0,57	0,00	0,52	0,47	0,57	3,70
F	0,43	0,44	0,53	0,54	0,36	0,00	0,48	0,47	3,26
G	0,33	0,32	0,56	0,46	0,42	0,20	0,00	0,41	2,71
H	0,30	0,56	0,50	0,56	0,22	0,29	0,34	0,00	2,76
								Max	3,70

Source: Author

6- Normalizing the direct relation matrix. The normalized direct relation matrix I may be constructed by solving the equation on the basis of the direct relation matrix A.

$$S = k \times A$$

$$k = \frac{1}{\max\limits_{1 \le i \le n} \sum_{j=1}^{n} aij}$$

Table 25: Normalized Direct Relation Matrix of Criteria

	A	B	C	D	E	F	G	H
A	0,00	0,11	0,15	0,17	0,09	0,09	0,08	0,16
B	0,13	0,00	0,16	0,11	0,09	0,12	0,10	0,12
C	0,14	0,14	0,00	0,17	0,09	0,10	0,08	0,11
D	0,10	0,09	0,07	0,00	0,08	0,15	0,10	0,05
E	0,11	0,16	0,15	0,16	0,00	0,14	0,13	0,15
F	0,12	0,12	0,14	0,15	0,10	0,00	0,13	0,13
G	0,09	0,09	0,15	0,12	0,11	0,05	0,00	0,11
H	0,08	0,15	0,14	0,15	0,06	0,08	0,09	0,00

Source: Author

7- Total relation matrix. After obtaining the normalized direct relation matrix S, the total relation matrix I is designated as the identity matrix.

$$T = X(I - X) - 1$$

Identity matrix and (1-X) matrixes are shown below, then Total relation matrix is calculated.

Table 26: Total Relation Matrix of Criteria

	A	B	C	D	E	F	G	H
A	0,42	0,56	0,63	0,70	0,42	0,50	0,46	0,58
B	0,52	0,45	0,64	0,64	0,41	0,51	0,47	0,54
C	0,53	0,57	0,49	0,68	0,41	0,50	0,45	0,53
D	0,41	0,44	0,46	0,42	0,34	0,45	0,39	0,39
E	0,59	0,68	0,72	0,77	0,40	0,60	0,56	0,65
F	0,54	0,58	0,65	0,69	0,44	0,42	0,52	0,57
G	0,45	0,49	0,57	0,59	0,40	0,41	0,34	0,48
H	0,45	0,54	0,57	0,61	0,36	0,44	0,42	0,39

Source: Author

8- Making a causal diagram. Within the total relation matrix M, the sum of rows and sum of columns are denoted individually as vectors D and R. By mapping the dataset of (D+R, D-R), a cause and effect graph may be obtained. The horizontal axis vector (D+R) called "Prominence" is formed by adding D to R, revealing how important the criterion is. Similarly, the vertical axis (D-R) labeled "Relation" is created by subtracting D from R, which may be used to organize criteria into a cause group. Alternatively, if the (D-R) is negative, the criteria is assigned to the impact group.

$$T = [t_{ij}]_{n\times n}, \quad i,j = 1,2,\ldots,n$$

$$D = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} = [t_j]_{n\times 1}$$

$$R = \left[\sum_{j=1}^{n} t_{ij}\right]_{1\times n} = [t_j]_{n\times 1}$$

Table 27: Total Relation Matrix of Criteria with Row and Column addition

	A	B	C	D	E	F	G	H	D
A	0,42	0,56	0,63	0,70	0,42	0,50	0,46	0,58	4,28
B	0,52	0,45	0,64	0,64	0,41	0,51	0,47	0,54	4,19
C	0,53	0,57	0,49	0,68	0,41	0,50	0,45	0,53	4,15
D	0,41	0,44	0,46	0,42	0,34	0,45	0,39	0,39	3,31
E	0,59	0,68	0,72	0,77	0,40	0,60	0,56	0,65	4,97
F	0,54	0,58	0,65	0,69	0,44	0,42	0,52	0,57	4,41
G	0,45	0,49	0,57	0,59	0,40	0,41	0,34	0,48	3,74
H	0,45	0,54	0,57	0,61	0,36	0,44	0,42	0,39	3,77
R	3,91	4,32	4,74	5,11	3,18	3,83	3,61	4,12	0,51

Source: Author

According to the responses of all 13 experts about 8 criteria, Fuzzy DEMATEL result matrix are stated above. The average of all the values is 0,51 and it is called the threshold value and it shown in the Total Relation Matrix.

9- After the creation of Total Relation Matrix, next step is conducting visual analysis based on the cause and effect diagram. For this calculation, D and R values were added and subtracted.

Table 28: Row and Column Calculations of Total Relation Matrix of Criteria

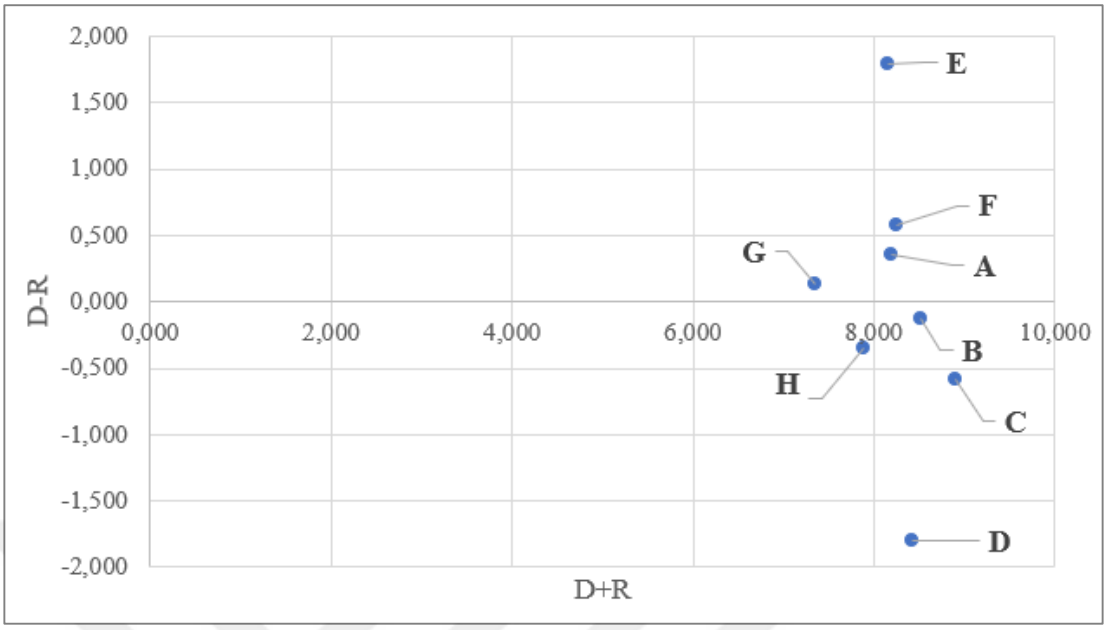
	D	R	D+R	D-R
A	4,276	3,914	8,190	0,362
B	4,190	4,321	8,511	-0,131
C	4,154	4,738	8,893	-0,584
D	3,312	5,107	8,419	-1,794
E	4,967	3,179	8,146	1,787
F	4,413	3,833	8,247	0,580
G	3,742	3,612	7,354	0,131
H	3,767	4,118	7,885	-0,350

Source: Author

Finally, all linguistic terms are transformed into a visual diagram through quantitative data. In this research result, A (Capacity), E (Digital Technology Integration), F (Value Added Services) and G (Security) are the influential criteria. (E) Digital Technology Integration is becoming the leading criteria which is stated in the upper right corner.

Additionally, influenced criteria are B (Capabilities), C (Transit time), H (Inverse Logistics) and D (Reliability) which is the most influenced criteria among the other ones.

Figure 16: Cause and Effect Diagram of Criteria



Source: Author

This is the general view of the results. In case of more detailed interpretation of all of them, threshold value is used and effect matrix is generated. In this calculation, the threshold value is equal to 0,51 which is calculated in the Total Relation Matrix. If the total relation matrix value is greater than the threshold, keep the value as it is. If the total relation matrix value is lower than the threshold, value is converted into 0,00.

Table 29: Effect Matrix of criteria

	A	B	C	D	E	F	G	H
A	0,0000	0,5635	0,6337	0,6991	0,0000	0,0000	0,0000	0,5794
B	0,5248	0,0000	0,6392	0,6379	0,0000	0,5123	0,0000	0,5388
C	0,5302	0,5716	0,0000	0,6765	0,0000	0,0000	0,0000	0,5270
D	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
E	0,5873	0,6774	0,7244	0,7707	0,0000	0,6016	0,5631	0,6462
F	0,5388	0,5840	0,6484	0,6940	0,0000	0,4246	0,5151	0,5668
G	0,0000	0,0000	0,5747	0,5913	0,0000	0,0000	0,0000	0,0000
H	0,0000	0,5392	0,5652	0,6130	0,0000	0,0000	0,0000	0,0000

Source: Author

Table 30: Relation bonds of Criteria

Relation Bonds	
Min	0,3380
Average	0,5128
Max	0,7707
Higher	1,0271

Weak

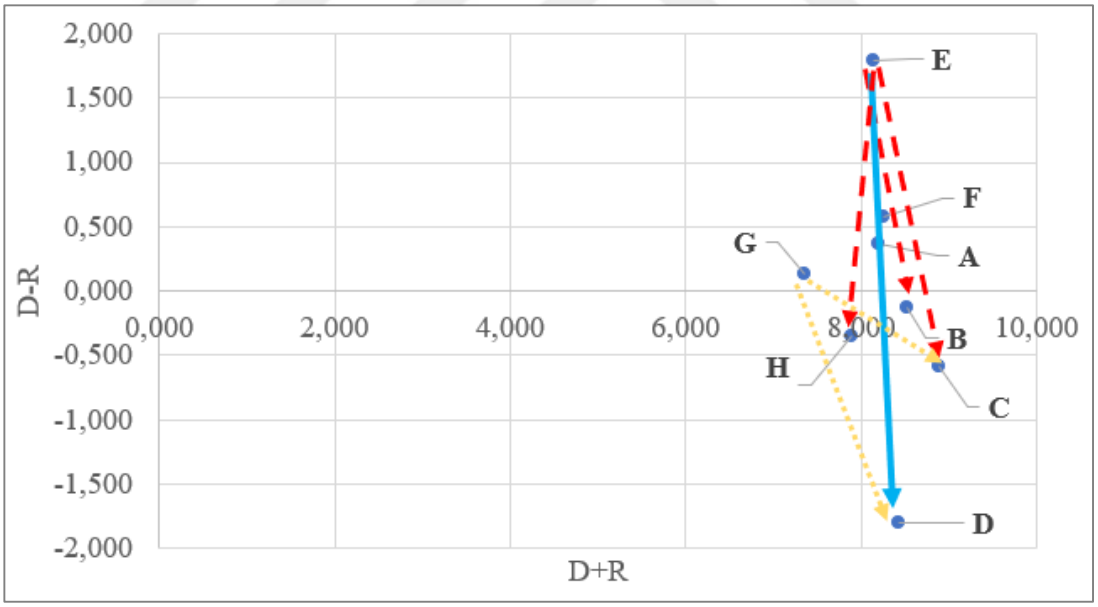
Medium

Strong

Source: Author

Also, importance relation bonds are calculated from total relation matrix values. According to minimum, average, maximum and higher calculations, bonds are grouped weak, medium and strong. So, importance relationship amounts to the all criteria will explain better.

Figure 17: Cause and Effect Diagram with Relation Bonds of Criteria



Source: Author

If the whole calculation of Fuzzy DEMATEL method for criteria is explained in detail, according to these visual diagrams:

- (E) Digital Technology Integration is the leading, or, in other words, decisive, criteria. Technological developments have been clearly important in recent years, and the last generation of port development emphasizes the importance of the technology. The development of EDI-based communication systems among the hinterland logistics actors eases the information flow and saves time during the hinterland services. Experts said that these databases prevent communication breakdowns and provide services in a more controlled manner as they reduce mail and telephone traffic. Additionally, it was concluded that other main criteria were positively affected by the updated technologies used in the services of the hinterland, such as well-developed shipyard equipment.
- (E) Digital Technology Integration has a strong relationship with (D) Reliability. Experts interpret the same quality and time hinterland services and to handle the problems via technology. To sum up, when the technology usage increases, reliability of hinterland service providers increases. Because of the globalization of the world and the regionalization of the ports, the whole system transfers into a technological base, and many new approaches are added to system design.
- (A) Capacity and (F) Value-Added Services have also had a moderate relationship with the affected group. Also, both of them have a more moderate relationship with Reliability and transit time, according to the relationship bond data. In the literature, what seems to be the key to organizational integration is the added value that ports can offer. Harding and Juhel (1997) evaluated the logistical potential of ports by differentiating between generic logistics services and value-added activities or logistics, with the former being a characteristic of containerized cargo. Carbone and De Martino (2003) discovered that crucial characteristics include information and communication technology as well as value-added aspects such as customer connections and satisfaction with provided services.
- (G) Security is also in the causal group. However, its bond with affected criteria is really low. Chen et al. (2018) explain in their study that, in most instances, terrorist attacks are difficult to anticipate. Nonetheless, it can be prevented to a certain extent through strategic investments. Price (2004) emphasized the significance of security investments and acknowledged their impact on reducing the likelihood of successful terrorist attacks. He recommended that seaports and terminal operators take the

terror threat seriously by establishing infrastructure and equipment, hiring security personnel, devising cargo inspection procedures, etc.

3.3.3.3.2. Application of Fuzzy DEMATEL Method for Indicator

According to criteria results, influential and effected criteria are identified. In addition to this formerly explained results, Fuzzy DEMATEL is applied to each indicator to deeply understand the importance relationship of each specific indicator.

This calculation has also the same steps and they followed in the next page.

The following steps are followed in order:

• Establish the 18 different indicators which are mainly used in the hinterland operations and studied in the literature.

• In this study to do pairwise comparison Chang's Triangular fuzzy numbers (TFNs) are used. Very high, high influence, low influence, very low and no influence values are shown below table.

Table 31: Saaty's Triangular Fuzzy Numbers (TFNs)

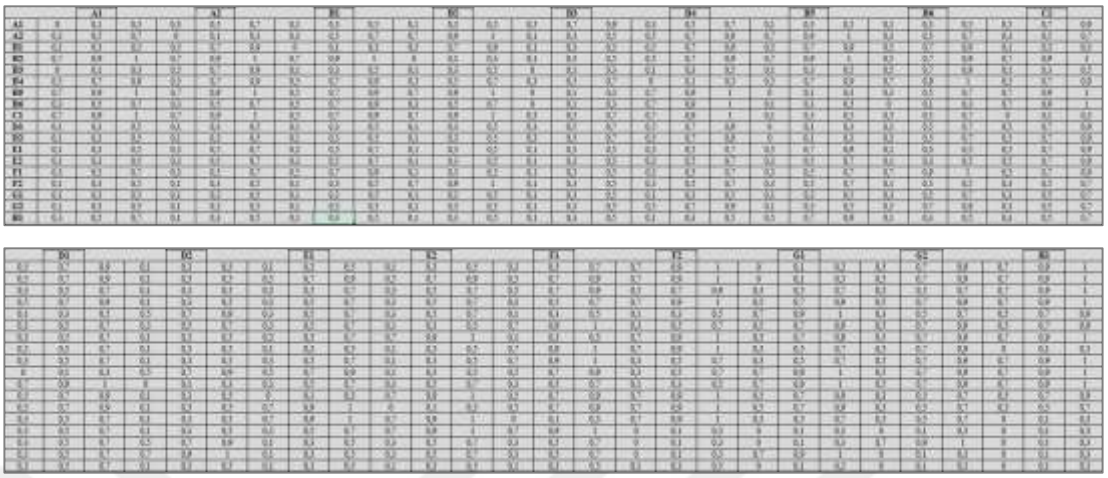
	TFNs			Inverse TFNs		
Linguistic Scale	**l**	**m**	**u**	**l**	**m**	**u**
Equal Importance (EI)	1	1	1	1	1	1
Modarate Importance (MI)	1	3	5	0,2	0,33	1
Strong Importance (SI)	3	5	7	0,14	0,2	0,33
Very Strong Importance (VSI)	5	7	9	0,11	0,142	0,2
Extreme Importance (EXI)	7	9	11	0,09	0,11	0,142

Source: Author

Following steps are belong to one of experts' response.

• As an example, one of Expert's linguistic information turn into TFN shown as below.

Table 32: Linguistic Terms with TFNs of Indicators



Source: Author

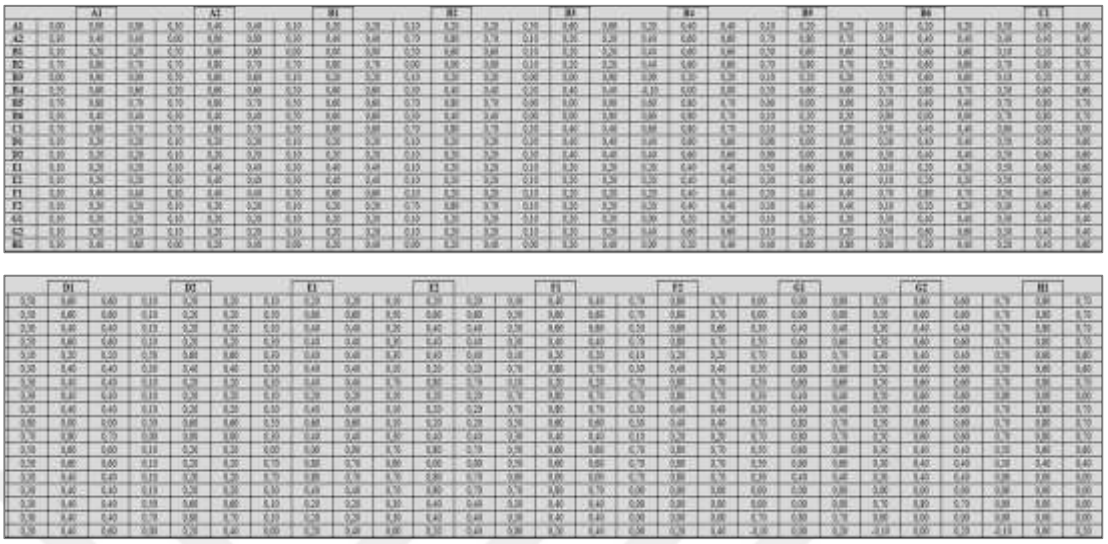
• Using linguistic information to transform fuzzy numbers into a crisp score, the fuzzy evaluations are applied, de-fuzzified, and aggregated as a crisp value. For each 13 experts, this whole calculation of crisp value done separately. Then, all the crisps values' average is calculated for the DEMATEL calculation.

Until 8th step only one of expert's response is calculated to crisps value then all 13 experts' average crisps is calculated in the 9th step.

10- Normalization of TFN valued response table:

$$xa_{1ij}^{k} = \left(a_{1ij}^{k} - \min a_{1ij}^{k}\right) \Big/ \Delta_{\min}^{\max}$$
$$xa_{2ij}^{k} = \left(a_{2ij}^{k} - \min a_{2ij}^{k}\right) \Big/ \Delta_{\min}^{\max}$$
$$xa_{3ij}^{k} = \left(a_{3ij}^{k} - \min a_{3ij}^{k}\right) \Big/ \Delta_{\min}^{\max}$$
$$\text{Where } \Delta_{\min}^{\max} = \max r_{ij}^{n} - \min l_{ij}^{n}$$

Table 33: Normalized TFNs of Indicators



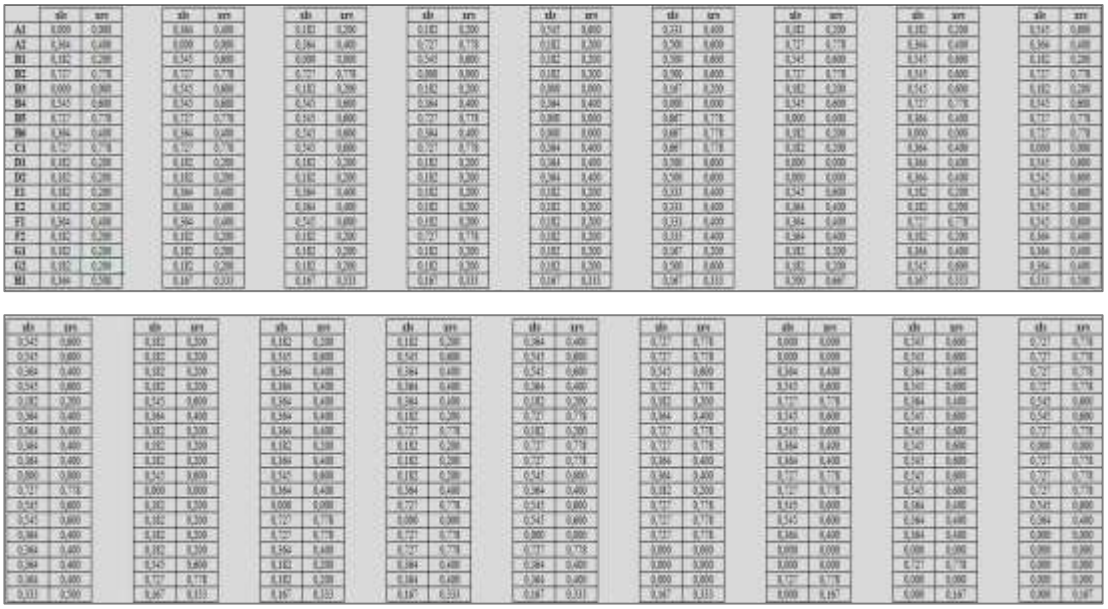
Source: Author

11- Compute Right (Rs) And Left (Ls) Normalized Values

$$xls_{ij}^{k} = xa_{2ij}^{k} \Big/ \left(1 + xa_{2ij}^{k} - xa_{1ij}^{k}\right)$$

$$xrs_{ij}^{k} = xa_{3ij}^{k} \Big/ \left(1 + xa_{3ij}^{n} - xal_{2ij}^{k}\right)$$

Table 34: Compute result of Right (Rs) And Left (Ls) Normalized Values of Indicators



Source: Author

12- Compute Total Normalized Crisp Values

$$x_{ij}^{k} = \left[xls_{ij}^{k}\left(1 - xls_{ij}^{k}\right) + xrs_{ij}^{k} \times xrs_{ij}^{n}\right] / \left(1 - xls_{ij}^{k} + xrs_{ij}^{k}\right)$$

Table 35: Total Normalized Crisp Values of Indicators

	xij	xij	xij	xij	xij	xij	xij	xij	xij	xij	xij	xij	xij	xij	xij	xij	xij	xij	xij
A1	0,000	0,378	0,185	0,185	0,576	0,358	0,385	0,185	0,576	0,578	0,185	0,385	0,385	0,578	0,765	0,000	0,576	0,765	
A2	0,378	0,000	0,378	0,765	0,185	0,555	0,765	0,378	0,378	0,576	0,185	0,576	0,576	0,576	0,765	0,000	0,576	0,765	
B1	0,185	0,576	0,000	0,576	0,185	0,555	0,576	0,576	0,185	0,378	0,185	0,378	0,378	0,576	0,576	0,378	0,378	0,765	
B2	0,765	0,765	0,765	0,000	0,185	0,555	0,765	0,576	0,765	0,576	0,385	0,378	0,578	0,378	0,765	0,576	0,576	0,765	
B3	0,000	0,576	0,185	0,185	0,000	0,173	0,185	0,576	0,185	0,185	0,576	0,378	0,378	0,185	0,185	0,765	0,378	0,576	
B4	0,576	0,576	0,576	0,378	0,378	0,000	0,576	0,765	0,576	0,378	0,378	0,378	0,385	0,765	0,378	0,576	0,576	0,576	
B5	0,765	0,765	0,576	0,765	0,000	0,744	0,000	0,378	0,765	0,378	0,185	0,378	0,765	0,185	0,765	0,576	0,576	0,765	
B6	0,378	0,378	0,576	0,378	0,000	0,744	0,185	0,000	0,765	0,378	0,185	0,185	0,185	0,765	0,765	0,378	0,576	0,000	
C1	0,765	0,765	0,576	0,765	0,378	0,744	0,185	0,378	0,000	0,378	0,185	0,378	0,185	0,765	0,378	0,378	0,576	0,765	
D1	0,185	0,185	0,185	0,185	0,378	0,555	0,000	0,378	0,576	0,000	0,576	0,576	0,185	0,576	0,378	0,765	0,576	0,765	
D2	0,185	0,185	0,185	0,185	0,378	0,555	0,000	0,378	0,576	0,765	0,000	0,378	0,378	0,378	0,185	0,765	0,576	0,765	
E1	0,185	0,378	0,378	0,185	0,185	0,358	0,576	0,185	0,576	0,576	0,185	0,000	0,765	0,576	0,765	0,576	0,378	0,576	
E2	0,185	0,378	0,378	0,185	0,185	0,358	0,378	0,185	0,576	0,576	0,185	0,765	0,000	0,576	0,765	0,576	0,378	0,378	
F1	0,378	0,378	0,576	0,185	0,185	0,358	0,378	0,765	0,576	0,378	0,185	0,765	0,765	0,000	0,765	0,378	0,378	0,000	
F2	0,185	0,185	0,185	0,765	0,185	0,358	0,378	0,185	0,378	0,378	0,185	0,378	0,765	0,765	0,000	0,000	0,000	0,000	
G1	0,185	0,185	0,185	0,185	0,185	0,173	0,185	0,378	0,378	0,378	0,576	0,185	0,378	0,378	0,000	0,000	0,765	0,000	
G2	0,185	0,185	0,185	0,185	0,185	0,555	0,185	0,576	0,578	0,378	0,765	0,385	0,578	0,578	0,000	0,765	0,000	0,000	
H1	0,424	0,214	0,214	0,214	0,214	0,214	0,595	0,214	0,405	0,405	0,214	0,214	0,214	0,214	0,214	0,024	0,024	0,000	

Source: Author

$$\tilde{\omega}_{ij}^{k} = \min a_{ij}^{n} + x_{ij}^{n}\Delta_{\min}^{\max}$$

13- Integrate Crisp Values from Different Opinions of 13 Respondents

$$\tilde{\omega}_{ij}^{k} = 1/\mathrm{k}\left(\tilde{\omega}_{ij}^{1} + \tilde{\omega}_{ij}^{2} + \ldots + \tilde{\omega}_{ij}^{k}\right)$$

Table 36: Average Normalized Crisp Values of Indicators

	zij	zij	zij	zij	zij	zij	zij	zij	zij	zij	zij	zij	zij	zij	zij	zij	zij	zij	zij
A1	0,000	0,556	0,319	0,706	0,230	0,700	0,572	0,215	0,707	0,647	0,200	0,483	0,396	0,663	0,614	0,292	0,513	0,513	
A2	0,423	0,000	0,455	0,512	0,558	0,577	0,586	0,500	0,586	0,516	0,470	0,418	0,365	0,601	0,554	0,173	0,320	0,498	
B1	0,438	0,619	0,000	0,892	0,289	0,671	0,602	0,561	0,260	0,587	0,260	0,676	0,381	0,576	0,691	0,335	0,289	0,469	
B2	0,586	0,706	0,527	0,000	0,378	0,671	0,544	0,706	0,735	0,531	0,501	0,395	0,469	0,646	0,605	0,304	0,395	0,691	
B3	0,413	0,486	0,512	0,471	0,000	0,259	0,497	0,691	0,319	0,289	0,393	0,304	0,215	0,601	0,471	0,231	0,259	0,394	
B4	0,576	0,424	0,484	0,437	0,200	0,000	0,246	0,423	0,707	0,556	0,378	0,705	0,531	0,348	0,616	0,277	0,488	0,561	
B5	0,677	0,648	0,488	0,649	0,260	0,730	0,000	0,393	0,349	0,556	0,200	0,440	0,514	0,440	0,675	0,543	0,573	0,408	
B6	0,647	0,546	0,557	0,601	0,171	0,686	0,501	0,000	0,482	0,556	0,501	0,512	0,394	0,721	0,319	0,512	0,573	0,260	
C1	0,588	0,559	0,587	0,663	0,215	0,686	0,334	0,230	0,000	0,259	0,348	0,333	0,289	0,544	0,646	0,349	0,290	0,409	
D1	0,557	0,557	0,409	0,393	0,527	0,715	0,364	0,720	0,707	0,000	0,561	0,605	0,411	0,531	0,675	0,393	0,486	0,453	
D2	0,557	0,501	0,601	0,531	0,215	0,539	0,304	0,378	0,424	0,467	0,000	0,497	0,353	0,558	0,486	0,423	0,409	0,378	
E1	0,586	0,452	0,497	0,661	0,259	0,656	0,319	0,289	0,483	0,602	0,289	0,000	0,424	0,663	0,725	0,424	0,527	0,290	
E2	0,573	0,512	0,572	0,617	0,468	0,538	0,319	0,646	0,691	0,632	0,500	0,617	0,000	0,605	0,648	0,409	0,497	0,289	
F1	0,691	0,275	0,591	0,366	0,274	0,626	0,542	0,289	0,561	0,500	0,691	0,663	0,349	0,000	0,378	0,259	0,333	0,514	
F2	0,441	0,557	0,586	0,645	0,378	0,582	0,440	0,646	0,245	0,556	0,200	0,646	0,423	0,498	0,000	0,246	0,172	0,276	
G1	0,441	0,305	0,319	0,307	0,230	0,437	0,366	0,486	0,587	0,528	0,517	0,488	0,425	0,439	0,144	0,000	0,349	0,157	
G2	0,542	0,305	0,379	0,387	0,320	0,452	0,366	0,647	0,471	0,275	0,560	0,601	0,425	0,366	0,411	0,334	0,000	0,514	
H1	0,408	0,618	0,589	0,539	0,229	0,449	0,300	0,522	0,661	0,310	0,617	0,317	0,405	0,434	0,478	0,302	0,200	0,024	

Source: Author

Then, calculation of the average crisps value table of all experts, DEMATEL methods are applied.

14- Generating the direct relation matrix. The values of each row are summed and the maximum total is determined.

$$T = [t_{ij}]_{n \times n}$$

Table 37: Direct Relation Matrix of Indicators

	A1	A2	B1	B2	B3	B4	B5	B6	C1	D1	D2	E1	E2	F1	F2	G1	G2	H1	ROW
A1	0,00	0,56	0,32	0,71	0,23	0,70	0,57	0,22	0,71	0,65	0,20	0,48	0,40	0,66	0,61	0,29	0,51	0,51	8,33
A2	0,42	0,00	0,45	0,51	0,56	0,38	0,59	0,50	0,59	0,52	0,47	0,44	0,37	0,60	0,55	0,17	0,32	0,50	7,93
B1	0,44	0,62	0,00	0,69	0,29	0,67	0,60	0,56	0,26	0,50	0,26	0,68	0,38	0,58	0,68	0,33	0,29	0,47	8,40
B2	0,59	0,71	0,53	0,00	0,38	0,67	0,54	0,71	0,73	0,53	0,50	0,40	0,47	0,65	0,60	0,30	0,39	0,69	9,39
B3	0,41	0,49	0,51	0,47	0,00	0,26	0,50	0,69	0,32	0,29	0,39	0,30	0,21	0,60	0,47	0,23	0,26	0,39	6,80
B4	0,58	0,42	0,48	0,44	0,20	0,00	0,25	0,42	0,71	0,56	0,38	0,71	0,53	0,35	0,62	0,28	0,49	0,56	7,95
B5	0,68	0,65	0,50	0,65	0,26	0,73	0,00	0,39	0,35	0,56	0,20	0,44	0,51	0,44	0,68	0,54	0,57	0,47	8,61
B6	0,65	0,55	0,56	0,60	0,17	0,69	0,50	0,00	0,48	0,56	0,50	0,51	0,39	0,72	0,32	0,51	0,57	0,26	8,54
C1	0,59	0,56	0,59	0,66	0,21	0,69	0,33	0,23	0,00	0,26	0,35	0,33	0,29	0,54	0,65	0,35	0,29	0,47	7,39
D1	0,56	0,56	0,41	0,39	0,53	0,72	0,36	0,72	0,71	0,00	0,56	0,60	0,41	0,53	0,68	0,39	0,49	0,45	9,06
D2	0,56	0,50	0,66	0,53	0,21	0,54	0,30	0,38	0,42	0,47	0,00	0,50	0,33	0,56	0,49	0,42	0,41	0,38	7,66
E1	0,59	0,45	0,50	0,66	0,26	0,66	0,32	0,29	0,48	0,60	0,29	0,00	0,42	0,66	0,73	0,42	0,53	0,29	8,16
E2	0,57	0,51	0,57	0,62	0,47	0,54	0,32	0,65	0,69	0,63	0,50	0,62	0,00	0,61	0,65	0,41	0,50	0,29	9,13
F1	0,66	0,27	0,59	0,37	0,27	0,63	0,54	0,29	0,56	0,50	0,60	0,66	0,35	0,00	0,38	0,26	0,53	0,51	7,78
F2	0,44	0,56	0,59	0,64	0,38	0,58	0,44	0,65	0,24	0,56	0,20	0,65	0,42	0,50	0,00	0,25	0,17	0,28	7,54
G1	0,44	0,30	0,32	0,31	0,23	0,44	0,37	0,49	0,59	0,53	0,52	0,47	0,43	0,44	0,14	0,00	0,35	0,16	6,50
G2	0,54	0,30	0,38	0,39	0,32	0,45	0,37	0,65	0,47	0,27	0,56	0,60	0,43	0,37	0,41	0,33	0,00	0,51	7,35
H1	0,41	0,62	0,50	0,54	0,23	0,45	0,30	0,52	0,66	0,32	0,62	0,32	0,40	0,43	0,48	0,30	0,20	0,02	7,50
																		max	9,39

Source: Author

15- Normalizing the direct relation matrix. The normalized direct relation matrix I may be constructed by solving the equation on the basis of the direct relation matrix A.

$$S = k \times A$$

$$k = \frac{1}{\max_{1 \le i \le n} \sum_{j=1}^{n} aij}$$

Table 38: Normalized Direct Relation Matrix of Indicators

	A1	A2	B1	B2	B3	B4	B5	B6	C1	D1	D2	E1	E2	F1	F2	G1	G2	H1
A1	0,00	0,06	0,03	0,08	0,02	0,07	0,06	0,02	0,08	0,07	0,02	0,05	0,04	0,07	0,07	0,03	0,05	0,05
A2	0,04	0,00	0,05	0,05	0,06	0,04	0,06	0,05	0,06	0,05	0,05	0,05	0,04	0,06	0,06	0,02	0,03	0,05
B1	0,05	0,07	0,00	0,07	0,03	0,07	0,06	0,06	0,03	0,06	0,03	0,07	0,04	0,06	0,07	0,04	0,03	0,05
B2	0,06	0,08	0,06	0,00	0,04	0,07	0,06	0,08	0,08	0,06	0,05	0,04	0,05	0,07	0,06	0,03	0,04	0,07
B3	0,04	0,05	0,05	0,05	0,00	0,03	0,05	0,07	0,03	0,03	0,04	0,03	0,02	0,06	0,05	0,02	0,03	0,04
B4	0,06	0,05	0,05	0,05	0,02	0,00	0,03	0,05	0,08	0,06	0,04	0,08	0,06	0,04	0,07	0,03	0,05	0,06
B5	0,07	0,07	0,05	0,07	0,03	0,08	0,00	0,04	0,04	0,06	0,02	0,05	0,05	0,05	0,07	0,06	0,06	0,05
B6	0,07	0,06	0,06	0,06	0,02	0,07	0,05	0,00	0,05	0,06	0,05	0,05	0,04	0,08	0,03	0,05	0,06	0,03
C1	0,06	0,06	0,06	0,07	0,02	0,07	0,04	0,02	0,00	0,03	0,04	0,04	0,03	0,06	0,07	0,04	0,03	0,05
D1	0,06	0,06	0,04	0,04	0,06	0,08	0,04	0,08	0,08	0,00	0,06	0,06	0,04	0,06	0,07	0,04	0,05	0,05
D2	0,06	0,05	0,07	0,06	0,02	0,06	0,03	0,04	0,05	0,05	0,00	0,05	0,04	0,06	0,05	0,05	0,04	0,04
E1	0,06	0,05	0,05	0,07	0,03	0,07	0,03	0,03	0,05	0,06	0,03	0,00	0,05	0,07	0,08	0,05	0,06	0,03
E2	0,06	0,05	0,06	0,07	0,05	0,06	0,03	0,07	0,07	0,07	0,05	0,07	0,00	0,06	0,07	0,04	0,05	0,05
F1	0,07	0,03	0,06	0,04	0,03	0,07	0,06	0,03	0,06	0,05	0,06	0,07	0,04	0,00	0,04	0,03	0,04	0,05
F2	0,05	0,06	0,06	0,07	0,04	0,06	0,05	0,07	0,03	0,06	0,02	0,07	0,04	0,05	0,00	0,03	0,02	0,03
G1	0,05	0,03	0,03	0,03	0,02	0,05	0,04	0,05	0,06	0,06	0,06	0,05	0,05	0,05	0,02	0,00	0,04	0,02
G2	0,06	0,03	0,04	0,04	0,03	0,05	0,04	0,07	0,05	0,03	0,06	0,06	0,05	0,04	0,04	0,04	0,00	0,05
H1	0,04	0,07	0,06	0,06	0,02	0,05	0,04	0,06	0,07	0,03	0,07	0,03	0,04	0,05	0,05	0,03	0,02	0,00

Source: Author

16- Total relation matrix. After obtaining the normalized direct relation matrix S, the total relation matrix I is designated as the identity matrix.

$$T = X(I - X) - 1$$

Identity matrix and (1-X) matrixes are shown in the below, then Total relation matrix is calculated.

Table 39: Total Relation Matrix of Indicators

	A1	A2	B1	B2	B3	B4	B5	B6	C1	D1	D2	E1	E2	F1	F2	G1	G2	H1
A1	0,34	0,38	0,35	0,41	0,22	0,44	0,33	0,33	0,41	0,38	0,28	0,37	0,30	0,41	0,41	0,25	0,30	0,33
A2	0,37	0,31	0,35	0,38	0,24	0,39	0,32	0,34	0,38	0,35	0,30	0,35	0,28	0,39	0,38	0,23	0,27	0,31
B1	0,39	0,39	0,32	0,42	0,23	0,44	0,34	0,37	0,37	0,38	0,29	0,40	0,30	0,40	0,42	0,25	0,28	0,33
B2	0,44	0,43	0,41	0,38	0,26	0,48	0,36	0,41	0,45	0,40	0,34	0,40	0,33	0,45	0,44	0,27	0,32	0,38
B3	0,32	0,31	0,31	0,33	0,16	0,33	0,28	0,32	0,31	0,29	0,26	0,30	0,23	0,34	0,33	0,20	0,23	0,27
B4	0,38	0,35	0,35	0,37	0,21	0,35	0,29	0,33	0,39	0,36	0,29	0,38	0,30	0,36	0,39	0,24	0,29	0,32
B5	0,42	0,40	0,38	0,42	0,23	0,45	0,28	0,36	0,38	0,38	0,29	0,38	0,32	0,40	0,42	0,28	0,32	0,33
B6	0,41	0,38	0,38	0,41	0,22	0,44	0,33	0,31	0,39	0,38	0,32	0,39	0,30	0,42	0,39	0,27	0,32	0,31
C1	0,36	0,34	0,34	0,37	0,20	0,39	0,28	0,29	0,30	0,31	0,27	0,32	0,26	0,36	0,37	0,23	0,25	0,29
D1	0,42	0,40	0,38	0,41	0,26	0,46	0,33	0,40	0,43	0,34	0,34	0,41	0,32	0,42	0,44	0,27	0,32	0,34
D2	0,37	0,35	0,36	0,37	0,20	0,39	0,28	0,32	0,35	0,34	0,24	0,35	0,27	0,37	0,37	0,24	0,27	0,29
E1	0,39	0,36	0,36	0,40	0,22	0,43	0,30	0,33	0,38	0,37	0,29	0,32	0,29	0,40	0,41	0,25	0,30	0,30
E2	0,43	0,40	0,40	0,43	0,26	0,45	0,33	0,40	0,43	0,41	0,34	0,42	0,28	0,43	0,44	0,28	0,32	0,33
F1	0,38	0,33	0,36	0,36	0,21	0,41	0,31	0,31	0,37	0,35	0,30	0,37	0,27	0,32	0,36	0,23	0,27	0,31
F2	0,36	0,35	0,35	0,38	0,22	0,40	0,30	0,34	0,33	0,35	0,26	0,36	0,28	0,37	0,32	0,23	0,25	0,28
G1	0,31	0,28	0,28	0,30	0,18	0,33	0,25	0,29	0,32	0,30	0,26	0,30	0,24	0,31	0,29	0,17	0,24	0,23
G2	0,35	0,32	0,32	0,34	0,21	0,37	0,28	0,33	0,34	0,31	0,29	0,35	0,27	0,34	0,35	0,23	0,22	0,29
H1	0,35	0,35	0,35	0,36	0,20	0,38	0,29	0,33	0,37	0,32	0,30	0,33	0,27	0,35	0,36	0,23	0,25	0,25

Source: Author

17- Making a causal diagram. Within the total relation matrix M, the sum of rows and sum of columns are denoted individually as vectors D and R. By mapping the dataset of (D+R, D-R), a cause and effect graph may be obtained. The horizontal axis vector (D+R) called "Prominence" is formed by adding D to R, revealing how important the criterion is. Similarly, the vertical axis (D-R) labeled "Relation" is created by subtracting D from R, which may be used to define criteria into a cause group. Alternatively, if the (D-R) is negative, the criteria is assigned to the impact group.

$$T = [t_{ij}]_{n\times n}, \quad i,j = 1,2,\ldots,n$$

$$D = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} = [t_j]_{n\times 1}$$

$$R = \left[\sum_{j=1}^{n} t_{ij}\right]_{1\times n} = [t_j]_{n\times 1}$$

Table 40: Total Relation Matrix of Indicators with Row and Column Addition

	A1	A2	B1	B2	B3	B4	B5	B6	C1	D1	D2	E1	E2	F1	F2	G1	G2	H1	D
A1	0,34	0,38	0,35	0,41	0,22	0,44	0,33	0,33	0,41	0,38	0,28	0,37	0,30	0,41	0,41	0,25	0,30	0,33	6,23
A2	0,37	0,31	0,35	0,38	0,24	0,39	0,32	0,34	0,38	0,35	0,30	0,35	0,28	0,39	0,38	0,23	0,27	0,31	5,93
B1	0,39	0,39	0,32	0,42	0,23	0,44	0,34	0,37	0,37	0,38	0,29	0,40	0,30	0,40	0,42	0,25	0,28	0,33	6,31
B2	0,44	0,43	0,41	0,38	0,26	0,48	0,36	0,41	0,45	0,40	0,34	0,40	0,33	0,45	0,44	0,27	0,32	0,38	6,96
B3	0,32	0,31	0,31	0,33	0,16	0,33	0,28	0,32	0,31	0,29	0,26	0,30	0,25	0,34	0,33	0,20	0,23	0,27	5,13
B4	0,38	0,35	0,35	0,37	0,21	0,35	0,29	0,33	0,39	0,36	0,29	0,38	0,30	0,36	0,39	0,24	0,29	0,32	5,95
B5	0,42	0,40	0,38	0,42	0,25	0,45	0,28	0,36	0,38	0,38	0,29	0,38	0,32	0,40	0,42	0,28	0,32	0,33	6,43
B6	0,41	0,38	0,38	0,41	0,22	0,44	0,33	0,31	0,39	0,38	0,32	0,39	0,30	0,42	0,39	0,27	0,32	0,31	6,38
C1	0,36	0,34	0,34	0,37	0,20	0,39	0,28	0,29	0,30	0,31	0,27	0,32	0,26	0,36	0,37	0,23	0,25	0,29	5,54
D1	0,42	0,40	0,38	0,41	0,26	0,46	0,33	0,40	0,43	0,34	0,34	0,41	0,32	0,42	0,44	0,27	0,32	0,34	6,68
D2	0,37	0,35	0,36	0,37	0,20	0,39	0,28	0,32	0,35	0,34	0,24	0,35	0,27	0,37	0,37	0,24	0,27	0,29	5,74
E1	0,39	0,36	0,36	0,40	0,22	0,43	0,30	0,33	0,38	0,37	0,29	0,32	0,29	0,40	0,41	0,25	0,30	0,30	6,10
E2	0,43	0,40	0,40	0,43	0,26	0,45	0,33	0,40	0,43	0,41	0,34	0,42	0,28	0,43	0,44	0,28	0,32	0,33	6,78
F1	0,38	0,33	0,36	0,36	0,21	0,41	0,31	0,31	0,37	0,35	0,30	0,37	0,27	0,32	0,36	0,23	0,27	0,31	5,83
F2	0,36	0,33	0,35	0,38	0,22	0,40	0,30	0,34	0,33	0,35	0,26	0,36	0,28	0,37	0,32	0,23	0,25	0,28	5,72
G1	0,31	0,28	0,28	0,30	0,18	0,33	0,25	0,29	0,32	0,30	0,26	0,30	0,24	0,31	0,29	0,17	0,24	0,23	4,91
G2	0,35	0,32	0,32	0,34	0,21	0,37	0,28	0,33	0,34	0,31	0,29	0,35	0,27	0,34	0,35	0,23	0,22	0,29	5,50
H1	0,35	0,35	0,35	0,36	0,20	0,38	0,29	0,33	0,37	0,32	0,30	0,33	0,27	0,35	0,36	0,23	0,25	0,25	5,62
R	6,78	6,44	6,35	6,85	3,94	7,33	5,48	6,10	6,70	6,29	5,25	6,52	5,10	6,85	6,87	4,35	5,02	5,49	0,33

Source: Author

According to response of all 13 experts about 18 indicators, Fuzzy DEMATEL result matrix are stated above. Threshold value is 0,33 and it shown in the Total Relation Matrix.

18- After the creation of Total Relation Matrix, next step is conducting visual analysis based on cause and effect diagram. For this calculation, D and R values were added and subtracted.

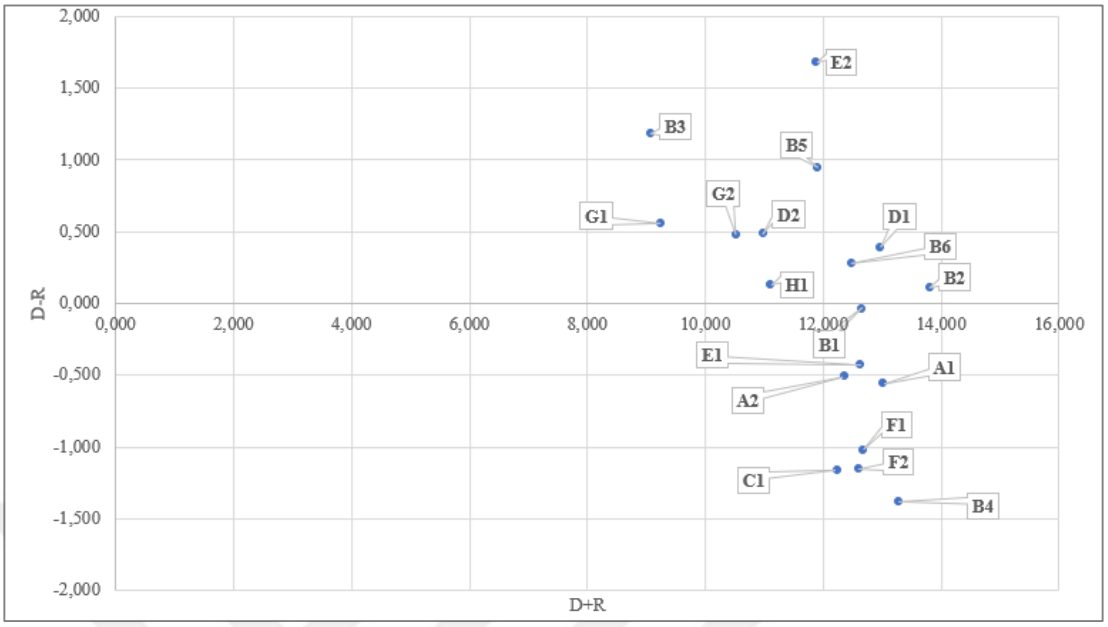
Table 41: Row and Column Calculations of Total Relation Matrix of Indicators

Indicator	D	R	D+R	D-R
A1	6,23	6,78	13,008	-0,556
A2	5,93	6,44	12,367	-0,510
B1	6,31	6,35	12,664	-0,039
B2	6,96	6,85	13,804	0,113
B3	5,13	3,94	9,068	1,184
B4	5,95	7,33	13,284	-1,383
B5	6,43	5,48	11,906	0,948
B6	6,38	6,10	12,478	0,278
C1	5,54	6,70	12,240	-1,163
D1	6,68	6,29	12,976	0,388
D2	5,74	5,25	10,985	0,489
E1	6,10	6,52	12,622	-0,426
E2	6,78	5,10	11,884	1,678
F1	5,83	6,85	12,674	-1,019
F2	5,72	6,87	12,597	-1,151
G1	4,91	4,35	9,256	0,560
G2	5,50	5,02	10,521	0,477
H1	5,62	5,49	11,117	0,130

Source: Author

Finally, all linguistic terms are transformed into a visual diagram through quantitative data.

Figure 18: Cause and Effect Diagram of Indicators



Source: Author

This is the general view of the results. In the case of a more detailed interpretation of all of them, a threshold value is used and an effect matrix is generated. In this calculation, the threshold value is equal to 0,33, which is calculated in the Total Relation Matrix. If the total relation matrix value is greater than the threshold, keep the value as it is. If the total relation matrix value is lower than the threshold, the value is converted into 0,00.

Table 42: Effect Matrix of Indicators

	A1	A2	B1	B2	B3	B4	B5	B6	C1	D1	D2	E1	E2	F1	F2	G1	G2	H1
A1	0,34	0,38	0,35	0,41	0,00	0,44	0,33	0,33	0,41	0,38	0,00	0,37	0,00	0,41	0,41	0,00	0,30	0,33
A2	0,37	0,00	0,35	0,38	0,00	0,39	0,00	0,34	0,38	0,35	0,00	0,35	0,00	0,39	0,38	0,00	0,27	0,00
B1	0,39	0,39	0,00	0,42	0,00	0,44	0,34	0,37	0,37	0,38	0,00	0,40	0,00	0,40	0,42	0,00	0,28	0,33
B2	0,44	0,43	0,41	0,38	0,00	0,48	0,36	0,41	0,45	0,40	0,34	0,40	0,33	0,45	0,44	0,00	0,32	0,38
B3	0,32	0,00	0,00	0,33	0,00	0,33	0,00	0,00	0,00	0,00	0,00	0,30	0,00	0,34	0,33	0,00	0,00	0,27
B4	0,38	0,35	0,35	0,37	0,00	0,35	0,00	0,33	0,39	0,36	0,00	0,38	0,00	0,36	0,39	0,00	0,00	0,00
B5	0,42	0,40	0,38	0,42	0,00	0,45	0,00	0,36	0,38	0,38	0,00	0,38	0,00	0,40	0,42	0,00	0,32	0,33
B6	0,41	0,38	0,38	0,41	0,00	0,44	0,33	0,00	0,39	0,38	0,32	0,39	0,00	0,42	0,39	0,00	0,32	0,00
C1	0,36	0,34	0,34	0,37	0,00	0,39	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,36	0,37	0,00	0,25	0,00
D1	0,42	0,40	0,38	0,41	0,00	0,46	0,35	0,40	0,43	0,34	0,34	0,41	0,00	0,42	0,44	0,00	0,32	0,34
D2	0,37	0,35	0,36	0,37	0,00	0,39	0,00	0,00	0,35	0,34	0,00	0,35	0,00	0,37	0,37	0,00	0,00	0,00
E1	0,39	0,36	0,36	0,40	0,00	0,43	0,30	0,35	0,38	0,37	0,00	0,00	0,00	0,40	0,41	0,00	0,00	0,00
E2	0,43	0,40	0,40	0,43	0,00	0,45	0,33	0,40	0,43	0,41	0,34	0,42	0,00	0,43	0,44	0,00	0,00	0,33
F1	0,38	0,33	0,36	0,36	0,00	0,41	0,00	0,00	0,37	0,35	0,00	0,37	0,00	0,00	0,36	0,00	0,00	0,00
F2	0,36	0,35	0,35	0,38	0,00	0,40	0,00	0,34	0,35	0,35	0,00	0,36	0,00	0,37	0,00	0,00	0,00	0,00
G1	0,00	0,00	0,00	0,00	0,00	0,35	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
G2	0,35	0,00	0,00	0,34	0,00	0,37	0,00	0,33	0,34	0,00	0,00	0,35	0,00	0,34	0,35	0,00	0,00	0,00
H1	0,35	0,35	0,35	0,36	0,00	0,38	0,00	0,33	0,37	0,00	0,00	0,00	0,00	0,35	0,36	0,00	0,00	0,00

Source: Author

Table 43: Relation Bonds of Indicator

Relation Bonds	
Min	0,16
Average	0,33
Max	0,48
Higher	0,64

Weak

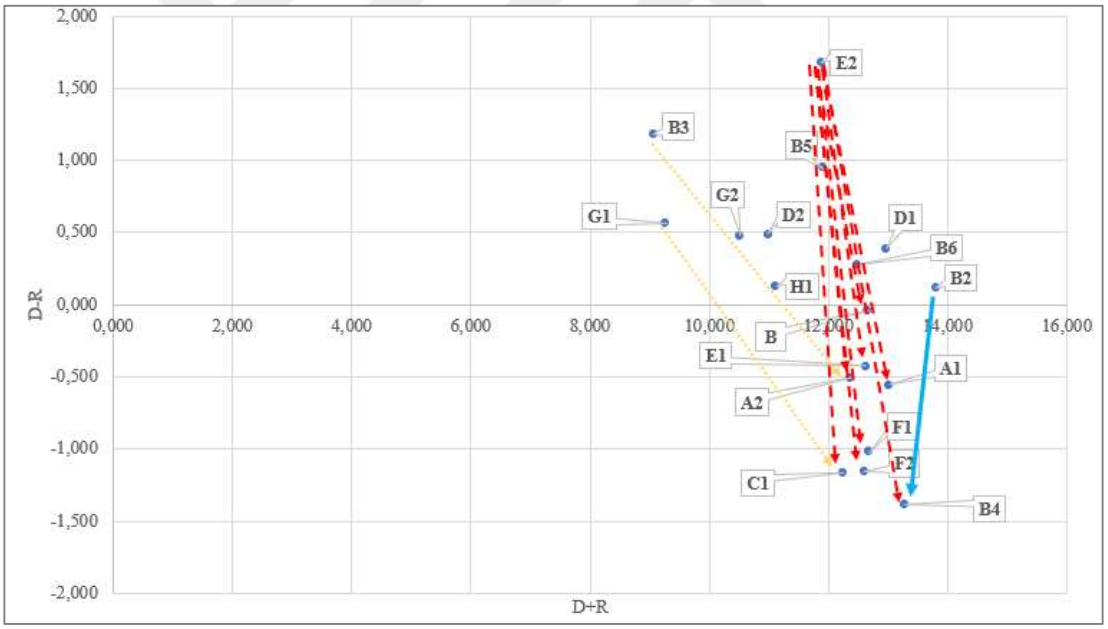
Medium

Strong

Source: Author

Also, importance relation bonds are calculated from Total relationship Matrix values. According to minimum, average, maximum, and higher calculations, bonds are grouped as weak, medium, and strong. So, the importance of relationships among all criteria will be explained better.

Figure 19: Cause and Effect Diagram with Relation Bonds of Indicators



Source: Author

Causal indicators are (B2) Inland transport alternatives: road / rail, (B3) To organize governmental process, (B5) Distance of the port to hinterland Service providers, (B6) Third party services based on goods, (D1) Given reliable hinterland services, (D2) Shows the attitude to be in the face of problems, (E2) Technology usage

and developments, (G1) Being prepared for external risks, (G2) Being prepared for internal risks and (H1) Delivery of canceled shipments to exporters.

Influenced indicators are (A1) Shipping time depending on the number of customers, (A2) Empty container operation agreements with hinterland service providers, (B1) Pricing agreements, (B4) Cooperation with the port's hinterland service providers, (C1) Time range of transit time between customers' place and depot which is given hinterland services of all the necessities of one booking, (E1) System connection with 3rd parties, (F1) Adding and specializing new and updated service features to existing services and (F2) Environmental sustainability activities.

- As with the criteria result, the indicator of (E) Digital technology integration and (E2) Technology usage and developments is the leading, decisive indicator among all of the indicators. (E2) Technology usage and developments have a moderate relationship with all the indicators. The most effective value is achieved with (B4) Cooperation with the port's hinterland service providers. It can be said that technology is important during cooperation processes. Because service providers' technological investments and usage of them in their operations Also, the second higher effect value (0,44) is with (F2) Environmental sustainability activities. From this point, this study shows that technology development and its application to hinterland services affect environmental sustainability the most. Thus, the developments of technology not only affect operational situations such as brand-new equipment but also their sustainable features. Jovic et al. (2020) discuss the importance of technology usage and its effect on sustainability in different aspects. For environmental sustainability, they emphasize that to achieve seaport sustainability, ecologically friendly approaches to seaport activities, operations, and management must be integrated. Because loading and discharging are two of the most important tasks in seaports, excessive waiting for goods owing to inadequate, outdated document exchange increases carbon dioxide emissions. Benemara et al. (2019), given its crucial economic and social relevance, as well as its relative environmental friendliness when measured in tons-miles, sea transport could become recognized as a sustainable development facilitator. However, if unsustainable transportation practices are continued,

maritime transit may lose some of its inherent benefits. For this reason, they stress in their work that technical advancements should be given more attention.

- Contrary to the indicator of (E2) Technology usage and developments, (E1) system connection with 3rd parties belongs to the influenced indicator group. In that point of view, system connection is still considered a need to develop as part of (E) Digital technology integration. More developed systems should be put in place. Also, this idea is supported by the experts' interpretation that it gives time and information advantages between actors such as hinterland service providers and container ports. (E1) The system connection with third parties belonging to the affected indicator groups is explained in the literature by the high costs of establishing these systemic connections and the need for a long time as a return.
- Another important point is (B2) Inland transport alternatives: road or rail. This causal indicator has a quite strong bond with (B4) Cooperation with the port's hinterland service providers. In addition to the availability and quality of road and rail connections, it is also important how contracted service providers can use these alternatives. In particular, the depots of the Aliaa container port area and the railway connection with Manisa have a positive effect on container operations. It is already mentioned in the literature that an effective port infrastructure should have a railway connection. Also, the importance of the special highway connection investment made a few years ago for the Aliaga container port area and the ports of the Nemrut Bay at the same time emerged at this point. Visser et al. (2007) support inland transport alternatives and connections; transportation between seaports and inland terminals is a critical component of this strategy. This notion requires low-cost, quick, and dependable services. Because of their strong direct links, these hinterland locations may position themselves as a true extension of the mainport (gateway); the 'port entrance' is effectively transferred inland. This implies that it can boost the seaport's competitive position by tying up cargo movements in the hinterland to the seaport. Also, Langen and Lugt (2017) in their study that the transport connection is critical for dry port operations because, as significant nodes in transportation networks, dry ports must have a high transport frequency as well

as enough transport infrastructure for optimal container distribution to and from seaports.

All other causal indicators have medium bond with the influenced indicators. In detail:

- (D1) Given reliable hinterland services influence the (B4) Cooperation with the port's hinterland service providers is most important. It can be said that the belief that reliable service will be provided plays an important role in the selection of hinterland service providers. Woxenius and Bergqvist, (2010) and Cullinane and Wilmsmeier, (2011) they agree that dry ports can enhance the cost-effectiveness, environmental performance, and logistical efficacy of hinterland connections.
- (D2) Shows the attitude to be in the face of problems and also has a stronger effect with (B4) Cooperation with the port's hinterland service providers most. Both (D1) and (D2) show that the attitude and reliability are the crucial features to cooperation between container ports and hinterland service providers. Accessibility to and from a dry port must be secure for its operations to run smoothly, and for the dry port to acquire the confidence of its clients. The reliability, punctuality, frequency, and information accessibility in the network are all improved by dry ports' safety and security features (Jarzemskis and Vailiauskas,2007)
- (B5) Distance of the port to hinterland service providers was most affected by (A1) Shipping time depending on the number of customers, (B2) Inland transport alternatives: road / rail and (B4) Cooperation with the port's hinterland service providers. In fact, the main factors affecting distance are time and transportation management. The results obtained comply with this logic. However, on contrary to some researches in the literature, distance term has more influential impact on the other indicators. For example, Deveci et. al. (2016), port location was determined to be the second-least significant factor among their 32 variables.
- (B6) Third-party services based on goods have the most effects (F1). Adding and specializing in new and updated service features for existing services It is also a consistent result. Some specialized goods, such as refrigerated goods, breakbulk, and OOG cargoes, need to be handled differently from standard container handling. Herein, hinterland service providers specialize in their usual services.

Some of them are famous for their specialized handling services. Aliaga container port region has this kind of specialized depot, such as breakbulk handling, for the containers.

- (G2) Being prepared for internal risks also has the most medium relationship with (B4) Cooperation with the port's hinterland service providers. it can be prevented to a certain extent through strategic investments of service providers, such as hiring security personnel.
- (H1) Delivery of canceled shipments to exporters has the most medium relationship between the most medium relationship with (B4) Cooperation with the port's hinterland service providers and (C1) Time range of transit time between customers' place and depot which is given hinterland services of all the necessities of one booking. In the time of cancellation of the shipment, cooperation between related actors and time are important, as seen in the effect matrix.
- (B3) To organize governmental processes that regarding transport and commerce facilitation, infrastructure, environment, investment, seaports, multimodal transport, logistics, and land can impact dry port operations (Hanaoka and Regmi, 2011) and (G1) Being prepared for external risks are in the causal group, however their bonds with the influenced group are quite low. As shown in the Effect Matrix of Indicators.

CONCLUSION

This study aims to determine the hinterland logistics success factors in the Aliaga container port region. Nemrut Bay, which hosts many different types of ports, is of great importance, especially for exporters. It is important to evaluate the hinterland logistics in this region, where exports are intense. At the same time, this region-specific study examines the concepts of maritime logistics and hinterland logistics that are still less studied in the literature of Türkiye. Hinterland logistics, which is still waiting to be examined and detailed and new approaches to be added, will be very useful in the literature as well as being added to the region.

This study, which was carried out with Aliaga container port employees, is divided into groups as criteria and indicators that can be called main and sub-factors based on the literature and knowledge. These criteria and indicators were evaluated and confirmed by the authorities in the preliminary study. Taking factors from the literature were evaluated by 5 authorities as a preliminary study. Based on the consensus, the definition of digital technology integration was approved for the (E) criteria title. (G) Security criteria was divided into two sub-indicators as internal and external risks. After the preliminary research step, 13 authorized employees of 3 container ports located in the Aliaga port area contributed to this study. At the stage of filling out the evaluation forms, the process was explained to the authorities either face-to-face or via telephone.

A total of 4 different evaluation questions received from the authorities were analyzed with Fuzzy AHP and Fuzzy DEMATEL methods, and results were obtained. As a result of the 4 evaluations obtained, the prominent success factor was (E) Digital technology integration. In the analyzes made for the criteria, this factor resulted as the most important factor. In the analyzes made for the indicators, the E group indicators come to the fore. In Fuzzy AHP result, both indicator (E1) System connection with 3rd parties and (E2) Technology usage and developments take the highest importance value. Additionally, in Fuzzy DEMATEL, (E2) Technology usage and developments is the most influential success factors among the all other causal factors. In addition, (E) Digital technology integration has a strong relationship with reliability. At that point, the port generation process's last step and the nature of maritime logistics are

supported. Technology usage and application are becoming more popular, and firms are investing in this area. The regionalization phase was responsible for the expansion of qualified inland connections. This includes investing in modern port infrastructure and implementing procedures and systems for efficient cargo handling, storage, and distribution, as well as supply chain management. This involves incorporating digital solutions, such as automated port management systems, data analytics, and artificial intelligence, that can increase productivity, reduce costs, and provide real-time insights into supply chain operations.

(A1) Shipping time, depending on the number of customers, is the second most important success criteria, and evaluation of the influential degree of these criteria also gives the same result. Thus, (A1) Shipping time, depending on the number of customers, is one of the influential criteria according to Fuzzy DEMATEL and has a moderate relationship with the affected group.

(F1) Adding and specializing new and updated service features to existing services is a success factor in the third due to the result of Fuzzy AHP. Also, it has high-medium relationship bonds with the influential indicators as an affected indicator.

Another important point in the results is (B4) Cooperation with the port's hinterland service providers. This success factor has a strong and moderately influential relationship with the causal group. Especially, (B2) Inland transport alternatives: road / rail have quite an effect on (B4) Cooperation with the port's hinterland service providers. Based on this result, the road and railway work carried out in the Aliaga container port area in recent years has yielded important results for the authorities in the region. This structural detail is important when choosing to work with its stakeholders.

To the professionals, the most significant contribution of this study for the sectoral moves and operations of the experts is to reveal how beneficial the technology investments are as a result of the calculations. This study has revealed that technological developments have a positive effect on reliability, especially among stakeholders.

As a limitation of the research, it can be considered that the region contains many types of ports. The operational processes of other ports in the region serving different cargo groups, of course, affect the container port hinterland. Aliaga port area

has a relatively complex structure and it is known that the operational processes in the region are affected by this situation. Also, the findings of this study should be evaluated considering some limitations. First of all, the main limitation of this study is that the evaluation form contains too many questions due to the methods used in the study. The number of participants was affected by this situation.

Based on the importance of the subject and the lack of similar studies in the literature, in this study, the concept of hinterland logistics was aimed at being developed by researching, evaluating, and finalizing it in the Aliaga container port area, which has a significant export capacity. On the other hand, it is the first study to be added from the Aliaga container port region to the existing studies for the hinterland logistics of Mersin, Antalya, and Marmara Region in the Turkish literature. Studies for the hinterland of the Aliaga region are available in the literature, but there is no other study that specifically focuses on the hinterland success factors of container ports. This study is open to development and has many details to work on. The results of the study are important for future studies. This study, which is evaluated from the perspective of container ports, can also be evaluated by hinterland service providers and liner or freight forwarders. The consistency and precision of the hinterland success factors in the Aliaga container port region is proven by the evaluation of other stakeholders.

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APPENDICES

APPENDIX 1: Evaluation Form for Hinterland Logistics Success Factors

HİNTERLAND LOJİSTİK BAŞARI FAKTÖRLERİNİN BELİRLENME ALİAĞA KONTEYNER LİMAN BÖLGESİ ÜZERİNE BİR ÇALIŞMA

Sayın yetkili,

Dokuz Eylül Üniversitesi – Denizcilik İşletmeleri Yönetimi yüksek lisans programı dahilinde Sayın Doç.Dr.Gül DENKTAŞ ŞAKAR ile hazırlamış olduğum "Hinterland Lojistik Başarı Faktörlerinin belirlenmesi: Aliağa Konteyner Liman Bölgesi Üzerine Bir Çalışma" isimli yüksek lisans tez çalışmama katkıda bulunacağınız için öncelikle teşekkür ederim.

Bu çalışma Aliaga bölgesi konteyner limanları hinterlandının başarı faktörleri hakkında detaylı bilgi edinmeyi amaçlamaktadır. Deniz lojistiğinin deniz taşıması dışında kalan bölgeyi ifade eden hinterland lojistiği, yüklerin limanlar ve iç bölgeler arasındaki akışı içermektedir. Hinterland lojistiği karayolu, demiryolu, iç su yolları, boru hatları olmak üzere dört rotayı kapsamaktadır. Bu rotalar ile hinterland hizmetleri alıcılarına ulaştırılır. Hinterland hizmetleri kapsamında denizcilik lojistiğini destekleyen çeşitli hizmetler bu çalışma içerisinde incelenmiş olup 8 ana kriter olarak gruplandırılmıştır. Her kriter farklı indikatörlere sahiptir ve toplam 18 indikatör bulunmaktadır. Bu yüksek lisans çalışmasında kullanılan metodolojiler doğrultusunda sizden kriterlere ve indikatörlere kendi içlerinde önem dereceleri vermeniz ve daha sonrasında birbirlerini ne kadar etkiliyor olduğunu belirlemeniz beklenmektedir.

Bu çalışmada verdiğiniz cevaplar için isminiz kullanılmayacaktır, bilgilerinize sunarım,

Teşekkürler,

Melike CANDAN

Kişisel Bilgiler	
Yaş:	
Ünvan:	
Görev tanımı:	
Toplam çalışma süresi:	
Limanda çalışılan toplam süre:	
Eğitim durumu:	

Tablo 1: Aliaga Bölgesi Konteyner Limanları Hinterlandında Sunulan Hizmet Kriterleri ve İndikatörleri

Hizmet kriteri	**İndikatör**	**Tanım**
(A) Kapasite	**(A1)** Müşteri sayısına bağlı olarak nakliye süresi	Belirli bir süre içinde sevk edilebilecek farklı müşterilere ait yük miktarı.
	(A2) Hinterland hizmet sağlayıcıları ile boş konteyner operasyon anlaşmaları	Anlaşmalı hizmet sağlayıcıları (örn. Depolar) ile boş konteyner depolama/yönlendirme imkanı ve depolama süresi kapasitesi
(B) Yetkinlikler	**(B1)** Fiyatlandırma anlaşmaları	Taşıma, elleçleme, depolama vb. hizmetlerin fiyatlandırma stratejileri.
	(B2) İç ulaşım alternatifleri: Karayolu / Demiryolu	Herhangi bir ulaşım alternatifi ile bağlantı kullanılabilirliği
	(B3) Devletin talep ettiği süreçlerin organize edilmesi	Resmi düzenleme uygulamaları, Gümrükleme faaliyetleri, Röntgen, VGM vb.
	(B4) Limanın Hinterland hizmet sağlayıcıları ile işbirliği	Depolama, tamir bakım vb.
	(B5) Limanın hinterland Hizmet sağlayıcılarına olan mesafesi	Anlaşmalı hizmet sağlayıcılarının konumu
	(B6) Yük cinsine bağlı olarak hinterland hizmet sağlayıcılarının hizmetleri	Örneğin, Soğutulmuş yüklerin istiflenmesi, Dökme yük ve taşmalı yüklerin elleçlenmesi

(C) Transit Süre	**(C1)** Hinterland hizmetleri verilen müşterinin konumu ile hinterland hizmet merkezinin arasında tek bir rezervasyona ait tüm hizmetlerin tamamlanma süresi	Taşıma rezervasyonu alındığında toplam hizmet süresine karar verilir ve teslimat yerinde transit faaliyeti bitene kadar bu süre sabit kalır.
(D) Güvenilirlik	**(D1)** Güvenilir Hinterland hizmetleri verilmesi	Her sevkiyatta aynı kalite ve sürede hizmet verilmesi
	(D2) Sorunlar karşısında tutarlı ve makul olma tavrının gösterilmesi	Herhangi bir sorun olması durumunda hinterland servis sağlayıcısı bu durumu uygun şekilde çözecektir.
(E) Dijital Teknoloji Entegrasyonu	**(E1)** Hinterland hizmet sağlayıcıları ile sistemsel bağlantının bulunması	Hinterland hizmet sağlayıcıları ile EDI tabanlı bilgi akışı
	(E2) Teknoloji kullanımı ve gelişmeler	Hinterland hizmetlerinin güncel altyapı ve güncel teknolojiler ile verilmesi
(F) Geliştirilmiş Hizmetler	**(F1)** Mevcut hizmetlere yeni ve güncellenmiş hizmet özellikleri ekleme ve uzmanlaşma	Reefer konteynerlerin özel raf sisteminde istiflenmesi Deponun özel hizmetleri; reefer konteyner hizmetleri, Flats ve Tank gibi özel ekipman hizmetleri üzerinde uzmanlaşmış olması
	(F2) Çevresel Sürdürebilirlik aktiviteleri	Karbon ayak izini azaltan Hinterland hizmetinin sağlanması, emisyon kontrolü, yeşil lojistik uygulamaları
(G) Güvenlik	**(G1)** Dış risklere hazılıklı olunması	Dış tehditlere karşı bir eylem planının varlığı: afetler, terör saldırısı vb.
	(G2) İç risklere karşı hazırlıklı olunması	Hinterland Hizmetleri sağlanırken çalışma ortamının güvenliği: takip cihazları, kamera vb.
(H) Tersine Lojistik	**(H1)** İptal edilen sevkiyatların ihracatçılara teslimi	İptal edilme aşamasına kadar verilen hizmetlerin uygun şekilde yapılmasının bırakılması ve müşteriye teslimi

Değerlendirme Bölümü

1- Kriter Önem Değerlendirmesi

Lütfen bu bölümde Kriterlerin birbiri karşısında ne kadar önemli olduğunu değerlendiriniz.

	Son Derece Önemli	Çok Önemli	Oldukça Önemli	Biraz Daha Önemli	Aynı Önemde	Biraz Daha Önemli	Oldukça Önemli	Çok Önemli	Son Derece Önemli	
A										**B**
A										**C**
A										**D**
A										**E**
A										**F**
A										**G**
A										**H**
B										**C**
B										**D**
B										**E**
B										**F**
B										**G**
B										**H**
C										**D**
C										**E**
C										**F**
C										**G**
C										**H**
D										**E**
D										**F**
D										**G**
D										**H**
E										**F**
E										**G**
E										**H**
F										**G**
F										**H**
G										**H**

2- İndikatör Önem Değerlendirmesi

Lütfen bu bölümde İndikatörlerin birbiri karşısında ne kadar önemli olduğunu değerlendiriniz.

	Son Derece Önemli	Çok Önemli	Oldukça Önemli	Biraz Daha Önemli	Aynı Önemde	Biraz Daha Önemli	Oldukça Önemli	Çok Önemli	Son Derece Önemli	
A1										A2
A1										B1
A1										B2
A1										B3
A1										B4
A1										B5
A1										B6
A1										C1
A1										D1
A1										D2
A1										E1
A1										E2
A1										F1
A1										F2
A1										G1
A1										G2
A1										H1
A2										B1
A2										B2
A2										B3
A2										B4
A2										B5
A2										B6
A2										C1
A2										D1
A2										D2
A2										E1
A2										E2
A2										F1
A2										F2
A2										G1
A2										G2
A2										H1
B1										B2
B1										B3
B1										B4
B1										B5
B1										B6
B1										C1
B1										D1
B1										D2
B1										E1
B1										E2
B1										F1
B1										F2
B1										G1
B1										G2
B1										H1
B2										B3
B2										B4
B2										B5
B2										B6
B2										C1
B2										D1
B2										D2
B2										E1
B2										E2
B2										F1
B2										F2
B2										G1

B2										G2
B2										H1
B3										B4
B3										B5
B3										B6
B3										C1
B3										D1
B3										D2
B3										E1
B3										E2
B3										F1
B3										F2
B3										G1
B3										G2
B3										H1
B4										B5
B4										B6
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B4										E2
B4										F1
B4										F2
B4										G1
B4										G2
B4										H1
B5										B6
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B5										D2
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B5										E2
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B5										G2
B5										H1
B6										C1
B6										D1
B6										D2
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B6										E2
B6										F1
B6										F2
B6										G1
B6										G2
B6										H1
C1										D1
C1										D2
C1										E1
C1										E2
C1										F1
C1										F2
C1										G1
C1										G2
C1										H1
D1										D2
D1										E1
D1										E2
D1										F1
D1										F2
D1										G1
D1										G2
D1										H1
D2										E1

D2										E2
D2										F1
D2										F2
D2										G1
D2										G2
D2										H1
E1										E2
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E1										G2
E1										H1
E2										F1
E2										F2
E2										G1
E2										G2
E2										H1
F1										F2
F1										G1
F1										G2
F1										H1
G1										G2
G1										H1
G2										H1

3- Kriter Etki Değerlendirme

Lütfen bu bölümde Kriterlerin birbirlerini ne derece etkilediğini değerlendiriniz.

Değerlendirme Ölçeği:	
Kısaltma	**Değer tanımlaması**
EY	Etkisi yok
BD	Biraz Daha Etkili
OE	Oldukça Etkili
ÇE	Çok Etkili
SD	Son Derece Etkili

	A	B	C	D	E	F	G	H
A	**EY**							
B		**EY**						
C			**EY**					
D				**EY**				
E					**EY**			
F						**EY**		
G							**EY**	
H								**EY**

4- İndikatör Etki Değerlendirme

Lütfen bu bölümde İndikatörlerin birbirlerini ne derece etkilediğini değerlendiriniz.

Değerlendirme Ölçeği:	
Kısaltma	**Değer tanımlaması**
EY	Etkisi yok
BD	Biraz Daha Etkili
OE	Oldukça Etkili
ÇE	Çok Etkili
SD	Son Derece Etkili

	A1	A2	B1	B2	B3	B4	B5	B6	C1	D1	D2	E1	E2	F1	F2	G1	G2	H1
A1	EY																	
A2		EY																
B1			EY															
B2				EY														
B3					EY													
B4						EY												
B5							EY											
B6								EY										
C1									EY									
D1										EY								
D2											EY							
E1												EY						
E2													EY					
F1														EY				
F2															EY			
G1																EY		
G2																	EY	
H1																		EY