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DOCTORAL THESIS
Doctor of Philosophy (PhD)

THE EFFECTS OF DRY PORTS ON INLAND CONTAINER LOGISTICS

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DECLARATION

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ABSTRACT

Doctoral Thesis

Doctor of Philosophy(PhD)

The Effects of Dry Ports on Inland Container Logistics

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The purpose of this thesis is to evaluate the effects of dry ports on inland container logistics in Turkey. The research process of this thesis has been designed in two parts. In the first part, stated choice experimentation has been used to evaluate how the variations in the attributes affect mode selection probabilities in the inland transportation corridor. The results of the stated choice experiment have shown that all of the attributes except transport time attribute is statistically significant. Additionally, the random coefficient mixed logit estimate has provided better model fit than the conditional logit estimate has. The elasticity analysis has indicated that the transportation cost attribute has the most substantial impact on the mode choice.

In the second part, how the variations in inland transportation service attributes affect dry port usage and inland container logistics using discrete event simulation modeling has been investigated. The impact of rail-based dry ports usage on inland container logistics depends on how well the shippers' preferences are met. The increase in the use of rail-based dry ports, in any case, reduces the ton-km of road transport. This can reduce the environmental impacts. However, the decline in total inland container transportation costs is depend on the ways to increase demand to rail-based dry port use. When the usage of rail-based dry port is increased by lowering the cost of the rail-based dry port, the total inland container logistics costs are reduced. Additionally, increasing the demand

for rail-based dry port usage by reducing the percentage of delayed shipments also decreases total inland container logistics costs. However, if the demand for the dry port is increased by increasing road transportation costs, the total inland container logistics costs are increased. The frequency of railway transport between dry port and seaport also has a significant impact on the inland container logistics. When the demand for rail-based dry port increases, it is necessary to increase the carrying capacity by increasing the frequency of the railway transportation to meet the demand.

Scientific contribution of this thesis is twofold. First, previous research has been extended by including aspects which are neglected. Preferences of potential dry port users have been took into account while analyzing the effects of dry port usage. Not only transportation cost has been considered as the determinant of inland transport mode choice, but also delays, transit time, frequency and free time have been considered. Additionally, the impacts of increasing dry port demand on railway capacity has been revealed.

Keywords: Dry Port; Denizli; Transport Mode Choice; Discrete-Event Simulation

ÖZET

Doktora Tezi

Kuru Limanların İç Konteyner Lojistiğine Etkileri

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Bu tezin amacı, Türkiye'de kuru limanların iç konteyner lojistiği üzerindeki etkilerini incelemektir. Tezin araştırma süreci iki bölüm olarak tasarlanmıştır. Birinci bölümde, ulaştırma modu tercihinde etkili değişkenlerin incelenen koridordaki konteynerde taşınan yüklerin iç ulaşım modu kullanım olasılıklarını nasıl etkilediği incelenmiştir. Analiz sonuçları, taşıma süresi değişkeninin dışındaki tüm değişkenlerin istatistiksel olarak anlamlı olduğunu gösterdi. Ek olarak, elastikiyet analizi, ulaşım maliyeti değişkeninin ulaştırma modu seçimi üzerinde en büyük etkiye sahip olduğunu ortaya koydu.

İkinci kısımda, iç ulaşım hizmeti değişkenlerindeki değişimlerin kuru liman kullanımı ve iç konteyner lojistiğini nasıl etkilediği ayrık olay simülasyon (discrete event simulation) modellemesi kullanılarak araştırılmıştır. Kuru liman kullanımının iç konteyner lojistiği üzerindeki etkisi, taşıtanların tercihlerinin ne kadar iyi karşılandığına bağlıdır. Kuru limanların kullanımındaki artış, her halükarda, karayolu ulaşımının ton-km'sini düşürmekte ve böylece çevresel etkileri de azaltmaktadır. Ancak, toplam konteyner lojistiği maliyetlerindeki düşüş, kuru liman kullanımına olan talebi artırma yollarına bağlıdır. Kuru liman kullanımı kuru limanın maliyetini düşürerek artırıldığında, toplam iç konteyner lojistik maliyeti azalır. Ek olarak, gönderilerin gecikme oranını azaltarak kuru liman kullanımına olan talebi arttırmak da, toplam konteyner iç lojistik maliyetlerini azaltmaktadır. Ancak, karayolu taşımacılığı maliyetlerinin arttırılmasıyla kuru limana olan talep arttığında, toplam konteyner lojistik maliyetleri artar. Kuru

liman ve liman arasındaki demiryolu taşımacılığının sıklığı da iç konteyner lojistiği üzerinde önemli bir etkiye sahiptir. Kuru liman talebi arttığında, talebi karşılamak için demiryolu taşımacılığının sıklığını artırarak taşıma kapasitesini arttırmak gereklidir.

Bu tezin bilimsel katkısı iki yönlüdür. İlk olarak, mevcut araştırmalarda ihmal edilen hususlar dahil edilerek bu araştırmalar daha ileriye taşınmıştır. Kuru liman kullanımının etkileri analiz edilirken potansiyel kuru liman kullanıcılarının tercihleri dikkate alınmıştır. İç ulaşım modunun seçiminde sadece ulaşım maliyeti değil, aynı zamanda gecikmeler, taşıma süresi, sıklık ve serbest süre de dikkate alınmıştır. Ayrıca, artan kuru liman talebinin demiryolu kapasitesindeki etkileri ortaya konmuştur.

Keywords: Kuru Liman; Denizli; Ulaştıma Modu Seçimi; Ayrık-Olay Simülasyonu

THE EFFECTS OF DRY PORTS ON INLAND CONTAINER LOGISTICS

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ABBREVIATIONS

CLM	Council of Logistics Management
CSCMP	Council of Supply Chain Management Professionals
FEU	Forty-foot Equivalent Unit
FIATA	International Federation of Freight Forwarders
NCPDM	National Council of Physical Distribution Management
OSB	Organize Sanayi Bölgesi
SCM	Supply Chain Management
TCDD	Türkiye Cumhuriyeti Devlet Demiryolları
TEU	Twenty-foot Equivalent Unit
TRL	Turkish Lira
TÜİK	Türkiye İstatistik Kurumu
UBAK	Türkiye Cumhuriyeti Ulaştırma Denizcilik ve Haberleşme Bakanlığı
UTİKAD	Uluslararası Taşımacılık ve Lojistik Hizmet Üretenleri Derneği

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INTRODUCTION

Globalization can be defined as an increase in the geographical dimension of economic, social and political interactions among nations including growth in traffic of import and export goods associated with international trade (Janelle and Beuthe, 1997). International trade has been deeply affected by globalization. Production facilities of companies have been moved to the countries which have lower labor costs (Dicken, 1998). This has increased the importance of efficient and effective transportation of goods.

The growth on the world population and globalization of production and consumption stimulated an increase in the world economy. According to the IMF, World GDP increased from $58.12 trillion to $79.87 trillion between 2007 and 2017 with an average growth of %3,74 per year (IMF, 2018). This economic growth resulted in a problem of moving raw materials to production places and finished goods to consumption places. Demand for transportation, which is the derived demand of international trade (Stopford, 2009), has risen along with the expectation of efficient and sustainable transportation.

Containerization has facilitated these developments. Demand for container transportation has risen enormously since the 1960's. International container trade increased 1.2 percent in 2015. In 2016, containerized trade had increased faster with a 3.1 percent and had reached 140 million TEUs. The volume of containerized trade was around 50 million TEUs in 1996 (UNCTAD, 2017). To enable such developments, container transportation industry has gone through changes to stimulate efficiency particularly in the three legs of container transportation; maritime transportation, container terminals and inland transportation of containers. To further exploit economies of scale, shipping lines operate larger container vessels and hub and spoke concept is put into practice. The larger sized vessels and increased container flow put capacity pressures on container terminals both in terms of handling equipment and container stacking area.

To cope with these issues, terminals took advantage of technological innovations and automation in their operations. However, land requirements can only be solved by

physical expansion. This is not possible for most terminals since they are surrounded by a city so that flawless inland transportation has gained importance for optimal capacity usage. According to Notteboom and Rodrigue (2005), the future of containerized maritime transport will be shaped by inland transportation that will enable the growth of international trade. Contemporary developments in maritime transport have essentially resulted from the improvements in inland transport systems (Notteboom and Rodrigue, 2007). Inland transportation of containers also has a big potential for cost reduction since the share of inland transportation costs of containers in the total transportation costs ranges between 40% to 80%, which makes it a crucial area for cost reduction (Notteboom and Rodrigue, 2005). Hinterlands of ports have become one of the key elements that link the supply chains by significantly impacting inland freight transportation regarding cost, availability, and time (Robinson, 2002).

Although hinterland is a well-known concept, it is difficult to draw the extent of hinterland since it varies with the type of commodity and the available transport infrastructure (Ferrari et al., 2011). Most of the flow going through the ports generated from their surroundings (Alonso et al., 2016). However, potential hinterlands of ports are dynamic: the size and shape of hinterlands can change over time because of economic conditions, seasonal changes, technological improvements, inefficiencies in infrastructure, policy and changing strategies of transport operators (Ferrari et al., 2011).

Containerization allowed different cargo types to be carried on the same ship creating economies of scale. Additionally, standardization in cargo transport systems brought by containerization made easier the cargo transshipment between different transport modes (Guerrero, 2014). Lower cargo handling and maritime transportation costs expanded the hinterlands by enabling door-to-door transport (Neufville and Tsunokawa, 1981).

Distance is no longer the only determining factor for hinterland development since land penetration of ports has expanded by containerization and intermodal transportation (Lihoussou and Limbourg, 2012). Traditionally, the distance used to be considered as the sole determinant factor for the hinterland of a port meaning that the shippers choose the closest port to ship their cargo overseas (Notteboom and Rodrigue, 2007). Containerization and intermodal transportation have changed this paradigm. Today

distance is one of the many determining factors of port hinterlands (Ferrari et al., 2011). After containerization, inland penetration abilities of ports become relevant for increasing volume of their traffic (Rodrigue and Notteboom, 2006). Total transport cost does not only affected by distance but also other factors such as “quality of infrastructure,” “frequency of inland transport service,” "efficient organization of inland transport” and “natural or political barriers” (Kramberger et al., 2015).

Intermodalism and containerization also changed the shapes of hinterlands: The shapes of hinterlands became discontinuous (Ferrari et al., 2011). The operational and infrastructural efficiency of inland intermodal connections plays a fundamental role in defining the hinterland of a port (Notteboom and Rodrigue, 2007). In the first stages of port development, transportation of inland cargo with trucks is a common practice. However, in the later stages, because of the growth in the volume of containers and extent of hinterlands, intermodal transportation become more favorable due to its low costs resulting from economies of scale (Van den Berg and De Langen, 2011). Hinterlands of ports do not have a continuous spatial pattern; they rather have a spatial pattern with blurred boundaries caused by the development of inland terminal facilities (Kronbak and Cullinane, 2011).

Development of inland terminal facilities plays a significant role in expanding the size of a port’s hinterland and easing inland access (Kramberger et al., 2015). Inland terminal facilities are usually called with different names: inland port, inland terminal, dry port, inland container depot and freight village, etc., but lately the term dry port has gradually become popular among academics and industry practitioners. A dry port refers to an inland terminal which has a direct link to a seaport with railway and/or highway (Beresford and Dubey, 1991).

Dry ports enable flawless inland access by reducing bottlenecks in seaports and inland transportation networks (Lättilä et al., 2013). They allow deeper inland penetration and penetration to hinterland markets of rival seaports, thus, create competitive advantage (Notteboom and Rodrigue, 2005; Wilmsmeier et al., 2011a). They also can be attraction factors for maritime transport flows (Kramberger et al., 2015). Additionally, building efficient inland logistics network by dry ports bring along agglomeration of logistics facilities in inland terminals that increase customer service proposition, form buffer

zones and help to reduce related costs (Rodrigue and Notteboom, 2012).

The rise of dry ports in inland container transportation is a favorable development of any policy aimed at use of environmentally friendly transport modes (Notteboom, 2008). Unfortunately, development of dry port facilities is in the infancy stage in many countries (Padilha and Ng, 2012). Freight transport policies and initiatives encouraging usage of dry ports play a fundamental role in creating the desired demand (Ng and Gujar, 2009b). Developing sound and effective policies for encouraging dry port usage requires an understanding of inland mode preferences of decision makers (Danielis and Marcucci, 2007). Additionally, dry port service providers must set their business strategies considering preferences of their customers to attract more customers.

The positive role of dry ports in reducing negative environmental impacts and increasing efficiency of inland transportation has attracted the attention of academics as well as industry practitioners. A great number of studies have been carried out about dry ports in recent years. However, a limited number of studies have empirically investigated the impacts of dry ports on inland logistics of maritime containers. In their analyses, current studies have only considered transport costs as a determining factor for the use of dry ports and have overlooked capacity constraints.

Turkey has been chosen as the research area for the research application of this thesis. Turkey is situated in a strategic location where it can be a hub for Europe-Asia cargo traffic with its rail and road connections to the main seaports. Considering road, rail and air transportation, Turkey is in a focal position for international transportation projects such as European Union's TRACECA project and China's Belt and Road initiative. Therefore, dry ports can support and facilitate international transportation corridors by providing necessary infrastructure and superstructure for movement of international freight. Turkish government authorities and private establishments have recently and increasingly shown interest in the construction of dry ports. Understanding of inland transportation mode preferences of shippers is important for developing effective policies for encouraging dry port usage. With this regard, in order to eliminate dead investments, it is required to empirically evaluate the impacts of dry ports usage on inland container logistics concerning the inland transportation mode choice of shippers in Turkish context.

This thesis aims to evaluate the effects of rail-based dry port usage on inland container logistics by considering the influence of transportation attributes on inland transportation mode choice. Following objectives assist to achieve the aim: the first objective is to investigate the effects of transportation attributes on the transportation mode choice in inland container logistics; the second objective is to evaluate the effects of rail-based dry port usage that caused by variations in the transportation attributes on inland container logistics.

The first chapter of the thesis explores dry port concept. In the first section of the chapter, seaport-inland transportation systems and models on seaport transportation system development is explored. Then, terminology of inland terminal facilities is investigated. After that, literature on dry ports is analyzed. At last, dry port facilities in the World and Turkey are introduced.

Second chapter provides information regarding emergence of logistics and role of dry ports in inland container logistics. First, emergence of logistics thought is explained. Then, logistics and supply chain management concepts are clarified. The role of logistics in the firm and in the economy is identified. Finally, roles of dry ports in inland container logistics are explored.

Third chapter includes research application which is conducted as two parts. In the first part, inland container transportation mode choice is analyzed by using stated choice experiment to accomplish the first objective. In order to apply stated choice experimentation method, alternatives, attributes and attribute levels must be identified. To determine them, literature review and semi-structured interview method were used. In the second part, to accomplish the second objective, dry port usage in the inland corridor was analyzed using discrete-event simulation method.

CHAPTER ONE
DRY PORT CONCEPT

The terminals located in hinterlands of seaports provide services and facilities for transportation of maritime freight between seaports and shippers' location. These terminals are called with various names: inland port, inland terminal, dry port, inland container depot and freight village, etc., but the term dry port gradually became popular among academics and industry practitioners. The first academic paper that used the terminology of "dry port" was published in 1981 (Munford, 1980). After this first paper until early 2000's, the scholars showed a faint interest in the subject. The scholarly interest in the dry port concept has increased since the early 2000's. Two academic journals (Research in Transportation Economics (vol. 33, 2011) and Maritime Economics and Logistics (vol. 14, 2012)) devoted special issues to the dry port concept.

Growing interest of shipping industry practitioners to the dry port concept increased the scholarly attention. Many reasons may behind this increased interest, but three factors come forward. The first factor is the increasing complexity of supply chains. To cope with intense competition resulted from globalization; manufacturing companies must minimize their costs. One way to achieve their objective is to get their supply chains highly integrated thus reducing their inventory carrying costs. Seaports can increase their integration in global supply chains by developing dry port facilities and making necessary logistics services available in the dry ports. The second factor is capacity issues resulting from increased volume of container transportation. Many ports in the world surrounded by a city and have a limited area to increase their capacity to deal with the increasing volume. This creates congestion on both sea and land sides of ports causing traffic jams and environmental externalities such as pollution and noise. Dry ports can solve those congestion and capacity issues. The third factor is the high costs emerging from the inland transportation of maritime containers. According to Rodrigue and Notteboom (2012), 80% of costs of container transportation generated from inland transportation of containers. The railway connection between seaport and dry port provides a high capacity of transportation making possible to take advantage of economies of scales.

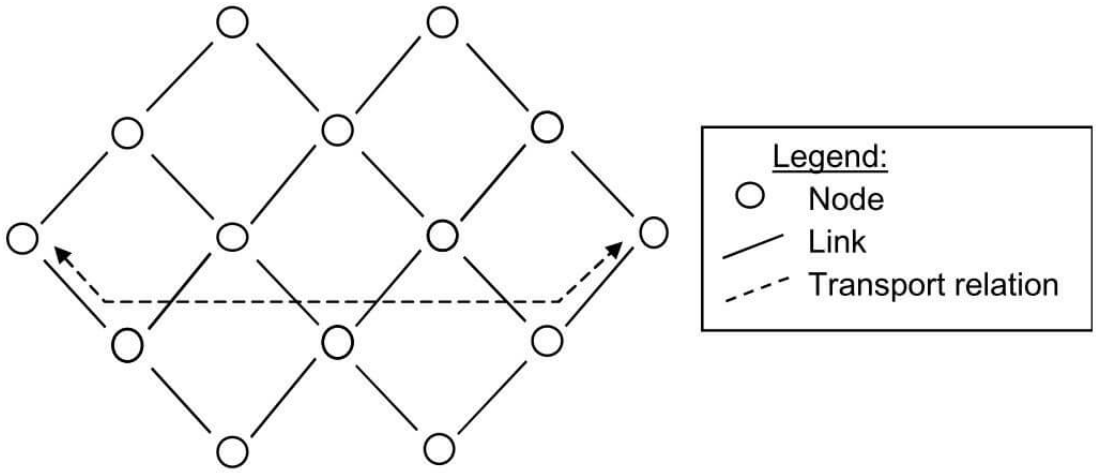
Dry port facilities smooth the way for efficient inland freight transportation by connecting seaports and hinterlands and providing services such as transshipment, consolidation, storage, and warehousing, etc. However, these dry port facilities come in different sizes, characteristics, and different functionality and vary in different countries even vary in different regions in a country. In this chapter, we aim to clarify dry port concept by reviewing spatial development seaport system and the emergence of dry port concept. In section 1, elements of an abstract freight transport system model such as nodes and links are explained. Section 2 reviews the previous models on spatial development of seaport system. In section 3, we revealed terminology and classification of inland nodes. Section 4 evaluates the dry port concept, and Section 5 investigates dry ports located in various parts of the World and Turkey.

1.1. FREIGHT TRANSPORTATION SYSTEM: NODES AND LINKS

Transfer of goods between the supply and demand points forms freight transport networks. Freight transport networks composed of nodes and links. Figure 1 illustrates a transportation network where transportation takes place between nodes through links. Nodes might be supply points where the goods are sourced into the system or demand points where the goods are consumed. They also might be transshipment nodes where facilities such as storage, consolidation, customs clearance as well as value added services, i.e., assembly, packaging and transshipment between means of transport modes are performed (Woxenius et al., 2004). The flow of goods stops in nodes. Links symbolizes movement of goods by connecting nodes with each other and forming freight transportation networks.

Node and link are the terms used for simplification and generalization of components in a freight transportation network (Woxenius et al., 2004). Supply and demand nodes can be warehouses, production bases or distribution centers of companies. Transshipment nodes can be areas where the terminal facilities, as well as value added services, are provided, i.e., seaports, airports or railway terminals. The links represent various means of transportation modes (seaborne, railway, airway, road, or combination or integration of these modes). Transportation of freight between supply and demand

Figure 1: A Transportation Network



Source: Woxenius et al. (2004)

nodes (such as production bases, warehouses or distribution centers of companies) takes place through transshipment nodes (i.e., seaports, airports, rail terminals) by utilizing one or various transportation modes, or combining and integrating different transportation modes.

1.2. SPATIAL DEVELOPMENT OF SEAPORT SYSTEM

Seaports are transshipment nodes where goods pass through while being transported from supply nodes to demands nodes. A large industrial and service cluster containing various terminals handling different types of cargoes can be considered as a port or a simple quay for berthing ships can be regarded as a port as well (Bichou and Gray, 2005). A seaport can be defined as a setting consisting of infrastructures and superstructures that can berth ships and serve various modes of transport, able to handle cargo from ship to shore and vice-versa, and able to provide value-added logistics services (Paixão and P., 2003). Seaports vary regarding their functions, sizes, and the type of cargo handled.

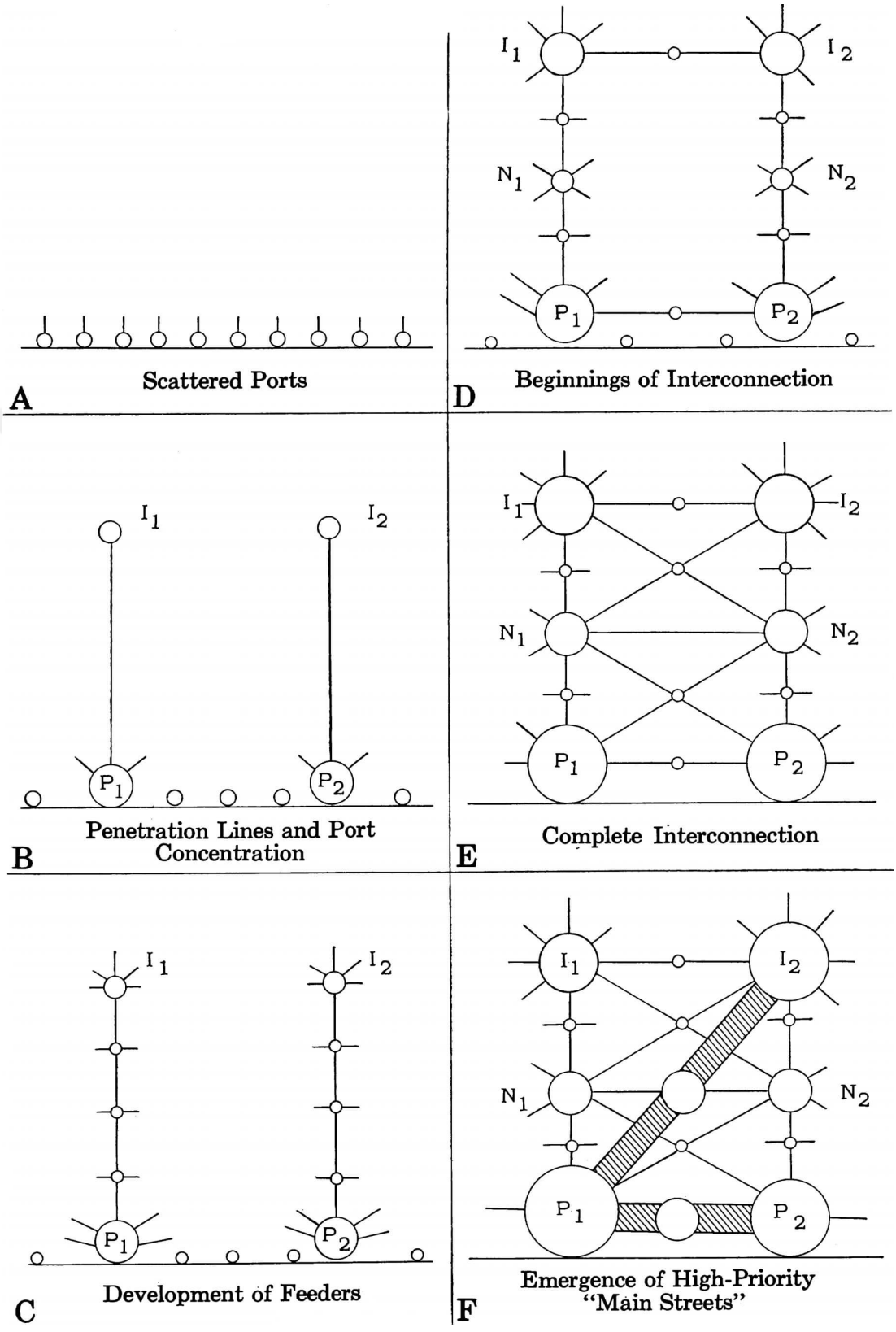
Seaports play an important role in the facilitation of international trade and economic growth of countries. They are the gateways, where import and export goods enter and exit a country or a region (Notteboom, 2010). Traditionally, seaports are

considered as mere transshipment nodes that transfer goods from ship to shore and visa a versa. However, with the widespread use of containers and the globalization of production and consumption, seaports undertook a new role in which they are the essential members of value chain (Robinson, 2002). Seaports evolved from being mere transfer nodes to gateways that add value to the goods passing through them. They are embed in supply chains providing information, value-added services, and inland accessibility to their customers (Robinson, 2002).

Attempts in understanding and modeling seaport development patterns date back to early 60's. Taaffe et al. (1963) put forward a model revealing sequence of transportation development that is illustrated in Figure 2. According to Taaffe et al. (1963), transportation development of a country or a region consist of six sequences; "scattered ports," "penetration lines and port concentration," "development of feeders," "beginnings of interconnection," "complete interconnection," and "emergence of high-priority main streets." At the first phase, there are disorderly lined up small ports along the seacoast. Hinterland is very limited and irregularly scheduled trading vessels call these ports. At the second phase, cost of hinterland transportation for some ports get smaller due to transport corridors penetrating to their hinterland causing port concentration. Relatively bigger ports and interior centers in the region begin to become hubs for feeder routes. At the third phase, hub ports expand their hinterland causing smaller ports to diminish. At the fourth phase, along with inland corridors, nodes start to develop, and feeder routes continue to develop from these nodes as well. These feeder routes trigger the formation of nodes along inland corridors. At the fifth phase, interior nodes and ports mostly establish connections with each other. At the last stage, main routes or "main streets" develop between ports and some of the connected inland nodes (Taaffe et al., 1963).

Bird (1963) developed a model called "anyport" which describes the spatial development of ports in time. The model proposes six stages to demonstrate how facilities of a typical port develop. Changes in the layout of a port are demonstrated in each stage of the anyport model that illustrates the way how present port facilities have evolved. The first stage is called "primitive era" and includes construction of storage area and jetty to make handling facilities possible. Increasing number and size

Figure 2: Taaffe's Model for Seaport Syatem Development



Source: Taaffe et al. (1963)

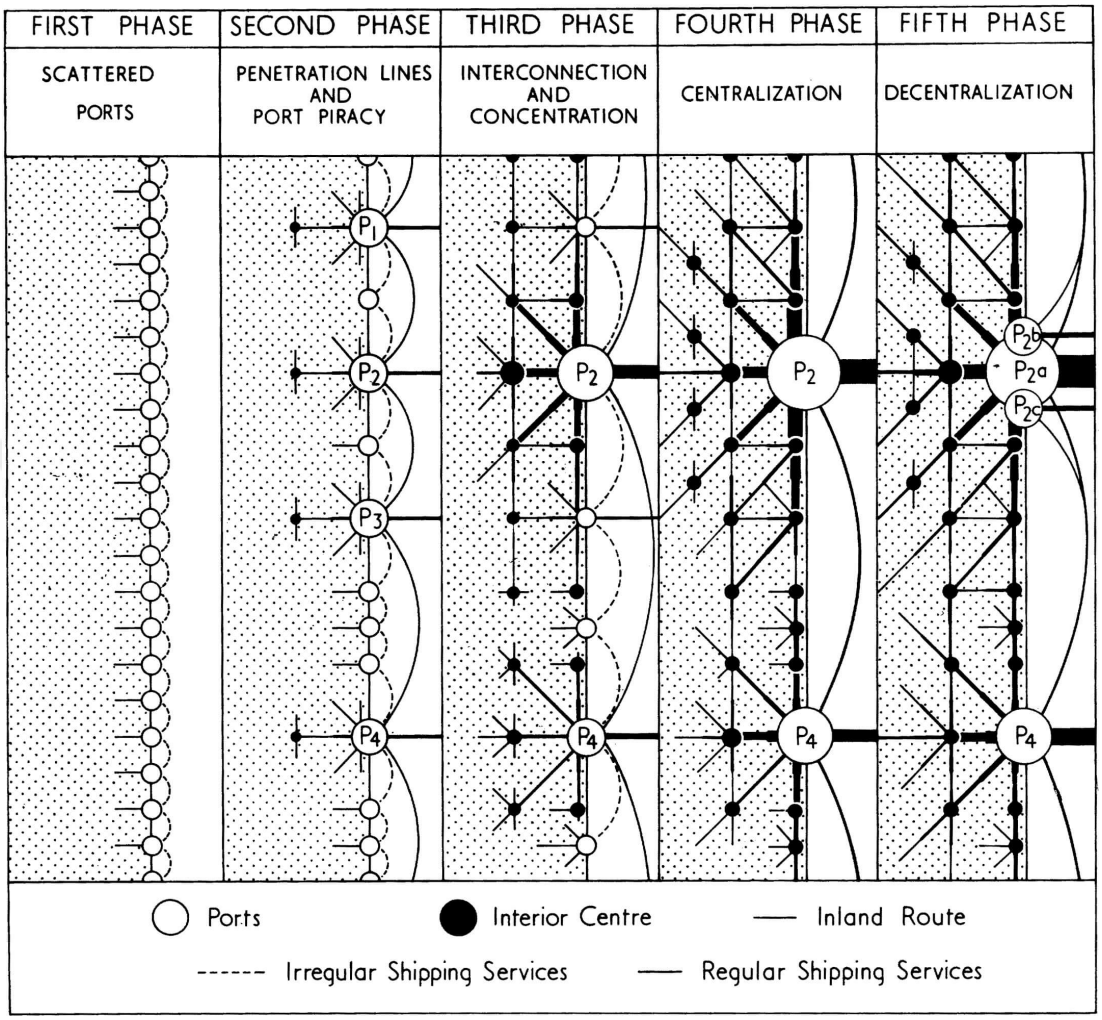
of the vessels calling ports force them to expand. The second stage is named "marginal quay extension" and is the stage of lineal extension of port facilities. The third stage named "marginal quay elaboration" includes the extension of quays into water and land. The fourth stage called "dock elaboration." In this stage, to make better use of limited water area, docks with locks are built to minimize the impacts of tides. Sizes of ships got larger, so that lineal development becomes necessary to safely berthing these large ships, in the fifth stage named "simple lineal quayage." The developments of specialized facilities to meet the needs of oil tankers, dry bulk carrying vessels, and container vessels mark the last stage named "specialized quayage."

Hoyle (1968) tested anyport model by evaluating the East African ports and revealed that the development of East African ports fits into five stages including "dhow traffic," "primitive," "marginal quay extension," "simple lineal quayage" and "specialized quayage." Hoyle (1968) added a new beginning stage called "dhow traffic" that involves the trafficking of dhows before the construction of jetties. The "marginal quay elaboration" and "dock elaboration" stages did not arise in the development of East African ports (Hoyle, 1968). Findings of Hoyle (1968) suggest that the anyport model is useful for analyzing the chronological and spatial development of ports (Hoyle, 1968).

Rimmer (1967a) argued that the model Taaffe et al. (1963) put forward neglected the seaward development of ports. To demonstrate changes in seaward and landward transportation networks of ports, Rimmer (1967a) developed a model and empirically tested it by applying the model to analyze the development of New Zealand's seaports during 1853 and 1960. Figure 3 illustrates the model. In the first phase, ports are scattered along the coast by serving very limited hinterlands, and irregular calls of vessels provide a very limited connection between the ports. In the second phase, the main transportation corridors penetrate to inland and some ports expand at the expense of others. In the third phase, port concentration is intensified, feeder routes continue to develop until the ports are connected. Some ports are becoming central points by expanding their influence and diminishing trade of other ports. In the fourth phase, connections between the ports are completed. The fifth phase, as an addition to Rimmer (1967a)'s model by Rimmer (1967b) after evaluating Australian seaport system, is characterized by decentralization of the major ports; new initial ports are established

around the major ports to allow them to concentrate in general cargo services.

Figure 3: Rimmer's Model for Seaport Syatem Development



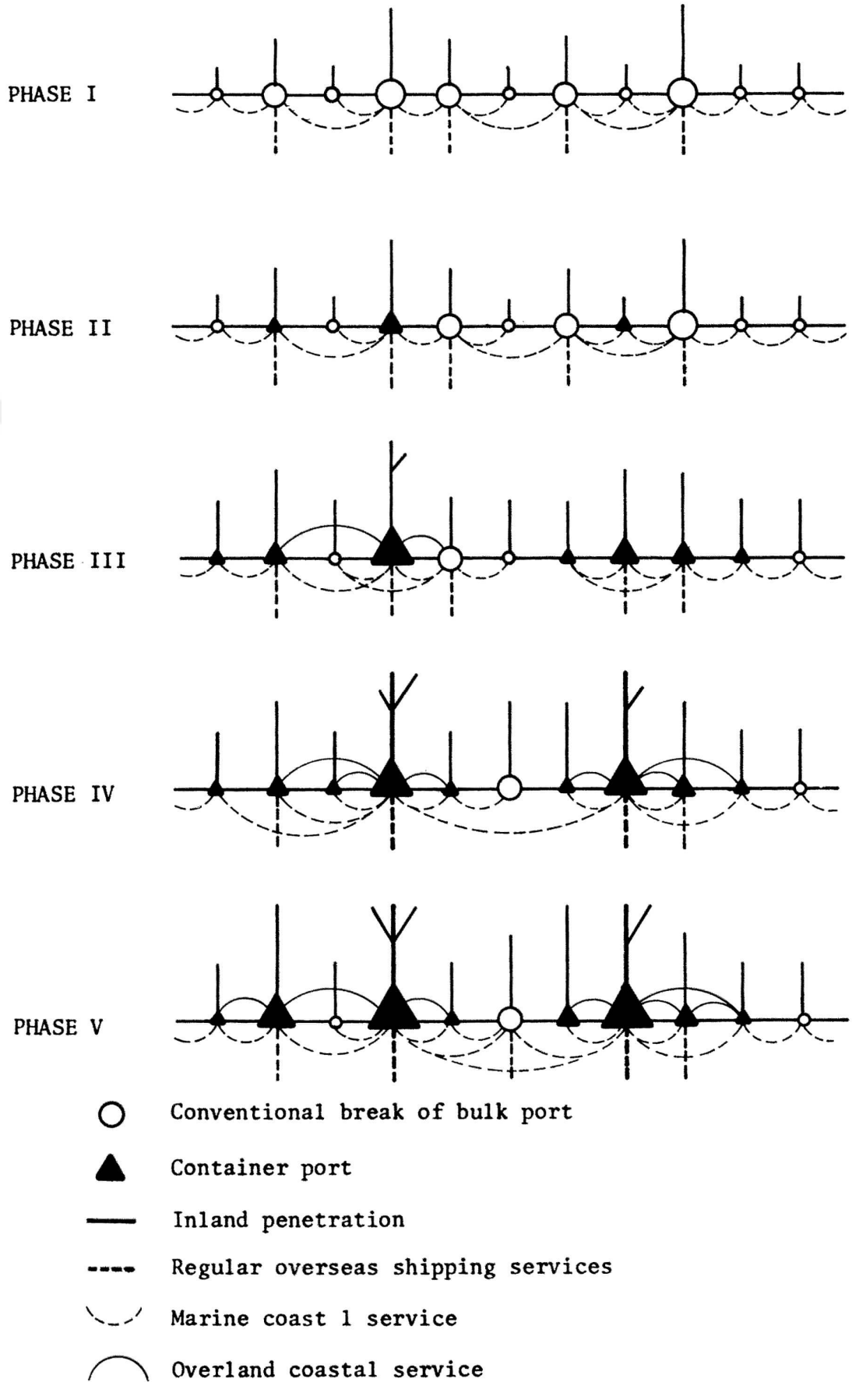
Source: Rimmer (1967b)

Containerization and intermodal transportation have made a tremendous impact on operations of ports and their hinterlands (Hayuth, 1981). Hayuth (1981) developed a model to illustrate the rationale behind container port development process by giving an emphasize on the concentration of container traffic in large ports which he calls "load centers." Hayuth (1981) revealed the factors which affect the development of regional load centers: "a large-scale local market, high accessibility to inland markets, advantageous site and location, early adoption of the new system, and aggressiveness of port management are major factors to consider" (Hayuth, 1981). The model illustrated in Figure 4 consists of five phases. In the first phase, ports face with difficulties that

disturb their functionality creating a need for fundamental change. At the second stage, ports begin to adapt containerization and container ships are in service but it is still limited to few ports, there are no significant changes in hinterlands and forelands. In the third phase, containerization is acknowledged and become a fully operational system. Ports are adapted to containerization by developing facilities for container ships and containerized cargo. However, many ports could not be adapted due to lack of financial sources. Container traffic begins to concentrate in the ports which are the first adapters of the containerized system. In the fourth phase, containers become the dominant way to transport general cargo and container traffic concentrates on few load centers for carriers to take advantage of economies of scales. In the last phase, container traffic is still mostly handled in load centers, but small container ports challenge them. Development of load centers faces with problems such as lack of space, congestion and inefficient operations. With the increased port competition, small ports which are desperate for increasing container traffic provide favorable terms for carriers; therefore, activities of carriers move to smaller ports.

After widespread adaptation of containerization, container traffic started to concentrate on a few "load centers" (Hayuth, 1981). Kuby and Reid (1992) tested this phenomenon on US container terminals. The findings of Hayuth (1988) claimed that there was a trend towards less concentration of US ports between 1975 and 1985. On the contrary, Kuby and Reid (1992) found that container traffic in US ports between 1970 and 1988 is in a trend of concentration because of some technological changes: "containerization, larger ships, larger trains, and computerization of freight tracking and billing." Kuby and Reid (1992) also argued their findings were consistent with the six-stage model explained earlier proposed by Taaffe et al. (1963) and contribution of Slack (1990) who put forward a seventh stage (deconcentration) in which redundant nodes vanish. Moreover, Kuby and Reid (1992) pointed out that the four technological changes mentioned earlier generate four kinds of intermodal services: "microbridge, minibridge, landbridge, and round-the-world" illustrated in Figure 5 and Figure 6. Microbridge coordinates maritime transport with inland transport to an interior node by expanding hinterlands of load centers with the help of fast and efficient rail or truck service. The difference of minibridge from microbridge is that the final node is not in at

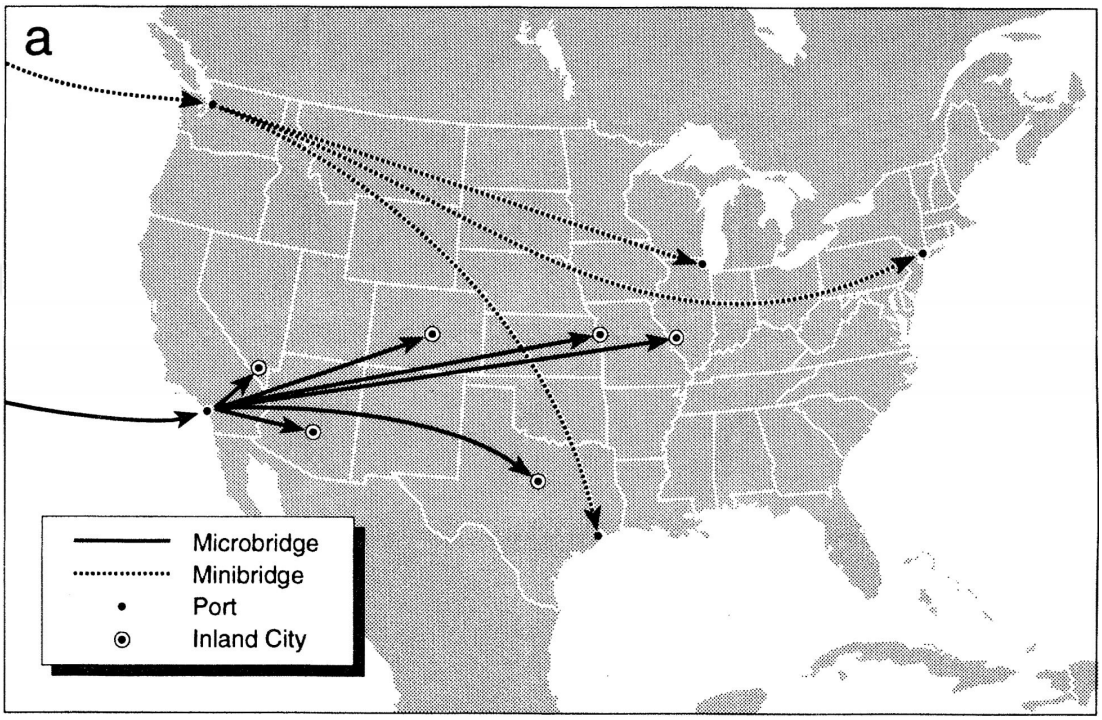
Figure 4: Development of the Container Port System



Source: Hayuth (1981)

the interior land, but it is a port on a coast that formerly had its liner service. Landbridge includes an overland leg inside the middle of an ocean voyage from one country to another. Round the world consists of a liner service in which ship is sailing over the world in one direction instead of going to one port to another.

Figure 5: Types of Intermodal Services: (a) Microbridge and Minibridge

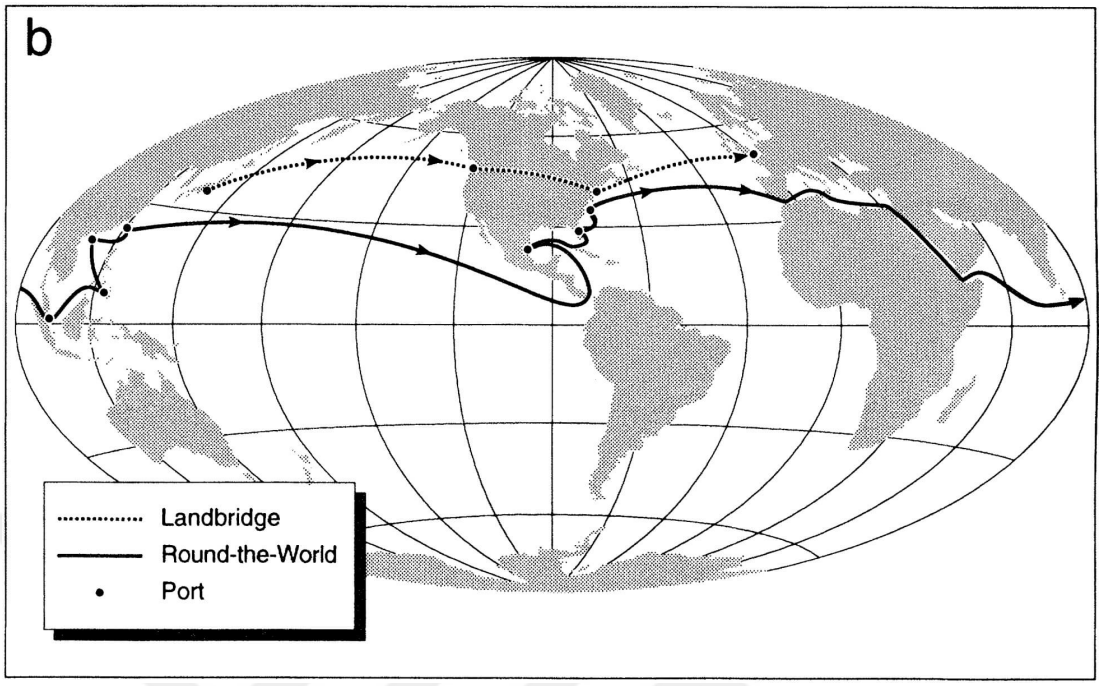


Source: Kuby and Reid (1992)

Notteboom (1997) examined concentration and deconcentration tendencies in European port industry in the light of Hayuth (1981)'s container port development model. He revealed that port concentration resulted from containerization eventually reach a limit and turn into deconcentration confirming previous studies, i.e., (Kuby and Reid, 1992; Slack, 1990; Rimmer, 1967a). On the other hand, Notteboom (1997) claimed deconcentration trend in European ports does not result by "peripheral port challenge" as stated by Hayuth (1981, 1988) but it arises from the shift of container traffic to mid-size ports which offer a better location for round-the-world container shipping services.

Notteboom and Rodrigue (2005) put forward port regionalization concept claiming port spatial development has entered a new phase. Notteboom and Rodrigue

Figure 6: Types of Intermodal Services: (b) Landbridge and Round-The-World

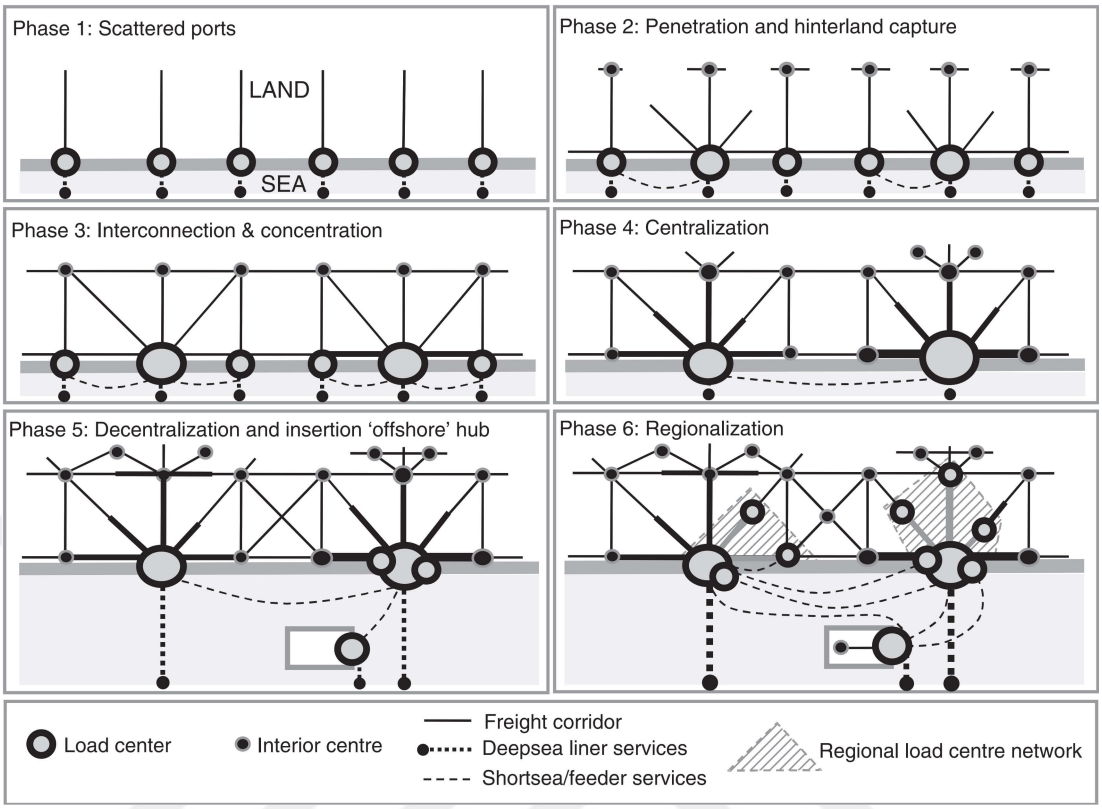


Source: Kuby and Reid (1992)

(2005) state that previous models are inadequate to explain recent port development. "The models on port system development up to now (a) did not explain the recent rise of new hub terminals and (b) did not incorporate inland freight distribution centers and terminals as active nodes in shaping load center development" (Notteboom and Rodrigue, 2005). They further argue that regionalization extends the existing port development models put forward previously by Taaffe et al. (1963) and Hayuth (1981).

Notteboom and Rodrigue (2005) pointed out that port regionalization, as illustrated in Figure 7, provides two extensions for the previously developed models. The first extension is the development of offshore hubs on islands and locations with no hinterland or very limited hinterland. In the beginning, those offshore hubs accommodate transshipment container flow, but sooner or later they will provide value-added services instead of just transferring containers from ship to ship (Notteboom and Rodrigue, 2005). The second extension contains inland intermodal terminals and freight distribution services as active nodes in the development of ports. Notteboom and Rodrigue (2005) emphasized that "the port regionalization phase . . . is characterized by strong functional interdependency and even joint development of a specific load center and (selected)

Figure 7: Spatial Development of A Port System



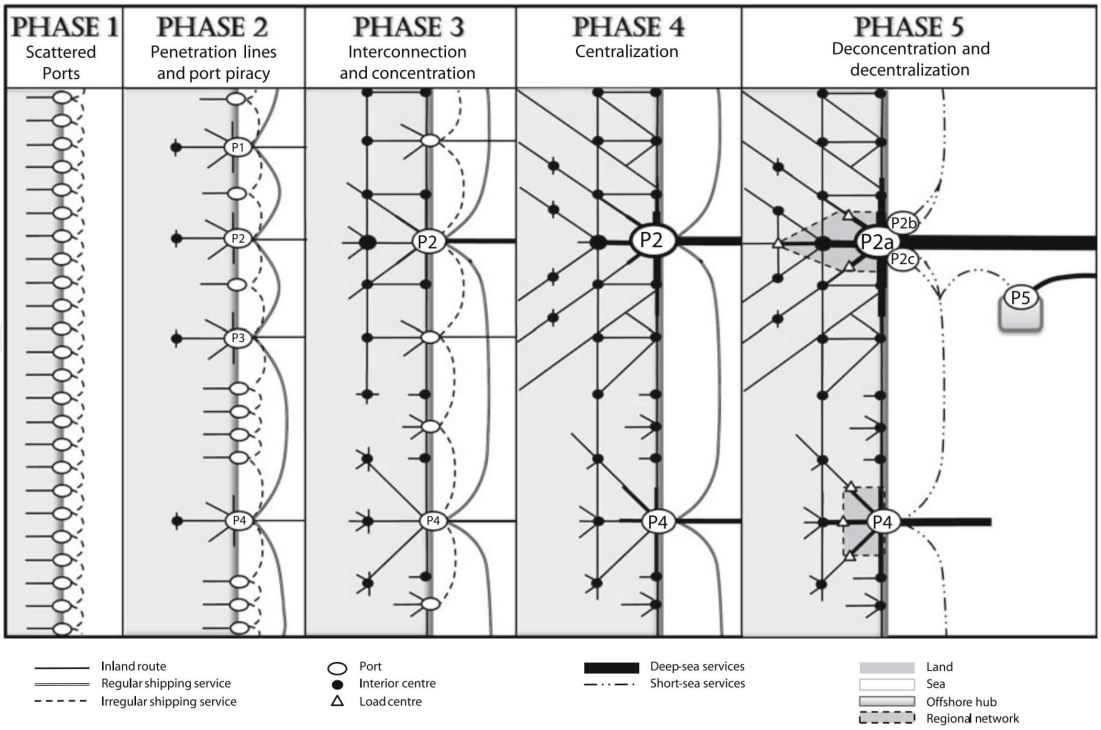
Source: Notteboom and Rodrigue (2005)

multimodal logistics platforms in its hinterland, ultimately leading to the formation of a -regional load center network".

Rimmer (2007) disagrees with the port regionalization thesis of Notteboom and Rodrigue (2005). He argues that offshore hubs can be included in the fifth phase of Rimmer (1967a)'s model as illustrated in Figure 8 that shows the modification of Rimmer (1967a)'s model in the light of Notteboom and Rodrigue (2005)'s extensions to the previous models. In fact, Rimmer (2007) considers the only contribution of Notteboom and Rodrigue (2005) to previous models is the inclusion of offshore hub; however, it can be included in the fifth phase of Rimmer (1967a)'s model. Port regionalization is simply nothing more than deconcentration/decentralization stage as stated by previous models (Rimmer, 2007; Rimmer and Comtois, 2009). Additionally, Rimmer and Comtois (2009) claims that "joint development of regional load center network" in the port regionalization phase stated by Notteboom and Rodrigue (2005) is stemmed from Robinson (2002)'s thesis. Robinson (2002) stated that in the globalized economy with

integrated supply chains, value chains that ports embedded in competes with each other rather than individual ports, hence, actors of a freight transportation network function as integrated elements of a supply chain.

Figure 8: Inclusion of Offshore Hubs in Rimmer (1967b)'s Model



Source: Rimmer (2007)

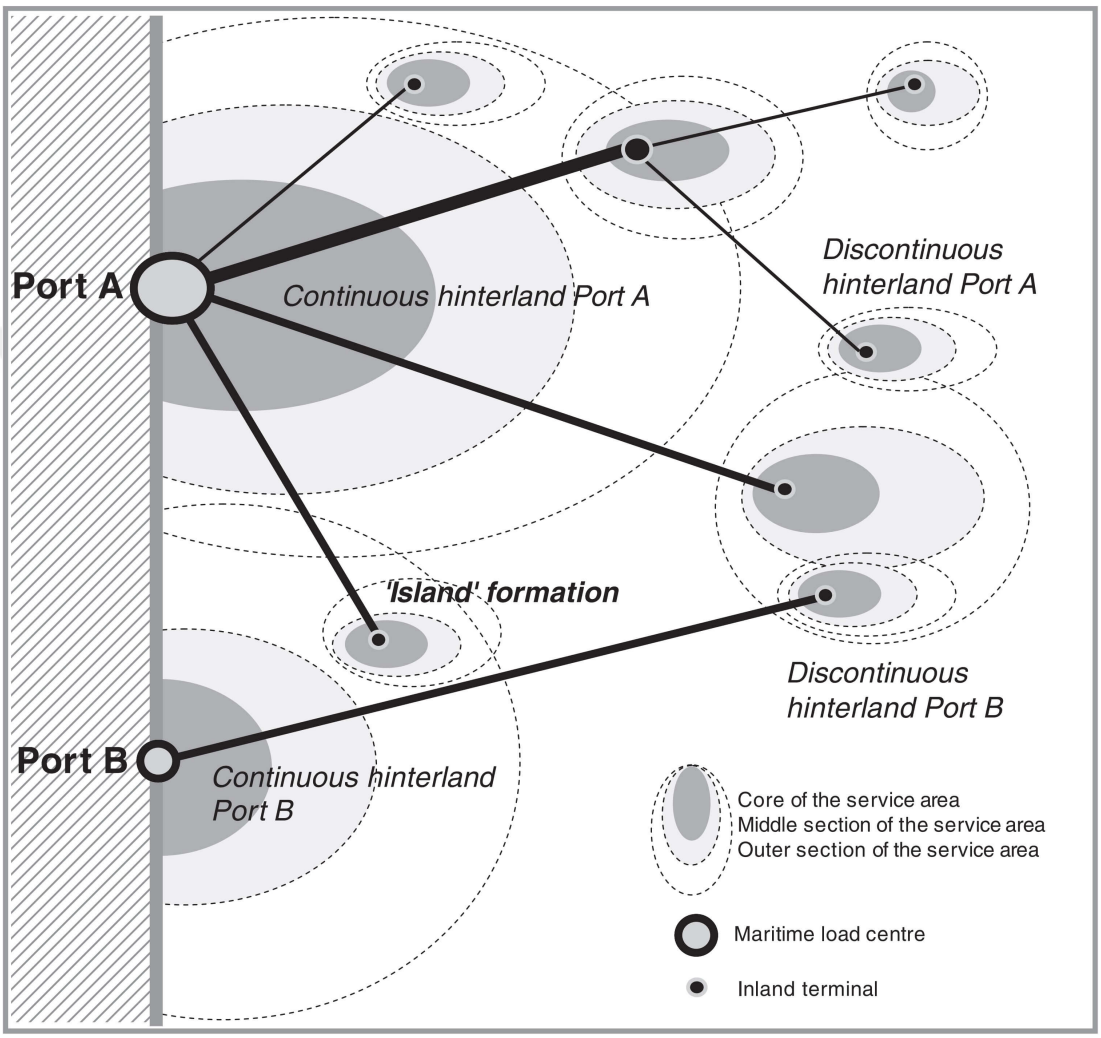
1.3. INLAND NODES AND CORRIDORS IN PORTS' HINTERLAND

Change in port systems being merely transfer points (from ships to shore or shore to ship) to providers of value-creating functions as an integrated member of supply chain promote establishment and development of inland terminals along freight distribution networks. Development of inland rail terminals and inland barge terminals contributes the mode shift from road transport to rail transport or inland water transport as sustainable transport modes. Inland terminals enable the shift of seaport facilities to inland locations to relieve the congested seaport area.

Although direct hinterland of a seaport is continuous, distant hinterland has discontinuous nature because of transportation corridors and inland terminals as

illustrated in Figure 9. Ports develop functional and robust hinterland connections with the help of inland terminals by forming "islands" providing competitive cost and service advantage in the distant hinterlands of rival ports (Notteboom and Rodrigue, 2005).

Figure 9: Nodes and Corridors in Ports' Hinterland



Source: Notteboom and Rodrigue (2005)

1.4. TERMINOLOGY AND CLASSIFICATION OF INLAND NODES

Examination of the literature reveals that there is not an agreed terminology exists upon the inland nodes. Various terms used to describe inland nodes such as freight village, logistics center, inland port, dry port, etc. (Higgins et al., 2012; Leitner and Harrison, 2001; Meidute, 2005; Notteboom and Rodrigue, 2009), Table 1

shows the most frequently used terms that cover wide variety of facilities from simple good transfer facility to complex logistics zones (Higgins et al., 2012; Notteboom and Rodrigue, 2009). Researchers agree that literature lacks a standard definition of inland nodes (Rimiene and Grundey, 2007; Tsamboulas and Dimitropoulos, 1999). This can be caused by inadequate empirical research comparing to other disciplines, ongoing theoretical development of freight transport and logistics (Higgins et al., 2012), different geographical conditions, and different legal and political structures in different countries (Notteboom and Rodrigue, 2009).

In spite of the variety of the terminology used for inland nodes, some researchers and organizations put forward their terminology and classifications. Independent of each other, authors attempted to provide their typology and classification according to different criteria. It is proposed by Holtgen (1996) that inland nodes can be classified in terms of functions, transport modes, transshipment techniques, network type or geographical location. Table 2 show classification of inland nodes proposed in previous studies.

Wiegmans et al. (1999) classified the inland nodes to five types in terms of geographical coverage, cargo volume and capacity: XXL (mainport terminal), XL (international European terminal), L (national terminal), M (regional terminal) and S (local terminal). XXL terminals are major seaports or major airports with worldwide connections. XL terminals have continental scale connections of sea, inland water, rail, and road transportation. L terminals have a barge, rail and road connections at a country scale serving as national distribution centers. M terminal is a small terminal serving as a regional distribution center with rail, barge and road connections. S terminal serves as local freight distribution center with mostly road connections.

Additionally, Wiegmans et al. (1999) proposed another classification which considers bundling network types. It covers four types of terminals: bulk terminal, transfer terminal, distribution terminal and hinterland terminal. Bulk refers to the large flow of cargo, not bulk cargo. Large flows of cargo arriving at these terminals are distributed in smaller flows for further transport. Bundling network type of these terminals is the point-to-point. Transfer terminals are intended for transshipping continental freight. They are characterized as large areas where transshipment between

Table 1: Terminology of Inland Nodes

Terminology	Reference
Container yard	UNESCAP (2009)
Container freight station	UNESCAP (2009)
Barge terminal	Notteboom and Rodrigue (2009)
Distribution center	Rimiene and Grundey (2007); Higgins et al. (2012); Notteboom and Rodrigue (2009)
Distribution terminal	Wiegmans et al. (1999)
Dry port	Beresford and Dubey (1991); Ng and Gujar (2009a); Roso et al. (2009); UNECE (1998, 2001); UNESCAP (2012); Woxenius et al. (2004)
Freight village	de Cerreño et al. (2008); Rimiene and Grundey (2007); Higgins et al. (2012); Tsamboulas and Dimitropoulos (1999); UNESCAP (2009); Holtgen (1996))
Hinterland terminal	Wiegmans et al. (1999)
Industrial park	de Cerreño et al. (2008)
Inland clearance depot	UNECE (1998)
Inland container depot	UNECE (1998); UNESCAP (2009); Beresford and Dubey (1991); Jaržemskis and Vasiliauskas (2007)
Inland customs depot	Beresford and Dubey (1991)
Inland freight terminal	UNECE (1998); UNESCAP (2012)
Inland port	Higgins et al. (2012); Leitner and Harrison (2001); Notteboom and Rodrigue (2004, 2009); Rodrigue et al. (2010)
Inland terminal	UNECE (2001); UNESCAP (2012); Woxenius et al. (2004)
Intermodal terminal	Higgins et al. (2012); UNESCAP (2009)
Load center	Notteboom and Rodrigue (2009)
Logistics center	Europlatforms (2004); Rimiene and Grundey (2007); Higgins et al. (2012); Meidute (2004, 2005)
Maritime feeder inland port	Leitner and Harrison (2001)
Rail terminal	Notteboom and Rodrigue (2009)
Satellite terminal	Notteboom and Rodrigue (2009); Slack (1999)
Trade and transportation center inland port	Leitner and Harrison (2001)
Transfer terminal	Wiegmans et al. (1999)
Transmodal terminal	Notteboom and Rodrigue (2009)
Transport terminal	Rimiene and Grundey (2007)
Warehouse	Rimiene and Grundey (2007)

Source: Author

different transportation modes are provided. Bundling network type of transshipment terminals is hub-and-spoke. In a distribution terminal, continental cargo is consolidated into shipments for customers. Bundling network type of distribution terminals is line network. In a hinterland terminal, continental cargoes are consolidated into large flows and are transported by rail or barge. Bundling network type of these terminals is trunk

Table 2: Classification of Intermodal Nodes

Criteria	Type
Wiegmans et al. (1999)	XXL or mainport terminal
	XL or international European terminal
	L or national terminal
	M or regional terminal
	S or local terminal
Wiegmans et al. (1999)	Bulk terminal
	Transfer terminal
	Distribution terminal
	Hinterland terminal
Leitner and Harrison (2001)	Inland waterway ports
	Air cargo ports
	Maritime feeder inland ports
	Trade and transportation center inland port
Notteboom and Rodrigue (2009)	Gateway (level 1)
	Freight distribution cluster (level 2)
	Inland port (level 3)
	Satellite terminal (level 4)
UNESCAP (2012)	Inland terminal
	Dry port
	Inland clearance depot (or inland customs depot)
	Inland freight terminal
Higgins et al. (2012)	Mainport terminals
	Freight Village
	Inland Port
	Intermodal Terminal
	Inland Container Depot
	Container Yard
	Warehouse

Source: Author

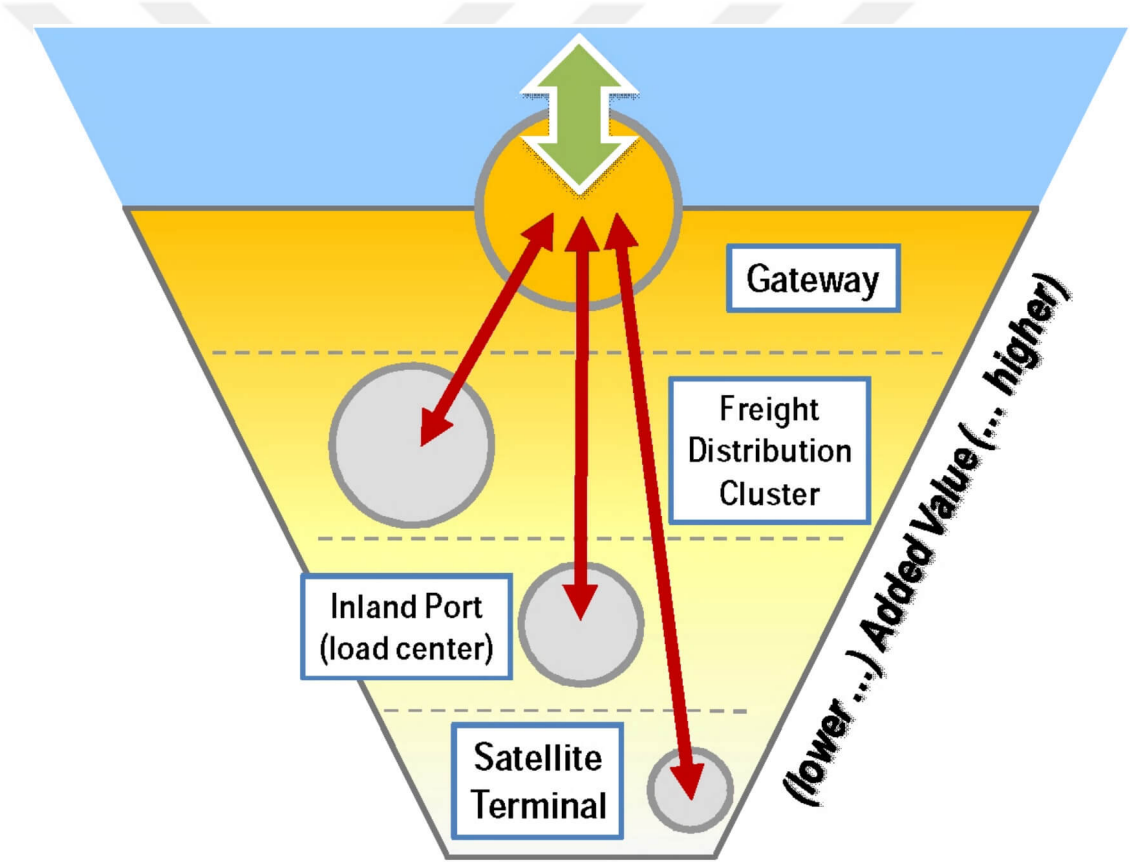
line with a distribution network.

Leitner and Harrison (2001) put forward their classification in terms of transport modes. Inland waterway ports deal with transportation of goods by barge. Air cargo ports classified as inland ports since passenger lines and dedicated carriers provides shipment of goods worldwide. Maritime feeders ports act as deconsolidation point for goods shipped to a hub port. Trade and transportation center inland ports are classified as inland ports where border process of good shifted inland from seaport and transshipment between multiple modes of transportation and value-added services are available.

Notteboom and Rodrigue (2009) proposed a hierarchical classification for port

transport systems considering geographical location and functions: gateway, freight distribution cluster, inland port and satellite terminal. Gateways provide a wide range of value-added logistics activities mainly focusing on transfer of goods between maritime transport systems and inland transport systems. Freight distribution cluster is characterized by a cluster of inland terminals and inland distribution centers which enable distribution of goods to the market area. Inland port provide distribution facilities and act as load centers for maritime freight. Satellite terminals perform trans-loading facilities. Figure 10 shows the detailed description of Notteboom and Rodrigue (2009)'s classification.

Figure 10: Freight Terminal Hierarchy and Added Value



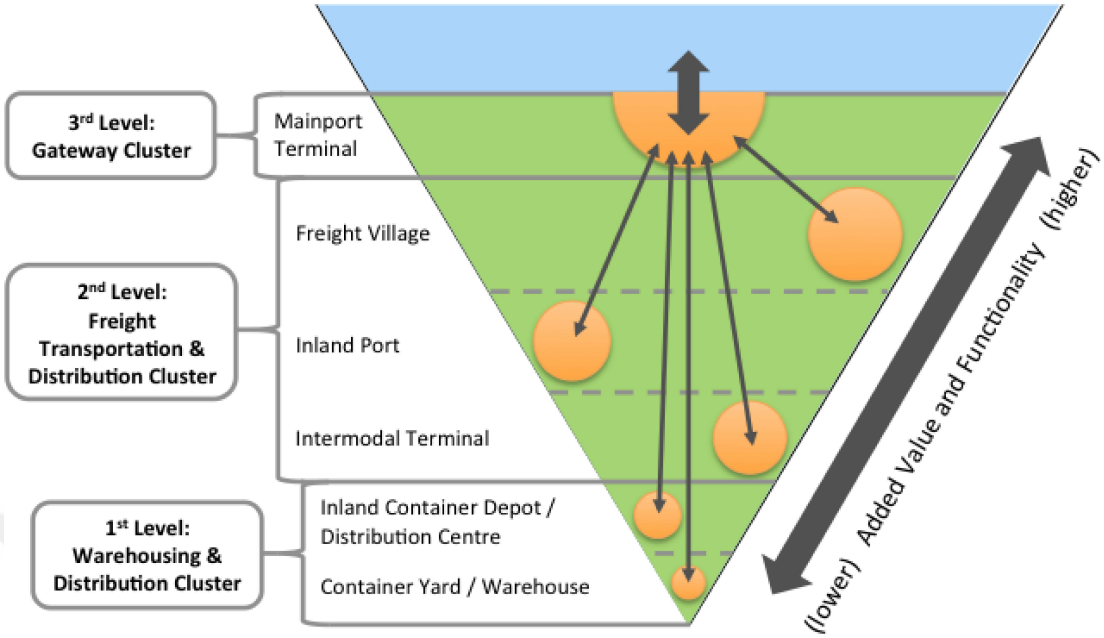
Source: Notteboom and Rodrigue (2009)

UNESCAP (2012) provided a classification of inland nodes in terms of their functions: inland terminal, dry port, inland clearance depot, and inland freight terminal. UNESCAP (2012) defined inland terminals as terminals located inland "to which shipping companies issue their bills of lading for import cargoes assuming full

responsibility for costs and conditions and from which shipping companies issue their bills of lading for export cargoes." A dry port is "an inland terminal that has direct connection to a seaport". Inland clearance depot (or inland customs depot) described as "a common-user inland facility with public authority status, equipped with fixed installations and offering services for the handling and temporary storage of any kind of goods (including containers) carried under customs transit by any applicable mode of inland surface transport, placed under customs control and with customs and other agencies competent to clear goods for home use, warehousing, temporary admissions, re-export, temporary storage for onward transit and outright export". International freight is gathered or distributed in inland freight terminals. They provide facilities on a common user basis.

Higgins et al. (2012) proposed classification and hierarchy for terminals by considering previous studies. They proposed six terminal types in three level of hierarchy which is illustrated in Figure 11. Mainport terminals are major seaports that provide interfaces between maritime and inland transport systems. A freight village is an area "hosting a cluster of industrial, intermodal, distribution and logistics infrastructure and supporting services dedicated to facilitating a flow of goods." Inland ports act as inland extensions of seaports. They are linked to mainport terminals by railway or inland waterway. An intermodal terminal provides "transshipment and consolidation of intermodal freight into bigger flows for regional and continental trade." Inland container depots are areas for handling and temporary storage of containerized freight. Their focus is container movement rather than storage. A container yard provides facilities for storage, cleaning, and repair. A distribution center is a large warehouse or a cluster of warehouses which are focused on seamless flow of freight. Warehouses are places for inventory and storage of freight.

Figure 11: Standardized Logistics Center Hierarchy



Source: Higgins et al. (2012)

1.5. DRY PORT CONCEPT

Proposing a definition reflecting all aspects of "dry port" concept is rather difficult since not just functions but also scale, complexity and services of a dry port vary in different countries and regions (Padilha and Ng, 2012; Beresford et al., 2012; Rathnayake et al., 2013). Table 3 shows various definitions of dry port concept. The first column of Table 3 demonstrates the definition and the study in which the definition was originated; the second column of the table demonstrates the references in which the definition was used.

Table 3 shows that the first definition of the dry port concept is provided in a UN document in 1982. The definition of dry port underlines the logistics clustering function and describes the services provided in dry port by emphasizing customs clearance facility and carriage of goods in customs transit. The definition lacks emphasis on connection with seaports and excludes carriage of good which is not under customs transit. Customs clearance can be done at seaports and goods can be carried to dry ports why do dry ports exclude goods which is not under customs transit. UNECE (2001) provides a definition of dry port: "a dry port is an inland terminal which is directly

Table 3: Definitions of Dry Port Concept

Definition	References
"A common user facility with public authority status, equipped with fixed installations and offering services for handling and temporary storage of any kind of goods (including containers) carried under customs transit by any applicable mode of transport, placed under customs control and with customs and other agencies competent to clear goods for home use, warehousing, temporary admissions, re-export, temporary storage for onward transit and outright export" (UNCTAD, 1982)	Beresford et al. (2012)
"A 'dry port' is defined as inland terminal which have direct link to the seaport(s) or, in the case of international land movements, are in contact with importing sources and exporting destination. Dry ports may be used whether a country has seaports or is land-locked, but only surface modes of transport are involved in giving access to them"(Beresford and Dubey, 1991)	Oey and Setiawan (2017); Ng and Cetin (2012)
"A dry port is an inland terminal that is directly linked to a maritime port" (UNECE, 2001)	Regmi and Hanaoka (2015)
"An inland intermodal terminal, directly connected to seaports with high capacity transport means, where customers can leave and pick up their standardized units as if directly to a seaport"(Leveque and Roso, 2002)	Jeevan et al. (2017); Talley and Ng (2017); Xie et al. (2017); Komchornrit (2017); Nguyen and Notteboom (2016); Crainic et al. (2015); Jeevan et al. (2015); Rodrigue and Notteboom (2012); Haralambides and Gujar (2011); Korovyakovsky and Panova (2011); Roso et al. (2009)
"A dry port is an inland intermodal terminal directly connected to a seaport, with high capacity traffic modes, preferably rail, where customers can leave and/or collect their goods in intermodal loading units, as if directly to the seaport" (Woxenius et al., 2004)	Roso (2009, 2008, 2007)
"Dry port refers to a defined inland location for the consolidation and distribution of goods that has functions similar to those of a seaport, and which includes customs clearance services"(ESCAP, 2006)	Rathnayake et al. (2013)

Source: Author

linked to a maritime port." This definition emphasizes the connection to maritime ports, but it is very broad and does not describe the characteristics of the transport link. Another broad definition was put forward by ESCAP (2006). The definition describes dry ports with vague terms as "inland location" and "functions similar to those of a seaport" without making a specification to seaport connections and terminal function.

Table 3 shows the most widely accepted definition of the dry port concept which is proposed by Leveque and Roso (2002). Roso et al. (2009) stated that Leveque and Roso (2002)'s definition takes UNECE (2001)'s and Beresford and Dubey (1991)'s definitions further. Roso et al. (2009) stated that the definition provided by Leveque and Roso (2002) extends earlier definitions by adding "intermodal/standardized units" and "high capacity transport means." However, both of these additions are wrong because they lack solid foundations. First, the phrases "intermodal terminal" and "standardized units" excludes dry bulk and general cargo meaning that inland terminals which only handle intermodal units can be regarded as dry ports. However, existing inland terminals with connections of seaports show us that they handle not only intermodal units, but also dry bulk and general cargo. If dry ports only handle intermodal units, they should not be named as dry ports since the terms such as "dry container terminal" or "inland container depot" would be more appropriate. Second, they specify the characteristics of the transport connection between an inland intermodal terminal and a seaport emphasizing "high capacity transport means." This is vague and can include inland waterway, railway, or road transport. If an inland terminal has connection to inland waterways, why the term "dry" is used. This is often criticized by other researchers as well (Rodrigue et al., 2010; Monios and Wilmsmeier, 2012a; Wilmsmeier et al., 2011b; Monios, 2011).

The definition proposed by Woxenius et al. (2004) is a variation of Leveque and Roso (2002)'s referring to usage of rail between seaport and inland intermodal terminals. But it still excludes goods which are not carried in an intermodal unit. Additionally, a dry port can be connected to a seaport or seaports with a highway connection why exclude it.

As a result of above discussion, this thesis adopts dry port definition provided by Beresford and Dubey (1991):

"A 'dry port' is defined as inland terminal which have direct link to the seaport(s) or, in the case of international land movements, are in contact with importing sources and exporting destination. Dry ports may be used whether a country has seaports or is land-locked, but only surface modes of transport are involved in giving access to them".

This definition includes different kinds of freight not only intermodal units. Additionally, direct connection to the seaport(s) is stated clearly. Because the term "dry" is included, it is only logical to think that transport connection between seaport(s) and dry port(s) generated through just surface transport modes which include railway and road.

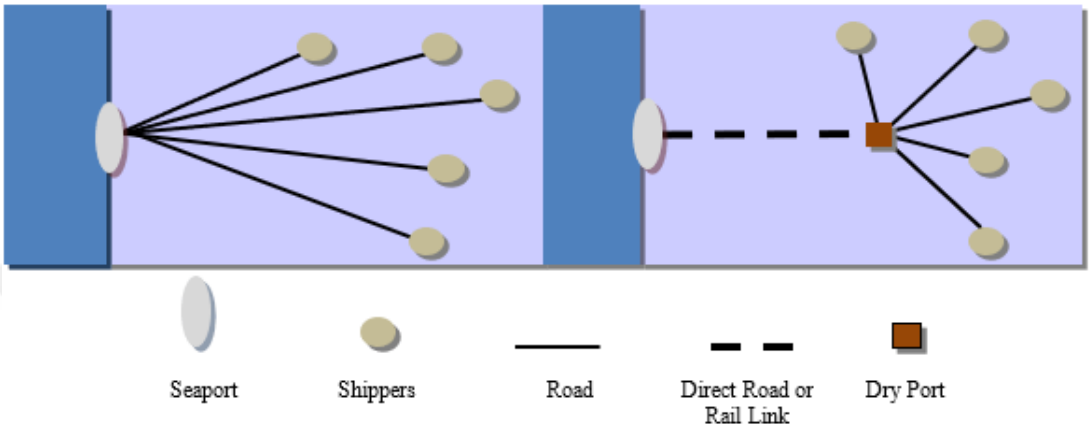
Dry ports, in addition to traditional services like transshipment, should provide services such as storage, consolidation, empty container storage, container repair, customs clearance, etc. (Roso, 2007; Woxenius et al., 2004). The service quality of a dry port is determined by the scheduled and reliable transport service. For this reason, a dry port is developed consciously to overcome the problems of increased container flow (Roso, 2007; Woxenius et al., 2004).

Dry port development is mainly motivated in two ways (Wilmsmeier et al., 2011b): dry ports can be established as extended gates of seaports, or they can be established as inland hubs facilitating movement of cargo between hinterland and seaports.

Figure 12 illustrates the hinterland transportation system of a seaport with and without a dry port. Dry ports extend the gates of seaports to inland. Shippers and logistics service providers perceive dry ports as interfaces to seaports and maritime transportation services (Roso, 2007; Roso et al., 2009; Veenstra et al., 2012; Haralambides and Gujar, 2011). As extended gates of seaports, dry ports offer shippers and logistics service providers an opportunity to procure logistics services such as customs clearance, security control, container weighing, information processing, empty container storage, container stuffing and unstuffing from inland terminals instead of seaports (Henttu and Hilmola, 2011; Henttu et al., 2011; Ng and Cetin, 2012). These services can be provided more economically in inland locations, where the cost of land is much cheaper than the land around seaport, thus reducing risks and increasing competitiveness (Ng and Cetin, 2012).

Additionally, with the use of high capacity transport, besides reducing the congestion in seaports, it is possible to reduce congestion in roads and emissions resulted by road transportation (Roso, 2007; Roso et al., 2009; Henttu and Hilmola, 2011; Henttu et al., 2011).

Figure 12: Inland Freight Transportation without and with A Dry Port



Source: Author

A dry port's performance is determined by the quality of its transport connections (Roso, 2007; Roso et al., 2009; Henttu and Hilmola, 2011; Henttu et al., 2011). However, the quality of transport services depends on the actors, such as port authorities, freight forwarders, road operators, terminal operators and rail operators, involved in inland transportation service provision (Roso, 2013). To successfully implement the dry port concept, transport infrastructure, regulatory and legislative settings must be properly designed to nurture cooperation and integration of actors involved in hinterland transportation (Roso and Lumsden, 2010; Rodrigue and Notteboom, 2012). Ng et al. (2013b) claims three success factors for dry port development that include: proper geographical location where sufficient demand is assured, provision of adequate value-added logistics services and high integration and collaboration with seaports and shipping lines. Furthermore, in the long term viable dry ports, services like transshipment, warehousing, container storage, container loading and unloading, consolidation, deconsolidation, empty container storage, container repair, customs clearance, container tracing and other necessary value-added logistics services should be provided (Henttu and Hilmola, 2011; Henttu et al., 2011; Regmi and Hanaoka, 2012; Hanaoka and Regmi, 2011; Ng and

Cetin, 2012). Dry ports need to provide services that are provided in seaports, and in many ways function as seaports (Ng and Gujar, 2009c).

1.5.1. Classification of Dry Ports

Scholars classify dry ports in various ways as illustrated in Table 4. Roso et al. (2009) classify dry ports regarding their distance to seaports. Rodrigue and Notteboom (2012) classify them based on their functions, and ownership status. Beresford et al. (2012) classify them regarding their ownerships arguing that ownership types of dry ports are the same as seaports. Beresford et al. (2012) propose another classification reflecting functional and locational characteristics of dry ports. Wilmsmeier et al. (2011b) classify dry ports regarding their direction of development.

Table 4: Classification of Dry Ports

Reference	Classification Criteria	Types
Roso et al. (2009)	Distance	Distant
		Midrange
		Close
Rodrigue and Notteboom (2012)	Function	Satellite Terminals
		Load Centers
		Transloading Centers
Rodrigue and Notteboom (2012)	Ownership	Single Ownership (Public/Private)
		Public-Private Partnership
		Landlord Model
Beresford et al. (2012)	Ownership	Landlord
		Tool port
		Public service port
Beresford et al. (2012)	Function and Location	Seaport-based dry ports
		City-based dry ports
		Border dry ports
Wilmsmeier et al. (2011b)	Direction of Development	Inside-out
		Outside-in

Source: Author

Roso et al. (2009) classifies dry ports regarding their distance to seaports: distant, mid-range, and close dry ports while assuming railway connections between dry ports and seaports. Distant dry ports are the most common dry ports (Bask et al., 2014) that are more than 500 km away from seaports (Crainic et al., 2015). The economic

viability of railway operations between a distant dry port and a seaport is achieved by full exploitation of economies of scope. Additionally, distant dry ports enable provision of direct high capacity freight transportation services to a broad geographical region. Implementation of distant dry ports provides a competitive advantage for seaports allowing them to enhance their hinterlands and reach new customers (Bask et al., 2014). Midrange dry ports are located in a range between 50 km and 500 km away from a seaport (Crainic et al., 2015). These distances usually are not feasible for railways, but with the consolidation of containers, it is possible to achieve high frequency and high volume of container transportation (Bask et al., 2014). Midrange dry ports act as buffer relieving zones for seaports' container stacking areas (Roso et al., 2009) and provide connections to other inland intermodal terminals with a railway. Close dry ports are located near seaports with a maximum range of 50 km (Crainic et al., 2015) to expand capacities of the seaports, where physical expansion is limited. Close dry ports provide consolidation and distribution facilities for shippers located outside a city by establishing high capacity corridors (Roso et al., 2009). These dry ports require highly reliable rail services with a dedicated track to improve productivity (Bask et al., 2014).

Rodrigue and Notteboom (2012) distinguishes dry ports regarding their functions: satellite terminals, load centers, and trans-loading centers. Dry ports can provide more than one of these functions (Rodrigue and Notteboom, 2012). Satellite terminals are located close to seaports, just outside the city, in a range of 100 km (Slack, 1999). They attract additional transportation flow by acting as consolidation centers and providing services, which are more expensive in seaports such as warehousing and empty container storage (Rodrigue and Notteboom, 2012). Load centers are dry ports that enable access to inland production and consumption zones, such as industrial zones and free trade zones, by providing transshipment, warehousing and additional value-added logistics services (Rodrigue and Notteboom, 2012). They serve as consolidation and distribution points. Load centers make seaports to reach deep hinterlands by optimizing transportation costs with efficient and effective railway and road connections (Rodrigue and Notteboom, 2012). Transloading centers link freight flows by offering transshipment facilities. They usually provide services outside of seaports' market areas and they are often located near country borders providing administrative services such as customs clearance, quarantine,

and health inspection, etc., as well as, value-added logistics services (Rodrigue and Notteboom, 2012).

Rodrigue and Notteboom (2012) also classify dry ports in term of their ownerships: single ownership, public-private partnership, and landlord model. Single ownership means that a public or a private organization owns the dry port and is responsible for managing of dry port facilities. Single ownership brings out some risks such as lack of flexibility and conflicts with other stakeholders. Public-private partnership indicates that public authorities plan the infrastructure and the operations are provided by a private party. Public-private partnership presents an opportunity to protect interests of the local community but usually tend to put public interest before private party's interest. Landlord model means that ownership of the land belongs to public authority; however, operations are provided by a private party with a long-term concession agreement. This ownership model provides flexibility regarding management of the facilities, and most of the financial risk is borne by the private operator.

Beresford et al. (2012) claimed that ownership statuses of dry ports are the same as seaports' ownership statuses: landlord model, tool port model, and public service port model. The landlord model is the same as the previous classification of (Rodrigue and Notteboom, 2012): a public authority, as the landlord, provides infrastructure with a long-term concession agreement -a private party is responsible for operations of dry port facilities. Tool port model means a public authority provides both infrastructure and superstructure, but a private organization is responsible for providing operations of the dry port facilities. Public service port model indicates that operations, infrastructures, and superstructures of a dry port are maintained by a public organization.

Beresford et al. (2012) also classify dry ports regarding their location and functions. The classification includes seaport-based dry ports, city-based dry ports, and border dry ports. The seaport-based dry ports provide additional capacity for seaports to capture more freight flow. These dry ports must provide customs clearance service and achieve a high level of consolidation to maintain an efficient inland transport corridor with shorter lead times. City-based dry ports are located near production and consumption centers such as free trade zones or industrial production zones providing a broad range of value-added logistics services with efficient intermodal connectivity

to seaports, and usually, there is a logistics cluster around them. Border dry ports, as indicated in their names, located near border areas, and provide administrative services -such as customs clearance, quarantine, and inspection services. They act as transfer points in between different modes of transportation and link seaports with regions out of their traditional hinterlands.

Wilmsmeier et al. (2011b) provide another classification for dry ports considering the direction of dry port development: inside-out developed dry ports and outside-in developed dry ports. Outside-in developed dry ports also named as seaport driven dry ports, meaning that the dry port development is driven by seaport authorities, seaport terminal operators (Nguyen and Notteboom, 2016), or shipping lines (Wilmsmeier et al., 2011b). Inside-out dry port development means that inland intermodal terminal operators take initiatives to develop dry port services to attract transport flows while facilitating transport corridors between seaports and dry ports and triggering regional development (Wilmsmeier et al., 2011b). Inside-out dry port development is driven by local authorities or logistics service providers to connect production or consumption centers, such as free trade zones or industrial zones, with seaports (Nguyen and Notteboom, 2016).

1.5.2. Previous Research on Dry Ports

Even though the dry port concept is not new, its popularity has increased lately. Increasing scholarly interest can be seen from the number of lately published scientific papers. This is mainly because of the role they play to overcome negative impacts of increased freight flows at seaports, as well as in the hinterlands of seaports.

To understand the research trends, the literature on dry ports are reviewed. The strings "dry port" and "dryport" is searched in Scopus database in abstracts, keywords, and titles of the journal articles. Only journal articles are included, conference papers, books, and book chapters etc. are excluded from the search to make sure the papers went through a blind review process. Additionally, to ensure the articles have a certain quality, journals listed at Thompson Reuters web of science indexes (SCI-Expanded, SSCI, and ESCI) has been included in the review. 62 articles have been identified. To

gain further insights into the research trends, the articles are categorized in terms of their research theme, methodology, journal, country of the investigation, and year of publication.

1.5.2.1. Research Themes

The literature on dry ports is categorized in terms of their research theme as shown in Table 5 to explore the research interests. Table 5 illustrates categorization of articles in twelve themes:

- Factors affecting dry port development: This theme includes articles dealing with factors affecting dry port development, such as motivations and barriers, and characteristics of dry ports in different countries.
- Empty container movement in hinterland: This theme refers to the articles dealing with empty container movement in hinterlands of seaports and role of dry ports with that regard.
- Location assessment: This theme includes articles that assess locations of dry ports or evaluates the selection of optimum locations for dry ports.
- Benefit assessment of dry ports: This theme includes articles that empirically assess the benefits of dry port development.
- Conceptual evaluation of dry ports: The articles in this theme conceptually evaluates dry ports and provide theoretical grounds and classifications to current industrial practices.
- Policies on dry ports: This theme inspects the policies regarding dry port development and current regulations of dry port operations.
- Seaport-hinterland connectivity: This theme examines articles that inspect seaport-hinterland connectivity and touched the role played by dry ports with that regard.
- Literature review: The articles in this theme includes literature reviews that include dry ports.

- Business ethics: This theme includes articles dealing with business ethics practices related to dry ports.
- Optimization Models: The articles in this theme propose mathematical and simulation models for optimization and decision support.
- Finance of dry ports: This theme includes articles deals with finance of dry ports.
- Assessment of dry port implementation: Articles in this theme evaluates the implementation of dry ports.

Table 5 shows the categorization of 62 papers in term of their research theme. The articles investigating "Factors affecting dry port development" in different countries is the most researched theme that includes 11 papers consisting of 17.7% of all the articles. The articles on "Location assessment" is the second most inspected research theme which include ten articles 16.1% of all the articles. The research themes "Policies on dry ports," "Benefit assessment of dry ports," "Seaport-hinterland connectivity," and "Assessment of dry port implementation" include six papers each, and they are the third most researched themes with percentages of 9.7. Five articles were published related to "Optimization Models," and four articles were published on "Conceptual evaluation of dry ports." The research themes of "Empty container movement," "Finance of dry ports," "Literature reviews," and "Business ethics" are the least researched themes only two papers published in each theme constituting 3.2% of the total number of papers.

Table 5: Research Themes

Research Themes	Number of Papers	Percentage %
Factors affecting dry port development	11	17.7
Location assessment	10	16.1
Policies on dry ports	6	9.7
Benefit assessment of dry ports	6	9.7
Seaport-hinterland connectivity	6	9.7
Assessment of dry port implementation	6	9.7
Optimization models	5	8.1
Conceptual evaluation of dry ports	4	6.5
Empty container movement	2	3.2
Finance of dry ports	2	3.2
Literature reviews	2	3.2
Business ethics	2	3.2
Total	62	100

Source: Author

1.5.2.1.1. Factors Affecting Dry Port Development

This theme includes articles that inspect dry port development in one or more countries with the focus on providing information about the status and unique aspects of the investigated country(s)' dry port development processes. The articles, as illustrated in Table 6, evaluate motivations, barriers, and status of dry port development in different countries as well as characteristics of dry ports.

As the fastest growing economy in the world, China has promoted dry port development to overcome negative impacts of freight traffic resulted from the increased economic activity. But dry ports built with inconsistent planning has brought many problems (Li et al., 2015). Li et al. (2015) investigate these problems and provide solutions: To avoid blind investments, port authority, national government, and local government have to be in coordination while planning dry ports. And to increase service quality of dry ports, cooperation between local government and logistics service providers has to be improved.

Zeng et al. (2013) also investigate Chinese dry ports. By interviewing the stakeholders, they explore motivation and challenges to dry port development. Motivations of dry port development in China include shifting of production facilities inland, rising inland consumption, and reduction of road and seaport congestion (Zeng et al., 2013).

Table 6: Articles on Factors Affecting Dry Port Development

Author	Methodology	Aim
Jeevan et al. (2017)	Survey	To investigate the influential factors of dry ports in Malaysia
Li et al. (2015)	Conceptual	To investigate current status dry port development and provide future directions of dry port development in China
Jeevan et al. (2015)	Interviews	To investigate the role of Malaysian dry ports and challenges they face
Bask et al. (2014)	Interviews	To investigate development of dry port–seaport dyads in Northern Europe
Zeng et al. (2013)	Interviews	To find out motivations and challenges for dry port development in China
Rodrigue and Notteboom (2012)	Conceptual	To investigate functions and actors of dry port development in North America and Europe
Beresford et al. (2012)	Interviews	To investigate development paths of dry ports in China
Rodrigue and Notteboom (2012)	Conceptual	To investigate similarities and difference of dry port development in North America and Europe
Hanaoka and Regmi (2011)	Conceptual	To investigate status of dry port development in Asia
Monios (2011)	Conceptual	To reviewed how dry ports developed in Spain
Roso and Lumsden (2010)	Interviews	To review characteristics, motivations, and barriers to dry port development in Asia, Europe, and Africa

Source: Author

And challenges include inadequate rail network, favoring road and waterways for inland transportation, and lack of planning and coordination among authorities (Zeng et al., 2013).

Additionally, Beresford et al. (2012) evaluated challenges to the effective dry port operation in China. Those challenges had included: The lack of coordination among ministries; lack of coordination between local and central government policies; lack of regulations for dry port development. Beresford et al. (2012) also categorized Chinese dry ports as seaport-based dry ports, city-based dry ports, and border dry ports.

Malaysia is another Asian country experienced a boost in the number of dry port facilities. Barriers to the dry port development and efficient operation of dry ports in Malaysia attracted scholarly interest because currently operational dry ports

are underutilized and provide little benefits to their stakeholders (Jeevan et al., 2015). Jeevan et al. (2015) investigated functions and challenges to dry ports in Malaysia by interviewing dry port users. The challenges to Malaysian dry ports include: "Insufficient rail and road infrastructure"; "lack of cooperation with other stakeholders"; "fierce competition"; "inadequate locations of dry ports"; "negative environmental impacts on locals resulting from the traffic of dry ports" (Jeevan et al., 2015).

In another study, Jeevan et al. (2017) investigated the factors affecting dry port operations in Malaysia. First, Jeevan et al. (2017) identified the influential factors in the literature. Second, they applied a survey to the dry port stakeholders in Malaysia. Their results showed that 12 factors impact dry port operations in Malaysia: "information sharing"; "freight forecasting", "customs clearance", "value-added services", "adequate highway infrastructure"; "existence of appropriate operational equipment" and "sufficient space for container storage"; "implementation of public-private partnerships"; "impact of seaport and short sea shipping policy"; "road connectivity" and "location" (Jeevan et al., 2017).

Apart from above articles, Hanaoka and Regmi (2011) examined dry ports located not only in one country but various Asian countries and compared their key features. They concluded that main drivers of dry port development in inspected Asian countries were government policies encouraging participation of private enterprises in dry port development and provision of value added logistics services. Additionally, government initiatives toward making customs clearance and inspection available in the dry ports increase their effectiveness (Hanaoka and Regmi, 2011).

Roso and Lumsden (2010) presented even wider perspective than Hanaoka and Regmi (2011) by reviewing dry ports in different continents. Roso and Lumsden (2010) analyzed characteristics, motivations, and barriers to dry port development in Asia, Europe, and Africa. Investigated dry ports had different characteristics showing no pattern. Roso and Lumsden (2010) identified five types of barriers: Regulations, environment, land use, finance, and infrastructure. Roso and Lumsden (2010) concluded that dry ports had not faced with substantial barriers. None of the dry ports experienced environmental barriers. Other than that, they all experienced at least one barrier. Furthermore, Roso and Lumsden (2010) identified eight advantages of dry ports:

"Increased port capacity, reduced congestion at the port, increased volumes handled, lower environmental impact, improved port inland access, regional growth, new jobs in the area, and improved customer service." All of the reviewed dry ports provided at least two advantages (Roso and Lumsden, 2010): "new jobs in the area"; and "improved customer service."

Rodrigue and Notteboom (2012) and Rodrigue et al. (2010) compared dry ports in Europe and North America and provided similar results. Rodrigue et al. (2010) distinguished three types of dry port functions: Satellite terminal, load center, and transmodal center. Rodrigue and Notteboom (2012) underlined that fundamental difference between dry ports in Europe and North America is the wider availability of barge transport in Europe (Rodrigue and Notteboom, 2012). In both continents, shuttle train service between dry ports and seaports make the position of intermediate hubs uncertain because direct shuttles can make intermediate hubs redundant diminishing their connectivity to seaports (Rodrigue and Notteboom, 2012). Both of the articles underlined the oversupply of dry port facilities in Europe an North America; private enterprises see dry ports as an opportunity of capturing revenue and governments sees them as centers generating employment; thus, they underestimate commercial potential and operational practicality while developing dry ports. Furthermore, both articles stated that seaport authorities and terminal operators are the main actors of developing dry ports in Europe, while rail operators and real estate promoters take their places in North America.

Furthermore, the direction of dry port development in various countries gained scholarly attention. Monios (2011) reviewed how dry ports are developed in Spain. He stated that seaports involved in the development of dry ports, but they are merely partners with dry port operators only hold minority shares. In Spanish context, integration of dry ports with seaports is low; rail operators organize container flows and deals with shippers (Monios, 2011). In another article, Bask et al. (2014) investigated the development of dry port–seaport dyads in Northern Europe. Their results showed that different forms and levels of collaboration is involved in the elaboration of a seaport-dry port dyad apart from the ownership of terminals. Such collaboration might include the development of value-added services and marketing activities. Additionally, seaport-dry

port dryad development had been affected by involved actors and collaboration among the authorities (government, regions, and municipalities).

1.5.2.1.2. Empty Container Movement in Hinterland

Articles in his theme analyze empty container movement in hinterlands of seaports, and the role played by dry ports in empty container movement. Table 7 shows the two articles classified under this theme. In the first one, Clott et al. (2015) analyzed the impact of empty container movement and delays on dry port operations with a mixed integer programming model. Their results showed that scarcity of empty containers resulting from trade imbalances and delays impede the efficiency of inland transportation systems increasing transportation costs. This makes the problem of the inefficient inland transport systems larger issue that necessitates local, regional and federal coordination to achieve lower transportation costs (Clott et al., 2015). In the second one, Xie et al. (2017) studied the problem of empty container inventory sharing and coordination in a dry port–seaport system by game theory modeling. They proposed two models: centralized and decentralized.

Table 7: Articles on Empty Container Movement in Hinterland

Author	Methodology	Aim
Xie et al. (2017)	Game Theory	To study the problem of empty container inventory sharing and coordination in a dry port–seaport system
Clott et al. (2015)	Mixed Integer Programming	To analyze the impact of empty container movement and delays on dry port operations

Source: Author

1.5.2.1.3. Policies on Dry Ports

Articles in this theme inspect the policies regarding dry port development and current regulations of dry port operations. Governments provide policies and regulations about dry port development that reflect their vision. These policies and regulations or

lack of them have substantially impact dry port development. Table 8 summarizes the articles under this category. Indian policies of dry port development gained particular attention. Vanden Bossche and Gujar (2010) proposed properties of sound pricing policies for dry ports services to eliminate monopolies and increase the efficiency of publicly owned dry ports in India. The government can set guiding principle for dry port pricing to eliminate cartels and monopoly thus resulting in enhanced efficiency of dry ports, improved competitiveness of shippers and higher supply chain integration (Vanden Bossche and Gujar, 2010).

Table 8: Articles on Policies Related to Dry Ports

Author	Methodology	Aim
Notteboom and Yang (2017)	Conceptual	To investigate port governance in China since 2004
Ng et al. (2013a)	Interviews	To investigate how institutional framework affects the bureaucratic and logistical roles of dry ports in emerging economies
Flämig and Hesse (2011)	Conceptual	To examine policies regarding planning conflicts resulted from dry port development in the hinterlands of seaports
Ng and Tongzon (2010)	Data envelopment analysis	To examine government policies on efficiency of dry ports
Vanden Bossche and Gujar (2010)	Conceptual	To investigate need for sound pricing policy for dry ports in India
Ng and Gujar (2009b)	Interviews	To examine government policies towards dry port development in India

Source: Author

Another article on the dry port development policies of Indian government showed that public dry ports improved their efficiency after the introduction of the private sector (Ng and Tongzon, 2010). However, efficiency improvements of public dry ports are incremental because of the dualistic policies of the Indian government (Ng and Tongzon, 2010).

Ng and Gujar (2009b) also inspected policies of the Indian government. The results indicated that the policy concerning dry port development, on the one hand, encourages foreign investment and private participation to increase the overall efficiency of the dry port sector, on the contrary, protecting publicly owned dry ports from negative impacts of competition (Ng and Gujar, 2009b).

Ng et al. (2013a) investigated Brazilian dry port development policies. The

results of their article showed that bureaucracy and complex import/export procedures lead companies to use nearby dry ports where informal practices may take place to facilitate customs clearance. The deficiencies in the institutions hindered the integration between seaports and dry ports (Ng et al., 2013a).

Notteboom and Yang (2017)'s investigation of Chinese seaport governance showed that the Chinese container seaport system is affected by the policies: "the 'Go West' strategy; the 'One Belt One Road' (OBOR) initiative; the implementation of modern corporate governance principles; and the establishment of Free Trade Zones." And, they argue that these policies have a number of implications on Chinese ports: (a) "an increased focus on port integration and co-operation", (b) "a strong orientation on hinterland development through corridors and dry ports", (c) "attracting foreign investments and trade to Chinese ports with an internationalization of Chinese port-related companies through investments in foreign ports".

Flämig and Hesse (2011) argue the dry port development in the hinterlands of seaports creates planning conflicts such as congestion, land consumption, land use conflicts and neighborhood conflicts. Their article investigated how these conflicts are being managed in case of the Süderelbe-region in the hinterland of the port of Hamburg, Germany. They found several deficiencies in the regional governance: focusing on economic gains rather than the environmental impacts; hostile attitudes of local NGOs; and the lack of coordination between state, regional and local authorities to manage the conflicts.

1.5.2.1.4. Benefit Assessment of Dry Ports

This theme includes articles that empirically assess the benefits of dry port development as illustrated in Table 9. The impacts of the dry port on transportation chain are empirically investigated by researchers providing proofs for possible benefits of successfully implemented dry ports. Regmi and Hanaoka (2015) investigated the mode shift potential from road transport to the railway and the resulting emissions after the introduction of a dry port service between Laos and Thailand. Their results indicated that rail transport mode share varies between 32% and 55% under various scenarios,

while emissions can be reduced between 23% and 39% compared to current situation.

Table 9: Articles on Impacts of Dry Ports on Transport Chain

Author	Methodology	Aim
Muravev and Rakhmangulov (2016)	Simulation	To examine impacts of a dry port-seaport system
Regmi and Hanaoka (2015)	Stated choice experiment	To investigate the mode shift potential from road transport to railway and the resulting emissions by examining the case of freight transport between Laos and Thailand
Lättilä et al. (2013)	Simulation	To investigate impacts of dry port usage on transportation costs and emissions
Iannone (2012)	Mixed integer programming	To investigate different scenarios to achieve private and social cost efficiency by using dry ports in the inland transportation of maritime containers
Henttu and Hilmola (2011)	Mixed integer programming	To examine dry port development in Finland and associated impacts.
Roso (2007)	Simulation	To examine dry ports environmental benefits

Source: Author

Lättilä et al. (2013) investigated impacts of dry port usage on transportation costs and emissions in Finland with a discrete-event simulation model. They found that CO2 emissions can be decreased up to 45%, and transportation costs savings are about 4–16%, depending on the price of electricity and fuel (Lättilä et al., 2013).

Iannone (2012) analyzed different scenarios to achieve private and social cost efficiency by using dry ports in the inland transportation of maritime containers in Italy. The results showed that the policies towards increasing road fares are more effective than subsidizing rail transportation. Promoting a shift towards environment-friendly inland transportation modes - in this case, railways- can help to reduce transportation costs as well as environmental externalities (Iannone, 2012).

Henttu and Hilmola (2011) examined dry port development and associated impacts in Finland. They found that with the implementation of dry ports, the cost of transportation and harmful environmental impacts can be decreased. The optimum number of dry ports ranged from four to six, and environmental impacts can be reduced by adding more than six dry ports up to nine (Henttu and Hilmola, 2011).

Roso (2007) examined dry ports environmental benefits with a simulation model. Implementation of dry port reduced CO2 emissions up to 25%. And, truck waiting time

in the seaport, and the seaport gate congestion was also significantly reduced (Roso, 2007).

Muravev and Rakhmangulov (2016) proposed a simulation model for optimization of a dry port-seaport system. Results show that dry port construction reduces the average ships' dwell time at anchorage area and reduces costs up to 33%. Additionally, dry port implementation reduces the number of containers in the storage area, the time of their storage in seaports, and environmental externalities.

Research on impacts of dry port development shows that implementation of the dry port concept comes with some advantages however it needs further investigation with different settings to eliminate waste of resources.

1.5.2.1.5. Conceptual Evaluation of Dry Ports

The articles in this theme conceptually evaluate dry ports and provide theoretical grounds and classifications to current industrial practices. Table 10 shows the details of the articles. Jaržemskis and Vasiliauskas (2007) conceptually investigated dry ports concluding that practitioners were not familiar with the concept and informed prospective dry ports users regarding dry port functionality and services. The authors also underlined advantages of dry ports: avoid traffic congestions, strengthen multimodal connections, and provide consolidation. Dry ports must be able to provide specialized service, ensure transportation chain effectiveness and provide custom clearance services (Jaržemskis and Vasiliauskas, 2007).

Table 10: Articles on Conceptual Evaluation of Dry Port Concept

Author	Methodology	Aim
Veenstra et al. (2012)	Conceptual	To propose an extension of dry port concept called extended gate
Wilmsmeier et al. (2011b)	Conceptual	To develop a conceptual model for directional development of inland intermodal corridors concerning dry ports
Roso et al. (2009)	Conceptual	To propose a theoretical extension of dry port concepts
Jaržemskis and Vasiliauskas (2007)	Survey	To provide conceptual basis for dry port concept

Source: Author

Roso et al. (2009) suggested that dry port concept goes beyond the conventional usage of rail shuttles in hinterland transport by strategically and consciously developing such service and involving the cooperation of various actors for consciously developing services to strengthen inland connections and increase capacity as well as reducing harmful environmental impacts. Authors also categorize dry ports as distant dry ports, midrange dry ports and close dry ports.

Veenstra et al. (2012) proposed an extension to the dry port concept. Seaport are consciously extending their gates to further inland by developing and operating inland intermodal terminals to manage inland freight transportation flow (Veenstra et al., 2012). The extended gates provide much control over transportation flow. Operations in inland intermodal terminals, which are called extended gates, provided by seaports significantly alter the role of seaports in supply chains (Veenstra et al., 2012).

Wilmsmeier et al. (2011b) categorized dry ports regarding their direction: inside-out developed dry ports, and outside-in developed dry ports. Inside-out development indicates that inland intermodal terminal seeks collaboration with seaports often derived by public authority. The outside-in development indicates the conscious development of dry ports by the port authority or terminal operators with the aim of expanding their hinterlands

1.5.2.1.6. Seaport-Hinterland Connectivity

This theme examines articles that inspected seaport-hinterland connectivity and touched the role played by dry ports with that regard. As illustrated in Table 11, various papers investigated dry ports from the perspective of seaport hinterland connection with a research scope of improving hinterland transportation seeing dry ports as nodes connecting seaport with its hinterland.

Talley and Ng (2017) investigated impacts of different factors on hinterland transportation chain choice with differential equations. They concluded that hinterland chain choice was affected by the seaport's and dry port's throughput, intermodal carriers' profit, importers' and exporters' logistics costs. Wang et al. (2016) proposed an inter-port connectivity assessment framework considering three aspects including hinterland

connectivity, feeder service connectivity and connectivity of international liner services.

Wei and Sheng (2018) examined the logistics connectivity of inland Chinese provinces along the 21st-Century Maritime Silk Road. They underlined three outcomes: First, the cooperation between dry ports and seaports is required for an effective import and export logistics network for connecting inland provinces to the Maritime Silk Road. Second, the logistics connectivity of inland provinces of China to the Maritime Silk Road is low failing to meet the development needs of inland regions; third, an increase in the number and the connectivity of the seaports increase the logistics connectivity of inland provinces which are linked to them.

Santos and Guedes Soares (2017) evaluated the current status of port regionalization in the Portuguese range. They concluded that a regional network of inland terminals was being developed in the proximity of seaports and mid-range locations. Development of intermodal corridors by seaports created islands in the natural hinterlands of their competitors and increasing collaboration between seaports and inland terminals was turning inland terminals into dry ports (Santos and Guedes Soares, 2017).

Wei et al. (2017) evaluated the hub-and-spoke logistics network that connects the Chinese inland regions with dry ports to the seaports. Their analysis showed that encouraging government policies are required for the development of logistics hubs and logistics radiation in the inland regions. The hub-and-spoke logistics network model proposed by the authors redefines the functions of dry ports in China to increase their effectiveness.

Chen et al. (2016) found that hinterland connectivity of the Malaysian major container seaports highly depend on road transportation, even though they have railway connection. The findings also revealed the barriers to Malaysia's hinterland connectivity: imbalanced modal share; insufficient rail capacity and limited services; road congestion; and space constraints of inland facilities.

1.5.2.1.7. Location Assessment

This theme includes articles that assess locations of dry ports or evaluates the selection of optimum locations for dry ports. Table 12 shows the details of those articles.

Table 11: Articles on Seaport Hinterland Connectivity

Author	Methodology	Aim
Wei and Sheng (2018)	Mathematical modeling	To examine the logistics connectivity of inland Chinese provinces along the 21st-Century Maritime Silk Road
Wei et al. (2017)	Gravity model	To evaluate the hub-and-spoke logistics network that connects the Chinese inland regions with dry ports to the seaports
Santos and Guedes Soares (2017)	Conceptual	To evaluate the current status of port regionalization in the Portuguese range
Talley and Ng (2017)	Differential Equations	To investigate the factors affecting hinterland transport chain choice
Wang et al. (2016)	Connectivity indexes, Gravity model, TOPSIS	To analyze inter-port connectivity in Bohai Bay, China
Chen et al. (2016)	Conceptual	To investigate Malaysian container seaport-hinterland connectivity

Source: Author

The location is one of the most important elements of dry ports thus effectiveness and efficiency of them depends on it thus determines the success of dry port implementation. With this perspective, assessment of dry ports' location gained attention in scholarly research.

Wang et al. (2018) investigated the dry port location selection problem with mixed integer programming for Tianjin Port. In their model, instead of having a capacity constraints for the dry ports, authors set up a lower bound of the required demand to survive in the market. Their findings suggested Tianjin Port should open some new dry ports or close existing dry ports which have low throughputs.

Komchornrit (2017) investigated location selection for development of a dry port in southern Thailand. They used a hybrid model of CFA-MACBETH-PROMETHEE. Their findings showed that Phatthalung railway station is the most suitable location for constructing a dry port in southern Thailand.

Nguyen and Notteboom (2016) developed a multi-criteria decision-making approach which includes qualitative and quantitative criteria for location selection of dry ports in developing countries. Their model consists of several steps: preliminary analysis on alternative locations, identification of measuring attributes and measuring criteria, deciding on the method for obtaining weights and applying multi-criteria

Table 12: Articles on Dry Port Location Assessment

Author	Methodology	Aim
Komchornrit (2017)	CFA-MACBETH-PROMETHEE	To investigate location selection for development of a dry port in southern Thailand
Wang et al. (2018)	Mixed integer programming	To investigated the dry port location selection problem for Tianjin Port
Nguyen and Notteboom (2016)	Multi-attribute decision-making approach	To develop multi-criteria decision-making framework for location selection of dry ports in developing countries
Chang et al. (2015)	Fuzzy c-means clustering, linear programming, genetic algorithm	To provide efficient and effective methodology to find optimal dry port location
Awad-Núñez et al. (2015)	Multi-criteria decision analysis and Bayesian networks	To generate a dry port location selection model that takes environmental variables into account
Feng et al. (2013)	Nonlinear programming, greedy algorithm, genetic algorithm	To propose a location selection model for the regional seaport-dry port network optimization
Ng and Cetin (2012)	Interviews, center of gravity model	To investigate locational characteristics of dry ports located in India
Padilha and Ng (2012)	Interviews	To investigating the spatial evolution of dry ports in Brazil
Ka (2011)	Fuzzy AHP and ELECTRE	To analyze site selection of dry ports in China
Ng and Gujar (2009a)	Interviews and Mixed Integer Programming	To investigate spatial characteristics of dry ports located in southern India

Source: Author

analysis to find the ranking of alternative locations.

Chang et al. (2015) proposed a dry port site selection model that combines fuzzy clustering and linear programming. In the first step, FCM clustering applied to classify cities into various categories. In the second phase, linear location model is implemented to find the optimal location for dry ports by considering costs related to the inland transportation system.

Feng et al. (2013) proposed a model for dry port location selection that optimizes transportation network. The model is applied successfully for development of dry ports near the west bank of the Taiwan Strait justifying development of dry ports in strategic locations.

Ng and Cetin (2012) investigated locational characteristics of dry Indian ports. The results showed because of the inadequate policies, the dry ports located near industrial clusters are preferred by shippers even though they are not the optimal ones impeding their supply chain integration. These indicated that dry ports in India are cluster oriented because of the inefficient supply chain management practices. Ng and Gujar (2009a) also investigated locational characteristics of Indian dry ports. They found similar results with Ng and Cetin (2012) showing that due to government policies and inadequate logistics services of dry ports, shippers do not use optimal dry ports but use dry ports located close to their production facilities.

Ka (2011) proposed a model for site selection of dry port development in China. The article combines two methods for dry port site selection taking into account fuzziness and preference of actors. The application in China showed that the model results are consistent with reality.

After investigating the spatial evolution of dry ports in Brazil, Padilha and Ng (2012) found that institutional and infrastructural barriers impede sound dry port development. They found that infrastructural and institutional barriers impede the development of dry ports in Brazil. This cause development of a large number of small dry ports with limited market catchment unable to benefit from economies of scale and economies of agglomeration (Padilha and Ng, 2012).

Awad-Núñez et al. (2015) generated a dry port location selection model that takes environmental variables into account. Their results indicated that environmental

variables are most important ones while selecting a dry port location. Feasible results also prove that combining BN and MCDA suitable for assessing dry port location.

Developing dry ports in a feasible location that ensures demand for its services and enables supply of necessary logistics services has great importance for the success of the fallibility since dry port investments usually put a high-cost burden on involved organizations.

1.5.2.1.8. Finance of Dry Ports

This theme includes articles dealing with finance of dry ports. The details of the articles summarized in Table 13. Dry ports investments can be quite costly, thus, eliminating waste of financial recourses have great importance.

Haralambides and Gujar (2011) investigated public, private partnership opportunities in Indian dry port sector. The results showed that successful PPP and greater participation of private establishments in dry port development necessitates a pricing strategy which aims for full recovery of public and private dry port operators. This eliminate wasteful subsidization and monopolies.

Panova and Hilmola (2015) proposed a financial model for assessment of dry port investment in Russia. Additionally, Panova and Hilmola (2015) analyzed the dry port investment with and without the participation of Russian Railways. Their findings showed the Economic potential of PPP concessions for dry port development in Russia is high. Including Russian Railways in the Public-Private-Partnerships of dry port development projects is the best investment strategy. It is beneficial for both Russian Railways and private investors (Panova and Hilmola, 2015).

There is a significant requirement for investigating the financing of dry port investments. Financial inspection of dry port investments can increase successful feasibility assessment of dry port development thus promising research area for further exploration.

Table 13: Articles on Financing Dry Port Investments

Author	Methodology	Aim
Panova and Hilmola (2015)	Net cash flow model	To provide a method for assessing dry port investments in Russia and analyze dry port PPP investments with and without the participation of Russian Railways
Haralambides and Gujar (2011)	Interviews	To investigate public, private partnership opportunities in Indian dry port sector

Source: Author

1.5.2.1.9. Literature Reviews

The articles in this theme include literature reviews. Two articles categorized under this theme as shown in Table 14. Lee et al. (2017) reviewed the related literature to identify key trends and potential research directions on the Belt and Road (B&R) initiative with a focus on maritime transport. They classified previous research into eight topics: Supply chain management and logistics; shipping and ports; connectivity, transportation, and routing; industry development and investment; trade and cross-border; infrastructure and Internet of Things; safety and risk; and environmental issues. They also identified four research directions: the effects of the development of freight railways and dry ports in China's inland regions; the impacts of corridors on the regional transport system; the design of coordination mechanism among the countries to achieve seamless cargo movements; and infrastructure investment and capacity along the B&R.

Table 14: Literature Review Articles

Author	Methodology	Aim
Lee et al. (2017)	Conceptual	To review the related literature to identify key trends and potential research directions on the Belt and Road (B&R) initiative with a focus on maritime transport
Rozic et al. (2016)	Conceptual	To review the literature on inland terminals

Source: Author

Rozic et al. (2016) review the literature on inland terminals. They categorized the research areas of the literature as inland terminal development, classification of inland terminals, technological processes in inland terminals, and location determination of inland terminals.

1.5.2.1.10. Business Ethics

This theme includes articles dealing with business ethics practices related to dry ports. Table 15 shows the details of these articles. Ng et al. (2016) analyzed the attitudes and behaviors of port planners and operators to climate change adaptation. Their results showed various challenges to effective planning for the climate change: current planning of climate change is too short-term to be effective; other stakeholders are not considered in the current planning; conservative status quo creates managerial obstructions for effective climate change planning. They concluded that individuals could not solve these ethical dilemmas by only themselves, an institutional paradigm shift is necessary.

Table 15: Articles on Business Ethics

Author	Methodology	Aim
Ng et al. (2016)	Survey	To analyze the attitude and behaviors of port planners and operators to climate change adaptation
Costa et al. (2015)	Interviews	To analyze the perspective of dockworkers on health and labor in the dry port of the Municipality of Uruguaiana, in the State of Rio Grande do Sul

Source: Author

Costa et al. (2015) analyzed the perspective of dockworkers on health and labor in the dry port of the Municipality of Uruguaiana, in the State of Rio Grande do Sul. They described five thematic categories of interpretation: The meanings of dock work; work process aspects; occupational hazards; work accidents; and suggestions.

1.5.2.1.11. Optimization Models

The articles in this theme propose mathematical and simulation models for optimization and decision support. Table 16 shows the details of the articles in this theme. Haralambides and Gujar (2012) proposed a DEA model to evaluate dry port-seaport system efficiency from an environmental perspective. The results show that after including environmental factors, the efficiency scores significantly changed. Adding

environmental factors to the model adjust efficiency scores of a seaport-based dry port-seaport system thus a balance between production and its environmental externalities can be provided.

Table 16: Articles on Optimization Models

Author	Methodology	Aim
Wei and Sheng (2017)	Bi-objective Mixed integer programming	To propose a hinterland logistics network optimization model
Qiu et al. (2015)	Bilevel programming	To present a model for storage pricing of dry ports to optimize objectives of both dry port operators and shippers
Fanti et al. (2015)	Simulation	To generate a decision support system for real-time management of transport operations
Crainic et al. (2015)	Mixed integer programming	To develop a model for optimization of dry port based hinterland transportation system
Haralambides and Gujar (2012)	Data envelopment analysis	To evaluate dry port- seaport system efficiency from an environmental perspective

Source: Author

Qiu et al. (2015) presented a model for storage pricing of dry ports to optimize objectives of both dry port operators and shippers. They applied the model to a case and validated proposed storage pricing model. Additionally, they found that the seaports' storage strategy significantly impact the performance of shippers and dry ports.

Fanti et al. (2015) generated a simulation-based decision support system for real-time management of transport operations to reduce lead time and utilize resources. The decision support system models transportation of goods and business transactions between seaport and a dry port. Proposed decision support system was successfully applied showing an application of information and communication technology-based solutions has a great potential for efficient real-time management of transport operations by reducing lead times in seaport and dry port and utilize human resources.

Crainic et al. (2015) developed a model for optimization of dry port based hinterland transportation system. Their application showed the suitability of the proposed network design model by providing feasible solutions in reasonable computational time.

Wei and Sheng (2017) proposed a model of hinterland logistics network optimization. While developing their model that consider a concession cooperation mechanism of seaports and dry ports and environmental issues. The concession cooperation mechanism between the seaports and the dry ports facilitate: the development of dry ports; attract hinterland cargo resources; and enhance the competitiveness of seaports (Wei and Sheng, 2017). They also found that dry ports enable sustainable multimodal transport network for transportation of export and import cargo.

1.5.2.1.12. Assessment of Dry Port Implementation

Articles in this theme evaluate the implementation of dry ports. Table 17 illustrates the details of the articles in this theme. Monios and Wilmsmeier (2012b) proposed three concepts for overcoming double periphery of Scotland: development of dry ports, port-centric logistics, and offshore logistics hubs. All three strategies provide benefits for government and private organizations but applying these strategies requires coordination and integration between institutions and government authorities (Monios and Wilmsmeier, 2012b).

Table 17: Articles on Assessment of Dry Port Implementation

Author	Methodology	Aim
Wanzala et al. (2015)	Conceptual	To introduce extended gate concept for the East African inland logistics network to manage supply chain disruptions
Berawi et al. (2015)	Simulation	To analyze feasibility of The Trans-Sumatera Toll Road project
Monios and Wilmsmeier (2012b)	Conceptual	To proposed solutions for overcoming double periphery of Scotland
Panova (2011)	Conceptual	To investigate the reason behind the absence of traffic in Trans-Siberian corridor
Korovyakovsky and Panova (2011)	Mathematic modeling	To analyze dynamics of dry port development in Russia
Do et al. (2011)	Simulation	To review possibilities and potential benefits of developing a dry port system in Indochina region

Source: Author

Panova (2011) investigated the reason behind the absence of traffic in Trans-Siberian corridor. They proposed that increasing cooperation with Far East railway operators and seaports by developing dry ports might be a solution for this problem and provide economic and environmental benefits.

Do et al. (2011) reviewed that possibilities and potential benefits of developing a dry port system in Indochina region to increase seaport capacities and straighten hinterland connections. An efficient dry port system in Indochina can help to improve the efficiency of inland freight transportation, straighten multimodal connections in seaports hinterland and boost seaport capacity (Do et al., 2011).

Korovyakovsky and Panova (2011) analyzed dynamics of dry port development in Russia. They concluded that construction of a dry port might be the best solution for the capacity expansion options of St. Petersburg's container. They evaluated two capacity development scenarios: Dry port development, physically expanding the storage area in the seaport. The results showed the implementation of dry ports increased seaport capacity up to 2,5 times, physical expansion of container storage area in the seaport increased capacity up to 1,5 times. However, increasing storage area can significantly decrease the efficiency of the seaport (Korovyakovsky and Panova, 2011).

Wanzala et al. (2015) introduced extended gate concept for the East African inland logistics network to manage supply chain disruptions. They underlined that the involvement of all stakeholders is needed to implement extended gates to meet the requirements of supply chains.

Berawi et al. (2015) analyzed the feasibility of The Trans-Sumatera Toll Road project. The Trans-Sumatera Toll Road (TSTR) project is planned to stretch from Bakauheni to Banda Aceh (2527 kilometers). The feasibility analysis is constructed by a system dynamic simulation model. The results show that six extensions to TSTR Project generate additional revenue. The extensions include rest area development, tourism park development, medial railways integration, dry port integration, motorcycle lane integration, and fiber optic networking. Simulation of the three tariff scenarios showed that extensions to the project improve the feasibility of the TSTR project by providing an internal rate of return that ranges from 8.28% to 13.77% Berawi et al. (2015).

1.5.2.2. Methodologies

Table 18 shows 28 different research methodologies applied in the articles. In some articles, more than one research methods were applied; on the other hand, 18 articles were conceptual which had not applied any research methodology only provided conceptual investigations or theoretical grounds. Table 18 presents the frequency of used research methodologies. The most used methodology is interviewing, which is used in 12 articles, while mixed integer programming was used in 7 articles and simulation was used in 6 articles. The other methodologies were rarely used –one or two times– as presented in Table 18.

1.5.2.3. Journals

Table 19 shows the journals and number of the articles they published. The articles were published in 30 different journals, which publish wide range and number of scientific articles that can be accessed through Web of Science and Scopus. Journal of Transport Geography and Maritime Economics & Logistics published 7 articles each, that is the highest number of articles a journal published related to dry ports. Two other journals, Research in Transport Economics and Maritime Policy & Management, published five articles each. Additionally, The Asian Journal of Shipping and Logistics published 5 articles. Other journals, as illustrated in Table 19, published either 1, 2 or 3 articles each. Publication of 62 articles by 30 different journals shows the broad interest of scientific journals to dry ports.

1.5.2.4. Investigated Countries

Table 20 illustrates how frequently a country was investigated in the articles. Totally 34 different countries were investigated: Some articles investigated more than one country; some investigated none. 13 articles study China, making it the most studied country about dry ports. India is the second most studies country with 8 articles. Russia, Spain, and the USA are also among the frequently inspected countries. Other countries,

Table 18: Methodologies

Methodologies	Frequency
Conceptual	18
Interview	12
Mixed integer programming	7
Simulation	6
Survey	3
Data envelopment analysis	2
ELECTRE	2
Gravity model	2
Mathematical modeling	2
Multi criteria decision analysis	2
Genetic algorithm	2
AHP/Fuzzy AHP	1
Net cash flow model	1
Stated choice experiment	1
Center of gravity	1
TOPSIS	1
Bilevel programming	1
Game theory	1
Fuzzy c-means clustering	1
Linear programming	1
Non-linear programming	1
Bayesian network	1
Greedy algorithm	1
CFA	1
MACBETH	1
PROMETHEE	1
Differential equations	1
Connectivity indexes	1

Source: Author

Table 19: Journals

Journals	Number of Papers	Percentage %
Journal of Transport Geography	7	11.3
Maritime Economics & Logistics	7	11.3
Maritime Policy & Management	6	9.7
Research in Transportation Economics	6	9.7
The Asian Journal of Shipping and Logistics	5	8.1
Research in Transportation Business and Management	3	4.8
Transportation Research Part E: Logistics and Transportation Review	3	4.8
International Journal of Shipping and Transport Logistics	2	3.2
Transport	2	3.2
Discrete Dynamics in Nature and Society	1	1.6
Eurasian Geography and Economics	1	1.6
European Journal of Operational Research	1	1.6
IATSS Research	1	1.6
International Journal of Sustainable Transportation	1	1.6
Journal of Computational Science	1	1.6
Regional Studies	1	1.6
Transport Policy	1	1.6
Transportation journal	1	1.6
Transportation Planning and Technology	1	1.6
Transportation Research Part A: Policy and Practice	1	1.6
Transportation Research Part C: Emerging Technologies	1	1.6
Transportation Research Part D: Transport and Environment	1	1.6
Ciencia e Saude Coletiva	1	1.6
International Journal of Engineering Research in Africa	1	1.6
International Journal of Production Economics	1	1.6
Journal of Business Ethics	1	1.6
Journal of Coastal Research	1	1.6
Open Engineering	1	1.6
Polish Maritime Research	1	1.6
Promet - Traffic & Transportation	1	1.6
Total	62	100

Source: Author

which attracted the attention of scholars, are also illustrated in Table 20.

Table 20: Countries

Countries	Frequency
China	13
India	8
USA	4
Spain	4
Russia	4
Sweden	3
Finland	3
Thailand	3
Brazilia	3
Tanzania	3
Malaysia	3
Italy	2
Laos	2
Vietnam	2
France	2
Netherlands	2
Belgium	2
Canada	2
Germany	2
UK	1
Australia	1
Cambodia	1
South Korea	1
Nepal	1
Swaziland	1
Saudi Arabia	1
Nepal	1
Pakistan	1
Portuguese	1
Indonesia	1
Kenya	1
Zambia	1
South Sudan	1
Ethiopia	1

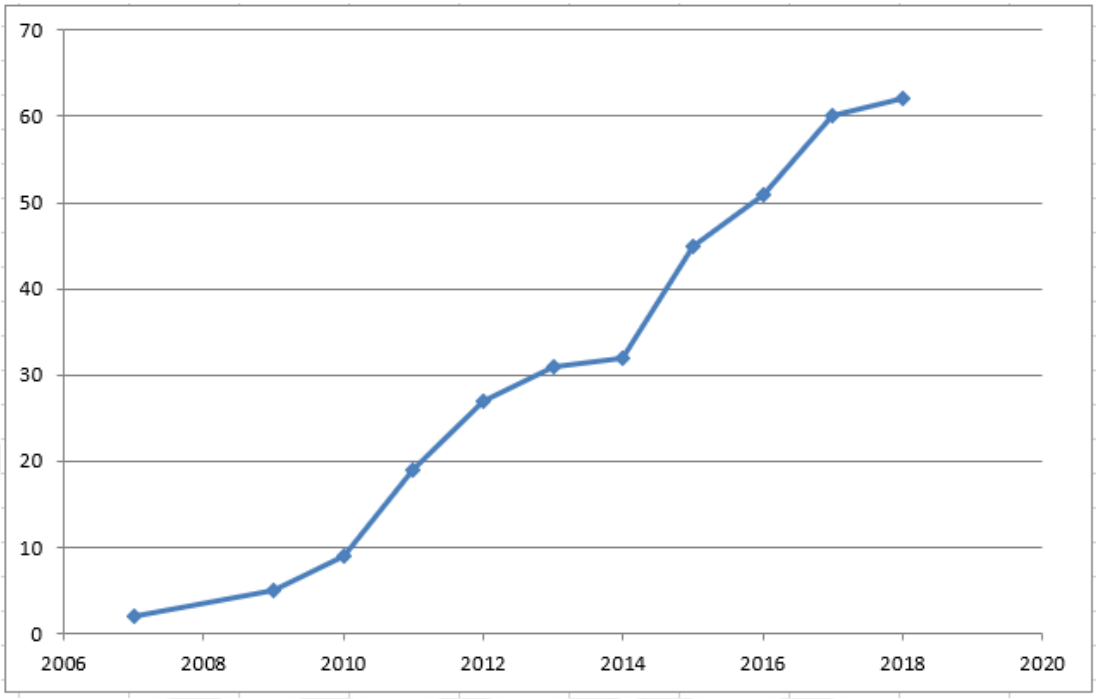
Source: Author

1.5.2.5. Publication Years

Figure 13 illustrates the yearly progress of the number of published articles on dry ports. Figure 13 shows a significant increase in the number of published articles in the past ten years. In 2007, only two articles, related to dry ports, had been published. Five years later, in 2012, the number of published articles had reached to 27. As of 2018, the number of published articles related to dry ports has become 62. These numbers

show an upward trend, indicating the increasing scholarly interest to dry ports.

Figure 13: Publication Years of the Articles



Source: Author

1.6. DRY PORTS IN THE WORLD

1.6.1. Dry Ports in Europe

1.6.1.1. Azuqueca Dry Port – Spain

The dry port started its operation in 1995 as a first dry port developed in Spain (Monios, 2016). It was built on an area of 60,016 m2 with an 11,000 m2 of a full container and a 13,800 m2 of empty container storage area (Puerto Seco Azuqueca, 2015). The service area of the dry port includes Madrid city and its metropolitan area where they connect with Spanish seaports by train service (Port of Santander, 2007). A private real estate company named Gran Europa played the major role in the development of the dry port and currently owns 75 % share in the facility (Monios, 2016). The remainder of the shares owned by seaports of Barcelona, Bilbao and Santander (Monios,

2016). The dry ports provide services to bulk and containerized cargo; currently, 70% of its throughput is containers, and 30% is bulk (Monios, 2016).

1.6.1.2. Dry Port of Madrid – Spain

The dry port developed by joint efforts of the Ministry of Public Works, the Municipalities of Madrid and Coslada, the Land Public Entity (SEPES), and Ports of Barcelona, Valencia, Bilbao and Algeciras (Puerto Seco de Madrid, 2017). Majority shares of the dry port still owned by those four seaports and it connects the four seaports to Madrid city with railways (Monios, 2016). The dry port was built on 140,000 m2 area, 16,000 m2 of which is closed storage area and 18,000 m2 of which is container staking area (Roso and Lumsden, 2010).

1.6.1.3. Dry Port Santander-Ebro – Spain

The dry port was built with the participation of the Port of Santander and started its operations in 2000 (Roso and Lumsden, 2010). It is located in Luceni, Zaragoza where the Port of Santander extends its hinterland to the Ebro Valley (Europa Press, 2015). The rail connection of the dry port extends to rail connections to five ports: Santander (400km), San Sebastian (260km), Bilbao (300km) and Barcelona (300km) (Roso and Lumsden, 2010). The dry port is located in an area of 105,000 m2, of which includes warehouses and provides value-added logistics services, such as container storage, customs warehousing, to manufacturers and logistics service providers (Europa Press, 2015).

1.6.1.4. Eskilstuna Dry port – Sweden

The dry port was built on an area of 83,000 m2 with a capacity of 300,000 TEU per year (Eskilstuna Logistik och Etablering, 2017). It was built by joint efforts of the Eskilstuna municipality and the two rail operators and had started its operations in 2003 (Roso and Lumsden, 2010). The terminal provides value-add logistics services such as

container storage, closed warehousing, container repair, and service station for trucks (Eskilstuna Logistik och Etablering, 2017). Additionally, daily rail services are being provided between the dry port and the seaports of Gothenburg, Halmstad, Malmo and Trelleborg (Eskilstuna Logistik och Etablering, 2017).

1.6.1.5. Hallsberg Dry port – Sweden

The dry port had been built and owned by the municipality of Hallsberg and a private logistics company called Green Cargo (Roso et al., 2015) and started its operations in 2003 (Roso and Lumsden, 2010). Daily train services provided between the dry port and the ports of Goteborg, Trelleborg, and Malmo (Logent, 2017). The dry port has a total area of 62,000 m2 (Roso and Lumsden, 2010) and provide services such as transshipment, container staking area, warehousing, container repair, cross-docking, forwarding and road haulage (Logent, 2017).

1.6.1.6. Muizen Dry port – Belgium

The dry port was developed by public investment (Monios, 2016). Belgian railways, which is a public initiative, built the dry port and provided superstructure investments (Monios, 2016; Roso and Lumsden, 2010). The facility started its operations in 1994 (Monios, 2016). A public initiative, Inter Ferry Boats, currently operates the dry port (Roso and Lumsden, 2010). Daily direct train services provided between the dry port and the port of Zeebrugge (Monios, 2016; Roso and Lumsden, 2010). The dry port has an area of 42,000 m2 and provides value-added services such container storage, repair, and warehousing (Roso and Lumsden, 2010).

1.6.1.7. Venlo Dry port – Netherlands

The dry port is located in Dutch-German border on an area of 70,000 m2 and has both inland water connection and rail connection (Europe Container Terminals, 2016). It was built by European Container Terminals (ECT), which is an initiative of Hutchinson

Port Holdings (HPH) (Europe Container Terminals, 2016), and started its operations in 1999 (Rodrigue et al., 2010). Daily train service is provided between Venlo Dry Port and Delta (APM) and Home (HPH) terminals in Rotterdam. Value-added logistics services such as short and long-term container storage, container repair and cleaning is being provided in the dry port (Europe Container Terminals, 2016). Venlo dry port agreed with APL Logistics to become extended gate of ECT Delta Terminal in 2007 (Rodrigue and Notteboom, 2009).

1.6.2. Dry Ports in North America

In America, facilities that act as dry ports are not often called dry ports. The terms such as intermodal center, inland ports, logistics park, etc. are used to describe a dry port facility.

1.6.2.1. BNSF Logistics Park – Chicago

The dry port was constructed by a private establishment, a rail operator BNSF, and started its operations in 2002 (Rodrigue et al., 2010). It was built on a 770 acres (3,116,190 m2) of areas with a capacity of 3 million TEU per year (Mid-America Freight Coalition, 2018). An automobile distribution facility is also present in the dry port (Mid-America Freight Coalition, 2018). It functions as an extended gate of seaports of West Coast (Rodrigue et al., 2016). Containers coming from the West Coast seaports are consolidated and distributed throughout the region. A variety of value-added logistics services provided in the facility including free trade zones (Rodrigue et al., 2010). The dry port current handles the largest volume of freight in North America and has a direct connection to the North American rail corridor, the Los Angeles-Chicago axis (Rodrigue et al., 2016).

1.6.2.2. CenterPoint-KCS Intermodal Center – Kansas

The dry port was developed by joint efforts of a private rail operator, Kansas City Southern KCS, and a real estate company, CenterPoint Properties, in 2007 (Rodrigue et al., 2010). It was constructed on a 1340 acres area on a reconverted military base (Rodrigue et al., 2016). The dry port is a part of Kansas City cluster aims to provide service to Mexican supply chains or international supply chains passing over Mexico (Rodrigue et al., 2010). The facility has a status of free trade zone and provides warehousing facilities (Rodrigue et al., 2016).

1.6.2.3. The Savannah Gateway Industrial Hub – Georgia

OmniTRAX, a private railway operator has partnered with Effingham County Industrial Development Authority to develop the dry port facility (Savannah Gateway Industrial Hub, 2018). The dry port recently started its operations at the beginning of 2018. The facility built on an area of 2,700 acres (10,926,900 m2) and located 20 kilometers away from The Port of Savannah (Margulis, 2018). The dry port is directly connected to the Port of Savannah via rail and the new two-lane road (Savannah Gateway Industrial Hub, 2018). It also connected to major US markets through interchanges to CSX and Norfolk Southern (NS) Railroads (Savannah Gateway Industrial Hub, 2018). Additionally, it has accessibility to Savannah/Hilton Head International Airport (Margulis, 2018).

1.6.3. Dry Ports in Asia

1.6.3.1. Shijiazhuang Dry Port – China

Shijiazhuang dry port is located Huabei province in Northeast China; 1.5km away from the city's eastern ring road and 29km away from Shijiazhuang airport (Beresford et al., 2012). The dry port was constructed by joint efforts of Tianjin Port Authority and the central, provincial and municipal governments (Ka, 2011). Operations in the

dry port started in 2006 (Beresford et al., 2012). The dry port has an area of 262,000 m2 (Beresford et al., 2012). Currently, customs, inspection and quarantine, port agents, and shipping companies are present in the dry port. Value-added logistics services, such as consolidation, storage, freight forwarding, customs clearance, transshipment (Rail-Road), bonded warehousing, is being provided in the dry port (Hanaoka and Regmi, 2011). The facility acts as an extended gate of Tianjin port (Hanaoka and Regmi, 2011; Beresford et al., 2012). The dry port operated by a public-owned company, Shijiazhuang Inland Port Company Ltd – SIPCL (Beresford et al., 2012).

1.6.3.2. Xi'an Dry Port – China

The dry port located in Shaanxi province in Northwest China (Morgan, 2017) covering an area of 683,000 m2 (Hongyan and Fan, 2015). It was completed in 2009 (Hongyan and Fan, 2015) by public initiative, the Municipal Government and four state-owned companies (Beresford et al., 2012), and started its operations in 2010 (Hongyan and Fan, 2015). The Xi'an International Trade and Logistics Park (XITLP) Committee, which is a branch organization of Xi'an Municipal Government, currently operates the dry port (Beresford et al., 2012). Xi'an plays a role as a China's gateway to the West connecting East Asia with Europe through plains of Central Asia via railways (Morgan, 2017). Rail services are provided between the dry port and various Asian and European cities, such as Warsaw in Poland, and Hamburg in Germany (Morgan, 2017). Xi'an dry port also cooperates with seaports of Shanghai, Qingdao, Ningbo, and Tianjin to develop inland transportation corridors for maritime freight (Morgan, 2017). It includes five areas (Beresford et al., 2012): a Container Freight Station, a B-type bonded logistics center, an international logistics zone, a domestic logistics zone and a logistics cluster area. Additionally, the dry port provides value-added logistics services such as customs clearance, warehousing, international and domestic freight forwarding, and bonded warehousing (Beresford et al., 2012).

1.6.3.3. Kunming Dry Port – China

Kunming Dry Port is located at West Kunming; 27 kilometers away from Kunming's city center (He, 2011). It was constructed as a part of an Export Processing Area within Kunming National Economic and Technological Development Zone (KETDZ) (Beresford et al., 2012), which is the biggest international warehousing and logistics center in Yunnan province of China (Jieru, 2014) since it has a 700,000 m2 warehousing area (Jieru, 2014), 7,000 m2 of which is bonded warehouse area (Beresford et al., 2012). Kunming Dry Port connects companies in Yunnan with other provinces of China and countries located in Southeast Asia and South Asia (Jieru, 2014; Beresford et al., 2012). The dry port is constructed by a government initiative, The KETDZ committee and started its operations in 2009 (Beresford et al., 2012). As a branch organization of Kunming Municipal Government, the KETDZ committee is responsible for land planning and infrastructure construction (Beresford et al., 2012). Operations in the dry port are managed by Yugang Logistics Company, which is a partnership of the Municipality with a private company (Beresford et al., 2012).

1.6.3.4. Riyadh Dry Port – Saudi Arabia

Riyadh Dry Port, developed by Saudi Railways Organization to improve commerce in the central region, became operational in 1982 (Saudi Gazette, 2014). Riyadh Dry Port handled more than 500,000 TEU in 2013 (BAAS International Group, 2013). Daily rail services are being provided between the dry port and the Seaport of King Abdulaziz (400km distant) in Dammam (Roso and Lumsden, 2010). The dry port has a total area of 918,639 m2, almost 40,000 m2 of the area includes warehousing facilities. BAAS International Group (BIG), which has an agreement for 10 years with Saudi Railways Organization (SRO), is the current operator of the dry port (BAAS International Group, 2013). Value-added logistics services provided in the dry port includes transshipment; refrigerated storage; customs clearance; container repair; road haulage and forwarding (Roso and Lumsden, 2010).

1.6.3.5. Birgunj Dry Port – Nepal

The dry port was developed by Nepal Intermodal Transport Development Board (Himalayan Terminals, 2017) with the support of World Bank Department of Customs (2018) and started its operations in 2005 (Cochran, 2016). The railway line from Raxaul Point of India to Sirsiya of Nepal constructed by Indian government Department of Customs (2018). A railway transportation agreement between Nepal and India is signed to connect the Indian seaports to the dry port in 2004 (Department of Customs, 2018). The dry port has daily train services to the Port of Kolkata, India, which is located about 700 km away (Roso and Lumsden, 2010). It also connects the capital of the country, Kathmandu, with a key industrial city, Hetauda (Cochran, 2016). The dry port has an area of 380,000 m2 (Roso and Lumsden, 2010) including two 1,000 m2 bonded warehouses (Cochran, 2016). In 2004, a private company called Himalayan Terminals made an agreement with NITDB for operating the dry port (Himalayan Terminals, 2017). Himalayan Terminals Pvt Ltd is a joint venture of Indian and Nepalese companies (Container Corporation of India Ltd, CONCOR, Transworld Group, Nepal Transit Warehousing Corporation and Interstate Multimodal Transport Pvt Ltd) (Himalayan Terminals, 2017).

1.6.3.6. Faisalabad Dry Port – Pakistan

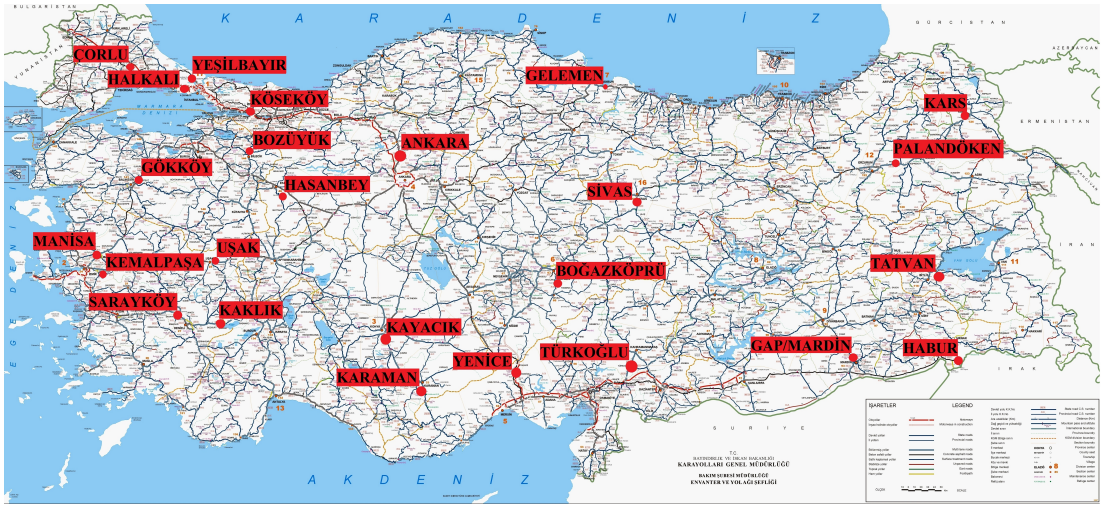
Faisalabad Dry Port started its operations in 1994 with the aim of facilitating imports and exports (Rana, 2017). It is the biggest (in terms of value and volume) dry port of Pakistan that built by a private initiative (Faisalabad Dry Port, 2009b) and being run by a 30-member board of trustees, which consists of entrepreneurs and importers/exporters (Faisalabad Dry Port, 2009a). Daily train services are being provided for transportation of export cargo to Karachi Port and import cargo from Karachi to Faisalabad dry port (Faisalabad Dry Port, 2009b). The dry port supports the development of industry and trade in Faisalabad region (Faisalabad Dry Port, 2009b). Faisalabad dry port has a custom bonded area and provides custom clearance facilities (Faisalabad Dry Port, 2009b) and shipping lines, forwarding agencies and road haulage

operators are currently present in the dry port (Akhtar, 2010).

1.7. DRY PORTS IN TURKEY

Terminology for inland terminal facilities as well as dry ports varies among different countries: "Freight Villages" in the United Kingdom, "Platformes Multimodales Logistiques" in France, "Interporti" in Italy, and "Gueterverkehrszentren" in Germany (Tsamboulas and Dimitropoulos, 1999; Roso et al., 2009; Cetin, 2007). In Turkey, they are often termed as "Lojistik Merkez" (translated as "Logistics Center" in English) or "Lojistik Köy" (translated as "Logistics Village" in English). Dry port facilities in Turkey mostly developed by government initiative usually by TCDD (Turkish Republic State Railways). TCDD plans to finish construction of 21 dry ports by the year of 2020 (Rayhaber, 2013). In addition to TCDD, some private establishments are also taking part in developing dry ports. The map of dry ports located in Turkey illustrated in Figure 14. In the below section, we will present the dry ports that are in operation and are planned to be in operation in the near future.

Figure 14: Map of Dry Ports in Turkey



Source: Author

1.7.1. Dry Ports of TCDD

Until 2020, TCDD plans to finish the construction of 21 dry ports all around the country (Rayhaber, 2013). As illustrated in Table 21, 8 of these planned dry ports already in operation, 6 of them are in still construction stage, and 7 of them are in project stage where the constructions have not been started (TCDD, 2018).

Table 21: Dry Ports of TCDD

Stage of Development	Dry Port
In Operation	Samsun (Gelemen)
	İstanbul (Halkalı)
	Eskişehir(Hasanbey)
	Denizli (Kaklık)
	İzmit (Köseköy)
	Uşak
	Balıkesir (Gökköy)
	Kahramanmaraş (Türkoğlu)
In Construction	Kars
	Bilecik (Bozüyük)
	Erzurum (Palandöken)
	Mersin (Yenice)
	Konya (Kayacık)
	İzmir (Kemalpaşa)
In project	İstanbul (Yeşilbayır)
	Mardin
	Şırnak (Habur)
	Kayseri (Boğazköprü)
	Sivas
	Bitlis (Tatvan)
	Karaman

Source: TCDD (2018)

1.7.1.1. Dry Ports in Operation

1.7.1.1.1. Gelemen (Samsun) Dry Port

The first phase of the dry port opened in 2007 and second phase is still under development (Rayhaber, 2013). When the second phase is finished, the dry port will reach an area of 350 square meters with a capacity of 1.1 million tons of freight (Yapıcı, 2015). The dry port is close to Kerimbey Organized Industrial Zone (Organize Sanayi

Bölgesi OSB) and Yeşilyurt Seaport. It is planned to handle varied types of freight: iron, scrap metal, copper, container, cement, coal, timer, fertilizer and as well grain and other edible substances (Ekinci, 2013).

1.7.1.1.2. Halkalı (İstanbul) Dry Port

The dry port is established on 1 million square meters of area. In 2016, 860 thousand tons of freight is handled in it. Currently, 4 container trains per week enter the dry port (Terzi and Bolukbas, 2016). The dry port has closed and open warehousing facilities. Additionally, it poses the infrastructure to provide RO-LA transportation (Karadeniz and Akpınar, 2011a). In future, it is planned to increase the area and transportation capacity of the dry port (Terzi and Bolukbas, 2016).

1.7.1.1.3. Hasanbey (Eskişehir) Dry Port

Hasanbey dry port started its operations in 2014. It is located 11 km east of Eskisehir and 9 km away from Organized Industrial Zone (OSB). The dry port established on 630 square meters of area. It is predicted that the dry port would increase the rail transportation in the area from 215,000 tons per year to 566,000 tons per year (UTİKAD, 2015).

1.7.1.1.4. Kaklık (Denizli) Dry Port

Kaklık dry port also got in operation in 2014. The dry port established in 120,000 square meters of area and located at 40 km northeast of Denizli city center. Currently 150,000 tons of freight transported by rail in the region. It is estimated that the dry port will increase the volume of freight transported by rail to 500,000 tons (Mustafa et al., 2017).

1.7.1.1.5. Köseköy (İzmit) Dry Port

The first phase of dry port development in Köseköy is finished in 2013. The dry port currently established on 115,000 square meters of area, but when the second phase of the project finishes, the area of the dry port will be increased to 765,000 square meters (Rail Turkey, 2017). It is predicted that the dry port would increase the rail transportation in the area from 600,000 tons to 1,500,000 tons. And, it is planned that the dry port will mostly handle automotive and automotive spare parts (Karadeniz and Akpınar, 2011b).

1.7.1.1.6. Uşak Dry Port

Usak dry port was got in operation in 2013. It is established in current rail terminal and has 140,000 square meters of area and expected to double the rail transportation, which is currently around 113,000 tons, in the area (Karadeniz and Akpınar, 2011b). Dry port expected to handle ceramic products, textile products, marble and dry food products (Rayhaber, 2013).

1.7.1.1.7. Gökköy (Balıkesir) Dry Port

Gökköy dry port started its operations in 2015. The dry port is established in 211,000 square meters of an area which has 8,247 square meters of administrative buildings and 59,560 square meters of open storage area (TCDD, 2015). It is located near Organized Industrial Zone and has 1 million of freight handling capacity per year. It is planned to handle iron ore, textile, automotive products, coal and dry food products (TCDD, 2015).

1.7.1.1.8. Turkoğlu (Kahramanmaraş) Dry Port

The dry port began its operations in 2017 in the county of Turkoglu and is 4.5 km near to Organized Industrial Zone (OSB). It is established on 805,000 square meters of

area with a handling capacity of 1.9 million tons of freight per year (Trenhaber, 2017).

1.7.1.2. Dry Ports under Construction

1.7.1.2.1. Kars Dry Port

The dry port is being constructed in 300,000 square meters of an area where it is located at the crossroads of Kars-Tiflis and Kars-Igdır railways (Haberler.com, 2017). It is planned to handle coal, fertilizers, grain and other containerized cargo and will be integrated into Kars-Tiflis-Baku railway project. It will have 412,000 tons of freight handling capacity (http://www.karsolay.com, 2017).

1.7.1.2.2. Bozüyük (Bilecik) Dry Port

Bozuyuk dry port located near Bozuyuk Organized Industrial Zone(OSB) and still under construction. The dry port is constructed in 650,000 square meters of area and when the construction finishes, freight handling capacity of the dry port will be 1.9 million tons (Uysal, 2015). When the dry port starts operation, it is expected to handle ceramic products, construction materials, iron-steel products and other containerized freight (Rayhaber, 2013).

1.7.1.2.3. Palandöken (Erzurum) Dry Port

The dry port is being established near Palandoken Organized Industrial Zone (OSB). After the dry port finishes, it will provide 437,000 tons of freight handling capacity per year in a 276,000 square meter of area (Karadeniz and Akpınar, 2011a). It is expected to provide service to automotive products, iron, coal and construction materials as well as containerized freight (Karadeniz and Akpınar, 2011a).

1.7.1.2.4. Yenice (Mersin) Dry Port

The dry port is being constructed on 415,000 square meters of area with a freight handling capacity of 1 million tons per year. It will have 50,300 square meters of container stocking area. The dry port will be connected to Mersin seaport and expected to be a transloading center for the freight of central Asia. The dry port expected to get in operation in 2018 (Bahçıvan, 2017; Terzi and Bolukbas, 2016).

1.7.1.2.5. Kayacık (Konya) Dry port

The dry port is being constructed in 1 million square meters of area and expected to have 1.7 million tons of freight handling capacity per year (Karadeniz and Akpınar, 2011a). The location of the dry port is near Konya Organized Industrial Zone. Construction of the dry port expected to be finished by 2019 (Timeturk.com, 2017).

1.7.1.2.6. Kemalpasa (Izmir) Dry Port

The dry port is located near Kemalpasa Organized Industrial Zone on an area of 1.2 million square meters. After it is finished, it will have 14,211 square meters of container stacking area and 173,000 square meters of close warehouse facility. The dry port will be connected to Ports of Izmir and the Port of Çandarlı that is projected to be built in future (UTIKAD, 2015).

1.7.1.3. Dry Ports in Project Stage

1.7.1.3.1. Yeşilbayır (İstanbul) Dry Port

The dry port will be established on 1 million square meters of area and expected to have a freight handling capacity of 6 million tons (UTIKAD, 2013). In future, the dry port will have an option to expand to 10 million square meters area (UTIKAD, 2013).

1.7.1.3.2. GAP (Mardin) Dry Port

The dry port will be established in an area between Mardin and Sekiduzu. It will be served as transloading center for export and import freight between Turkey and Syria and Iraq and will connect those countries to southern seaports of Turkey. The dry port will have a capacity of handling 1.5 million tons of freight per year and located on an area of 316,000 square meters of area (UTIKAD, 2013).

1.7.1.3.3. Şırnak (Habur) Dry Port

TCDD is planning to build a dry port in Habur to facilitate export and import freight transport between Turkey and Middle Eastern countries (TCDD, 2018). The dry port is still in project stage so that exact location and specification of it remain to be determined by the authorities.

1.7.1.3.4. Boğazköprü (Kayseri) Dry Port

Construction of the dry port is continuing. The first phase is finished but still not in operation since the construction of planned second phase is going on. When the dry port starts operations, it will provide 1.8 million tons of freight handling capacity per year (UTIKAD, 2013). The dry port has 1 million square meters of area and planning to handle transportation of freight from Kayseri Organized Industrial Zone, Incesu Organized Industrial Zone, Mimarsinan Organized Industrial Zone and Kayseri Free Trade Zone to domestic and international markets (Sabah, 2014).

1.7.1.3.5. Sivas Dry Port

The dry port is planned to be built 40 kilometers south of the Sivas city center on an area of 600,000 square meters. Construction of the dry port is started in 2017. After the construction is finished, the dry port will provide services to containerized and bulk freight by facilitating international trade of newly established Organized Industrial

Zone of Sivas (Hurriyet.com, 2017).

1.7.1.3.6. Tatvan (Bitlis) Dry Port

The project is introduced as a port of TCDD logistics center development initiative (TCDD, 2018). Similar to Habur dry port, Tatvan dry port is also in project stage without any clarified features. The location and the capacity of the dry port to be determined by TCDD and related authorities.

1.7.1.3.7. Karaman Dry Port

The bidding for the construction of the dry port is completed in October 2017. The construction of the dry port is remaining to be started soon. The dry port is planned to be build in an area of 425,551 square meters in the Organized Industrial Zone of Karaman with an aim to provide logistics and transportation service of the international freight of the manufacturing companies located in the zone (Rayhaber, 2016).

1.7.2. Private Dry Ports

Besides dry ports of TCDD, private establishments also take the initiative in dry port development in Turkey. Those dry ports include Corlu (Tekirday) Dry Port, Manisa (MOSBAR) Dry Port, Sarayköy (Denizli) Dry Port, and Ankara Dry Port.

1.7.2.1. Çorlu (Tekirday) Dry Port

The dry port is currently under project stage; thus, the construction has not started. In 2013, Çorlu Chamber of Commerce and Industry prepared a feasibility report for construction of a dry port. The dry port is being planned to be built in an area 11 km away from Çorlu Airport, 31 km away from the seaport of Martaş, 41 km away from the seaport of Akport, and 49 away from the seaport of Asiaport (Corlu Ticaret ve Sanayi Odası, 2014).

1.7.2.2. Manisa (MOSBAR) Dry Port

The dry port is established in Manisa Organized Industrial Zone and started its operations in 2010. It is built on 306,000 square meters of area with 12,770 square meters of open warehousing area, 1,200 square meters of closed warehousing area, and 25,000 square meters of container stacking area. The capacity of the dry port was increased with further constructions. In 2014, container stacking area was increased to 75,500 square meters and closed warehousing area was increased to 22,770 square meters (MOS Lojistik, 2015). The dry port is directly connected to seaports of Izmir (Alsancak, TCE EGE, Nemport, and APA MAERSK-Pektim).

1.7.2.3. Sarayköy (Denizli) Dry Port

The dry port established in Saraykoy county, 26 km near the city of Denizli, and started its operations in 2011. It is constructed on an area of 100.000 square meters with 5,000 TEU's of container stacking area. It is operated by GNW Logistics which is a joint venture established by Med Log and Gunaydın Logistics (Sarayköy Kaymakamlığı, 2012). This dry port also has a rail connection to seaports of Izmir.

1.7.2.4. Ankara Dry Port

The dry port was named as Ankara Lojistik Üssü (Ankara Logistics Hub) and is being operated by a private establishment called Ankara Lojistik Yatırımları ve Akaryakıt Tic. A.Ş. that is a joint venture of 52 different companies (Kargohaber.com, 2010). It has started its operations in 2010 on a total area of 700.000 m2 and has 198,000 m2 of closed storage area and 191,000 m2 of open storage area. Currently, more than 400 companies located in the dry port (Ankara Lojistik Ussu, 2018).

CHAPTER TWO
ROLE OF DRY PORTS IN LOGISTICS

The geographical distance between buyer and seller has always been an issue since merchandise needs to be delivered to customers to complete a commercial transaction. Before technological developments such as containerization, information and communication systems, the integration of companies in their supply chains were limited, and order delivery was taking long times. The long transit times was even getting longer when disruptions, i.e., misplaced orders, accidents, and out-of-stock occurred in the flow of goods.

To overcome lengthy transit times and disruptions in the flow of materials, companies kept safety stocks. Since the supply chain partners did not share information regarding their inventory levels, the same stocks of materials have been kept by other members of the supply chain. Managing this extensive inventory took financial resources and did not prevent the disruptions in the flow of goods.

Traditional business practices have changed rapidly. Consumers' needs and wants have shaped the markets where consumers actively participate in the design and delivery of the products or services. Consumers desire a wide variety of products or services and expect timely and fast delivery. This market-oriented approach has also changed the business to business markets. Fast and reliable delivery of goods and services become as important as the prices of them (Notteboom, 2008). To meet the requirements of customers, new means of transportation is adapted such as containerization and intermodal transportation which brought standardization in freight transportation so that freight transportation capacity and performance have increased (Guerrero, 2014).

As enablers of intermodal transportation and efficient inland freight transportation, dry ports play a significant role in logistics activities of international supply chains (Rodrigue and Notteboom, 2012). Besides improving inland access of maritime freight, they offer facilities and infrastructure to providers of value-added logistics services (Roso, 2009). In this chapter, we aim to reveal the role of dry ports in business logistics. Section 1 examines the chronological development of business logistics thought. Section 2 demonstrates the functions of dry ports in business logistics.

2.1. DEVELOPMENT OF BUSINESS LOGISTICS THOUGHT

Movement and storage of commodities have always been an issue for businesses. Although logistics activities separately carried out from the beginning of the organized trade, relatively newness of business logistics comes from the coordinated management of those activities and recognition of added value through logistics activities for generating revenue and satisfying customers (Ballou, 2004). The idea of coordinated management of logistics activities dated back to 1844 (Ballou, 1992). Ballou (1992) quoted in his book that Dupuit (1844) underlined it is essential to consider the exchange of transportation and inventory costs between each other when choosing between water and road transport in his paper called "On the Measurement of the Unity of Public Works."

"The fact is that carriage by road being quicker, more reliable and less subject to loss or damage, it possesses advantage to which businessmen often attach a considerable value. However, it may well be that the saving of 0 fr.87 includes the merchant to use the canal; he can buy warehouses and increase his floating capital in order to have a sufficient supply of goods on hand to protect himself against slowness and irregularities of the canal, and if all told the saving of 0 fr.87 in transport gives him an advantage of a few centimes, he will decide in favor of the new route. . . " Dupuit (1844).

2.1.1. Emergence of Physical Distribution Concept

Early literature related with business logistics focus on the physical distribution aspects of business logistics. Physical distribution sparked attention as a marketing function. First marketing literature interested in problems of distribution of agricultural commodities at the beginning of 1900's.

Crowell (1901) was the first one to address the issues in related to the distribution of farm products in the U.S. In his pioneer paper called "Some Problems in Market Distribution," Shaw (1912) distinguished the business in two separated departments: production and distribution. "Industry is concerned with the application of motion to matter to change its form and place. The change in the form we term production; the change in place, distribution. The end in each case is the same: a better adjustment of

matter to the wants of man (Shaw, 1912)." He claimed the scientific studies focused on manufacturing operations rather than moving the finished products to hands of customers (Shaw, 1912). He urged scientific research leading to the better organization of distribution facilities. According to Stock and Lambert (2001) and Kent Jr and Flint (1997), marketing utilities which are time, place, possession, and channels of distribution are first identified in Weld (1916)'s study called "The Marketing of Farm Products."

Clark (1922) distinguished marketing into two areas: efforts to the transaction of ownership of goods and efforts to physical distribution of those goods (Kent Jr and Flint, 1997). "Readings in Marketing" by Clark (1924) included a chapter in "physical distribution" that Mentzer et al. (1989) and Smykay (1973) considered it as the first time usage of the term. Borsodi (1927) defined the physical distribution for the first time:

"There are two uses of the word distribution that must be clearly differentiated. . . first, the use of the word to describe physical distribution such as transportation and storage; second, the use of the word distribution to describe what is better-termed marketing."

Until 1950's, the overall process of physical distribution did not get much attention from both industry practitioners and academics (Bowersox, 1969). Growing attention to physical distribution in 1950's and 1960's linked to two subsequent developments: availability of new computer capabilities and new cost control systems emerged from the need of profit squeeze of 1950's (Bowersox, 1969; Mentzer et al., 1989).

Converse (1954) underlined that the study of marketing problems related to physical distribution was often neglected, researchers usually interested in buying and selling the goods. However, Converse (1954) underlined that physical distribution is the other half of marketing: "One part of marketing deals with buying and selling, with creating desires and demands for goods, of transferring title to the goods. This part of marketing creates possession utility. The other part deals with the physical handling of goods, transporting them from farm and mine to mill and factory and from factory to processing to the consumers and storing when and where necessary. This part of marketing creates time and place utilities."

Lewis et al. (1956) brought up "total cost concept" to physical distribution. Air

transportation costs are high, but it is faster and more reliable causing less inventory cost (Ballou, 2007; Hou et al., 2017; Lewis et al., 1956). Physical distribution costs should be assessed from a total cost perspective rather than just transportation costs (Lewis et al., 1956).

In 1960's attention and awareness on the significance of physical distribution had grown. The first textbook on the physical distribution called "Physical Distribution Management" was published in 1961 by Smykay, Bowersox, and La Londe (Ballou, 2007). Drucker (1962) identified physical distribution as the economy's dark continent and urged more attention to the management of physical distribution. He underlined that good management practices could result in significant cost reductions.

In 1963, the National Council of Physical Distribution Management (NCPDM) was founded by "a group of educators, consultants, and managers who envisioned the integration of transportation, warehousing, and inventory as the future of the discipline" (CSCMP, 2013a).

Stewart (1965) stated that physical distribution adds up time utility and place utility to the form utility provided by manufacturing. Stewart (1965) defined physical distribution as: "Physical distribution is the science of business logistics whereby the proper amount of the right kind of product is made available at the place where demand for it exists at the time it exists."

Stewart (1965) noted four major factors behind the increased attention on physical distribution: trend toward more frequent ordering of smaller quantities; increase in variety of products thus more stock keeping units; more efficient distribution channels as a result of pressure for lower prices; existing limitations on pricing flexibility; usage physical distribution as a tool for competitive advantage by outperforming rivals' customer service and product availability. He emphasized that carefully designed physical distribution can help to generate sales and reduce the physical distribution costs so that profits can be increased (Stewart, 1965).

In 1967, the National Council of Physical Distribution Management defined physical distribution management (Kent Jr and Flint, 1997):

"A term in manufacturing and commerce to describe the broad range of activities concerned with the efficient movement of finished products from the end of the production

line to the consumer, and in some cases includes the movement of raw materials from the source of supply to the beginning of the production line. These activities include freight transportation, warehousing, material handling, protective packaging, inventory control, plant and warehouse site selection, order processing, market forecasting and customer service."

2.1.2. From Physical Distribution to Business Logistics

Southern (2011) points out that at the beginning, physical distribution and physical supply had treated separately. National Council of Physical Distribution Management (NCPDM) was found to represent outbound logistics, on the other hand, National Association of Purchasing Management was found to represent the inbound side of logistics (Southern, 2011). A scientific journal was published by NAPM in 1965. It was called "Journal of Purchasing." Its name had changed several times and in 1999 become Journal of Supply Chain Management (Southern, 2011). In 1964, Heskett (1964) published a book called "Business Logistics: Management of Physical Supply and Distribution" that was the first book the term logistics appeared in its title. The book included the physical distribution and physical supply under one subject called business logistics.

Inbound side of business logistics gained a great amount of attention in 1970's. In 1970's there was a tendency among researchers to combine physical supply and physical distribution facilities into the broader concept of business logistics (Kent Jr and Flint, 1997). The first academic journal that included the term logistics in its title called "International Journal of Physical Distribution and Logistics Management" published in 1970. Ronald Ballou published a book titled "Business Logistics Management" in 1973. Ballou (1973) distinguished the business logistics into four decision-making areas: customer service standards; inventory decisions, transportation decision and facility location decisions.

In 1976, NCPDM had changed its definition of physical distribution management. The definitions stated as (Lambert et al., 1978):

"Physical distribution management is the term describing the integration of

two or more activities for planning, implementing, and controlling the efficient flow of raw materials, in-process inventory and finished goods from point-of-origin to point-of-consumption. These activities may include, but are not limited to, customer service, demand forecasting, distribution communications, inventory control, material handling, order processing, parts and service support, plant and warehouse site selection, procurement, packaging, return goods handling, salvage and scrap disposal, traffic and transportation, and warehousing and storage."

2.1.3. Era of Business Logistics

The term physical distribution began to disappear in 1980's instead logistics which includes physical distribution, and physical supply (inbound and outbound sides of logistics) took its place. In 1985, the name of NCPDM was changed to the Council of Logistics Management (CLM) (CSCMP, 2013a) "to represent the evolution of physical distribution into logistics management."

In 1986, the council replaced the term "physical distribution management" to "logistics management" and altered the definition provided earlier (Taylor, 1997):

"Logistics management is the process of planning, implementing, and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods, and related information from point-of-origin to point-of-consumption for the purpose of conforming to customer requirements."

In the 1980's academic interest to business, logistics had dramatically increased. Many books and research papers published on the subject. Business logistics established as a major research area in the business related subjects.

Sharman (1984) noted that there is a need for rediscovering business logistics since the current logistics systems designed for stable conditions of 1960's and 1970's. He claimed that logistics would be the future battleground for competitive advantage, but the managers see it as just another name for physical distribution and often ignore logistics related costs and necessity of planning and computer systems.

2.1.4. Emergence of Supply Chain Management

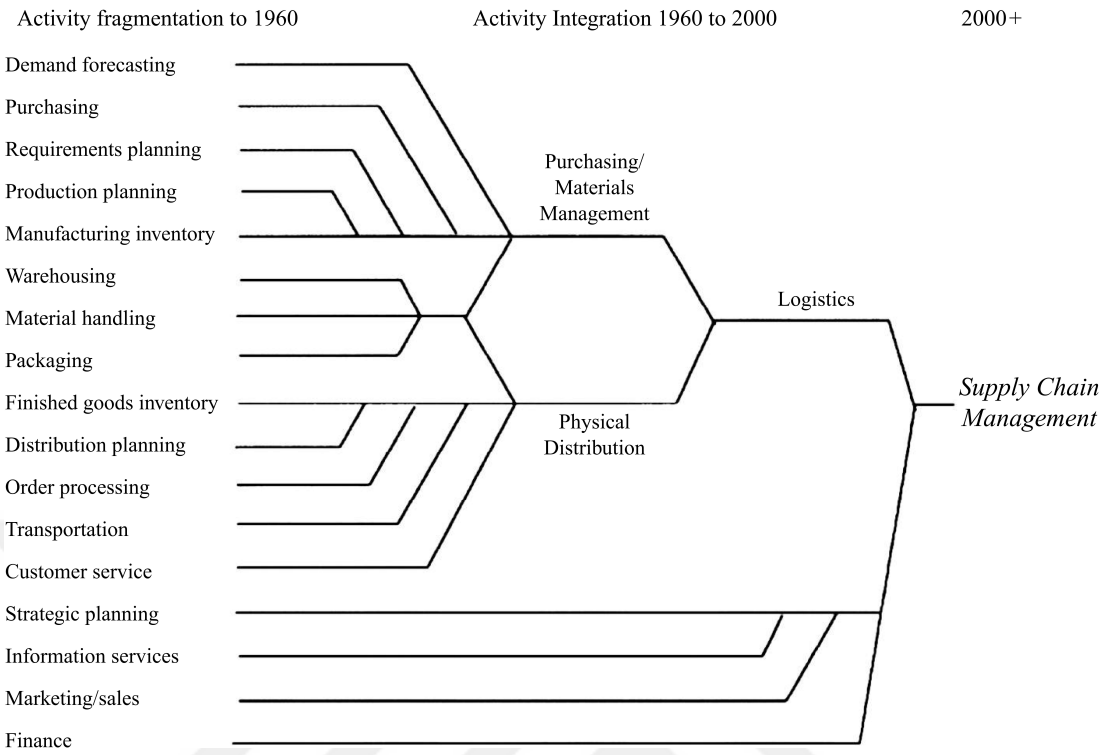
Porter (1985) introduced the value chain concept that meaning organizations consist of activities distinguished as primary and supportive. These activities create values and connected to each other as a chain. Margin, in another word profit, only occurs, if the value that is the amount customers willing to pay exceeds the costs of creating these activities. Inbound and outbound logistics activities are the primary activities which play a vital role creating that value. Porter (1985) claimed customer and supplier organizations as value chains are connected with each other forming value chain systems. This view is accepted by researchers as one of the first ideas behind the emergence of supply chain management (Hou et al., 2017). The term "supply chain management" is first time used by Oliver and Webber (1982) in their paper called "Supply-chain management: logistics catches up with strategy." After the first introduction of the term SCM, the literature and theory related to it grew rapidly.

Ballou (2007) argues that concept of supply chain management basses its roots to the early premise of activity integration introduced by physical distribution management and business logistics management concepts. Figure 15 demonstrates the development of Supply Chain Management concept from the fragmented activities to the totally integrated management of these activities.

The Council of Logistics management decided to rename in 2005 as the Council of Supply Chain Management Professionals (CSCMP). The reason behind this name change is "to meet the changing needs of its members, whose responsibilities had expanded within their companies and the profession... Since then, the organization has provided its members with enhanced content that incorporates not only logistics, but procurement, manufacturing operations, and sales and marketing functions."

Supply chain management stresses the interaction between marketing, production and logistics functions within the firm and those interactions of functions in the separate firms so that cost reductions and customer service developments achieved through coordination and collaboration among the firms (Ballou, 2004). Supply chain management in a sense has a broader scope than business logistics. Definitions of supply chain management concept underline this broader scope:

Figure 15: Evolution of Fragmented Logistics Activities to Supply Chain Management



Source: Ballou (2004)

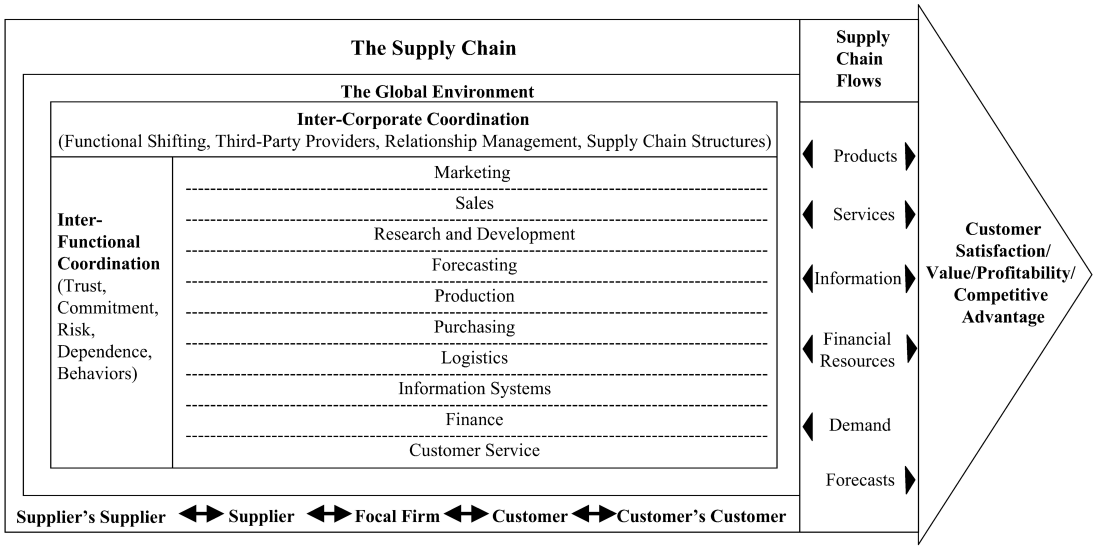
"Supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage (extraction), through to the end user, as well as the associated information flows. Supply chain management is the integration of these activities, through improved supply chain relationships, to achieve a sustainable competitive advantage (Handfield and Nichols, 1999)."

Mentzer et al. (2001) modeled supply chains as in Figure 16 and also defined supply chain management after reviewing the previous definitions:

"Supply chain management is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole (Mentzer et al., 2001)."

Ballou (2004) highlighted that sole purpose of supply chain management is coordination of product flows within and across companies with the aim of achieving sustainable competitive advantage and profitability for the individual supply chain

Figure 16: A Model Of SCM



Source: Mentzer et al. (2001)

members and supply chain as a whole.

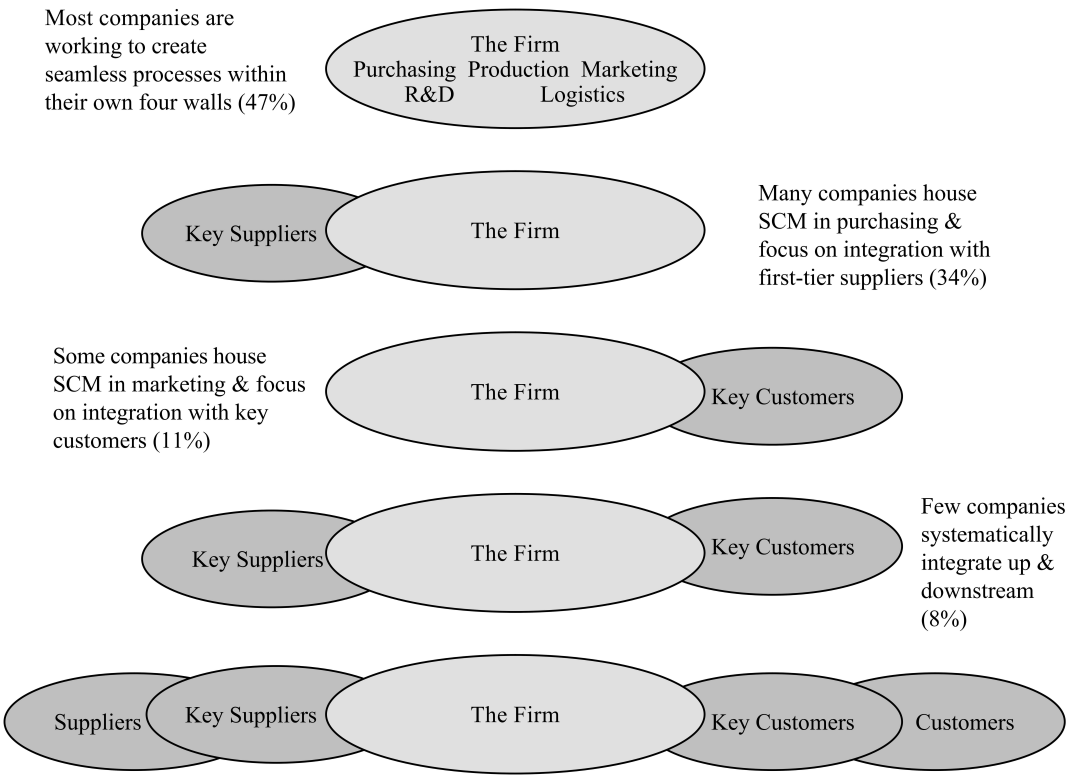
Lambert et al. (1998) introduced the eight key processes for the supply chain management. Those are:

1. "customer relationship management";
2. "customer service management";
3. "demand management";
4. "order fulfillment";
5. "manufacturing flow management";
6. "supplier relationship management";
7. "product development and commercialization"; and
8. "returns management".

These processes need to be coordinated through collaboration from first suppliers to the final consumers throughout the entire chain (Ballou, 2007).

Even though extending the management of product flow with inter-organizational collaboration and integration maintains the essence of the supply chain management, researchers question that to what extent this theory of supply chain collaboration practiced in reality by the organizations. Fawcett and Magnan (2002) conducted research related to the practice of supply chain integration, and they claim that integration among all supply chain members is not practiced by the companies. Transparency throughout channel members necessary to manage the entire chain has not available for most of the supply chains (Fawcett and Magnan, 2002). At best companies collaborate with first-tier members, collaboration with second-tier members is rare and usually, the responsibility of managing toward the first-tier is left to the first tier members with a little supervision (Fawcett and Magnan, 2002). Figure 17 explains the extent of practiced supply chain management.

Figure 17: Scope of Supply Chain Management



Source: Fawcett and Magnan (2002)

2.1.5. Relationship between Supply Chain Management and Business Logistics

Council of Supply Chain Management Professionals provided definitions for SCM and Logistics Management that two definitions make a distinction between two concepts claiming Logistics Management is a part of Supply Chain Management. CSCMP define SCM as (CSCMP, 2013b):

"Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies."

On the other hand, CSCMP defines Logistics Management as (CSCMP, 2013b):

"Logistics management is that part of SCM that plans, implements, and controls the efficient forward and reverse flow and storage of goods, services, and related information between the point of origin and point of consumption to meet customer requirements."

The first definition emphasized sourcing and procurement that implicitly involves labor sourcing, raw or semi-finished products purchase and service outsourcing. The conversion that includes manufacturing, assembly or modification activities is also emphasized. Additionally, coordination and collaboration among the channel members are underlined. These are excluded in the definition of logistics management. Logistics activities complement supply chain management because the primary objective of logistics is movement and positioning of material in a supply chain.

Ballou (2007) argues that SCM has three dimensions that are "activity and process administration, inter-functional coordination, and inter-organizational coordination." Activity and process administration is in the responsibility of logistics management that includes management of activities and processes such as transportation, inventory, and warehousing. Inter-functional coordination includes the cooperation and collaboration among different departments of the same organization for example procurement, produc-

tion, marketing, and finance. Inter-organizational coordination includes collaboration and relationship building with channel members which are separate organizations. Supply chain management is the management of the product flow on an inter-organizational level on the other hand logistics management is the management of the product flow within the organization (Ballou, 2007).

2.1.6. Logistics in the Economy

Increasingly sophisticated demand and influence of the consumers drove the product and service variety in the international and national markets. Globalization of the economy made possible to distribute and sell these products to customers around every corner of the world. To overcome these challenges companies increased in size and pursue more complex production operations, sourcing from a higher number of suppliers and maintaining production in multiple plants. Logistics processes of the products from the point of origin to the point of consumption constitute a significant share of the GDP's of the countries.

According to International Monetary Fund, cost of logistics activities is average of 12 percent of GDP of the World. In the firm level logistics costs range between 50 and 60 percent of the sales for the average manufacturing firm (Stock and Lambert, 2001).

Providing more efficient logistics operations contributes the entire economy in many ways. For example, with the reduction for the logistics costs, companies can increase their profitability and/or customers would be able to buy products at lower prices. This would result in higher living standards for the people and more tax income for the governments. Additionally, logistics facilitates the transaction of goods and services, if goods do not arrive on time, on proper condition to the right place with the acceptable costs the transaction would not be made, and the economy would suffer.

2.1.7. Logistics in the Firm

It is recognized that product proposition is not just consisting of the physical product but is comprised of the combination of the physical product and customer

service. Efficient and effective operation of logistics activities creates value through providing the place and time utility by delivery of the customer service as a part of the marketing mix. Additionally, the efficient and efficient conduct of logistics function can have a significant impact on cost reduction. Therefore, well-designed logistics systems provide a resource for sustaining competitive advantage.

2.1.7.1. Delivery of Customer Service

Logistics plays a fundamental role in the marketing of a product. Marketing incorporates four P's that called marketing mix: product, price, promotion, and place. Product stands for the value that a customer receives from a purchase; price refers the pricing of a product; promotion is the advertising and direct selling of a product; place refers to the customers' service maintaining high order-fill rate with reliable delivery of the product to the location it is needed. Logistics play a substantial role in delivering the customer service by making the right product available at the right place at the right time in the right condition for the right cost.

Products provide four types of utility for their customer: form utility, time utility, place utility and possession utility (Stock and Lambert, 2001). Form utility is provided by manufacturing activities while time and place utility is provided by logistics activities, and possession utility is provided by other marketing activities (Stock and Lambert, 2001). Place utility is created by making a product available for purchase in the place where it is needed. Time utility is created by making a product available at the time it is needed. Products propose no value if they are unavailable where they are needed or when they are needed. The importance of logistics activities lies in the fact that improvement in the time and place utility created by product proposition is reflected as an increase in profits. Additionally, the efficiency of logistics activities results in cost reductions.

2.1.7.2. Minimization of Costs

The cost of logistics activities forms a significant portion of total costs; thus, efficient operation of logistics activities poses a great potential for cost savings. Although it is debated, logistics costs of a company, rank second after the purchase of cost of goods that constitutes 50% to 60% of total revenue, rage between 4% to 30% of the total revenues (Ballou, 2004). Value is created by minimizing logistics costs can be passed to customers and the shareholders of the company.

Total logistics cost concept developed by Lewis et al. (1956). They put forward that logistics activities create different costs and these costs can be optimized by making trade offs. For example, the high cost of air transportation can be compensated by savings in inventory carrying cost by reducing the transit time of product delivery. The total cost concept brought a new perspective to cost minimization efforts of logistics activities and also changed the industry practices since companies focus change from minimizing the cost of each logistics activity to minimizing total cost of overall logistics activities.

2.1.7.3. Logistics and Competitive Advantage

Any level of customer service can be accomplished by a company if managers of the company willing to provide necessary resources. High level of service is preferred by sales managers and customers; however, it creates extensive costs. The key is to perform better than the competitors in terms of customer service (Bowersox et al., 2007). Not every customer requires the same level of customer service; some customers are more sensitive to logistics performance. The logistics value is achieved when the logistics competency matched the requirements of the customers (Bowersox et al., 2007). Companies seek to achieve logistics competency to meet customers' requirements while achieving minimum total logistics costs. Sound logistics strategy requires assessment of different customers service levels' impact on total logistics costs (Bowersox et al., 2007). Well designed and well-operated logistics systems can help to achieve and sustain competitive advantage in the market (Bowersox et al., 2007).

2.2. FUNCTIONS OF DRY PORTS IN LOGISTICS

The requirement of shippers for international transportation service has gained a supply chain focus because of the wider geographical range among souring, production, and distribution of products resulted from containerization and globalization of economies. Companies determined to minimize their overall costs so that keeping a minimum level of inventory and increasing integration among supply chain members present a great opportunity. Production strategies of manufacturing companies have shifted from push structure, which is supply driven, to pull structure, which is demand driven, with the just-in-time production approach (Notteboom and Rodrigue, 2008). This situation has changed expectations of shippers from logistics service providers. Besides transportation cost, quality of the transportation service gained significance (Notteboom, 2008).

Competition between companies occurs between supply chains rather than individual firms (Christopher, 2016). Robinson (2002) states that seaports are not merely transshipment points, but they are elements of supply chains where value added to the goods passing through them. This point of view applies to every element taking part in shipping service provision. Seaports, inland transportation service providers, dry ports, shipping lines, and other shipping service providers, all need to cooperate and be integrated with shippers and each other to achieve a sustainable competitive advantage and survive and prosper in today's highly competitive market.

Total logistics costs have become the sole component of supply chain routing and transport mode selection. For instance, shippers may prefer more expensive transport mode or other logistics solutions since the excessive costs can be balanced by cost savings from other cost components of logistics activities. The other cost shippers take into account while designing supply chain routing include (Notteboom, 2008):

1. Time costs: Includes opportunity cost of tied up capital and depreciation costs.

2. Cost of safety stocks: Cost of holding additional inventory to cope with unexpected inventory shortages.

3. Costs from deficiencies in the quality of transportation service: These costs result

from failure to meet customer requirements such as flexibility, information sharing and problem-solving.

These generalized costs of logistics service increased importance of dry ports as shippers focus on integrated management of their supply chains while placing greater concern on disruption of goods. Notteboom (2008) argues the existence of two reasons behind this changed perspective. First, congestions in ports and bottlenecks in inland freight transport hinder freight flows and cause market players to force adjusting their logistics requirements to adopt increased time of transportation which comes at an additional cost. Second, supply chain focus enhances the need for higher level of reliability in logistics activities. Increasing distance and volume of international trade demands a complex freight transportation network which requires a high level of synchronization among the actors involved in logistics service provision.

As a fundamental part of logistics of international trade, maritime freight transportation consists of three stages: Maritime shipping, seaport facilities, and inland transportation. Maritime shipping and seaport facilities become better integrated because of the co-dependent relationship between them. This integration achieved through adaptation of different maritime service structures such as hub and spoke systems, bigger ships, better handling technologies in seaports, automation in seaport operations, and high level of collaboration between seaport operators and maritime shipping companies. High level of integration between seaport facilities and maritime shipping shifted the focus on the inland transportation where dry ports play a fundamental role. Dry ports integrate seaports into inland freight transportation providing efficient connections and terminal facilities as well as value added logistics services in the hinterlands of seaports.

2.2.1. Extended Gate Function

Development of dry port facilities creates a competitive advantage for seaports. Shuttle train and shuttle truck connection between seaport and dry port provide deeper inland penetration. This causes discontinuous hinterland formation, creating hinterland "island formation" around the dry ports. The areas of those hinterland islands depend on the performance and cost of transport link between the seaport and the dry port.

Additionally, seaports can penetrate their rivals' hinterland by achieving cost and service advantage over competitor through developing dry ports.

Efficient usage of shuttle train and shuttle truck links between seaport and dry port eliminate bottlenecks in inland freight transportation by reducing congestion in roads (Roso, 2009). Additionally, harmful environmental impacts, such as CO2 emissions, noise, and accidents, resulted from freight transportation can be minimized with the use of dry ports (Roso, 2007; Henttu and Hilmola, 2011; Lättilä et al., 2013).

Traditionally, many coastal cities have been formed around seaports. The increased volume of maritime freight transportation pressure seaports to improve their capacities. However, the seaports surrounded by cities have little room for physical expansion. Dry ports provide an opportunity for freight to pass through the seaport without using seaport capacity and use the facilities, which are the same as seaport facilities, provided in the dry ports. Therefore, dry ports increase seaport capacities relieving the seaport from congestion and inefficiencies (Roso, 2009; Korovyakovsky and Panova, 2011).

2.2.2. Buffer Function

The increasing role of dry ports in the supply chains led to the creation of a buffer function, where shippers use container storage in dry port as warehousing. The dry port becomes buffer zone where terminal facilities in the dry port are seen as a storage facility rather than a delay. This strategy provides supply chains to reduce warehousing cost and to keep safety stock as a buffer in dry ports. Notteboom and Rodrigue (2009) name this as "inventory in terminal" and claim that when this strategy combined with "inventory in transit," the need for warehousing facilities is substantially decreased.

Using the dry port as storage facilities rather than transshipment and cargo delivery points between shippers and logistics service providers resulted with a requirement of longer dwell times in dry ports. Usually longer free dwell times, compared to seaports, is provided in dry ports because they are located outside residential areas where real estate values are comparatively low with plenty of area for further capacity extension. They usually have spare container stacking capacity. The shippers use available free

dwell times efficiently to minimize their warehousing costs. The higher the volume of transported freight, the higher the free dwell time has significance for the shippers.

2.2.3. Logistics Clustering Function

Dry ports attract facilities of logistics service providers creating a cluster of logistics facilities around their location. The cluster of logistics activities around dry ports leads to the formation of logistics zones because they became a suitable location for support activities for freight transportation and logistics companies. In his pioneer paper, Robinson (2002) claimed that seaports are not merely transshipment points, but they add value to the goods passing through them. As the seaports' extended gates, the same logic applies to dry ports. Dry ports are more than just inland transshipment facilities; they add value to the goods passing through them by attracting activities related to freight transportation, i.e., shipping agents, third party logistics service providers, trucking service providers, freight forwarders as well as packaging and container repair companies.

Dry ports located in suitable places with proximity to production and market-places (at least in theory, to sustain their existence, they have to be located in appropriate sites). Their advantageous locations, efficient transport connections and support facilities for freight transport attract logistics companies. Because most logistics companies attracted by the same location factors, they form clusters, and these clusters provide additional advantages of economies of scales making the dry ports even more attractive locations (Notteboom and Rodrigue, 2009). This situation leads to the development of large logistics zones around dry ports.

Logistics clustering around the dry ports is usually a slow market-driven process. However, their impact on regional development required governments to participate in the dry port development process directly. Local and national authorities encourage the development of dry ports by providing incentives, financial support and real estates for constructions of dry ports facilities because of the clustering of logistics facilities and impacts of this logistics clustering on regional development (Notteboom and Rodrigue, 2005).

2.2.4. Empty Container Positioning Function

The trade imbalance is a common issue as result of international trade because some countries are export-oriented and some others are import-oriented. Even in different regions or cities of a country show different characteristics: production facilities often concentrate in particular regions making them export centers and big cities are placed where the population is concentrated making them consumption and import centers. This imbalance between export and import volumes create empty container shortages or abundance in particular regions. Therefore, the empty containers are required to be repositioned from the regions contain an abundance of empty containers to the regions contain shortages of empty containers. The repositioning of empty containers creates a substantial cost burden on shipping lines. Additionally, empty container shortages result in delayed shipments hence customers dissatisfy from the freight transportation service and go to rival companies or find alternative freight transportation solutions. Dry ports present a solution for this requirement of empty container repositioning in inland container transportation market by acting as empty container depots in the hinterlands of seaports (Rodrigue and Notteboom, 2009).

Dry ports in the hinterland of seaports act as empty container hubs where shipping lines stack their empty containers to meet the need of empty container for export shipments and reposition the excess empty containers to other regions where there is a need for empty containers (Rodrigue and Notteboom, 2012). Because the land in seaport is more valuable than inland locations, dry ports provide cheaper tariffs than seaport for empty container storage. Therefore, dry ports are focal points for optimization of empty container flows in inland regions in order to minimize the costs and maximize customer satisfaction.

2.2.5. Trade Facilitation Function

Dry ports as focal points of inland freight transportation host logistics activities and play an important role in supporting economic activity by attracting manufacturing facilities or constructed close to manufacturing company clusters (Ng and Tongzon,

2010; Ng and Cetin, 2012; Roso, 2008; Haralambides and Gujar, 2012). Dry ports are either constructed near places where manufacturing facilities concentrated or expected to create and foster industrial and service clusters such as special customs free export production zones and industrial zones around their locations (Haralambides and Gujar, 2011; Ng and Cetin, 2012). This trade facilitation function of dry ports promote regional development since industrial activities do not need to take place coastal areas close to seaports thus efficient transport infrastructure with well developed dry port facility support international trade and regional economic development in inland locations (Roso, 2008; Haralambides and Gujar, 2011; Ng and Tongzon, 2010; Ng and Cetin, 2012).

Dry ports also play a fundamental role in facilitating international trade by providing cost advantages for logistics activities of shippers (Roso, 2008; Haralambides and Gujar, 2012). A cluster of logistics service providers creates an environment where the economies of scale are better exploited, and cost of logistics activities are reduced. Additionally, efficient transport connections of dry ports to seaports reduce inland transportation costs and further attract production plants of manufacturing companies to their proximity.

CHAPTER THREE
EVALUATING THE EFFECTS OF DRY PORT USAGE IN INLAND CONTAINER LOGISTICS: AN APPLICATION IN INLAND CORRIDOR BETWEEN SEAPORTS OF IZMIR AND DENIZLI

3.1. RESEARCH PROBLEM AND AIM

Increasing interest has triggered scholarly studies on dry ports. Much research in recent years has evaluated dry ports. However, research which empirically analyzing the impact of dry ports in inland logistics of maritime containers is rather scarce. Studies examining the effects of dry ports basically examine either the effects of the dry ports on the environment (i.e. Roso (2007), Regmi and Hanaoka (2015), and Muravev and Rakhmangulov (2016)) or examine their impacts on both environment and transportation costs (i.e. Henttu and Hilmola (2011), Lättilä et al. (2013), and Iannone (2012)). Additionally, these studies have either considered that transportation cost is the only factor that is intervening the decision of inland transportation mode selection or has not considered any railway capacity limitations in their analyses. For instance, Lättilä et al. (2013) studied dry port usage effects in Finland by using a discrete-event simulation model but they only included transportation cost as a determinant of inland transport mode usage and assumed unlimited railway transportation capacity. On the other hand, Regmi and Hanaoka (2015) includes transit time and delays besides transportation cost as parameters impacting inland transport mode choice preference. However, they left out railway capacity limitations.

Turkey has been selected as the research area in this thesis. It is a partner of TRACECA project, which is an initiative for connecting Europe to Caucasus and Central Asia with road and rail links. With rail and road links to the main sea ports, Turkey can be a hub for the Europe-Asia cargo traffic. And, seaports of Turkey can act as the natural seaports of landlocked Asian countries. Additionally, its strategic location as a gateway to Middle East, Europe, Central Asia and North Africa, puts Turkey in central position for China's Belt and Road initiative considering road, rail and air transportation. Therefore, dry ports and railway transport is becoming increasingly important for

providing necessary infrastructure and superstructure for movement of international freight for providing necessary infrastructure and superstructure for movement of international freight through the country. Dry ports are attracting more and more interest from Turkish government authorities and private establishments. Recently, public authorities in Turkey shows increased initiative for the development of logistics centers. In 2005, Turkish State Railways introduced a project that includes the development of 17 logistics centers in various cities of the country. As of today, the project consists of the construction of 4 more logistics centers, totally 21, and 8 of the logistics center projects have been completed and have commenced operations. Besides that in the last decade, the length of railways increased substantially around 38% (TCDD, 2016). In 2004, Turkish State Railways started to provide block train services that increased efficiency and effectiveness of railway transportation services and enabled to reduce cost and increased the satisfaction of users. Additionally, implementation of block train services provides an opportunity for the introduction of dry port facilities, and in some parts of the country, dry port systems are already in operation. There is increasing attention of public authorities and private transport operators in the development of railways services and dry port facilities in Turkey. Understanding of inland transportation mode preferences of shippers is important for developing effective policies for encouraging dry port usage. With this regard, in order to eliminate dead investments, it is required to empirically evaluate the impacts of dry port usage on hinterland logistics concerning the inland transportation mode choice of shippers in Turkish context.

The purpose of this thesis is to evaluate the effects of rail-based dry port usage on inland container logistics, taking into account the influence of transportation attributes on inland transportation mode choice. Following objectives developed to assist in achieving the aim:

1. To investigate the effects of transportation attributes on the mode choice in inland container logistics.

2. To evaluate the effects of rail-based dry port usage that caused by variations in the transportation attributes on inland container logistics.

These two objectives should not be considered separately because they are

interlinked and related to each other. The first objective will reveal how the variations in the attributes (cost, transit time, delays, free time, and frequency) of inland transport modes will affect the hinterland transportation mode choice of shippers and logistics service providers. The second objective integrates the outcomes of the first objective into scenario analysis in which freight transport attributes take particular values. According to these values, mode share of previously revealed container flow will be found, and the effects of mode shift towards the rail-based dry port on inland container logistics will be analyzed.

3.2. AREA OF THE RESEARCH

The research in this thesis applied in Turkey, because of its central location in the transportation corridors between Europe and Central-Asia and Middle-East. Turkey is a partner of TRACECA project that is originated from European Union's desire to strengthen economic ties with countries in Central-Asia and Middle-East (Uzumcu and Akdeniz, 2014). TRACECA is initiative for "promoting the development of regional transport dialogue and ensuring the efficient and reliable Euro-Asian transport links, promoting the regional economy on the whole" (TRACECA, 2018). Turkey can be a hub for transportation corridor between Europe and Asia with its main seaports and inland road and rail transportation links to these seaports. Main seaports of Turkey can be gateways for landlocked countries of Central-Asia.

Turkey is also central for Belt and Road initiative of China. The aim of the initiative is to develop transportation corridors linking China with Central-Asia, Europe, Middle-East, and Africa. In terms of road, rail and air transportation, Turkey is located in a central position providing entrance to Europe Central-Asia and Middle-East and Northern-Africa. Turkey and China already signed several agreements within Belt and Road initiative regarding development and railway and highway corridors and usage of seaports (Akçay, 2017).

Considering the international transportation corridors, dry ports in Turkey plays an important role providing access for international freight to main seaports. Additionally, dry ports can be enablers in the international freight corridors providing

value added services to the freight passing through them. Therefore, empirical research on dry ports located in Turkey has a great importance for policy development regarding international projects such as TRACECA and OBOR.

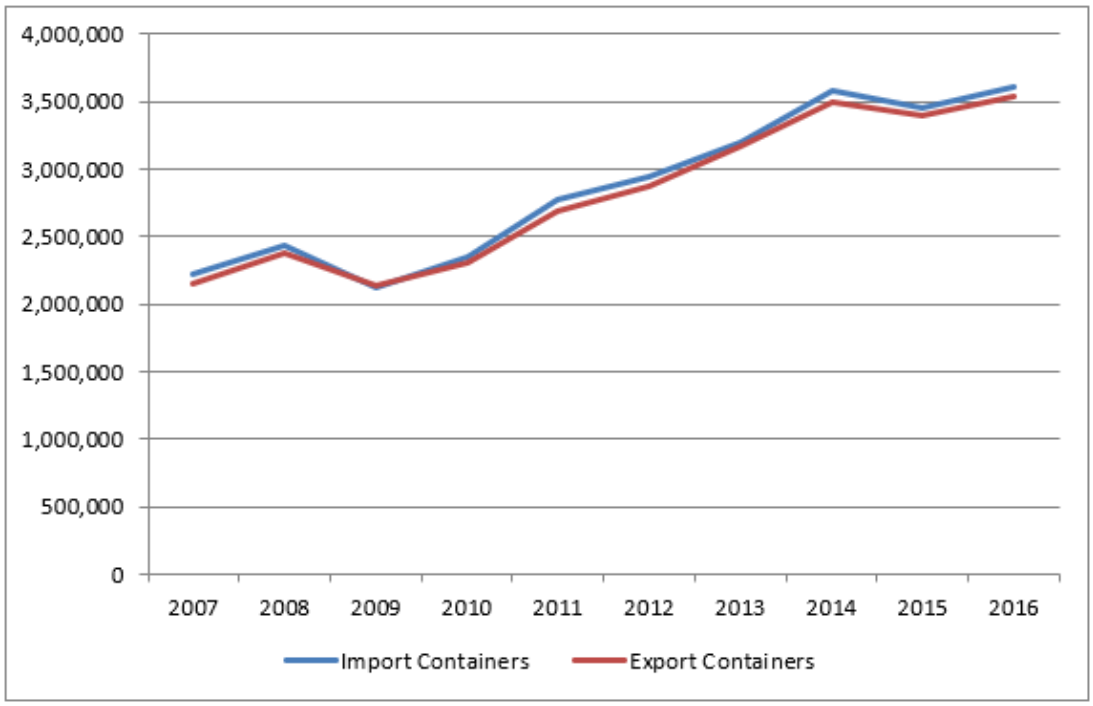
3.2.1. Containerized Shipments

This study focuses on containerized freight transportation in the inland corridor between Izmir and Denizli. In order to gain deeper insights with regard to freight transportation in the corridor, it is required to distinguish between containerized freight and non-containerized freight that particularly includes bulk and general cargo. Non-containerized freight is usually transported in high volumes and inland transportation of such freight require transportation modes capable of high capacity transportation. Transportation costs have primary importance for non-containerized freight. On the other hand, different transportation modes compete for containerized freight because, besides transportation costs, quality of transportation service is crucial for the shippers. Additionally, containerized freight has more potential for growth. As can be seen in Figure 18, in last ten years, containerized freight transportation in Turkey has increased 62% for import containers and 65% for export containers (UBAK, 2016a). As a consequence, this situation leads to search for sustainable inland containerized freight transportation alternatives that are capable of solving port access and capacity problems in hinterlands of ports.

3.2.2. Inland Freight Transportation Corridor between Izmir and Denizli

Research model proposed in this study is implemented to a case of inland containerized freight transportation corridor between container terminals of Izmir and Denizli, Turkey. As an important port city located in western Turkey, Izmir has four container terminals providing a gateway to import and export container flows in the region. Three of the container terminals namely TCE Ege, Nemport, and Petkim APM are located in Nemrut Bay whereas Alsancak-TCDD container terminal is located in Izmir Bay, as can be seen in Figure 19. In 2016, according to Transportation Ministry

Figure 18: Containerized Imports and Exports in Turkey (Tonnes)

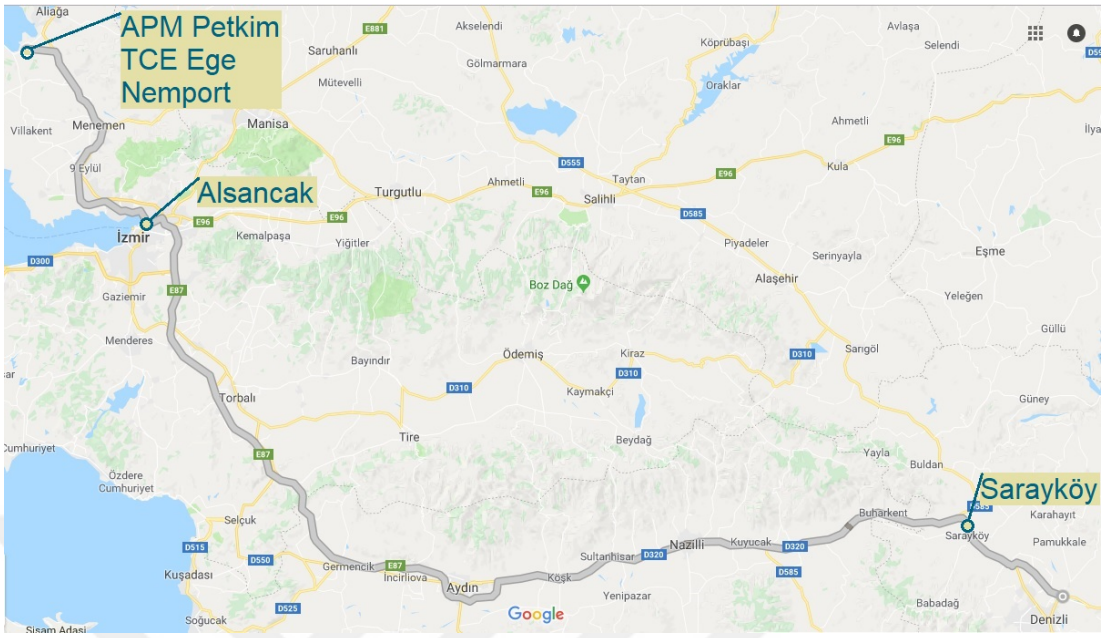


Source: UBAK (2016a)

of Turkey, these container terminals handled 652,761 TEU of export and 605,156 TEU of import containers which accounts for 18% of total export and 17% of total import containers handled in Turkish ports (UBAK, 2016a).

The city of Denizli, as one of the most important export centers of the country, is located in the hinterlands of container terminals in Izmir. Denizli covers 12.134 square kilometers of administrative area and accommodates 1,005,687 people. Additionally, three industrial zones are located in the city (Bilim, Sanayi ve Teknoloji Bakanlığı, 2018): One of them is newly established and not in operation yet; another one was got in operation in a short time ago and accommodates 13 manufacturing companies; the last one was established in 1990 and currently accommodates 181 manufacturing companies. Currently, there are 1,375 manufacturing companies in operation in the administrative area of the city (Denizli Sanayi Odası, 2018).

Figure 19: Map of Container Terminals in Izmir Region



Source: Author

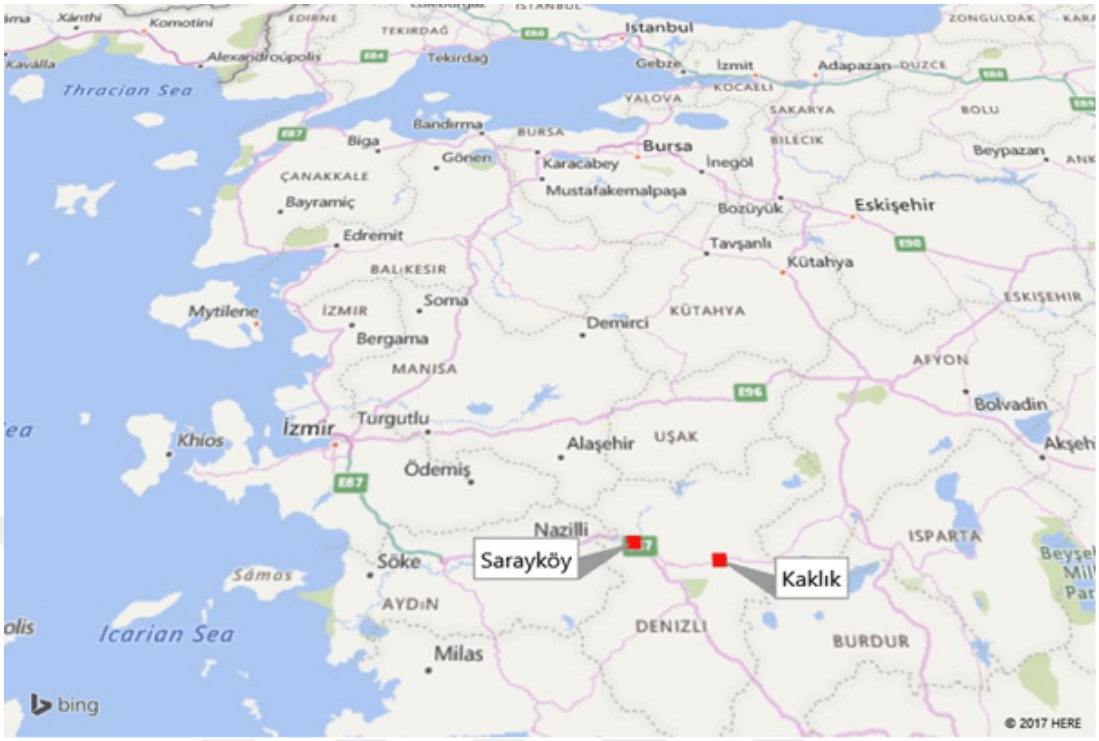
3.2.3. Dry Ports in the City of Denizli

A report published by Turkish Ministry of Transportation, Maritime Affairs and Communications indicates that as of 2013, only 2,4% of the inland transportation of maritime freight is transported through railway transportation whereas 97,6% is transported through road transportation (UBAK, 2016b). As described in the first chapter of this thesis, dry ports are inland terminals located inland and connect the hinterland with seaports. There are two dry ports which connect container terminals of Izmir and Denizli with railways and they are located in the city of Denizli.

3.2.3.1. Sarayköy Dry Port

One of these rail-based dry ports as illustrated in Figure 20 is located in Sarayköy county of Denizli. Railway distance between Sarayköy dry port and Izmir Bay is 230 kilometers and this railway distance to Nemrut Bay is 249 kilometers. Transportation of freight between the dry port and final destinations has to be made with road transportation thus road distance between the dry port and industrial centers and Denizli city center

Figure 20: Dry Ports of Denizli



Source: Author

has utmost importance. The road distance between the dry port and city center is 26 kilometers.

Sarayköy dry port is established in 2011 in an area of 100,000 square meters and operated by a private company that is jointly established by Medlog and Gunaydin Logistics. Medlog is the logistics company of MSC lines. This shows that the shipping lines take an active part in dry port development in the inland corridor between Izmir and Denizli. Some area of the dry port is leased from the government, some other area of it leased from private owners and other parts are owned by the operating company. The operating company manages handling operations in dry port as well as block train operations between Izmir and the dry port. Additionally, the operating company has its own rail cars. However, transportation service of these railway cars procured from Turkish State Railways-TCDD because TCDD is the only company authorized to provide such a service. On the other hand, deregulation of railway transportation service in Turkish railways is currently in an undergoing process.

Sarayköy dry port has a total capacity of 5,000 TEU's. Besides transferring of

containers between trucks and trains, the dry port provides services such as container stuffing and unstuffing, maintenance, lashing, and sanitation. Additionally, the dry port has an open storage area for goods and full and empty containers.

3.2.3.2. Kaklık Dry Port

Figure 20 shows that Kaklık dry port is located at the east of the Denizli city. The road distance between the city and the dry port is 33 kilometers. The dry port is not located in between Denizli city and Izmir ports. The railway distance between the dry port and Izmir port is 283 kilometers and this distance is 302 kilometers for ports located in Nemrut Bay.

The dry port was established in 120,000 square meters of area and started its operations in 2014. The dry port is operated by Turkish State Railways (TCDD), which is a company owned by the state and currently the only company authorized to railway transportation operations in Turkey. With a yearly capacity of handling 1,000,000 tons of freight, the dry port has an open storage area for containerized and non-containerized freight. Additionally, the dry port includes administration buildings for the provision of customs clearance facilities however customs clearance facilities currently not available in it. Interviews with the Turkish State Railways revealed that currently, containerized freight shippers do not choose to use the dry port. Very few containers handled in the dry port. The freight between the dry port and Izmir ports mainly consists of cement which is produced in a nearby cement factory.

3.3. RESEARCH MODEL

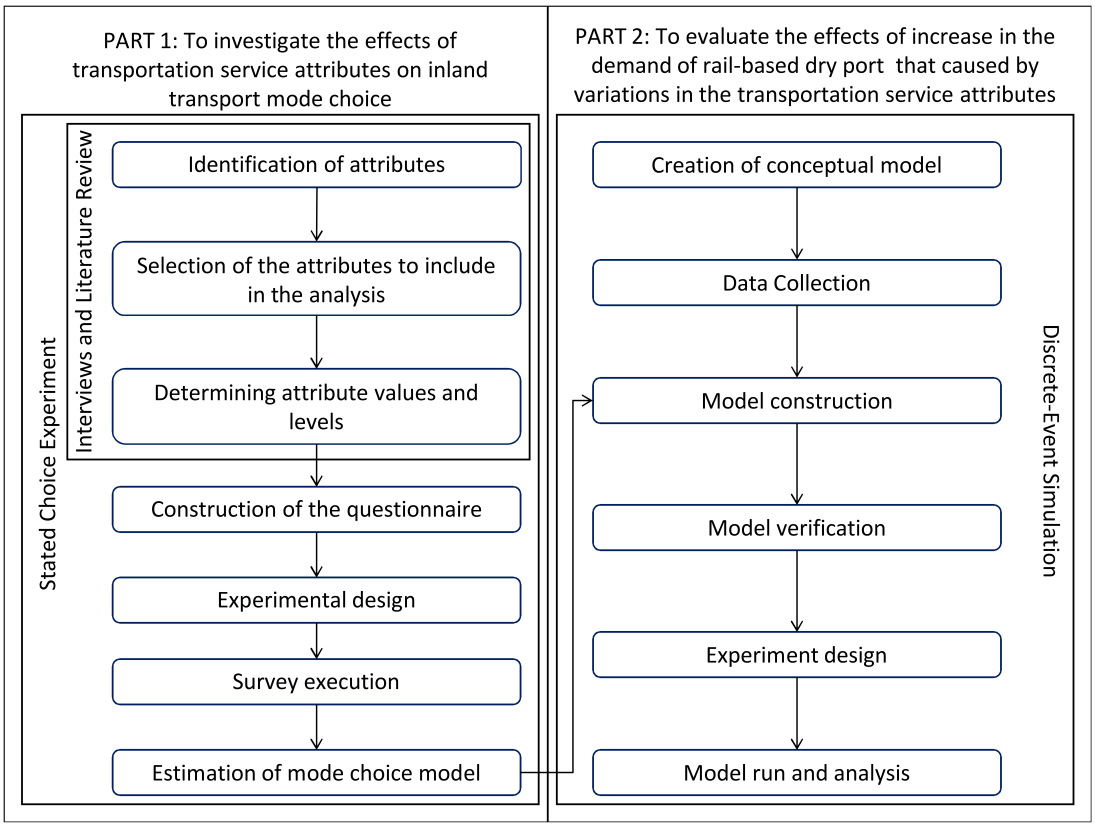
This thesis aims to evaluate the effects of rail-based dry port usage on inland container logistics by considering the influence of transportation attributes on inland transportation mode choice. Following objectives assist to achieve the aim: the first objective is to investigate the effects of transportation attributes on the transportation mode choice in inland container logistics; the second objective is to evaluate the effects of rail-based dry port usage that caused by variations in the transportation attributes on

inland container logistics.

The research model illustrated in Figure 21 consists of two parts: each part illustrates the research process and methodology to meet the objectives. This stepwise process enables a systematic and comprehensive methodological approach. The first part includes stated choice experiment to meet the first objective of the thesis. The first three steps of the first part includes qualitative research. To implement stated choice experiment, the attributes and the values of the attribute levels must be determined by the qualitative research using literature review and semi-structured interviews. The three steps comprise of identification of attributes, selection of measurement unit for the attributes, and specification of attribute levels. After the attributes and values of the attribute levels have been determined, statistical design of the experiment is created. Then, the questionnaire incorporating stated choice scenarios and descriptive variables are constructed. After that, stated choice experiment is executed to freight forwarders, shipping lines, and manufacturing enterprises that use the freight transport corridor. Finally, in the last step, discrete choice model is estimated.

The second part includes the simulation study to meet the second objective of the thesis. It consists of various steps which are shown in Figure 21. The steps presented in Figure 21 is constructed by evaluating the literature that explains the process of simulation model building (Banks et al., 2010; Rossetti, 2015; Altiok and Melamed, 2010). The impacts of rail-based dry port usage on the performance indicators of inland container logistics will be investigated with what-if-scenarios where certain changes in the inland transport attributes occur to increase the mode share of rail-based dry ports. The first step consists of conceptual modeling of the inland container logistics in the corridor to capture basic components and behavior of the system. The required data and details of the model is identified on the basis of this conceptual model. The second step includes data collection. The data is collected considering the conceptual model of the system. In the third step, the simulation model is built using the computer simulation software called Anylogic 7. After model construction, in the fourth step, the model is verified. In the fifth step, experiment design is constructed. The last step includes model run and analysis.

Figure 21: Research Model



Source: Author

3.4. ANALYSIS OF TRANSPORT MODE CHOICE IN THE INLAND CORRIDOR

3.4.1. Methodology: Stated Choice Experiment

The research is conducted as two parts to reach the above mentioned two objectives. In the first part, stated choice experimentation method is used to investigate the effects of transportation attributes on the transportation mode choice in inland container logistics. The literature review in the first chapter shows that different methodology can be used to analyze the impacts of dry ports. Stated choice experiment method is used in this thesis since it lets to estimate utilities of transportation alternatives. And, impacts of transportation service attributes on the selection of inland transportation service can be analyzed. With using stated choice experiment methodology not only the

severity of the impact but also its extent and demand elasticities can be revealed.

Stated preference experiment emerged as a data collection methodology for disaggregate modeling of freight demand. Classification of freight transportation demand modeling as aggregated and disaggregate models is widely accepted by scholars (Winston, 1983; Abdelwahab and Sargious, 1992; Regan and Garrido, 2001). Aggregate and disaggregate models distinguish from each other regarding unit of observation: for aggregate models, the unit of observation is the aggregate share of freight transportation mode in a certain geographical level i.e., a region or a country; for disaggregate models, unit of observation is a decision maker's choice of a freight transportation mode for a particular shipment (Winston, 1983; Regan and Garrido, 2001). Winston (1983) further categories disaggregate models as inventory models and behavioral models. Inventory model sees freight transportation mode choice as a part of overall business process. Decision makers select the freight transportation mode which minimizes total logistics costs (García-Menéndez et al., 2004). Behavioral models are based on freight transport mode choice decisions of individuals who motivated by maximization of utility gained from the freight transport mode (Abdelwahab and Sargious, 1992). Two types of data characterize behavioral models of freight transportation mode choice: stated preference and revealed preference.

Stated preference technique of data collection refers to a family of methods which gather individuals' responses regarding their preference in a set of transportation alternatives (Kroes and Sheldon, 1988)). There are three types of stated response regarding preference of individuals: individuals asked to order the alternatives, rate the alternatives or, choose one of the alternatives in a set of alternatives (Hensher, 1994). Stated preference technique which is based on the choice of individuals are called stated choice experiments (Masiero and Hensher, 2012) or discrete choice experiment (Klojgaard et al., 2012; Louviere et al., 2010) or choice-based conjoint analysis (Haaijer et al., 2001). In this thesis, we will use the term "stated choice experiment".

Stated choice experiments incorporate a number of alternatives including mixes of attributes and attributes' levels in which respondents choose among alternatives in fixed or varying choice sets thus allowing estimation of discrete choice models and make projections on the market shares of the alternatives (Hensher, 1994). Revealed

preference data, as it is explicit in its name “revealed”, consists of data in relation to past choices made by the individuals thus revealing their preferences. Revealed preference data includes the actual choice data in which alternatives include attribute values determined by the actual market. It seems that revealed preference is the most appropriate in terms of reliability while estimating discrete choice models. However, revealed preference has major drawbacks (Kroes and Sheldon, 1988):

1. It is difficult to gather enough variability to estimate discrete choice models with the revealed preference data.
2. It is difficult to estimate the discrete choice model with a proper trade-off, because of the correlations between independent variables such as time and cost.
3. It is not possible to evaluate demand for alternatives which do not currently exist in the market.
4. Revealed preference data only include numeric attributes such as time and costs excluding qualitative attributes.

With the usage of stated choice experiments, these drawbacks are eliminated. Stated preference experiments became the desired method for data collection because they are easy to control (the choice situations are defined by the researchers), able to deal with varied attributes, and cheaper to apply since respondents provide multiple observations on alternatives which include different combinations of values of attributes (Kroes and Sheldon, 1988).

3.4.2. Modeling Approach

Discrete choice models were estimated to obtain the impacts of freight transport service attributes on decision makers. Discrete choice models adapted in this study is based on random utility theory. Random utility theory postulates that decision maker assigns a utility value for each alternative and select the option which has highest utility value (McFadden, 1973, 1974; Domenich and McFadden, 1975; McFadden, 1975).

The utility function can be represented as:

$$U_{jq} = V_{jq} + \epsilon_{jq}$$

V is the measurable component of the utility. It is the function of the attributes, which the alternatives are consisted of, and it changes from person to person thus carries subscript q. On the other hand, ϵ is random component has a certain probability distribution represents the residuals with a mean of 0.

V can be postulated as:

$$V_{jq}(\beta) = \sum_{k=1}^{n} \theta_{jk} X_{jkq}$$

In which the coefficient θ of kth number of the attribute is fixed for every person in the population, but in the case of alternative specific attributes they can vary among alternatives (Ortúzar S and Willumsen, 2011).

The probability distributions of residuals are not known, however, to estimate the discrete choice model, assumptions regarding the probability distributions of the residuals must be made. The different assumptions regarding the probability distribution of the residuals lead to different discrete choice models. To search for model fit, two different discrete choice models were tested: conditional logit and mixed logit with random coefficients.

The multinomial logit model is often used when the residuals assumed to be identically and independently distributed according to Gumbel distribution (also called Extreme Value Type 1-EVT1). The conditional logit model is a variation of the multinomial logit model that requires the same assumptions about the probability distributions of the residuals. The conditional logit model is developed by McFadden for behavioral modeling of discrete choice situations (McFadden, 1973, 1974; Domenich and McFadden, 1975). The conditional logit model is not merely an alternative to the multinomial logit model, instead, conditional logit model is appropriate for choice situations where choice situation treated as the function of the characteristics of the choice alternatives not the function of the characteristics of decision making individuals (Hoffman and Duncan, 1988).

According to conditional logit, the probability of the person q chooses the

alternative A_i can be expressed as:

$$P_{iq} = \frac{e^{\beta_{ik} X_{ikq}}}{\sum_{A_j \in A_{(q)}} e^{\beta_{jq} X_{jkq}}}$$

Mixed logit, which is also used to estimate random utility models, is a flexible model that eliminates three limitations of standard logit: enable for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time (Train et al., 2009). Mixed logit estimates both mean and standard deviation of the weights of the attributes' effect across the sample (Hauber et al., 2016). Mixed logit probabilities are presented as integrals of standard logit probabilities over a distribution function of coefficients (Train et al., 2009; Ortúzar S and Willumsen, 2011):

$$P_{iq} = \int L_{iq}(\beta) f(\beta) d(\beta)$$

Where $L_{iq}(\beta)$ is the logit probability estimated with parameters (β) and $f(\beta)$ is distribution function of parameter (β). The mixed logit takes the form:

$$P_{iq} = \int \left(\frac{e^{\beta_{ik} X_{ikq}}}{\sum_{A_j \in A_{(q)}} e^{\beta_{jq} X_{jkq}}}\right) f(\beta) d(\beta)$$

The probability of the mixed logit is a weighted average of the probabilities estimated by the logit formula at different values of (β) of which the weights are given by the distribution function $f(\beta)$ (Train et al., 2009). Heterogeneity among individuals presented in the random coefficient mixed logit model by assuming that preference of individuals randomly distributed in the population (Train et al., 2009).

3.4.3. Construction of Data Collection Instrument

3.4.3.1. Semi-structured Interviews

Semi-structured interview method with open-ended questions was applied in order to determine which attributes to include in the survey and values of these attributes' levels.

There were three interrelated aims of these interviews. First aim is to reveal the attributes of inland container transportation that are considered by shippers while selecting inland container transportation service. It will be found whether the attributes considered by the shippers in the transport corridor is compatible with the attributes identified in the literature. They are illustrated in Table 22. Additionally, attributes that are characteristic for inland container transport and has not been identified in the literature will be revealed. Second aim of the interviews is to find how the identified attributes are interpreted by the participants and how these attributes can be measured. Third aim is to determine values and levels of the attributes identified for inclusion in the stated choice experiment. In order to achieve this aim, the variations in the attribute values will be identified.

Table 22: Freight Transportation Attributes Used in Previous Stated Choice Experiment Studies

Reference	Cost	Time	Delay/ Punctuality	Frequency	Emissions	Notice for contracting	Risk of damages	Flexibility
Meers et al. (2017)	X	X	X	X				
Román et al. (2017)	X	X	X	X				
Tao et al. (2017)	X	X	X					
Larranaga et al. (2016)	X	X	X					
Nugroho et al. (2016)	X	X	X		X			
Feo-Valero et al. (2016a)	X	X	X	X				
Feo-Valero et al. (2016b)	X	X	X	X		X		
Arencibia et al. (2015)	X	X	X	X				
Regmi and Hanaoka (2015)	X	X	X					
Bergantino et al. (2013)	X	X						
Masiero and Hensher (2012)	X	X	X				X	
Li and Hensher (2012)	X	X	X				X	
Rotaris et al. (2012)	X	X	X	X			X	X
Feo et al. (2011)	X	X	X	X				
Feo-Valero et al. (2011)	X	X	X	X				
Masiero and Hensher (2011)	X	X	X					
Zamparini et al. (2011)	X	X	X	X			X	X
Masiero and Hensher (2010)	X	X	X					
	18	18	17	9	1	1	4	2

Because participants work in three different type of companies, three versions of the question form were prepared considering that these different companies have different roles to play in inland transportation of maritime containers. The interview question forms can be seen in Appendix 1.

Face-to-face interviews were conducted with rail operators, dry port operators and freight forwarders operating in the corridor during 04.10.2016-23.11.2016. Interviews' participants include 4 freight forwarders, 2 rail operators and 1 participant from Turkish State Railways and 2 participants from the Sarayköy dry port. The details of the participants are illustrated in Table 23.

Table 23: Details of Interview Participants

Position	Company Type	Experience	Date
Branch Manager	Forwarder	15 years	04.10.2016 09:00
Agency Manager	Forwarder	25 years	04.10.2016 14:00
Marketing Department Manager	Forwarder	12 years	27.10.2016 15:00
General Manager	Forwarder	22 years	27.10.2016 15:30
Operations Department Manager	Logistics Service Provider	9 years	10.10.2016 11:30
Branch Manager	Logistics Service Provider	12 years	12.10.2016 17:00
Freight Department Deputy Manager	Public Company	24 years	07.11.2016 10:00
Operations Officer	Dry port	5 years	23.11.2016 11:00
Operations Manager	Dry port	16 years	23.11.2016 13:00

3.4.3.2. Attributes

Table 22 shows that attributes such as the risk of damage/safety, security/theft, and environmental emissions are used in previous stated preference studies. In this case, the interviews revealed that the attributes "risk of damage" and security do not vary between the available transport modes therefore including these attributes would lead to unrealistic choice situations. Additionally, the interviews also showed that environmental emissions caused by freight transportation are not considered as an important factor by decision makers while selecting an inland transport mode.

It was decided to include two alternative transportation modes in the stated

choice experiment because currently there are two inland transportation modes available for decision makers to choose in the transport corridor: Road transportation and rail-base dry port service. Additionally, as the result of interviews, it was decided to include five attributes as described Table 24: cost, time, delays, frequency and free time. Table 22 shows that they are the most widely used ones in the previous stated choice studies for freight transportation mode selection. They are gathered through literature review and interviews revealed that they also have great significance for decision makers of inland transport service choice in the corridor.

Table 24: Attributes

Attribute	References
Transport Cost	(Meers et al., 2017) (Román et al., 2017; Tao et al., 2017; Larranaga et al., 2016; Nugroho et al., 2016; Feo-Valero et al., 2016a,b; Arencibia et al., 2015; Regmi and Hanaoka, 2015; Bergantino et al., 2013; Masiero and Hensher, 2012; Li and Hensher, 2012; Rotaris et al., 2012; Feo et al., 2011; Feo-Valero et al., 2011; Masiero and Hensher, 2011; Zamparini et al., 2011; Masiero and Hensher, 2010)
Transit Time	(Román et al., 2017; Tao et al., 2017; Larranaga et al., 2016; Nugroho et al., 2016; Feo-Valero et al., 2016a,b; Arencibia et al., 2015; Regmi and Hanaoka, 2015; Bergantino et al., 2013; Masiero and Hensher, 2012; Li and Hensher, 2012; Rotaris et al., 2012; Feo et al., 2011; Feo-Valero et al., 2011; Masiero and Hensher, 2011; Zamparini et al., 2011; Masiero and Hensher, 2010)
Delay	(Román et al., 2017; Tao et al., 2017; Larranaga et al., 2016; Nugroho et al., 2016; Feo-Valero et al., 2016a,b; Arencibia et al., 2015; Regmi and Hanaoka, 2015; Masiero and Hensher, 2012; Li and Hensher, 2012; Rotaris et al., 2012; Feo et al., 2011; Feo-Valero et al., 2011; Masiero and Hensher, 2011; Zamparini et al., 2011; Masiero and Hensher, 2010)
Frequency	(Meers et al., 2017; Román et al., 2017; Feo-Valero et al., 2016a,b; Arencibia et al., 2015; Rotaris et al., 2012; Feo et al., 2011; Feo-Valero et al., 2011; Zamparini et al., 2011)
Free Time	Identified from the interviews

An attribute which has a significant impact on inland transport choice of containers and specific to the case of this study, named “free time” is identified with the interview process. Free time is the duration a container stays in a seaport or a dry

port without paying a container storage charge. The attribute “free time” is specific to the inland transportation of maritime containers and it has not been considered in the previous studies. The reason behind this is the limited number of studies that use stated choice experiment to investigate inland transportation of maritime containers.

The inclusion of these attributes in the choice situations presents realistic trade-offs for the respondents. All of these attributes show variation between transport modes in the corridor. This makes the presented choice situations more realistic for the respondents.

It is decided to use five attributes in the survey in order to lower task complexity and minimize the burden on the respondents. If more attributes were used, the respondents would have to face an extensive number of choice situations. In the literature, it is widely accepted that while designing stated choice experiments the maximum number of attributes need not exceed five in order to produce a manageable number of choice situations and minimize impacts of respondent fatigue (Hair et al., 2007).

3.4.3.3. Attribute Values

Attribute values and measurement units were determined because attributes can be perceived differently and can be qualitatively and quantitatively valued. In our case, all of the attributes are quantitatively valued. As it can be seen in Table 25, all of the attribute values consist of numeric values. Additionally, all the values of attributes were determined by considering shippers’ perspective rather than carriers’ perspective. For example, the value of the attribute "port to door transport cost" means the price of transportation service that the carrier charges to the shipper. This consists of the port-to-door transportation cost of a shipper.

The attribute “port to door transportation cost” for the alternative of “rail-based dry port” includes the total of all the transport costs between port and a shipper’s factory of warehouse. It includes handling costs at port, railway transportation costs, handling costs at the dry port, road haulage from the dry port to shippers’ factory or warehouse, container stuffing/unstuffing costs and empty container movement. For the

road alternative the attribute “port to door transportation cost” includes handling costs at the port, road transport costs, container stuffing/unstuffing costs and empty container movement.

The attribute “port to door transport time” includes the duration that starts when the container handled to the carrier, ends when the container is delivered to the shipper. For rail-based dry port alternative, this duration includes handling time at port, train transportation time, handling time at the dry port, and road haulage time from the dry port to the shipper. For road alternative, it includes handling time at port, road haulage from port to shippers’ factory or warehouse.

The attribute “delays” refers to the percentage of late arriving containers with regard to specified arrival time. For rail-based dry port alternative, it includes not just the late arrival of the train but also the road haulage between the dry port and the shipper’s factory or warehouse. For road alternative, it includes the percentage of late arrivals because of the traffic or other factors.

Frequency attribute only applies for the railway alternative as the outcomes of the interviews show that it is not possible to appoint frequency for trucks. When there is a need for road haulage, the shipper or the forwarder gets in touch with a road transport operator. Considering the availability of proper trucks, the road operator sends a truck in order to carry out inland transportation of the container. As for the railway alternative, trains are operated under a specified schedule. The departure times and the number of departures per week has to be consistent with the schedule.

The attribute “free time” is specific for the inland transportation of maritime containers. It reflects the characteristics of inland transportation decision making because excessive time spent at a port can cause substantial container storage costs on the carriers that is reflected shippers as demurrage charges. This especially happens when a high number of containers to be transported in one shipment. In this situation, shipper usually lacks container storage space and an adequate number of container stuffing/unstuffing equipment. Container stuffing/unstuffing has to be done in port or another place that meet these requirements of the shipper. As the storage cost and other handling charges are usually high in seaports because of the limited space and high demand. A dry port perfectly matches these requirements. The free time attribute is

only applicable to railway alternative because free time in container terminals of Izmir is fixed to 5 days without showing variation.

3.4.3.4. Attribute Levels

Levels of the attributes were also generated from the information gathered by interviews. At First, the attribute values for inland transportation of one twenty-foot container between the container terminals and city of Denizli were determined for both road haulage and rail-based dry port. After determination of the values, the variations in the attributes values of the alternatives were identified.

Table 25 shows the levels of the attributes. All of the attributes has 3 levels in order to measure non-linear effects. Cost attribute for the road alternative has the levels of TRL 1,000, TRL 1,150 and TRL 1,300. On the other hand, cost attribute of rail alternative has the levels of TRL 750, TRL 850 and TRL 950. Time attribute of road alternative has the levels of 5 hours, 6 hours and 7 hours but time attribute of rail-based dry port alternative has levels of 14 hours, 16 hours and 18 hours. Delays meaning the percentage of the late arrivals for road alternative changes between 3%, 5% and 7%. However, for rail alternative it changes between 5%, 10%, and 15%. Frequency attribute is not applicable the road alternative. Therefore, a fixed statement indicating "transportation service provided upon shippers' request" is included in the survey. Frequency attribute for the rail alternative is changing between 6 trains per week, 9 trains per week and 12 trains per week. Free time attribute for road alternative also is not applicable because trucks pick the container from the seaport and free time in seaport is fixed to 5 days without showing variation. In the survey, it is also fixed to 5 days. Free time in the dry port shows variation and longer free times can be provided because of the availability of space and lower costs of the lands. Free time attribute of the rail-based dry port alternative changes between 5 days, 15 days and 30 days.

Table 25: Values of the Attributes and Their Levels

	Transport Mode	1. Level	2. Level	3. Level
Transport Cost	Road	TRL 1.000	TRL 1.150	TRL 1.300
	Dry port	TRL 750	TRL 850	TRL 950
Transit Time	Road	5 hours	6 hours	7 hours
	Dry port	14 hours	16 hours	18 hours
Delay	Road	3%	5%	7%
	Dry port	5%	10%	15%
Frequency	Road	-	-	-
	Dry port	6 Trains per week	9 Trains per week	12 Trains per week
Free Time	Road	5 days	5 days	5 days
	Dry port	5 days	15 days	30 days

3.4.3.5. Experimental Design

Designing a stated choice experiment consists of a process in which the levels of the attributes are combined to create the experimental design (Hensher, 1994). Experimental design is displayed as a matrix as shown in the Table 27, that is a framework for doing a stated choice experiment (Kuhfeld, 2010). In order to clearly explain the experimental design process of this study, it is necessary to define some terminology used in the stated preference literature. The components of a stated choice experiment consist of three basic components: factors, profiles, and sets.

Factor: Factors are columns of the design matrix representing an attribute of an alternative and they consist of two or more fixed values or levels (Kuhfeld, 2010).

Profile: Profile means a combination of attribute levels that describe an alternative. It is also referred as a treatment (Hensher, 1994).

Set: A set includes a combination of profiles or treatments in one choice situation. Respondents select a profile in this combination of profiles. Sets represent the rows of the design matrix and also referred as runs (Kuhfeld, 2010).

The design of a stated choice experiment is constructed by putting together a combination of factors, profiles, and sets in a scientific way to create an optimum combination (Hensher et al., 2005).

Table 26: Factors of the Design

Factors	Levels	Alternatives	Attributes
1. Road-cost	3	Road	Cost
2. Road-time	3	Road	Time
3. Road-reliability	3	Road	Reliability
4. Rail-cost	3	Rail	Cost
5. Rail-time	3	Rail	Time
6. Rail-reliability	3	Rail	Reliability
7. Rail-frequency	3	Rail	Frequency
8. Rail-freetime	3	Rail	Freetime

Another issue requires to shine a light on is the determination of effects to be tested in the experiment. The degrees of freedom that determine design size is directly related with which effect to be estimated with the design. Particularly, there are two types of effect can be tested: main effects and interaction effects. An effect is the impact of an attribute level on a dependent variable (response variable), in this case, the dependent variable is the choice (Hensher et al., 2005). The main effect can be described as the direct independent effect of each attribute on the dependent variable (choice) (Hensher et al., 2005; Kuhfeld, 2010). The interaction effect is combined effect of two or more attributes on dependent variable which cannot be observed by estimating each attribute separately (Hensher et al., 2005; Kuhfeld, 2010).

Another issue requires explanation is related to the size of the experiment design. A full factorial design includes all possible combinations of factor levels. It allows to estimate all main effects and all interaction effects. There is a proble with full factorial designs. Most of the time, they include an extensive number of sets (in another words profile combinations). The number of sets in the full factorial design is calculated according to the formula: $(N_1 * N_2 * ... * N_j)$. N equals to the number of levels of the factors from 1 to j. For example, in this study, the design consists of 8 factors and each factor has 3 levels. The number of sets in the full factorial design calculated as: $3 * 3 * 3 * 3 * 3 * 3 * 3 * 3 = 6,561$. It is impossible to include this number of sets in an experiment design so that researchers generally use fractional factorial design. The reason it is named as fractional factorial design is that researchers use only a fraction of a full factorial design. The issue with the fractional factorial design is all interaction effects cannot be estimated with a fractional factorial design. The fractional factorial

designs usually include only main effects. If it is desired, lower order interactions also can be included. Another issue is how to select the fraction of the total number of profile combinations. It is possible to randomly select the profile combinations to be used in the experiment design from the all possible combinations included in the full factorial design but this results with inefficient and suboptimal designs (Hensher et al., 2005). This selection process needs a scientific approach to measure efficiency and goodness of a design in order to construct a design from optimal profile combinations.

The goodness of a stated choice design can be evaluated by looking at its orthogonality and balance. The balance of a design is obtained when each level appears equally often in each factor (Kuhfeld, 2010). Additionally, a design is orthogonal when every pair of levels appears equally often across every pair of factors. In other words, in order a design to be orthogonal, appearance frequencies of level pairs need to be equal or proportional (Kuhfeld, 2010). In statistical terms, attributes in orthogonal designs are statistically independent of each other with zero correlation (Hensher et al., 2005). Orthogonal and balanced fractional factorial designs are the most optimal designs so that researchers prefer to use orthogonal and balanced fractional factorial designs. However, considering the number of factors and their number of levels to be included in the experiment, it is not always possible to construct orthogonal designs or minimum orthogonal design includes an extensive number of sets. In that situation, a number of things can be done (Kuhfeld, 2010): first, the number of factor levels can be changed to fit an orthogonal design; second, some factors can be excluded from the experiment; third, the large orthogonal design can be divided into blocks; forth, a design that is not orthogonal but has maximum efficiency can be selected to be used. Usually, it is not desirable to change the number of levels or exclude factors because achieving the aim of the experiment can be compromised (Kuhfeld, 2010). Additionally, blocking the large orthogonal design puts an additional burden on the researchers because an equal number of questionnaires including each block of design need to be collected. Furthermore, in small populations, it makes difficult to reach the required number of observations because blocks include a small number of sets hence a small number of sets with a small number of respondents may result with an insufficient number of observations. Designs that are not orthogonal but show highest efficiency can be used in these situations

(Kuhfeld, 2010). The efficiency of a design can be measured with various measures of design efficiency: A-efficiency, D-efficiency and G-efficiency (Kuhfeld, 2010).

In this study, only main effects will be estimated. The interactions across the levels of the factors will be ignored by making an assumption that the interaction effects equal to zero. First of all, the degrees of freedom required estimating main effects need to be calculated to determine the minimum number of sets to be included in the design. Degrees of freedom required for estimating main effects can be calculated according to the formula (Kuhfeld, 2010): $N_1-1+N_2-1+\ldots+N_j-1+1$. N represents the number of levels of factors from 1 to j. In this study, 8 factors were included and each factor has 3 levels. The minimum number of degrees of freedom in order to estimate the main effect model is calculated as: $(3-1)+(3-1)+(3-1)+(3-1)+(3-1)+(3-1)+(3-1)+(3-1)+1 = 17$. Therefore, the minimum number of sets that need to be included in the experimental design of this study equals to 17. With using SAS OPTEX procedure, various possible designs that include different numbers of sets are generated. Three possible designs were generated; the one that includes 18 sets, the other one that includes 27 sets, and the last one that includes 36 sets. The designs with 27 and 36 sets were orthogonal however they include an extensive amount of sets to include in one questionnaire. The design with 18 sets was not orthogonal but the number of 18 sets was optimum. It did not require blocking. The design with 27 sets could be divided into 3 blocks with 9 sets but considering small population it would be difficult to obtain a sufficient number of observations. The design with 36 sets could be divided into 2 blocks with 18 sets or 4 blocks with 9 sets. The blocks with 9 sets would have the same problem as the previous design that is the difficulty of obtaining sufficient observations. The blocks with 18 sets also would cause difficulty because an equal number of responses for each block needs to be collected for the sake of validity and reliability of the experiment. In consequence, it is decided to use the design with 18 sets. This design was not orthogonal but it did not require blocking thus the efficiency loss could be compensated by eliminating the difficulties caused by blocking the design. The design is generated with SAS OPTEX procedure with D-efficiency approach and it is illustrated in Table 27. After the generation of the design, the sets of the design are randomized to eliminate any correlation across the levels of the factors.

Table 27: Design of the Discrete Choice Survey

Sets	Road Cost	Road Time	Road Delay	Rail Cost	Rail Time	Rail Delay	Rail Frequency	Rail Free Time
1	1150	7	3	850	16	5	12	30
2	1150	7	5	750	14	10	12	5
3	1300	7	5	950	18	5	6	5
4	1300	6	3	750	14	5	9	30
5	1150	5	7	950	14	5	9	15
6	1150	6	3	950	18	10	6	15
7	1300	5	3	950	16	15	12	5
8	1000	7	7	950	16	10	9	30
9	1150	6	7	750	16	15	6	5
10	1300	5	7	750	18	10	12	30
11	1000	6	5	950	14	15	12	30
12	1150	5	5	850	18	15	9	30
13	1300	7	7	850	14	15	6	15
14	1300	6	5	850	16	10	9	15
15	1000	7	3	750	18	15	9	15
16	1000	5	3	850	14	10	6	5
17	1000	6	7	850	18	5	12	5
18	1000	5	5	750	16	5	6	15

3.4.4. Pilot Study

After generating the experimental design, the preliminary questionnaire is constructed with including profile questions and questions related to the importance of included attributes. This preliminary questionnaire is tested in a pilot study. A pilot study is defined as " ...test of the methods and procedures to be used on a larger scale if the pilot study demonstrates that the methods and procedures can work" (Last et al., 2001). With a purpose identified in this definition, the pilot study is conducted to 9 participants; 4 people working as management positions in freight forwarder companies located in Izmir city and 5 people working as import or export specialists in manufacturing companies located in Denizli city. As results of pilot study, the levels of the attributes are adjusted to increase the variation between the alternatives. It is eliminated to pile-up of the respondents' choice on one alternative. Additionally, other adjustments on the attribute levels are made for the sake of increasing the reality of choice situations. Furthermore, the reluctance of respondents for answering some profile questions is observed and those questions are removed to increase the response rate of

the final survey. Ambiguity in the wording of some questions and explanatory text are corrected with the suggestions of the pilot study participants. Feedback of respondents with regard to the duration of questionnaire completion and respondents' burden and boredom are gathered. Those feedbacks showed that the number of questions and duration for completion of these questions cause an acceptable level of burden on the respondents.

After the adjustment completed on the preliminary questionnaire as the results of the pilot study, the final questionnaire is constructed. The questionnaire consists of three parts. In the first part, the importance of the attributes is asked with Likert scale questions. After those questions, the usage frequency of inland transport services in the corridor between Izmir and Denizli city is asked. The second part of the questionnaire consists of the stated choice scenarios. This part starts with an introductory text that explains the scenarios and inland transport activity. After this explanation, it is asked from the respondent to choose the primary type of freight they transported in the corridor. Then, the scenarios, one of them described in Table 28, is asked to respondents. The last part of the questionnaire consists of profiles questions in order to identify characteristics of the respondents. The questionnaire is included in Appendix-2 and Appendix-3.

Table 28: A Scenario in the Discrete Choice Experiment

1. Scenario	Dry Port (Railway + Road)	Road
Port to Door Transportation Cost	TRL 850	TRL 1,150
Port to Door Transportation Time	16 Hours	7 Hours
Delay Percentage	%5	%3
Frequency	12 Trains Per Week	Containers Transported upon Request
Free Time	30 days	5 Days
Please check the box for your preference	□	□

3.4.5. Population

Decision making for inland transportation service choice can involve several actors. The literature review related to stated preference studies in freight transportation contexts show that shippers or logistics service providers or both of them might involve in freight transportation mode choice process. Some studies consider logistics service providers or freight forwarders as the sole decision makers of freight transportation mode choice. In other studies, shippers are considered as the sole decision makers of freight transportation mode choice. On the other hand, some other studies consider both shippers and logistics service providers as the decision makers of freight transportation mode choice. In this study, the latest approach where both shippers and logistics service providers considered decision makers of freight transportation mode choice is adopted as a result of interviews and pilot study.

Freight forwarders and shipping lines located in Izmir city and manufacturing companies located in Denizli is considered as the population of this study. The interviews and the pilot study showed that almost all freight forwarders that operate shipments from Denizli are located in Izmir. Manufacturing companies in Denizli works with those freight forwarders for transportation of their import and export containers. The freight forwarders located in Izmir are identified among FIATA (International Federation of Freight Forwarders Associations) members and UTİKAD (Association of International Forwarding and Logistics Service Providers) members in Turkey. Manufacturing companies located in Denizli are identified from the lists provided by Denizli Exporters' Association and Denizli Chamber of Commerce.

3.4.6. Survey Process and the Respondents

The survey was conducted in two ways: the first approach was to request from the participants to fill the questionnaire by face to face and the second approach was to send the questionnaire as a web survey to the emails of the freight forwarders, shipping lines and manufacturing companies. Face to face survey with manufacturing companies located in Denizli is conducted in between dates of November 2016 and December

2016. Additionally, during the same period, the questionnaire was sent to the emails of the manufacturing companies, freight forwarders, and shipping lines. List of freight forwarders and manufacturing companies are gathered together as explained in the previous section. From these lists totally 105 freight forwarders and 489 manufacturing companies were identified. Moreover, the contact details of these companies were collected through the web and then these companies were contacted by telephone in order to explain the research and request them to complete the web survey. The questionnaires were sent them with emails as a web survey and they were followed up by reminder emails and phone calls. Table 29 shows the response rate.

Table 29: Responses to The Survey

Company Type	Questionnaires Sent	Responses	Response Rate	Sets
Manufacturer/Shipper	489	78	16%	$78 * 18 = 1404$
Freight forwarder	105	27	26%	$27 * 18 = 486$
Shipping Line	21	11	52%	$11 * 18 = 198$
Total	605	116	19%	$116 * 18 = 2,088$

Determination of acceptable minimum sample size is necessary in order to decide the number of questionnaires to be collected and to finish the data collection process through the conduction of the survey. With related to minimum sample size for stated choice experiments, researchers point forward different claims. In this study, the minimum sample size is calculated according to the formula provided by Orme (2010):

$$\frac{n * t * a}{c} \geq 500$$

Where n represents the number of respondents, t represents the number of sets, a represents the number of alternatives (excluding none alternative if it is applicable) and c represents the number of analysis cells. In the case of a main effect model c represents the largest number of levels any one attribute has however in the case of a model estimating interaction effects alongside main effects, c represents the products of the number levels that the interactions to be estimated (Orme, 2010). For example in the case of two-way interactions, such as cost and time attribute, c represents the products of the number of levels of cost attribute and time attribute.

In this study we calculated the minimum sample size as follows:

$$n \geq \frac{500 * c}{t * a}$$

When the values of the variable put into their places:

$$t = 18, a = 2, c = 3$$

$$n \geq \frac{500 * 3}{18 * 2}$$

$$n \geq 41.6$$

The calculation shows that the minimum acceptable sample size of this study equals to 42 respondents. As it is stated earlier, the collected number of questionnaires from the respondents is 116, thus the minimum acceptable sample size shows that the collected number of questionnaires are sufficient in order to estimate coefficients of the main effects model.

3.4.7. Validity and Reliability Assessment

Researchers describe reliability and validity in different ways. In particular, reliability refers to the degree of the reproducibility of a measurement, on the other hand, validity refers to the level to which the study succeeds to measure what is intended to be measured (Pearce and Özedemiroglu, 2002). Validity and reliability of a study are not independent of each other. The low reliability of a study reduces the level of its validity and lack of validity shows itself from unreliable responses (Rakotonarivo et al., 2016; Murphy and Davidshofer, 1988). Therefore, various types of evaluations for validity and reliability are not mutually exclusive.

3.4.7.1. Reliability Assessment

In this thesis, the reliability of stated choice experiment is tested by using the Kuder and Richardson (1937) formula 20. The test evaluates the internal consistency of a survey instrument with dichotomous choices (Kuder and Richardson, 1937). The

stated choice experiment administered in this thesis has dichotomous choices with two choice alternatives. Reliability of 5 point Likert scale questions of the survey is assessed with Cronbach (1951)'s alpha coefficient. Formulas of Kuder and Richardson (1937) formula 20 and Cronbach (1951)'s alpha coefficient are stated as:

$$r_{tt(KR20)} = \frac{n}{n-1} * (1 - \frac{\sum_{i=1}^{n} p_i * q_i}{V_i}); (i = 1, 2, \ldots n)$$

Where ;

i represents items in the discrete choice experiment survey.

n represents total of the items in the discrete choice experiment survey.

p_i represents the proportion of selecting first alternative in the scenario i.

q_i represents the proportion of selecting second alternative in the scenario i.

V_t represents the variance of total discrete choice experiment questions.

$$\alpha = \frac{n}{n-1} * (1 - \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} C_{ij}}{V_i}); (i, j = 1, 2, \ldots n; i \neq j)$$

Where ;

i and j represents items in the Likert scale survey.

n represents total of the items in the Likert scale survey.

C_{ij} represents the covariance between item i and j.

V_t represents the variance of total items in the Likert scale survey.

The resemblance between two formulas is obvious because Cronbach (1951)'s alpha coefficient was developed through Kuder and Richardson (1937) formula 20 (Cronbach, 1951). Kuder and Richardson (1937) formula 20 can only be applied to the surveys that consists of binary response questions. The responses must include only two possible outcomes. Cronbach (1951)'s alpha coefficient can be applied to the survey questions with responses include more than two possible outcomes. When Cronbach

(1951)'s alpha coefficient is applied to the questions with binary outcomes, it yields the same result as Kuder and Richardson (1937) formula 20 (Cronbach, 1951).

Both of the above internal consistency tests are mathematically related to the split-half method (Kuder and Richardson, 1937; Cronbach, 1951). Both of the tests represent the average correlation coefficient that would be obtained from averaging correlation coefficients from all possible split halves (Cronbach, 1951). For example, if every possible split-half correlations of a survey is calculated, the average of all of those split-half correlations will be equal to coefficient alpha. In the case of binary response questions, it will be equal to the result of Kuder and Richardson (1937) formula 20.

As explained earlier, the first section of the questionnaire administered in this thesis consists of Likert scale questions that are asking for the importance of inland freight transportation service attributes. This section consists of five 5 point Likert scale questions. The reliability of the responses for these questions is assessed with Cronbach (1951)'s alpha coefficient. The calculated Cronbach (1951)'s alpha coefficient of this section of the questionnaire equals to 0,72. The second part of the questionnaire consists of stated choice experiment scenarios with binary responses so that reliability test of this section of the questionnaire is assessed with Kuder and Richardson (1937) formula 20. The result of Kuder and Richardson (1937) formula 20 of the stated choice experiment scenario questions equals to 0,92. Depending on the number of items in the measurement scale, Nunally (1978) recommends the level of reliability minimum 0,7. In consequence, both reliability test scores exceeded this threshold confirming reliability of the survey instrument.

3.4.7.2. Validity Assessment

A methodology is valid when it measures what is intended to be measured. In order to ensure content validity a systematic approach was followed while developing the stated choice experiment. Development of the stated choice experiment administered throughout six steps: identification of the attributes, selection of measurement unit for the attributes, specification of attribute levels, experimental design and construction of the questionnaire. In the first step, while identifying the attributes, the relevant literature

was reviewed to reveal the attributes that used in previous research. And, interviews were conducted to identify the most relevant attributes in the scope of this study for the sake of realism of the scenarios and content validity of the questionnaire. Interviews were also used while specifying measurement units for the attributes and specifying the levels of the attributes to reflect the conditions of the actual inland transportation market in the specified corridor. Stated choice experiment design is created with SAS OPEX procedure which is frequently used in the previous research.

In the final step, the questionnaire was constructed. It has three sections. The first section and the second section include questions with the identified attributes. The third section includes profile questions in order to apprehend the details about the containerized freight and decision makers. Furthermore, after the construction of the questionnaire, a pilot study is conducted to identify and correct any inadequacies in the questionnaire. Following a systematic approach while developing the questionnaire with the help of literature review, interviews, and pilot study, the utmost care was performed to establish the realism and the validity of the stated choice experiment.

Data collection process is validated by ensuring that respondents are actual decision makers of inland transportation mode choice, ensuring that number of sample is enough for representation of the population, and ensuring that respondents understand the content of the questionnaire before answering it. Literature review and the interviews revealed that the decision makers of inland transportation mode selection involve shippers, freight forwarders, and shipping lines. We administered the survey to these companies. The required sample size is calculated by using a formula proposed in the previous research. While administering the survey, web-based survey and face-to-face survey approaches were used. In the case of the face-to-face survey, the study and the content of the questionnaire were explained to the respondents. In the case of the web survey, a cover letter explaining the survey was included in the emails and the respondents were contacted by phone to explain the survey and kindly requesting their contributions.

3.4.8. Findings

3.4.8.1. Descriptive Findings

The first section of the questionnaire consists of the questions asking the respondents the importance level of the freight transportation mode selection attributes on a 5-point scale. Results in Table 30 show that respectively, 71%, 45%, 76%, 42% and 70% of the respondents see the cost, time, reliability, frequency, and free time attributes having very high and high importance. Therefore, this result shows that cost, reliability and free time attributes have primary significance to the shippers while time and frequency attributes have secondary importance.

Table 30: Importance of the Attributes

	Cost	Time	Reliability	Frequency	Free Time
5-Very High Importance (%)	40	20	35	14	40
4-High Importance (%)	31	25	31	28	30
3-Moderate Importance (%)	23	42	31	42	19
2-Low Importance (%)	5	10	4	11	9
1-Very Low Importance (%)	1	3	0	5	2
Total	100	100	100	100	100

Table 31: Frequency of Dry Port Usage

	Number	Percentage (%)
1-Never	58	50
2-Rarely	35	30
3-Sometimes	13	11
4-Frequently	5	4
5-Always	5	4
Total	116	100

Table 31 shows the usage frequency of the rail-based dry port in the inland container transport. Results indicate that 50% of the respondents never used the rail-based dry port for their inland transportation requirements and, 30% of the respondents rarely used the rail-based dry port alternative. 11% of the respondents indicated that they sometimes use the rail-based dry port while only 5% of the respondents report that they frequently use that option. Additionally, just 5% of the respondents always use the rail-based dry port alternative for their inland transportation needs in the corridor.

Table 32: Type of Containerized Freight

	Number	Percentage (%)
Textile	54	47
Marble/Natural Stone	28	24
Dry Food	8	7
Machinery	5	4
Electronics	4	3
Iron-Steel Products	4	3
Paper Products	3	3
Fresh Fruit and Vegetable	2	2
Chemical	2	2
Minerals	2	2
Plastics	2	2
Glass Products	1	1
Timber	1	1
Total	116	100

Table 32 shows the types of containerized freight transported in the corridor. The respondents transport 13 different kind of containerized cargo in the corridor. Textile takes the first place; thus 47% of the respondents transports textile products. 24% of the respondents transports marble/natural stones, and 7% of the respondents transports dry food products and 4% of the respondent transport machinery. Additionally, almost 10% of respondents transports containerized freight consisting of electronics (3%), iron-steel (3%) and paper products (3%).

Table 33 shows the size of the respondents' company with regard to the number of employees they have. 28% of the respondents work in micro-companies which have 10 or less than 10 employees. Additionally, 28% of the respondents work in small companies having employees between 11 and 50 while 25% of the respondents work in medium-sized companies which employ a number of persons in between 51 and 250. Furthermore, 18% of the respondents work in large companies which have more than 250 employees. As a consequence, the distribution of the companies' sizes shows homogeneity. Hence, this represents the companies' sizes in the population.

The experience of the respondents illustrated in Table 34. It shows that 114 of the respondents indicated their years of experience, 2 of the respondents did not provide information about their experience. The table illustrates that majority of the respondents

Table 33: Sizes of the Respondent Companies

Number of Employees	Number of Respondents	Percentage (%)
0-10	33	28
11-50	33	28
51-250	29	25
250+	21	18
Total	116	100

have many years of experience. 14% of the respondents have 2 years or less experience while 25% of the respondents have experience in between 3 and 5 years. Additionally, 18% of the respondents have years of experience in between 6 and 10 years. 19% of respondents have experience in between 11 and 15 years as 25% of the respondents have experience more than 15 years. Results indicate that the respondents have average 10,8 years of experience, therefore this shows that the respondents demonstrate an adequate level of experience and knowledge on transport mode choice decisions regarding inland transportation of maritime containers.

Table 34: Experiences of the Respondents

Number of Years	Number of Respondents	Percentage (%)
0-2	16	14
3-5	28	25
6-10	20	18
11-15	22	19
15+	28	25
Total	114	100

Table 35 shows the respondents' positions in their companies. The table provides information about 113 of the respondents' position because 3 of the respondents did not provide information about their positions. The positions of the respondents were categorized as managerial positions and non-managerial positions. Managerial positions include department managers, CEO's, general managers, and company owners. Table 35 indicates that 54% of the respondents work in managerial positions of their companies while 46% of the respondents work in non-managerial positions. A big portion of the respondents works as managers. This show consistency with the experience of the respondents because the majority of the respondents had the experience required to get

promoted to managerial positions.

Table 35: Positions of the Respondents

Position	Number of Respondents	Percentage (%)
Managerial	61	54
Non-managerial	52	46
Total	113	100

3.4.8.2. Estimation Findings

Two alternatives (Road and rail-based dry port) and five attributes (cost, time, delay percentage, frequency and free time) were included in the stated choice experiment. Two of the attributes (frequency and free time) were alternative specific. They only apply to the rail-based dry port alternative. Experiment design was conducted through SAS statistical software by using OPEX procedure of the software. The design which includes 18 sets was chosen so that the questionnaire was included 18 scenarios. As explained earlier, 116 usable responses were gathered. $116 * 18 = 2,088$ data sets were used for the analysis. Data analysis was conducted with R Programming software using mlogit package.

Parameter estimation was done for various models. The first model estimated was the generic model which included an alternative specific constant for road (ASC) and generic parameters of cost, time, and delays. The parameters of frequency and free time is alternative specific (specific to the rail-based dry port alternative). They do not apply to the road alternative. Estimations were done by using conditional logit and random coefficient mixed logit analyses. While conducting random coefficient mixed logit estimates, it was assumed that parameters of cost, time, delay, frequency and free time have a normal distribution.

The utility functions of the generic model are presented as:

$$U_{Road} = ASC + \beta_1 * Cost + \beta_2 * Time + \beta_3 * Delay + \epsilon_{Road}$$

$$U_{DryPort} = \beta_1 * Cost + \beta_2 * Time + \beta_3 * Delay + \beta_4 * Frequency + \beta_5 * FreeTime + \epsilon_{DryPort}$$

Where,

ASC: The alternative specific constant of road alternative represents the preference for

the road alternative

U_{Road}: Utility of road alternative

$U_{DryPort}$: Utility of rail-based dry port alternative

$Cost$: Transport cost

$Time$: Transit time

$Delay$: Percentage of late arrivals

$Frequency$: Frequency of rail service between the seaports and the dry port (does not apply to road alternative)

$FreeTime$: Free time provided in the dry port measured as days (does not apply to road alternative)

β_1: Generic parameter of $Cost$

β_2: Generic parameter of $Time$

β_3: Generic parameter of $Delay$

β_4: Alternative specific parameter of $Frequency$

β_5: Alternative specific parameter of $FreeTime$

$\epsilon_{DryPort}$: Error component of $U_{DryPort}$

ϵ_{Road}: Error component of U_{Road}

Table 36: Estimation of Generic Model

	Conditional Logit		Random Coefficient Mixed Logit	
Variable	Coefficient	P-Value	Coefficient	P-Value
ASCRoad	2.14086920	3.526e-09***	4.19059752	9.922e-09***
Cost	-0.00381572	2.2e-16***	-0.00782505	2.2e-16***
Time	-0.00169746	0.95109	-0.06567062	0.22137
Delay	-0.06172528	2.596e-07***	-0.20977761	4.885e-15***
Frequency	0.03641517	0.09566*	0.05381958	0.15078
FreeTime	0.00950102	0.07063*	0.02097872	0.03323**
Cost.sd	-	-	-0.00713118	2.2e-16***
Time.sd	-	-	0.27044388	2.2e-16***
Delay.sd	-	-	0.21392730	2.531e-14***
Frequency.sd	-	-	-0.14935381	2.798e-14***
FreeTime.sd	-	-	-0.08505459	2.220e-16***
			Draws = 500	
	Log-likelihood: -1111.2		Log-likelihood: -729.94	
	McFadden R^2: 0.067044		McFadden R^2: 0.38716	

Signif. codes: 0.01'***'0.05'**'0.1'*'

Table 36 shows the estimation results of generic model. Estimation results show

that Time variable in both conditional and mixed logit estimates was not statistically significant(p-value in conditional logit was 0.95109 and p-value in mixed logit was 0.22137). Additionally, in mixed logit estimate Frequency variable also was not statistically significant (p-value was 0.15078). The model with alternative specific parameters is estimated to find a better model.

The utility functions of the alternative specific model are presented as:

$$U_{Road} = ASC + \beta_1 * RoadCost + \beta_2 * RoadTime + \beta_3 * RoadDelay + \epsilon_{Road}$$

$$U_{DryPort} = \beta_4 * DryportCost + \beta_5 * DryportTime + \beta_6 * DryportDelay + \beta_7 * Frequency + \beta_8 * FreeTime + \epsilon_{DryPort}$$

Where,

ASC: The alternative specific constant of road alternative represents the preference for the road alternative

U_{Road}: Utility of road alternative

$U_{DryPort}$: Utility of rail-based dry port alternative

$RoadCost$: Transport cost of road alternative

$RoadTime$: Transit time of road alternative

$RoadDelay$: Percentage of late arrivals of road alternative

$DryportCost$: Transport cost of rail-based dry port alternative

$DryportTime$: Transit time of rail-based dry port alternative

$DryportDelay$: Percentage of late arrivals of rail-based dry port alternative

$Frequency$: Frequency of rail service between the seaports and the dry port (does not apply to road alternative)

$FreeTime$: Free time provided in the dry port measured as days (does not apply to road alternative)

β_1: Alternative specific parameter of $RoadCost$

β_2: Alternative specific parameter of $RoadTime$

β_3: Alternative specific parameter of $RoadDelay$

β_4: Alternative specific parameter of $DryportCost$

β_5: Alternative specific parameter of $DryportTime$

β_6: Alternative specific parameter of $DryportDelay$

β_7: Alternative specific parameter of $Frequency$

β_8: Alternative specific parameter of $FreeTime$

$\epsilon_{DryPort}$: Error component of $U_{DryPort}$

ϵ_{Road}: Error component of U_{Road}

Table 37 shows estimation results of alternative specific model. The estimation results show that RoadTime and DryportTime variables in both conditional and mixed logit estimate are not statistically significant. Time variable in the previous model also was not statistically significant as described in Table 36. This indicates that the decision makers of inland container transportation do not consider transit time while deciding their transportation alternative in the corridor between Izmir and Denizli. Feo-Valero et al. (2011) analyzed the inland shipments of maritime containers in Spain, and they found that transit time in the inland transportation has a minimal impact. Consequently, the transit time parameter is omitted from the model. The parameters were estimated again without including transit time.

Table 37: Estimation of Alternative Specific Model

	Conditional Logit		Random Coefficient Mixed Logit	
Variable	Coefficient	P-Value	Coefficient	P-Value
ASCRoad	1.51564272	0.138314	1.45079940	0.380881
RoadCost	-0.00363385	2.2e-16***	-0.00805096	2.2e-16***
DryportCost	-0.00419865	6.747e-11***	-0.01110023	2.2e-16***
RoadTime	0.02244280	0.722960	0.10795278	0.301685
DryportTime	-0.01039052	0.746127	-0.01134904	0.839032
RoadDelay	-0.09055204	0.005011***	-0.19577514	0.000482***
DryportDelay	-0.05782279	4.395e-06***	-0.15122883	1.875e-10***
Frequency	0.03709201	0.091131*	0.06401615	0.071677*
FreeTime	0.00971835	0.065996*	0.01384619	0.128558
RoadCost.sd	-	-	0.00278900	2.2e-16***
DryportCost.sd	-	-	0.00268850	2.2e-16***
RoadTime.sd	-	-	0.02384082	0.732180
DryportTime.sd	-	-	0.01467071	0.339270
RoadDelay.sd	-	-	-0.16229970	3.912e-05***
DryportDelay.sd	-	-	0.17369856	2.2e-16***
Frequency.sd	-	-	0.10203030	1.387e-05***
FreeTime.sd	-	-	0.09662008	2.2e-16***
			Draws = 500	
	Log-likelihood: -1110.3		Log-likelihood: -748.94	
	McFadden R^2: 0.067794		McFadden R^2: 0.3712	

Signif. codes: 0.01'***'0.05'**'0.1'*'

The utility functions of the alternative specific model, in which *RoadTime* and

$DryportTime$ variables were omitted, are presented as:

$U_{Road} = ASC + \beta_1 * RoadCost + \beta_2 * RoadDelay + \epsilon_{Road}$

$U_{DryPort} = \beta_3 * DryportCost + \beta_4 * DryportDelay + \beta_5 * Frequency + \beta_6 * FreeTime + \epsilon_{DryPort}$

Where,

ASC: The alternative specific constant of road alternative represents the preference for the road alternative

U_{Road}: Utility of the road alternative

$U_{DryPort}$: Utility of the rail-based dry port alternative

$RoadCost$: Transport cost of road alternative

$RoadDelay$: Percentage of late arrivals of road alternative

$DryportCost$: Transport cost of the rail-based dry port alternative

$DryportDelay$: Percentage of late arrivals of the rail-based dry port alternative

$Frequency$: Frequency of rail service between the seaports and the dry port (does not apply to road alternative)

$FreeTime$: Free time provided in the dry port measured as days (does not apply to road alternative)

β_1: Alternative specific parameter of $RoadCost$

β_2: Alternative specific parameter of $RoadDelay$

β_3: Alternative specific parameter of $DryportCost$

β_4: Alternative specific parameter of $DryportDelay$

β_5: Alternative specific parameter of $Frequency$

β_6: Alternative specific parameter of $FreeTime$

$\epsilon_{DryPort}$: Error component of $U_{DryPort}$

ϵ_{Road}: Error component of U_{Road}

Table 38 shows the estimation results of the alternative specific model in which $RoadTime$ and $DryportTime$ variables were omitted. The results in Table 38 illustrate that all of the parameter estimations of conditional logit and random coefficient mixed logit are statistically significant. The model was estimated with two different methods: conditional logit and random coefficient mixed logit. All of the parameters of both methods in Table 38 are statistically significant, therefore, it is necessary to determine which estimation method provided the better model fit. The parameters of the estimation

Table 38: Estimation of Alternative Specific Model in which the Time Variable Was Excluded

	Conditional Logit		Random Coefficient Mixed Logit	
Variable	Coefficient	P-Value	Coefficient	P-Value
ASCRoad	1.81083566	0.022678**	2.46152512	0.0363381**
RoadCost	-0.00363649	2.2e-16***	-0.00667927	2.2e-16***
DryportCost	-0.00421300	5.388e-11***	-0.00866967	4.885e-15***
RoadDelay	-0.09108404	0.004649***	-0.20033351	0.0001328***
DryportDelay	-0.05785335	4.322e-06***	-0.13676824	5.512e-10***
Frequency	0.03692484	0.092720*	0.06870227	0.0384539**
FreeTime	0.00984425	0.061620*	0.01977997	0.0189199**
RoadCost.sd	-	-	0.00230894	2.2e-16***
DryportCost.sd	-	-	-0.00278017	2.2e-16***
RoadDelay.sd	-	-	-0.10071609	0.0406288**
DryportDelay.sd	-	-	0.11810730	2.220e-15***
Frequency.sd	-	-	0.06923868	0.0174038**
FreeTime.sd	-	-	0.05410528	2.854e-11***
			Draws = 500	
	Log-likelihood: -1110.4		Log-likelihood: -761.63	
	McFadden R^2: 0.067704		McFadden R^2: 0.36055	

Signif. codes: 0.01'***'0.05'**'0.1'*'

model which provide better model fit will be used for interpretation and elasticity analysis.

Likelihood ratio test is used for determining which model provides the better model fit. The formula of the likelihood ratio test takes following form (Ortúzar S and Willumsen, 2011):

$$-2(LogLike_{model1} - LogLike_{model2}) = -2(-1110.4 - (-761.63)) = 697.54$$

Where,

$LogLike_{model1}$: Log-likelihood of conditional logit from Table 38

$LogLike_{model2}$: Log-likelihood of random coefficient mixed logit from Table 38

For 6 degree of freedom (degree of freedom difference between two models 13–7 = 6) and significance level of 0.01, the reference value is 16.82. The calculated likelihood ratio is 697.54 that is much higher than the reference value. This indicates that the difference in the model fit of two models is statistically significant. At this point $-2LL$ of the two models need to be compared. The smaller $-2LL$ gets, the model has

better goodness of fit.

$-2(LogLike_{model1}) = -2 * (-1,110.4) = 2,220.8$

$-2(LogLike_{model2}) = -2 * (-761.63) = 1,523.26$

Where,

$LogLike_{model1}$: Log-likelihood of conditional logit from Table 38

$LogLike_{model2}$: Log-likelihood of random coefficient mixed logit from Table 38

The result of the above equation show that $-2LL$ of random coefficient mixed logit is lower than $-2LL$ of conditional logit. This shows that estimation results of random coefficient mixed logit has better model fit. Since the random coefficient mixed logit has better model fit, elasticity analysis will be done using parameters of random coefficient mixed logit as illustrated in Table 38.

Table 38 shows that all of the parameters have the expected signs. The positive sign for the alternative specific constant of road alternative indicates the existence of the respondents' preference for road transportation service. The parameters of cost attribute (RoadCost and DryportCost) has negative signs meaning that the increase in the cost of transportation services causes a decrease in the probability of that alternative to be selected. Furthermore, parameter signs of delay attributes (RoadDelay and DryportDelay) are also negative. Because the delay is expressed as the percentage of delays in the shipments, the increase in the percentage of delayed shipment reduces the probability of that transportation mode to be chosen. Increase in the frequency of train service between the dry port and the container terminals increases the demand for the dry port. Additionally, results show a positive sign for the parameter of FreeTime attribute indicating that the increase in the free time of the dry port increases the probability of rail-based dry port alternative to be selected.

3.4.8.3. Elasticities

Aggregated elasticities were calculated to analyze percentage variations of mode shares concerning the marginal changes in the attributes of the transportation alternatives. Parameters of random coefficient mixed logit from Table 38 are used for elasticity analysis. First, direct and cross point elasticities of the model are calculated. Then, point

elasticities are aggregated using probability-weighted sample enumeration technique. Direct elasticity stands for the percentage change in the probability of choosing an alternative concerning a marginal change in one of its attributes while cross elasticity means the change in the probability of choosing an alternative with respect to a marginal change in an attribute of a competing alternative (Ortúzar S and Willumsen, 2011). The direct and cross point elasticities are calculated by using the equations provided by (Ortúzar S and Willumsen, 2011):

$$E_{P_{iq}X_{ikq}} = \beta_{ik} X_{ikq}(1 - P_{iq})$$

$E_{P_{iq}X_{ikq}}$ represents the direct point elasticity, meaning the percentage change in choice probability (P_{iq}) of alternative i (A_i) with respect to marginal change in kth attribute (X_{ikq}) of alternative i (A_i) for individual q.

$$E_{P_{iq}X_{jkq}} = -\beta_{jk} X_{jkq} P_{jq} \qquad i \neq j$$

$E_{P_{iq}X_{jkq}}$ represents the cross point elasticity, meaning the percentage change in choice probability (P_{iq}) of alternative i (A_i) with respect to a marginal change in the kth attribute (X_{jkq}) of alternative j (A_j) for individual q.

To aggregate the elasticities, we used probability weighted sample enumeration technique, where direct and cross point elasticities of each individual choice is calculated, and each individual direct and cross point elasticity is weighted by the associated choice probability. The elasticities are aggregated using probability weighted sample enumeration technique according to the formula provided by Hensher et al. (2005):

$$E_{\overline{P}_i X_{ikq}} = \frac{(\sum_{q=1}^{Q} \hat{P}_{iq} E_{P_{iq}X_{ikq}})}{\sum_{q=1}^{Q} \hat{P}_{iq}}$$

Where, $E_{\overline{P}_i X_{ikq}}$ is the aggregate elasticity of kth attribute (X_{ikq}) of alternative i (A_i) for individual q. It stands for percentage change in the aggregate probability ($\overline{P}_i$) of choosing alternative i (A_i) with respect to marginal change in kth attribute (X_{ikq}) of alternative i (A_i) for individual q. $\hat{P}_{iq}$ stands for the estimated choice probability of alternative i (A_i) in for individual q.

Table 39 shows the direct and cross aggregate elasticities of the demand for the road and rail-based dry port alternative with respect to marginal changes in the attributes (transport cost, delay percentage, frequency, and free-time).

Table 39: Elasticities

Attribute		Road	Intermodal Rail
Cost	Road	–1.61	1.13
	Intermodal Rail	5.38	–3.77
Delay	Road	–0.14	0.24
	Intermodal Rail	0.47	–0.80
Frequency	Road	-	–0.10
	Intermodal Rail	-	0.34
Free-Time	Road	-	–0.08
	Intermodal Rail	-	0.27

Table 39 shows that variations in cost have the most substantial impact on mode share changes. 1% increase in the cost of the road cause a 1.61% decrease in the choice probability of road while increasing the probability of rail-based dry port service 5.38%. These results correspond to findings of Feo-Valero et al. (2016b). Their study concludes that the cost is the most influential attribute of mode choice in inland transport corridor between Valencia and Zaragoza. Vermeiren and Macharis (2016) also indicated that the cost is the determining factor for mode choice decisions. Additionally, Table 39 shows the mode share is more sensitive to the variations in road costs than the variations in the cost of rail-based dry port service because the 1% increase in the cost of rail-based dry port service reduces its mode share 3.77% while increasing the share of road 1.13%. The results suggest that provision of competitive railway service regarding cost has the utmost impact to achieve sustainable mode shift from road to the rail-based dry port service in the corridor. Efficient operation in the dry port and the railway is fundamental to compete in terms of cost.

Impact of delay attribute on mode share is not as high as the cost. Table 39 presents that 1% increase in the percentage of delayed shipments of road transport reduces its mode share 0.14% while increasing the mode share of rail-based dry port service 0.47%. On the other hand, the mode share is more sensitive to the delays of rail-based dry port service since a 1% increase in the percentage of delayed shipments causes a 0.80% decrease in its mode share while causing a 0.24% increase in the demand

for road transport. Minimizing the delays of railway service is essential to assure a decent level of demand. This is in line with findings of Feo-Valero et al. (2016b), that they state the decision makers strongly penalize the transport mode if its percentage of delayed shipments over the acceptable value.

According to the results, the frequency of rail transport service plays an essential role in the competitiveness of rail-based dry port service in the corridor. Table 39 presents that a marginal increase in the frequency increases the share of rail-based dry port by 0.34 times meaning that if the frequency of trains doubles up, the share of rail-based dry port will increase 34% while reducing the share of the road by 10%. This indicates that train frequency is an important factor for achieving mode shift towards rail-based dry port service. Additionally, increasing frequency can help minimizing delay in railways services, inadequate train frequency increases the delay durations and transportation times. A considerable mode shift towards rail-based dry port service will be achieved by focusing on providing intermodal-rail service with an adequate level of frequency with minimum delays. These Findings are confirmed by Meers et al. (2017) that they indicate the utility of frequency attribute is relatively less but railway services with lower frequencies are not preferable. Feo-Valero et al. (2016b) also, underlines that only rail service with high level of frequency is capable of competing with road transport.

Free-time attribute, which is specific to this study, also have an impact on the mode shares though it is a slight one. Table 39 shows that 1% increase in the free-time increase the mode share of rail-based dry port service by 0.27% while reducing the share of the road by 0.08%. The influence of free-time can be expanded by making required value-added logistics services available during extended free-times in the dry port.

3.5. ANALYSIS OF DRY PORT USAGE IN THE INLAND CORRIDOR

3.5.1. Methodology: Discrete-Event Simulation Modeling

In the previous section, we investigated the impact of changes in inland transportation attributes (which are cost, the percentage of delayed shipments, the frequency

of rail service, and free time in the dry port) on the demand for inland transportation services in the corridor between seaports of Izmir and Denizli city. In this section, the impacts of mode shift towards rail-based dry port service on the inland logistics of export and import containers will be analyzed by discrete event simulation modeling. Different scenarios of alterations in the attributes of inland transportation services to increase the demand for rail-based dry port service is simulated and their impacts on the inland container logistics are revealed. Discrete-event simulation modeling approach lets the research to model uncertainties in a transportation system. With usage of discrete-event simulation modeling, advanced transportation system can be modeled easily. It is a flexible modeling approach with a built-in optimization and experimentation tools optimization analysis or what-if-scenario analysis can be conducted a little effort. In this thesis, discrete-event simulation modeling was particularly necessary to model railway capacity constraints.

Most of the time, it is either impossible to manipulate a system or it is very costly to manipulate it to investigate the impacts of changes. Therefore, researchers develop a model of a system that they intend to evaluate. A model is described as a simplified representation of a complex system (Banks et al., 2010).

Different kinds of models exist. Altiok and Melamed (2010) distinguish models as three types: physical models, analytical models, and simulation models. Physical models are the simplified physical form of a real system or an object. Analytical models are the formulas and equations that describe the relationship between variables. Simulation models mimic the behavior of a system over a period of time. Simulation models have the particular interest in this section of this thesis because the inland transportation corridor under study will be simulated to evaluate certain scenarios.

Cambridge dictionary defines simulation as “a model of a real activity, created for training purposes or to solve a problem”. Simulation modeling includes creating an artificial history of the modeled system and observing this artificial history in order to gain insights with regard to operational characteristics of the real system (Banks et al., 2010). Simulation models are either developed manually by hand or developed on a computer using specific software or programming language. Computer simulation modeling is described as a technique of modeling the behavior of a real system with

using a software or a programming language to build the model and describe logical relationships in order to make experiments and draw inferences about the real system (Rossetti, 2015).

With developing a simulation model of a system, researchers evaluate the behavior of the system over a period of time while considering a set of assumptions with regard to logical relationships among the components and objects of the system (Banks et al., 2010). Simulation modeling is used to estimate changes in performance indicators of a system with regard to what-if-scenario analysis (Altiok and Melamed, 2010). The major benefit of a simulation model relies on its capacity of modeling a system with complex interrelationships so that important interactions among components and objects of the system can be modeled to imitate a complex system (Rossetti, 2015). Basically, two distinct usages of simulation modeling exist: first, to model an existing system to gain knowledge regarding impacts of certain changes on the performance of the system; second, to model a system which does not exist but planned to be constructed so that alternative designs can be compared (Banks et al., 2010).

Simulation modeling with computer attracts attention because a real-world system, most of the time, is too complex for analytical modeling (Altiok and Melamed, 2010). Additionally, real systems usually are either too risky or too expensive for directly experimenting with them. Computer simulation modeling of a real system enables to include complex relationships in the model and let the modelers experiment with the simulation model to gain insight about the real system without baring costs or risks of experimenting with the real system (Choi and Kang, 2013). Furthermore, simulation modeling lets the modeler model and experiment with a system which is hypothetical or in a design stage (Banks et al., 2010).

Simulation models are classified as being static or dynamic, deterministic or stochastic, and discrete or continuous (Rossetti, 2015; Banks et al., 2010). A static model simulates a system that does not change over time and a dynamic simulation models a system that changes over time. A deterministic simulation model does not contain random variables but a stochastic model contains random variables. A simulation model is considered continuous if the state of the system changes continuously over time and a simulation model is considered discrete event if the state of the system changes at

discrete points, which are called events, in time.

Discrete event simulation modeling of a system is a dynamic simulation model of the system where the processes are represented as a chronological sequence of events (Choi and Kang, 2013). The sequence of event occurrences is governed by a simulation clock and an event list. A simulation run is started by the occurrence of the initial event in the event list and goes on by the occurrence of the most imminent event and the simulation ends when the event list becomes empty (Altiok and Melamed, 2010).

3.5.2. Simulation Software Selection

Hundreds of different simulation software packages exist in the market (Maria, 1997; Saidallah et al., 2016). Price of these simulation packages usually changes between $1,500 and $80,000 (Banks, 1991). Therefore, it is important to choose a simulation software that satisfies the complexity of the project on the one hand and meets the budget and time constraints on the other hand (Maria, 1997). Each simulation software in the market has different features (Kokkinogenis et al., 2011); some of them are transportation specific so they only simulate transportation cases; some others are generic so they do not only simulate transport cases but also simulate cases such as manufacturing, healthcare and warehousing. A single universal simulation software that is ideal for every case and application area does not exist (Maciejewski, 2010). Selecting the appropriate simulation software depends on the requirements of the project (Kokkinogenis et al., 2011).

In the following section, various well-known simulation software will be evaluated. Since it is impossible to evaluate all the available software in the market, eight well-known simulation software packages were chosen.

3.5.2.1. VISSIM

VISSIM is a microscopic traffic simulation software developed by PTV (Planung Transport Verkehr AG), a German company (Saidallah et al., 2016; Maciejewski, 2010). It is a component of the Vision Traffic Suite which includes other software for transport

analysis such as PTV Visum (traffic forecasting and analysis) and PTV Vistro (signal optimization) (Saidallah et al., 2016). VISSIM is based on discrete event simulation modeling principles (Kokkinogenis et al., 2011). VISSIM can model motorized private transport, goods transport, rail and road related public transport, and even pedestrians and cyclists PTV Group (2018). Besides simulating road infrastructure, VISSIM users can make adjustments in vehicle properties (Maciejewski, 2010). Additionally, It is possible to create detailed 2D/3D animations using VISSIM (Maciejewski, 2010).

3.5.2.2. PARAMICS

PARAMICS is a microscopic traffic simulation software which is marketed by SIAS Ltd and Quadstone Ltd of Scotland (Kokkinogenis et al., 2011). Paramics can simulate different cases such as an intersection of a congested highway or traffic system of an entire city (Kokkinogenis et al., 2011). It is possible to model realistic representation of an actual case with 2D and 3D animations (Saidallah et al., 2016). Besides cars, the simulation software lets users model buses, trams and pedestrians (Saidallah et al., 2016). Paramics lets its users model individual vehicle movements by using microsimulation, therefore, it makes possible to predict changes in travel pattern behavior when traffic volume or road layout changes (Saidallah et al., 2016).

3.5.2.3. AIMSUN

AIMSUN is developed by TSS-Transport Simulation Systems, Spain (Kokkinogenis et al., 2011; Saidallah et al., 2016). AIMSUN is the acronym for "advanced interactive microscopic simulator for urban and non-urban networks" (Casas et al., 2010). It includes macroscopic, mesoscopic and microscopic models (Casas et al., 2010; Saidallah et al., 2016). It aims to provide solutions to short-term and medium-term planning and operational problems (Casas et al., 2010). AIMSUN can realistically simulate components of any transport network such as traffic control systems, traffic management rules, access controls, the location of tolls, public transport networks (Saidallah et al., 2016). The late versions of the software include dynamic modeling

tools such as dynamic traffic assignment models which are based on user equilibrium or stochastic route choice (Casas et al., 2010). Therefore, the software can be used for offline traffic engineering or real-time traffic management decision support (Casas et al., 2010).

3.5.2.4. Arena

Arena is a generic (not only used for transportation but a wide range of business processes) simulation software which lets users develop and execute simulation models on a computer (Rossetti, 2015). It is used for simulating and analyzing existing or proposed systems to provide insight into optimum operational arrangements (Jadrić et al., 2014). Arena lets users simulate any scenario involving the flow of transactions through a set of processes (Altiok and Melamed, 2010). It has a graphic user interface that allows users to develop models using a drag and drop approach on a flow chart with an access to underlying simulation language called SIMAN (Rossetti, 2015). Arena transcribes the whole model into SIMAN and debugs the model automatically to detect syntactic errors (Altiok and Melamed, 2010).

3.5.2.5. ProModel

ProModel is also a generic simulation software that is used for simulation of complex systems besides transportation (Kelle and Jin, 2016). It is based on discrete-event simulation approach and used for planning and designing new systems or improving an existing system (ProModel, 2017). And it is used in operational areas such as manufacturing and logistics (Benson, 1997). It provides a realistic representation of real systems to predict and analyze the impacts of potential changes (ProModel, 2017). The software has an algorithm for system optimization. Additionally, ProModel has extensive visualization tools such as 2D and 3D animation (ProModel, 2017).

3.5.2.6. Simio

Simio is a simulation software which is based on object-oriented approach (Pegden, 2011). It supports wide range of application areas by modeling both discrete and continuous systems (Zheng et al., 2010). It also supports four kinds of simulation modeling approaches event-oriented, process-oriented, object-oriented, and agent-based modeling (Zheng et al., 2010). Simio allows users to develop dynamic models of a wide range of systems such as factories, supply chains, emergency departments, and airports (Pegden and Sturrock, 2014). A model is constructed by bringing together objects that represent the components of a real system (Pegden, 2011; Pegden and Sturrock, 2014). The objects built by users can be saved in libraries and can be reused in different models (Pegden, 2011). Anything that is in a real system, such as a machine, a robot, an airplane, a customer, a doctor, a tank, a bus, or a ship, can be modeled as an object (Pegden, 2011). The logic and animation of a model are developed as a single step (Pegden, 2011). It supports 2D and 3D animation (Pegden, 2011; Zheng et al., 2010; Pegden and Sturrock, 2014). Developing an object is completely graphical so that users are not require to write programming code to create objects (Pegden, 2011).

3.5.2.7. AnyLogic

The simulation model in this thesis is built with AnyLogic which is a general purpose simulation software. It was first introduced in Winter Simulation Conference in 2000 (Kopytov and Abramov, 2012). AnyLogic is object-oriented simulation software which employs Java programming language (Merkuryeva and Bolshakovs, 2010; Emrich et al., 2007). It lets its users to develop simulation models in three different simulation approaches: agent-based modeling, discrete event modeling and system dynamics modeling (Merkuryeva and Bolshakovs, 2010). Additionally, it enables the users to create hybrid models by combining these simulation approaches (Emrich et al., 2007). Models in AnyLogic are developed by using simultaneously functioning active objects which interact each other (Merkuryeva and Bolshakovs, 2010). It has a component called state chart that defines the behaviors of an active object (Merkuryeva and Bolshakovs,

2010). It supports optimization with OptQuest optimizer (Merkuryeva and Bolshakovs, 2010). The software is currently being used in various areas such as manufacturing, supply chains and logistics, warehousing, business processes, healthcare, pedestrian dynamics, railroads, vehicle traffic, oil and gas, mining, defense, social processes and marketing, ports and container terminals etc (Swain, 2015). The biggest advantage of AnyLogic arises from its ability to allow users to place a JAVA code at anywhere in the model to adopt the model to the users' requirements (Emrich et al., 2007). In this thesis, discrete event simulation modeling feature is used to develop the simulation model.

3.5.2.8. Reason for Selecting AnyLogic

After considering other options, the author of this thesis chose to use AnyLogic simulation software to build the model. Justifying reasons for selecting AnyLogic are:

- It allows combining specifications of discrete event, agent-based, and system dynamics modeling approaches.
- It can utilize other software such as MS Access, MS Excel, OptQuest, Java programming.
- Models developed by AnyLogic can be exported as Java applications.
- It allows users to place a JAVA code at anywhere in the model to adopt the model to the users' requirements.
- It has graphical model development feature by drag-and-drop without writing programming code.
- It has runtime debugging tool to detect mistakes.
- It has tools for input distribution fitting.
- It has tools for output analysis such as reports, charts and execution logs.
- It lets users to create various kinds of experiments.
- It supports 2D and 3D animation.

- It has Free Personal Learning Edition.

3.5.2.9. Features of AnyLogic

Table 41 describes the AnyLogic blocks that were used while developing the simulation model. Ten different blocks that were used in the simulation model were described in Table 41. Table 40 describes five different AnyLogic elements that were used in the simulation modeling.

Table 40: Some Elements in the Software

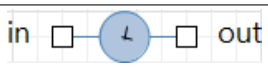
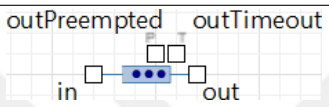
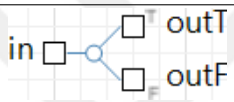
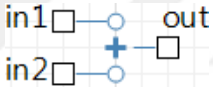
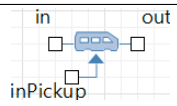
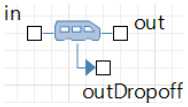
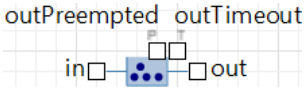
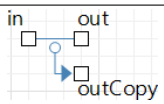
Element	Description
Entity	Entity can represent anything that is an object in the simulation: a person, a document, a vehicle, etc.
Parameter	Parameters represent characteristics of objects in the simulation model.
Variable	Variables are used to store simulation results or to model object characteristics that are changing over time.
Function	Returns the value of a previously defined expression whenever it is called in the model.
Event	Events are used for schedule an action in the model.

3.5.3. Conceptual Model

A conceptual model is defined as a non-software description of a computer simulation: it describes what is to be included and how it is to be represented in the computer simulation (Robinson et al., 2010). The conceptual model of this study includes four sub-models: (1) transportation of export containerized cargo from Denizli to the seaport of Alsancak; (2) transportation of export containerized cargo from Denizli to the seaports of Aliaga; (3) transportation of import containerized cargo from the seaport of Alsancak to Denizli; (4) and transportation of import containerized cargo from the seaports of Aliaga to Denizli.

Figure 22 illustrates the model of export shipments of containerized cargo from Denizli to the seaport of Alsancak. When the order is ready, a decision has been made regarding the inland transportation mode choice for the export cargo. Decision makers have two options: road or rail-based dry port. After the choice has been made, the cargo

Table 41: Discrete Event Modeling Blocks of Any Logic that Are Used in the Model

Symbol	Block	Description
	Source	Generates entities and it is usually starting block of a model.
	Delay	Delays the entities for a given period of time.
	Queue	Acts as a buffer for entities waiting for availability of the next block.
	SelectOutput	Routes the incoming entities to an out-port in terms of a condition or a probability.
	Hold	Holds the entity flow in a connection.
	Combine	Combines two entities coming from the in-port 1 and 2. Waits for two entities to arrive and creates a new entity going out of out-port.
	Pickup	Picks up entities from queues and add them to the content of the entity coming from in-port.
	Dropoff	Extracts the entities from the content of the incoming entity and out them from the outDropoff port.
	Wait	Similar to queue block except it supports manual removal of entities from the block.
	Split	Each incoming entity creates one or several entities and new entities leave via outCopy port.

waits for the truck and empty container. Then, the cargo is stuffed into the container. The container that assigned to road shipment goes directly to the seaport of Alsancak. The container that assigned to rail-based dry port goes to the dry port by road. The container in the dry port waits for the train departure. When the time arrives, the container is shipped to the seaport of Alsancak by rail.

Figure 22: Export Shipments from Denizli to the Seaport of Alsancak

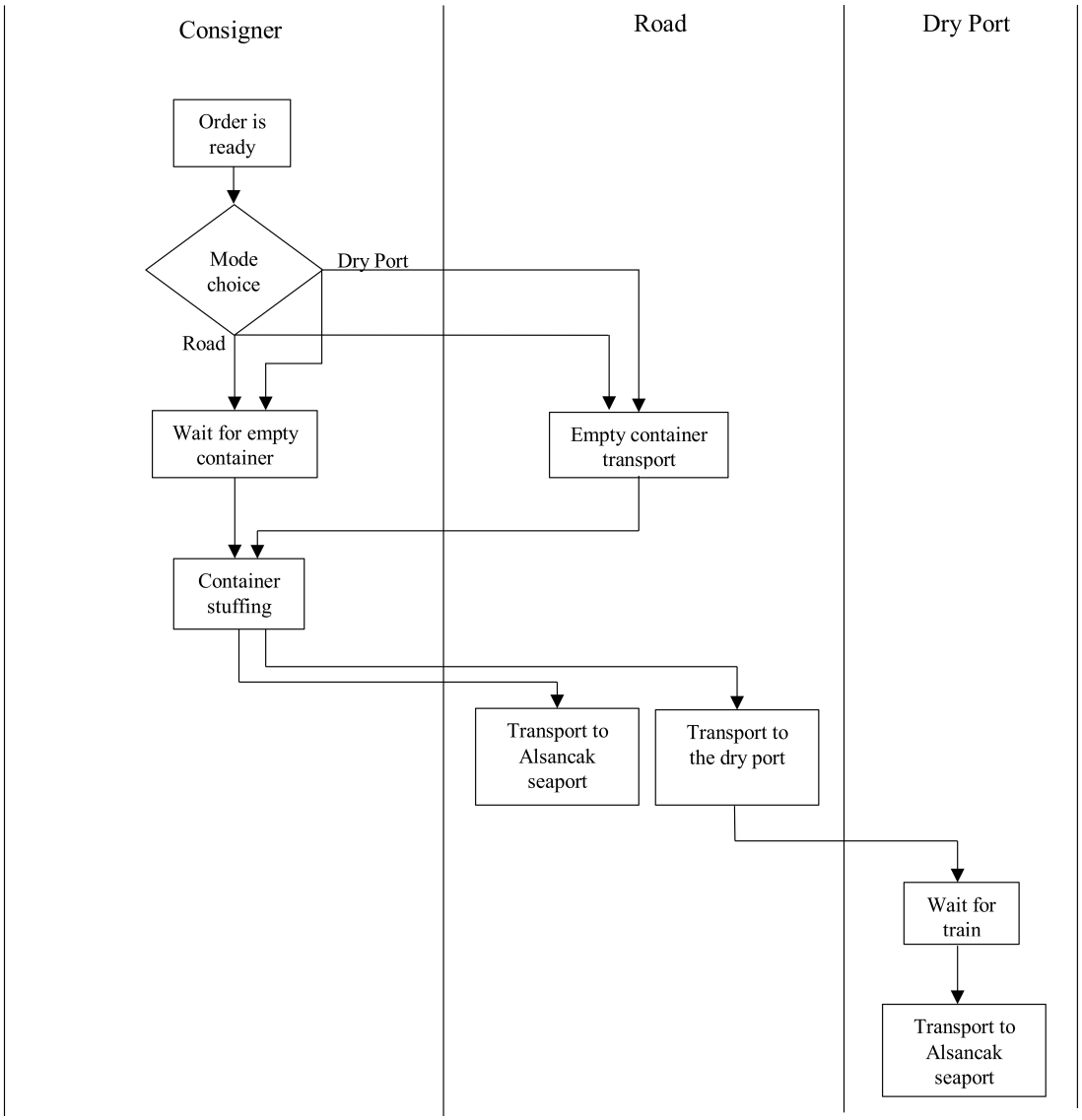


Figure 23 shows the diagram of export shipments from Denizli to the seaports in Aliaga. The diagram is almost the same as the Figure 22 except two differences: First, the container that assigned to road transport goes directly to the seaports of Aliaga, after stuffing completed; second, the containers that assigned to rail-based dry port is

transported to Bicerova by rail and then, the container is transported to the seaports of Aliaga by road.

Figure 23: Export Shipments from Denizli to the Seaports in Aliaga

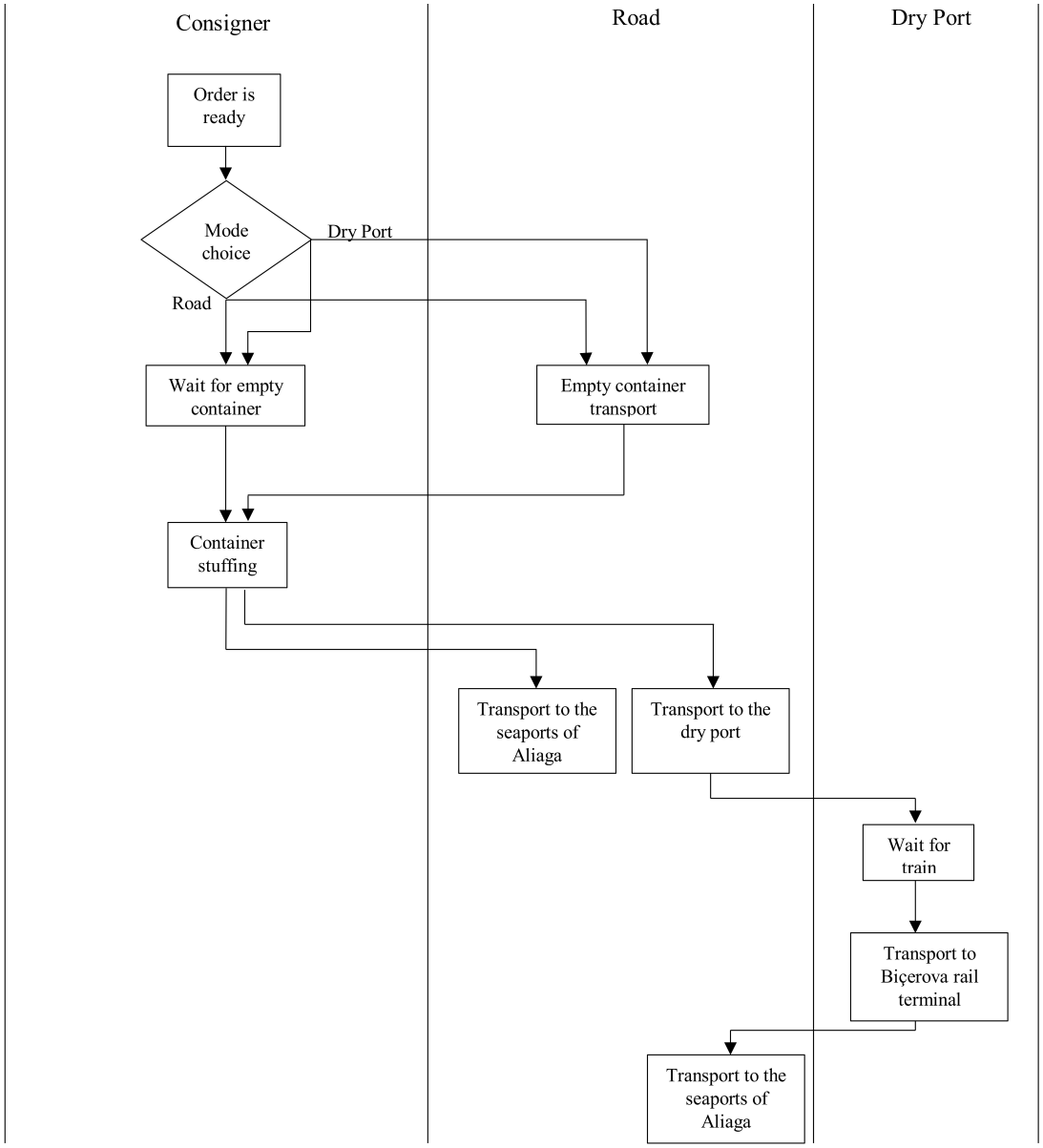


Figure 24 shows the inland shipment of import containerized cargo from Seaport of Alsancak to Denizli. When the container is ready for inland transportation, the decision makers select the transportation mode to be used. The container assigned to road transport goes directly to the location of the consignee. It gets unstuffed in the location of the consignee and the empty container is transported back to the seaport. The container assigned to the rail-based dry port waits for the train in the seaport of

Alsancak and it is transported to the dry port by rail. When the container arrives at the dry port it is transported to the consignee by road. Unstuffing takes place in the location of the consignee and the empty container transported back to the dry port.

Figure 24: Import Shipments from the Seaport of Alsancak to Denizli

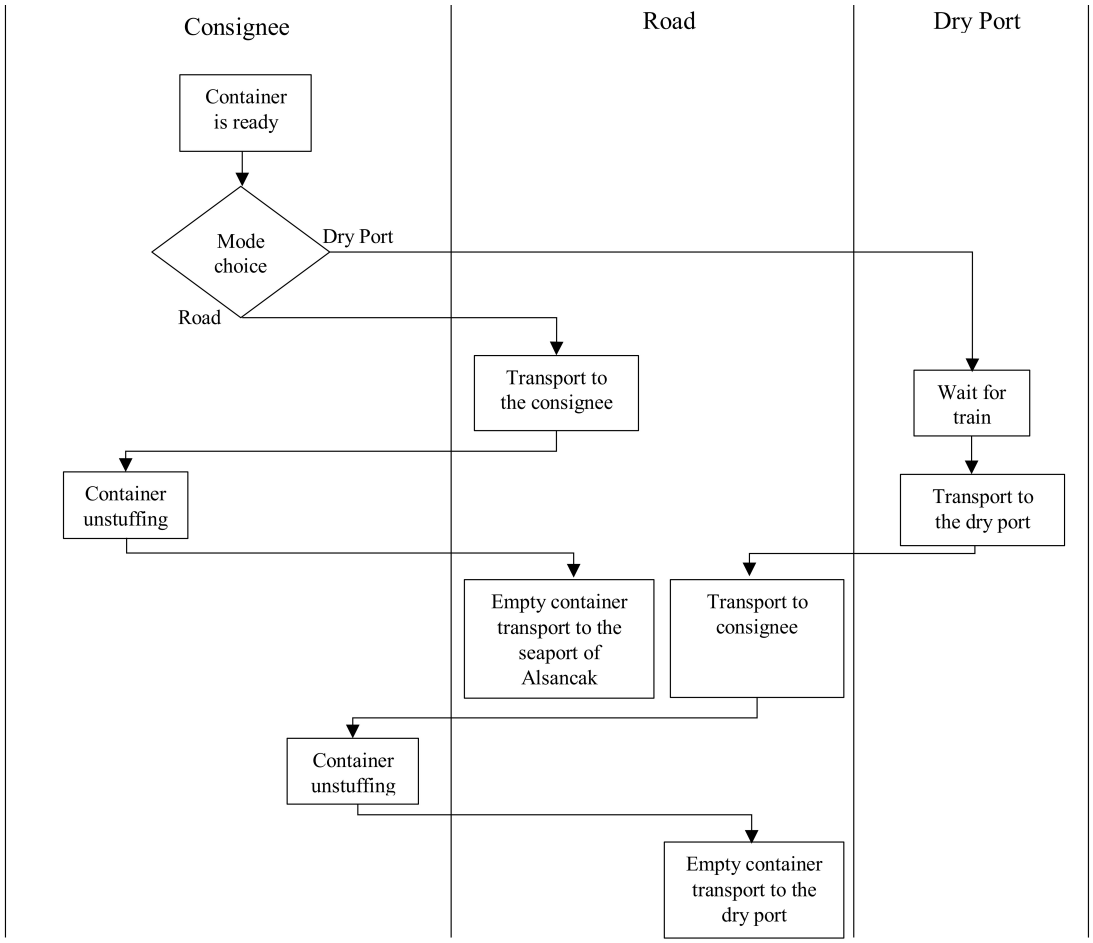
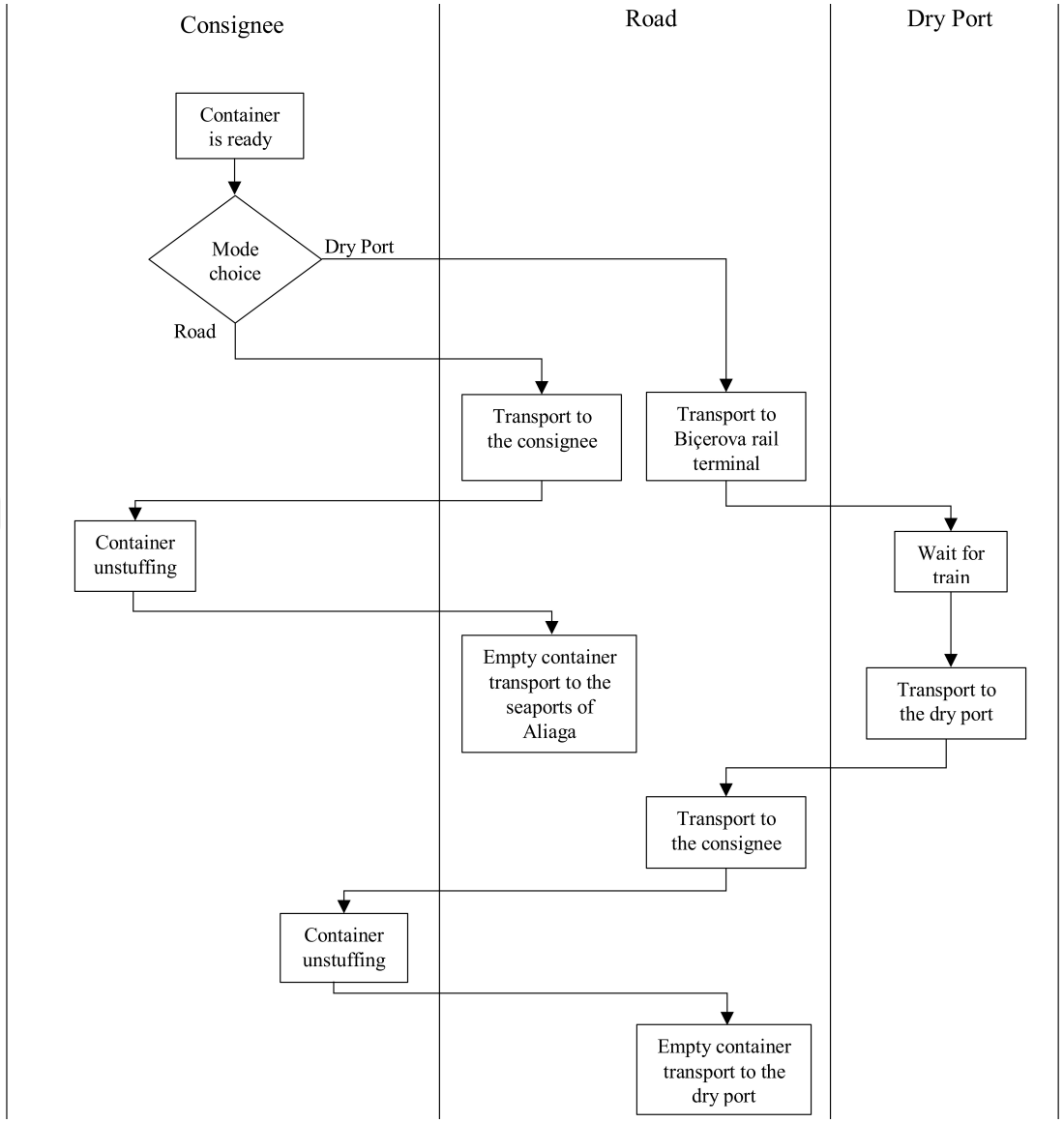


Figure 25 illustrates the inland shipment of imported containerized cargo from seaports of Aliaga to Denizli. The process is similar to the one explained in the Figure 24. After the mode choice decision took place, the container that assigned to the road is directly transported to Denizli by a truck and after unstuffing completed, it is transported back to the seaports of Aliaga. The container that assigned to the rail-based dry port service, first goes to Bicerova terminal and then it is transported to the dry port by rail. When the container arrives to the dry port, it is transported to the consignee by road and after unstuffing, empty container is transported back to the dry port.

Figure 25: Import shipments from Seaports of Aliaga to Denizli



3.5.4. Input Data

The input data for the simulation model is presented in Table 42, Table 43, Table 44, and Table 45. The data is gathered from varied sources: Turkish Statistical Institute (TURKSTAT) (in Turkish, Türkiye İstatistik Kurumu, TUİK); Turkish Ministry of Transport, Maritime Affairs and Communications (in Turkish, Türkiye Cumhuriyeti Ulaştırma, Denizcilik ve Haberleşme Bakanlığı); Interviews; and Google Maps.

Table 42 illustrates the tonnage of import and export containerized freight that

was transported between seaports of Izmir and Denizli city. The table is prepared from the foreign trade data which is based on customs entry and exit statistics in 2016. The data of foreign trade was gathered upon a request from TUİK headquarters in Ankara, Turkey. The data is included: import freight tonnage, export freight tonnage, if the freight was containerized or not, export exit customs, import entrance customs, the city of importer, the city of exporter, freight type, the transportation mode used for export, and the transportation mode used for import.

Table 42 shows that in 2016, 955,677 tons of containerized cargo was exported from Denizli via seaports of Izmir. 586,601 tons (61%) of this cargo was exported from seaports located in Aliaga and 369,077 tons (39%) of it was exported from the seaport of Alsancak. In the same period, 178,493 tons of containerized cargo was imported by Denizli via seaports of İzmir. 26,390 tons (15%) of the imported containerized cargo was transported through seaports located in Aliaga while 152,103 tons (85%) of it was transported through the seaport of Alsancak.

Table 42: Export and Import Tonnage between Denizli and the Seaports of Izmir in 2016

	Seaports of Aliaga	Seaport of Alcancak	Total
Export (Tons)	586,601 (61%)	369,077 (39%)	955,677
Import (Tons)	26,390 (15%)	152,103 (85%)	178,493

Source: TUİK[1]

Table 43 shows the full container unit weights, empty container unit weights, unit weight of the freight carried in a 20', and unit weight of the freight carried in a 40' container in the seaports located in İzmir. Additionally, Table 43 illustrates the percentage share of containerized tonnage that is carried in 20' and 40'. The data was compiled from the container statistics in 2016. It is provided in the website of Turkish Ministry of Transport, Maritime Affairs, and Communications (UBAK, 2016a). Table 43 also shows the unit weight of empty 20' and 40' containers.

The data in Table 44 is compiled from the data in Table 43 and Table 42. Tonnages in the Table 42 is proportionated according to the share of container types in total tonnage that was illustrated in Table 43. The proportionated tonnages divided

[1]The table prepared from the foreign trade data which is based on customs entry and exit statistics in 2016. The data of foreign trade was gathered upon a request from TUİK headquarters in Ankara, Turkey.

Table 43: Unit Weight of Empty 20' and 40' Containers and Their Share in Total Export and Import Tonnage

	TEU	FEU
Full Weight(Tons)	18.7	21.6
Empty Weight(Tons)	2.3	4.3
Weight of Freight(Tons)	16.4	17.3
Share in total tonnage (%)	45	55

Source: UBAK (2016a)

by the unit weight of freight carried in each container type (it was also illustrated in Table 43). As a result, numbers of 20' and 40' containers exported via seaports of Izmir from Denizli and imported via seaports of Izmir to Denizli were gathered. The numbers of containers are showed in Table 44. They will be used in generating containers in the simulation model.

Table 44: Numbers of Export and Import 20' and 40' Containers Transported between the Seaports of İzmir and Denizli

	Seaports of Aliaga		Seaport of Alsancak	
	TEU	FEU	TEU	FEU
Export (Number)	16,498	18,978	10,380	11,941
Import (Number)	742	854	4,278	4,921

Table 45 illustrates the transportation times and distances: road transport between Alsancak and Denizli; road transport between Aliaga and Denizli; road transport between the dry port and Denizli; road transport between Bicerova and the seaports of Aliaga; rail transport between Alsancak and the dry port; rail transport between Bicerova and Alsancak. Table 45 also illustrates operation times of train unload in Alsancak, train unload in the dry port, train unload in Biçerova; container stuffing/unstuffing. The transportation and operation times, which are gathered from interviews with industry practitioners, are shown as triangular distributions with minimum, most likely and maximum value.

3.5.5. Assumptions

The inland transportation system of containerized export and import cargo can be complex with certain uncertainties. For this reason, a discrete event simulation

Table 45: Transportation and Operation Times and Transportation Distances

	Time (Hour) (Minimum, most likely and maximum)	Distance (Km)
Road between Alsancak and Denizli	triangular(4, 5, 6)	245
Road between Aliaga and Denizli	triangular(5, 6, 7)	295
Road between the Dry Port and Denizli	triangular(0.5, 0.75, 1)	30
Road between Bicerova and Seaports of Aliaga	triangular(0.25, 0.35, 0.5)	5
Rail between Alsancak and Sarayköy dry port	triangular(6, 7, 8)	230
Rail between Bicerova and Alsancak	triangular(1, 1.25, 1.5)	20
Train unload in Alsancak	triangular(1, 1.5, 2)	-
Train unload in the dry port	triangular(1, 1.5, 2)	-
Train unload in Biçerova	triangular(1, 1.5, 2)	-
Container stuffing/unstuffing	triangular(1, 2, 4)	-

Source: Interviews and Google Maps

model is developed to model the inland transportation of export and import containers in the corridor between seaports of Izmir and city of Denizli. The model will be used to analyze the impacts of demand increase to the rail-based dry port services resulted from the changes in the attributes of available inland transportation modes. Several assumptions are considered while modeling the real system:

3.5.5.1. Empty Container Movement

It is assumed that empty containers for the export cargo to be transported to seaports of Aliaga by road comes from the seaports of Aliaga. The same principle applies to the road transportation of export cargo between Denizli the seaport of Alsancak; empty containers for the export cargo to be transported to seaports of Alsancak comes from the seaport of Alsancak. There are no empty container shortages in the seaports.

The interviews with officials in the operating company of the dry port and Turkish State Railways show that if a cargo to be transported in railways, a reservation has to be made at least in the previous day of the shipment. In the simulation model, reservations of empty containers for the cargo to be transported by intermodal-rail via the dry port gathered one day prior of the shipment. The available empty containers in the dry port are reserved for the next day's export cargo. If there are not enough empty containers available in the dry port, the empty containers are shipped to the dry

port from the seaports with the import container train that arrives to the dry port in the morning of the day that the export shipments scheduled.

It is assumed that after an import container is transported to a consignee in Denizli by road, the container gets unstuffed and the empty container is transported back to the seaport where the import container was received at the first time.

It is assumed that after an import container is transported to the consignee in Denizli by intermodal-rail via the dry port, the container gets emptied and the empty container is transported back to the dry port. The empty containers generated from the import container shipments stay in the dry port for one day. After one day, if they were not reserved for the export cargo, they are transported back to the seaports by the export train.

3.5.5.2. Container Arrivals

It is assumed that container inter-arrival times are determined by exponential distribution. This assumption is based on the discrete event literature. In the literature, it is widely accepted that inter-arrival times are exponentially distributed (Altiok and Melamed, 2010; Rossetti, 2015; Banks et al., 2010; Choi and Kang, 2013). Inter-arrival times of export 20' container shipments to the seaports of Aliaga calculated as (number of containers gathered from Table 44):

$$\frac{Q}{D * H} = \frac{16,498}{365 * 24} = 1.883$$

Where,

Q is the number of 20' containers transported from Denizli to the seaports of Aliaga gathered from Table 44. D is the number of days in a year. H is the number of hours in a day.

Thus, the inter-arrival time of export 20' containers transported from Denizli to the seaports of Aliaga is exponentially distributed with a mean of 1.883 hours:

$$\exp(1.883) hours$$

The same procedure applies to the other containers and destinations. Table 46 show the all inter-arrival times of export and import containers.

Table 46: Inter-Arrival Times of Export and Import Containers

	Seaports of Aliaga		Seaport of Alcancak	
	TEU	FEU	TEU	FEU
Export inter-arrival times (Hours)	exp(1.883)	exp(2.166)	exp(1.184)	exp(1.363)
Import inter-arrival times (Hours)	exp(0.084)	exp(0.097)	exp(0.488)	exp(0.561)

3.5.5.3. Truck Movements

It is assumed that there is always available trucks and empty truck movements are avoided. When a truck is called for the simulation model creates a truck and the truck picks up the container without spending any time. The only time a truck waits for picking up a container is when there is not any empty container in the dry port.

3.5.5.4. Container Types

Only 20' and 40' containers are included in the simulation model: it is assumed that containerized export and import cargo between seaports of Izmir and Denizli is only carried in 20' and 40' containers.

3.5.6. Mode Choice Criteria

Mode choice probabilities are calculated according to the analyses conducted in section 3.4.2.3. Estimation Results. The probability of the person q chooses the rail-based dry port alternative can be expressed as:

$$P_{DryPort} = \frac{e^{U_{DryPort}}}{e^{U_{DryPort}} + e^{U_{Road}}}$$

The utility functions of the alternative specific model, in which $RoadTime$ and $DryportTime$ variables were omitted, are presented as:

Table 47: Estimations of Alternative Specific Model in which the Time Variable Was Excluded

	Conditional Logit		Random Coefficient Mixed Logit	
Variable	Coefficient	P-Value	Coefficient	P-Value
ASCRoad	1.81083566	0.022678**	2.46152512	0.0363381**
RoadCost	-0.00363649	2.2e-16***	-0.00667927	2.2e-16***
DryportCost	-0.00421300	5.388e-11***	-0.00866967	4.885e-15***
RoadDelay	-0.09108404	0.004649***	-0.20033351	0.0001328***
DryportDelay	-0.05785335	4.322e-06***	-0.13676824	5.512e-10***
Frequency	0.03692484	0.092720*	0.06870227	0.0384539**
FreeTime	0.00984425	0.061620*	0.01977997	0.0189199**
RoadCost.sd	-	-	0.00230894	2.2e-16***
DryportCost.sd	-	-	-0.00278017	2.2e-16***
RoadDelay.sd	-	-	-0.10071609	0.0406288**
DryportDelay.sd	-	-	0.11810730	2.220e-15***
Frequency.sd	-	-	0.06923868	0.0174038**
FreeTime.sd	-	-	0.05410528	2.854e-11***
			Draws = 500	
	Log-likelihood: -1110.4		Log-likelihood: -761.63	
	McFadden R^2: 0.067704		McFadden R^2: 0.36055	

Signif. codes: 0.01'***'0.05'**'0.1'*'

$$U_{Road} = ASC + \beta_1 * RoadCost + \beta_2 * RoadDelay$$

$$U_{DryPort} = \beta_3 * DryportCost + \beta_4 * DryportDelay + \beta_5 * Frequency + \beta_6 * FreeTime$$

$$U_{Road} = 2.46152512 + -0.00667927 * RoadCost + -0.20033351 * RoadDelay$$

$$U_{DryPort} = -0.00866967 * DryportCost + -0.13676824 * DryportDelay + 0.06870227 * Frequency + 0.01977997 * FreeTime$$

Where,

ASC: The alternative specific constant of road alternative represents the preference for the road alternative

U_{Road}: Utility of the road alternative

$U_{DryPort}$: Utility of the rail-based dry port alternative

$RoadCost$: Transport cost of road alternative

$RoadDelay$: Percentage of late arrivals of road alternative

$DryportCost$: Transport cost of the rail-based dry port alternative

$DryportDelay$: Percentage of late arrivals of the rail-based dry port alternative

$Frequency$: Frequency of rail service between the seaports and the dry port (does not apply to road alternative)

$FreeTime$: Free time provided in the dry port measured as days (does not apply to road

alternative)

β_1: Alternative specific parameter of $RoadCost$

β_2: Alternative specific parameter of $RoadDelay$

β_3: Alternative specific parameter of $DryportCost$

β_4: Alternative specific parameter of $DryportDelay$

β_5: Alternative specific parameter of $Frequency$

β_6: Alternative specific parameter of $FreeTime$

The values of the betas of the above equation are generated from the results of the estimation of the discrete choice model described in Table 47. Because random coefficient mixed logit estimates provided better model fit as explained in the previous section, the coefficients of random coefficient mixed logit estimates are used as betas in the mode choice equation of the simulation model.

The base case of the simulation model is analyzed by using the current values of the inland container transportation attributes in the corridor described in Table 48. The scenarios to be analyzed are developed on the basis of the base case and the results of the scenario analyses are also compared with the base case that simulates the current situation.

Table 48: Current Values of the Inland Transportation Service Attributes

Attribute	Value
Cost of the rail-based dry port service	
Between Alsancak and Denizli for 20' container	TRL 750
Between Alsancak and Denizli for 40' container	TRL 800
Between Aliaga and Denizli for 20' container	TRL 800
Between Aliaga and Denizli for 40' container	TRL 850
Cost of direct truck service	
Between Alsancak and Denizli for 20' container	TRL 950
Between Alsancak and Denizli for 40' container	TRL 1000
Between Aliaga and Denizli for 20' container	TRL 1000
Between Aliaga and Denizli for 40' container	TRL 1050
Percentage of delayed shipments	
Dry port service	10%
Direct truck service	5%
Free time	
Dry port service	30 Days

Source: Interviews

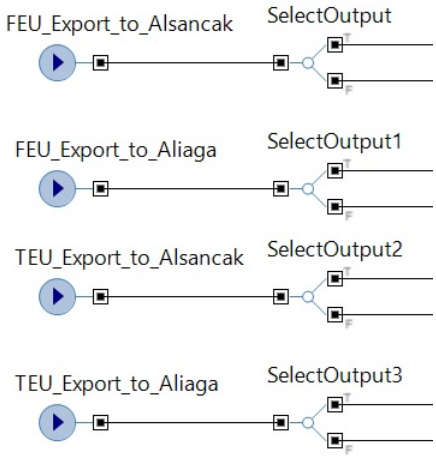
3.5.7. Simulation Model

The simulation model consists of two modules: export and import module. The import and export container flows are simulated separately but the two modules are connected to each other. Export and import modules include submodules where road transport and rail-based dry port service are modeled. In the following section, these modules and sub-modules will be explained in detail.

3.5.7.1. Export Module

As explained earlier, only 20' and 40' containers are included in this model. Additionally, two destinations are simulated: the destination between Denizli and seaport of Alsancak; the destination between Denizli and the seaports of Aliaga. Therefore, Figure 26 shows that four *Source* blocks (*FEU_Export_to_Alsancak, FEU_Export_to_Aliaga, TEU_Export_to_Alsancak, FEU_Export_to_Aliaga*) generate four types of cargo: (1) the cargo to be transported in 20' containers from Denizli to the seaport of Alsancak; (2) the cargo to be transported in 40' containers from Denizli to the seaport of Alsancak; (3) the cargo to be transported in 20' container from Denizli to the seaports of Aliaga; (4) the cargo to be transported in 40' container from Denizli to the seaports of Aliaga. The cargoes are generated according to inter-arrival times that are defined in Table 46.

Figure 26: Export Cargo Generation and Transport Mode Choice



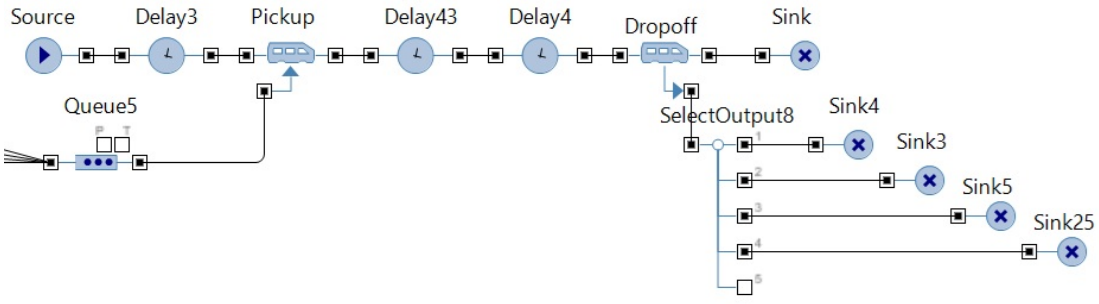
Cargo arrivals simulate the orders that are ready for export from Denizli through

the seaports of Izmir. After the cargoes were created, they go through *SelectOutput* blocks for inland transportation mode choice as illustrated in Figure 26. Inland transportation mode choice of the cargoes are determined according to the procedure explained in the previous section (3.5.1.6. Mode Choice Criteria). There are four different *SelectOutput* blocks for mode choice because the cost of inland transportation differs in terms of container type and destination.

3.5.7.1.1. Direct Road Module

Figure 27 shows the direct road transportation of export cargo after the inland transportation mode was chosen. Export cargo which chooses to be transported directly by road enters *Queue5*. On entering *Queue5*, it activates a code: `Source.inject(1)`. The code creates one truck from *Source*. And, the export cargo waits for the truck to arrive. After the truck was created by *Source*, it enters *Delay3* that simulates the empty container transport time. After empty container transportation, the truck picks up the cargo in *Queue5* by *Pickup* and enters *Delay43* that simulates container stuffing time. After containers are stuffed, full containers enter *Delay4* that simulates full inland container transport by road. When the delay ends, the full containers are dropped off at *Dropoff*. Dropped containers are separated by *SelectOutput8* for statistics collection regarding each container type and destination.

Figure 27: Direct Road Transportation of Export Cargo



3.5.7.1.2. Dry Port Module

3.5.7.1.2.1. Export Reservation

There is a requirement for making a reservation at least one day before shipment for the cargo to be transported through the dry port. Figure 28 shows that after mode choice, the cargo goes in the sub-module of cargo reservation for transportation through the rail-based dry port. The cargo first goes in a *SelectOutput4* that separates the cargo that come in office hours from the cargo that come before and after office hours. The office hours in the model include hours between 09:00 and 17:00. The cargo that come in office hours enter *Queue* that is a buffer queue for *Hold*. When *Hold* is blocked, the cargoes wait in *Queue*. The cargoes that come before and after office hours get separated in *SelectOutput5*. The cargoes that come before 09:00 go in *Delay* where they get delayed until 09:00; the cargoes that come after office hours go in *Delay1* where they get delayed until the next day 09:00. *Hold* is get blocked on Sundays because it is not possible to make a reservation on Sundays. *eventSunday1* activates a code on Sundays at 00:00. The code reads as:

```
Hold.block();
Hold1.block();
```

The code blocks *Hold* and *Hold1.eventSunday2* activates a code on Mondays at 00:00. The code reads as:

```
Hold.unblock();
Hold1.unblock();
```

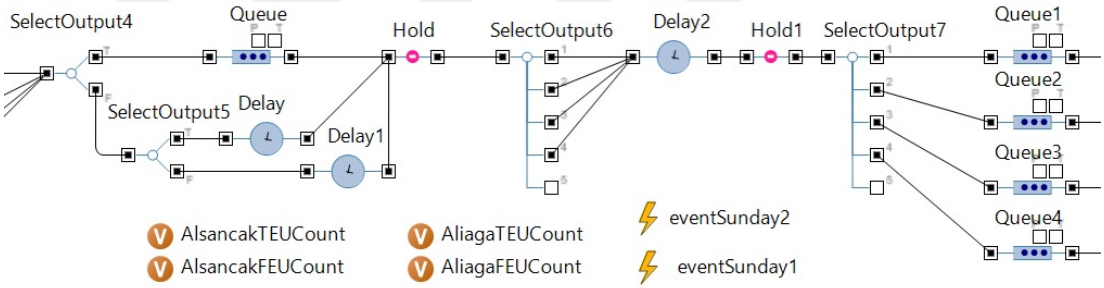
It unblocks *Hold* and *Hold1* on Mondays at 00:00.

SelectOutput7 separates cargoes to four in terms of their destination and container types. When each type of cargo passes through *SelectOutput7*, they activate four codes separately in each exit:

```
AlsancakTEUCount=AlsancakTEUCount+1
AlsancakFEUCount=AlsancakFEUCount+1
AliagaTEUCount=AliagaTEUCount+1
AliagaFEUCount=AliagaFEUCount+1
```

The codes record the number of required empty containers separately in terms of their types and destinations in the variable elements *(AlsancakTEUCount, Alsancak-FEUCount, AliagaTEUCount, AliagaFEUCount)*. Empty containers of each type are reserved for the next day, according to these recorded numbers. Because the reservation has to be made one day before the shipment, the cargoes enter in *Delay2* where they delayed for 24 hours. Since there are no train departures on Sundays, *Hold1* blocks the cargoes on Sundays. Then, the cargoes get in *SelectOutput7* where they get separated in terms of their types and destinations. They get separated because each type of cargo requires a different type of empty containers. The road transportation between Denizli and the dry port is simulated for each type and destination. After they got separated, the cargoes enter separate queues: *Queue1, Queue2, Queue3, and Queue4*.

Figure 28: Reservation for Inland Transportation through the Dry Port for Export Cargoes



3.5.7.1.2.2. Road Transportation Between Denizli and the Dry Port

Figure 29, Figure 30, Figure 31, and Figure 32 show the simulation of road transportation between locations of exporters in Denizli and the dry port respectively for 40' containers that are transported to the seaport of Alsancak; 20'containers that are transported to the seaport of Alsancak; 20'containers that are transported to the seaports of Aliaga; 40' containers that are transported to the seaports of Aliaga.

Since the process is identical for each type and destination, in this section, only one of them will be explained. Therefore, this section explains the sub-model of road transportation between Denizli and the dry port for 40' containers that will be transported to the seaport of Alsancak. The sub-model is illustrated in Figure 29.

Figure 29: Road Transportation between Denizli and the Dry Port for 40' Containers that Are Transported to the Seaport of Alsanca

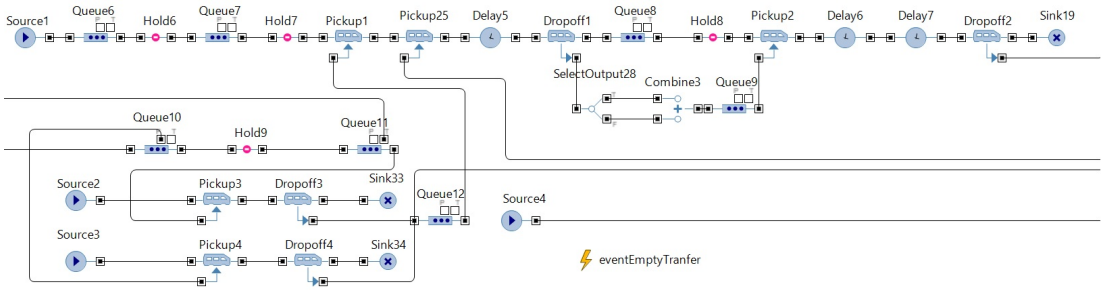


Figure 30: Road Transportation between Denizli and the Dry Port for 20' Containers that Are Transported to the Seaport of Alsancak

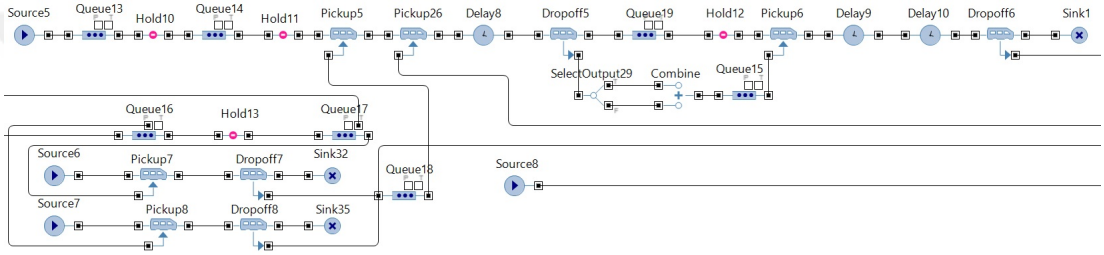
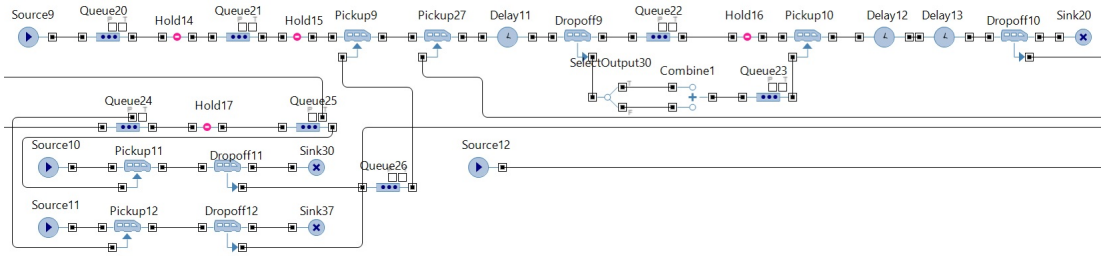


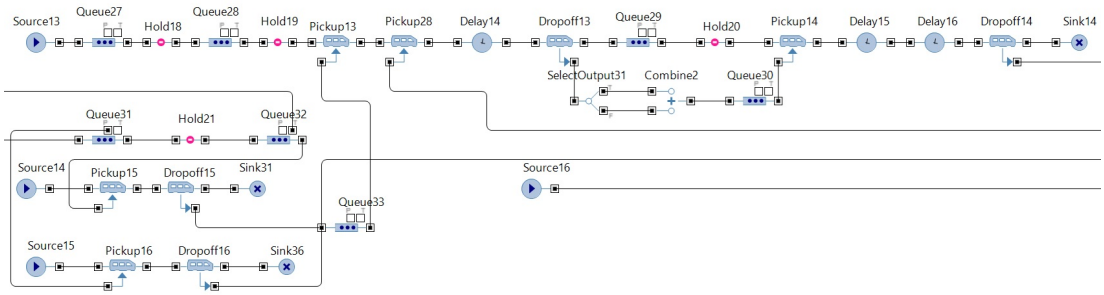
Figure 31: Road Transportation between Denizli and the Dry Port for 20' Containers that Are Transported to the Seaports of Aliaga



In the last step shown in Figure 28, the cargoes enter *Queue1, Queue2, Queue3, and Queue*. When a cargo enters *Queue1*, a code is activated: `Source1.inject(1)`. The code creates one truck from *Source1* and the cargo starts waiting for the truck to arrive in *Queue1*.

After the truck is created, it enters *Queue6* that act as a buffer when *Hold6* is blocked. *Hold6* is blocked after one truck passes it. The reason behind blocking *Hold6*

Figure 32: Road Transportation between Denizli and the Dry Port for 40' Containers that Are Transported to the Seaports of Aliaga



after one truck is to prevent trucks to pass through *Pickup1* without picking up empty containers. Therefore, the trucks pass through form *Hold6* to *Pickup1* one by one. When a truck enters *Queue7*, it activates a code:

```
if (Queue12.size() < 1)
Hold7.block();
if (Queue12.size() < 1 && Queue10.size() >= 1)
Source3.inject(1);
```

After the 40' import containers that were imported from the seaport of Alsancak were transported to importers' location in Denizli and unstuffed, the empty containers were transported back to the dry port. Those empty containers are stocked in *Queue10*. The code first checks the size of *Queue12* where the reserved empty containers are stored. If the size of *Queue12* less than 1, *Hold7* is blocked. If the size of *Queue12* is less than 1 and the size of *Queue10* equals to 1 or more than 1, one truck from *Source3* is created, the created truck instantaneously transfers one empty container from *Queue10* to *Queue12*. If the size of both *Queue12* and *Queue10* is less than 1, the truck waits in *Queue7* until one empty container enters either one of *Queue12* and *Queue10*. After the truck picks up one empty container at *Pickup1*, a code is activated: `Hold6.unblock();`. The code unblocks *Hold6*, because the empty container pick up process completed for one truck, another truck can enter the same process.

After the truck picks up an empty container at *Pickup1* from *Queue12*, it also picks up the cargo at *Pickup25* from *Queue1* that was illustrated in Figure 28 of previous section. Then, they got into *Delay5*, which simulates the container stuffing time.

At *Dropoff1*, the empty container and the cargo are dropped off. After the

truck drops off the empty container and the cargo, the truck enters *Queue8*, which act as a buffer when *Hold8* is blocked. Dropped off empty container and cargo go to SelectOutput28 where they are separated. When both the empty container and the cargo enter *Combine3*, they are combined into full container. When the full container goes into *Queue9*, it activates a code: `Hold8.unblock()`. The code unblocks *Hold8* to let the truck pick up the full container. When the full container got picked up at *Pickup2*, it activates another code: `Hold8.block()`. It blocks *Hold8*. The reason behind this mechanism is to prevent the truck leaving *Pickup2* without picking up the full container so that the simulation works properly.

After picking up the full container at *Pickup2*, the truck enters *Delay6*, where it is delayed for the transportation time between the dry port and the exporters' location in Denizli to simulate the empty container transportation. Then, the truck goes into *Delay7* where it is delayed for the duration of road transportation from the exporters' location to the dry port to simulate the full container transportation. The full container is dropped off at *ContDropoff* and the truck is disposed at *Sink19*. The dropped off full container goes into *Queue34* (it is illustrated in Figure 33) for export train departures.

An event element *(eventEmptyTransfer)* manages empty container flow: *eventEmptyTransfer* activates a code every day at 17:50, after the office hours ends. The code reads as:

```
Hold9.unblock();
Hold17.unblock();
Hold21.unblock();
Hold13.unblock();
Source10.inject(1);
Source14.inject(1);
Source6.inject(1);
Source2.inject(1);
Hold9.block();
Hold17.block();
Hold21.block();
Hold13.block();
```

```
Source4.inject(AlsancakFEUCount - Queue12.size());
Source8.inject(AliagaFEUCount - Queue18.size());
Source12.inject(AlsancakTEUCount - Queue26.size());
Source16.inject(AliagaTEUCount - Queue33.size());
AlsancakTEUCount = 0;
AlsancakFEUCount = 0;
AliagaTEUCount = 0;
AliagaFEUCount = 0;
```

The code has similar sub-codes for four sub-models of each destination and container type. Since the process for each sub-model is identical, only the part of the code related to the sub-model illustrated in Figure 29 will be explained.

First the code unblocks *Hold9* to let the empty containers to enter *Queue11* and a truck is created from *Source2*. The created truck picks up at most the the reserved number of empty containers which is recorded in the variable element *AlsancakFEUCount*(as shown in Figure 29) and drops of the empty containers in *Queue12*. If the number of empty container in *Queue11* is higher than *AlsancakFEUCount* the excess number of empty containers go to *Queue34* (it is illustrated in Figure 33) for export train departures to get transported to the seaport of Alsancak. If the size of *Queue11* is less than *AlsancakFEUCount*, empty containers are created from *Source4*. The number of the generated empty containers is equal to the reserved number of empty containers *(AlsancakFEUCount)* minus the size of the *Queue12*. After the new empty containers are created, the value of *AlsancakFEUCount* is set to zero to start recording the next day's reserved empty containers from the zero. The newly generated empty containers go to *Queue45* (it is illustrated in Figure 39) to wait for import train departures. When the import train arrives at the dry port, these created empty containers go to *Queue12*.

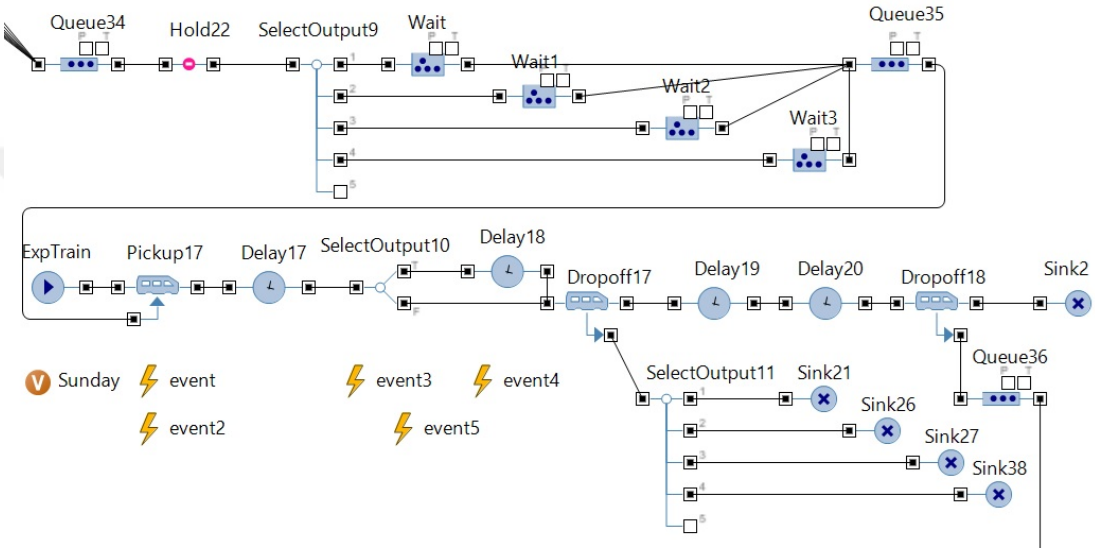
3.5.7.1.2.3. Rail Transportation of Export Containers from the Dry Port

Figure 33 shows the rail transportation of export containers from the dry port. As explained in the previous section, the excess empty containers in *Queue11* and the full containers after dropped off at *Dropoff6* as illustrated in Figure 29 go into *Queue34*

where they wait for the train to pick them up. When the containers go through *Queue34*, they activate a code:

```
if((Wait.size()*ExpFullFEUWeight+Wait1.size()*
ExpFullTEUWeight+Wait2.size()*EmptyFEUWeight+Wait3.size()*
EmptyTEUWeight)>=750)
Hold22.block();
```

Figure 33: Rail Transportation of Export Containers between the Dry Port and the Seaports



The code manages the capacity of the train by checking the weights of the containers stored in *Wait*, *Wait1*, *Wait2*, and *Wait3* that must not exceed the carrying capacity of the train which is 750 tons. *SelectOutput9* separates containers in term of their type: if they are 20' or 40' and if they are empty or full. With the four wait blocks *(Wait, Wait1, Wait2, and Wait3)*, the containers are separately stored. The unit weight of each container type multiplied by the size of the wait block they are in. Then, the weights are summed and checked if the total weight exceeds the capacity. As soon as the total weight gets equal to or higher than 750 tons, *Hold22* is blocked and does not let more containers to exit *Queue34*.

Since there are no train departures on Sundays, a mechanism was created to simulate the train departures on six days of the week. *event* activates a code every Sundays at 00:00 that reads as: `Sunday = 1;`. And, *event* activates a code every Mondays at 00:00 that reads as: `Sunday = 0;`. These codes make *Sunday* variable

equal to one on Sundays and make it equal to zero on the other days of the week. *event3* activates a code on every day at 19:00 (it is the train departure time). The code reads as:

```
if (Sunday == 0 && (Wait.size() + Wait1.size() + Wait2.size()
+ Wait3.size()) >= 5)
ExpTrain.inject(1);
```

The code first checks if *Sunday* equals to 0 (checks if it is Sunday or not). If it is not Sunday and the sum of the sizes of *Wait*, *Wait1*, *Wait2*, and *Wait3* equals to or more than 5, one train is created from *ExpTrain*. Because at most three train departures are possible if there is a demand, *event3* activates the same code on every day at 19:30 for the second train departure and *event4* activates the same code on every day at 20:00 for the third train departure.

Before exiting *ExpTrain*, the train activates a code. The code reads as:

```
Wait.freeAll();
Wait1.freeAll();
Wait2.freeAll();
Wait3.freeAll();
Hold22.unblock();
```

The code frees all the containers in *Wait*, *Wait1*, *Wait2*, and *Wait3* to the *Queue35* where they get picked up by the train. The train picks up containers at *Pickup17* from *Queue35*. Then, it enters *Delay17* where it gets delayed for the duration of train transportation between the dry port and the seaport of Alsancak.

In *SelectOutput10*, a certain percentage of the trains enter *Delay18* that simulates unexpected delays on the railway. The containers which are destined for the seaport of Alsancak get dropped off at *Dropoff17*. After the containers are dropped off at *Dropoff17*, they enter *SelectOutput11* where they are separated in terms of their types to collect statistics. Then, the containers go in sink blocks to get disposed.

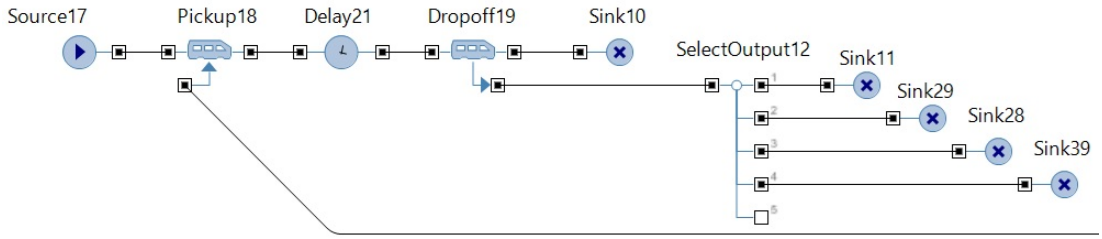
The train goes in *Delay19* where it is delayed for the duration of container unloading operation in the seaport of Alsancak. Then it enters *Delay20* where it is delayed for a duration of rail transportation between the seaport of Alsancak and Bicerova rail station. The containers are dropped off at *Dropoff18* and the train enters *Sink2* where it is disposed. The dropped containers enter *Queue36* to wait for trucks to

transport them to the seaports of Aliaga by road.

3.5.7.1.2.4. Road Transportation of Export Containers from the Bicerova Station to the Seaports Aliaga

Figure 34 illustrates the simulation module of road transportation of export containers from Bicerova rail station to the seaports of Aliaga. When each container enters *Queue36* (illustrated in Figure 33), they activate a code: `Source17.inject(1)`. The code generates one truck from *Source17*.

Figure 34: Road Transportation of Containers Between Bicerova Station and the Seaports of Aliaga



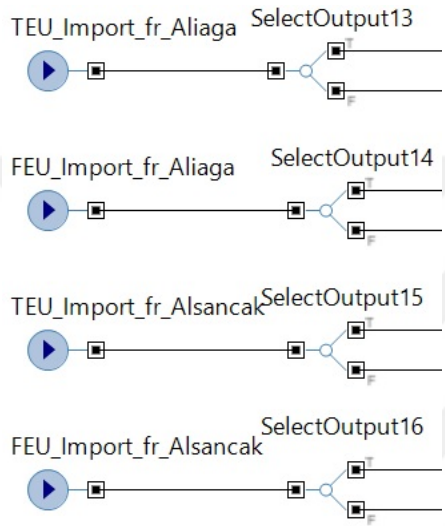
After the truck is created, it enters *Pickup18* to pick up a container from *Queue36* (illustrated in Figure 33), and enter *Delay21* where it gets delayed for a duration of road transportation between Bicerova rail station and the seaports of Aliaga. The trucks drop off the containers at *Dropoff19* and the they go in *Sink10* to get disposed. The dropped containers enter *SelectOutput12* where they are distinguished according to their types to collect statistics. Then, they get disposed in *Sink* blocks.

3.5.7.2. Import Module

Figure 35 shows the simulation module of the arrivals of import full containers. Four different *Source* blocks *(TEU_Import_fr_Aliaga, FEU_Import_fr_Aliaga, TEU_Import_fr_Alsancak, and FEU_Import_fr_Alsancak)* generate four types of import full containers: 20'containers that are transported from the seaports of Aliaga to Denizli; 40' containers that are transported from the seaports of Aliaga to Denizli; 20' containers

that are transported from the seaport of Alsancak to Denizli; 40' containers that are transported from the seaport of Alsancak to Denizli. The inter-arrival rates of the containers are applied as described in Table 46. After the full containers are generated, they enter four different *SelectOutput* blocks *(SelectOutput13, SelectOutput14, SelectOutput15, and SelectOutput16)* where they choose inland transportation mode: road or rail-based dry port.

Figure 35: Import Full Container Arrivals



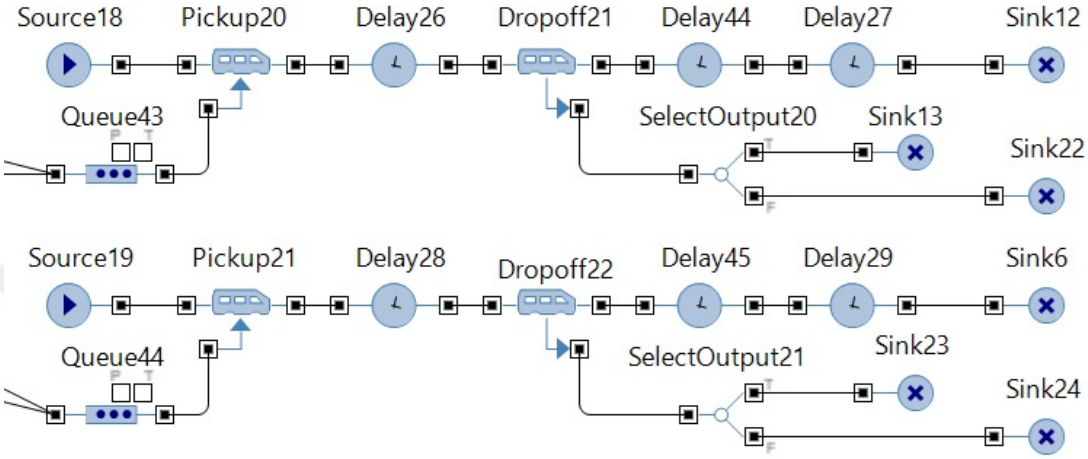
If the full containers that arrive from the seaports of Aliaga choose to use rail transportation, they first need to enter in simulation sub-module of road transportation between seaports of Aliaga and Biceraova rail station. However, if the full containers, which arrive from the seaport of Alsancak, choose to use the rail-based dry port, they go directly in the *Queue* block to wait for the import train. If the full containers choose to use direct road transportation to Denizli, they go in the simulation sub-module of direct road transport.

3.5.7.2.1. Direct Road Module

In Figure 36, there are two sub-modules: (1) direct road transportation from the seaports of Aliaga to Denizli city; and (2) direct road transportation from the seaport of Alsancak to Denizli city. The two modules are identical except the delay times. Because the road transportation time from the seaports of Aliaga to Denizli takes longer than the

road transportation time from the seaport of Alsancak to Denizli. Therefore, one of the sub-modules in Figure 36, which is the direct road transportation between the seaports of Aliaga and Denizli, will be explained.

Figure 36: Direct Road Transportation from the Seaports of Aliaga and the Seaport of Alsancak to Denizli



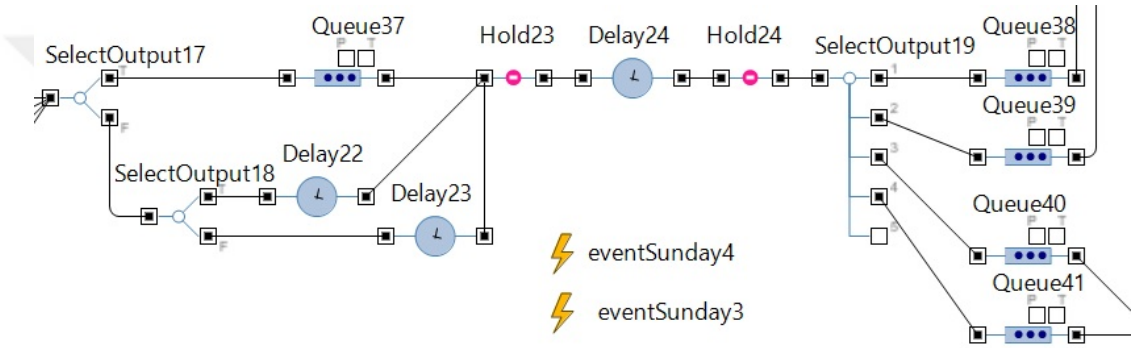
After the full containers that arrive at the seaports of Aliaga choose the inland transportation mode at *TEU_Import_fr_Aliaga* and *FEU_Import_fr_Aliaga* (as illustrated in Figure 35), the ones that choose to be transported by direct road enter in *Queue43*. When a full container enters *Queue43*, it activates a code: `Source18.inject(1)`. The code commands to *Source18* to create one truck. The truck picks up the full container from *Queue43* by *Pickup20*. Then, the truck goes in *Delay26* where it gets delayed for a duration of road transportation between the seaports of Aliaga and Denizli. At *Dropoff21*, the full containers are dropped off and they enter *SelectOutput20* where they are separated according their types for a statistics collection purpose. Finally, the full containers are disposed in *Sink13* and *Sink22*. After the trucks dropped off the full containers, they enter *Delay44* where they are delayed for a duration of container unstuffing to simulate container unstuffing duration. Then, the trucks enter *Delay27* where they are delayed for a duration of road transportation between Denizli and the seaports of Aliaga to simulate empty container transportation after the full containers were unstuffed.

3.5.7.2.2. Dry Port Module

3.5.7.2.2.1. Import Reservation

There is a requirement for making a reservation at least one day before shipment for the cargo to be transported through the dry port. Figure 37 shows that after mode choice, the full containers to be transported through the dry port go in the sub-module of cargo reservation for transportation through the rail-based dry port.

Figure 37: Reservation for Inland Transportation through the Dry Port for Import Containers



The full containers first go in *SelectOutput17* that separates the full containers that come in office hours from the full containers that come before and after office hours. The office hours in the model include hours between 09:00 and 17:00. The full containers that come in office hours enter *Queue37* that is a buffer queue for *Hold23*. When *Hold23* is blocked, the containers wait in *Queue37*. The full containers that come before and after office hours get separated in *SelectOutput18*: the full containers that come before 09:00 go in *Delay22* where they get delayed until 09:00; the full containers that come after office hours go to *Delay23* where they get delayed until the next day 09:00. *Hold23* is blocked on Sundays because it is not possible to make a reservation on Sundays. *eventSunday3* activates a code on Sundays at 00:00. The code reads as:

```
Hold23.block();
Hold24.block();
```

The code blocks *Hold23* and *Hold24* on Sundays at 00:00. *eventSunday4* activates a code on Mondays at 00:00. The code reads as:

```
Hold23.unblock();
Hold24.unblock();
```

The code unblocks *Hold23* and *Hold24* on Mondays at 00:00.

Because the reservation has to be made one day before the shipment, the full containers enter in *Delay24* where they are delayed for 24 hours. Since there are no train departures on Sundays, *Hold24* blocks the full containers on Sundays. Then, the full containers get in *SelectOutput19* where they get separated in terms of their types and destinations.

20' containers that to be transported from the seaport of Alsancak to Denizli enter in *Queue38*. 40' containers that to be transported from the seaport of Alsancak to Denizli enter in *Queue39*. Then, they go into *Queue45* (illustrated in Figure 39) where they wait for the train.

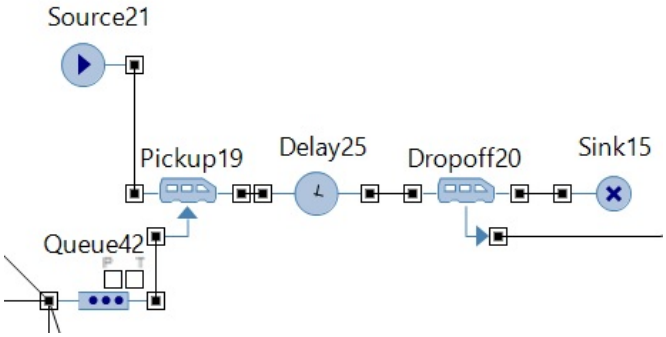
20'containers that to be transported from the seaports of Aliaga to Denizli enter in *Queue40*. 40' container that to be transported from the seaports of Aliaga to Denizli enter in *Queue41*. Then, they go into *Queue42* (illustrated in Figure 38) where they get picked up by trucks for road transportation between the seaports of Aliaga and Bicerova rail station.

3.5.7.2.2.2. Road Transportation between the Seaports of Aliaga and Bicerova Rail Station

Figure 38 shows the simulation module of road transportation of containers that arrive from the seaports of Aliaga and choose to use the dry port. After the full import containers arrive at the seaports of Aliaga (as described in Figure 35), the ones that choose to use rail transportation through the dry port need to get to Bicarova rail station by road, then, they are transported to the dry port in Denizli by rail.

Figure 38 illustrates that the full import containers, which are coming from the seaports of Aliaga, to be transported through the dry port by rail enter *Queue42*. As soon as a container enters *Queue42*, it activates a code: `Source21.inject(1)`. The code commands *Source21* to create one truck. After the truck is created, it goes in *Pickup19*, where it picks up the container from *Queue42*. Then, the truck goes in

Figure 38: Road Transportation Between the Seaports of Aliaga and Biçerova Rail Station



Delay25 where it is delayed for a duration of road transportation between the seaports of Aliaga and Bicerova rail station. The container is dropped off at *Dropoff20* and it enters *Queue45* (illustrated in Figure 39)to wait for the departure of import train. The trucks are disposed at *Sink15*.

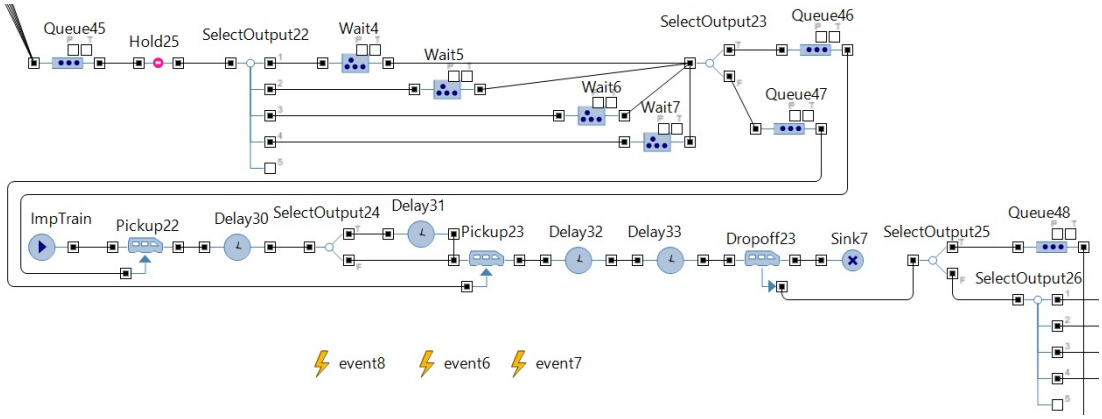
3.5.7.2.2.3. Rail Transportation of Import Containers

Figure 39 illustrates the simulation module for rail transportation of import containers. Containers enter *Queue45*, where they wait for the import train to pick them up. When a container enter *Queue45*, it activates a code:

```
if((Wait4.size()*ImpFullFEUWeight+Wait5.size()
*ImpFullTEUWeight+Wait6.size()*EmptyFEUWeight+Wait7.size()
*EmptyTEUWeight)>=750)
Hold25.block();
```

The code manages the capacity of the train. When the containers go through *SelectOutput22*, they are separated according to their types: if they are 20' or 40' containers and if they are full or empty containers because each type has different weights. The capacity of the train is determined according to the sum of the weights of the containers. After they are separated, they enter *Wait4*, *Wait5*, *Wait6*, and *Wait7*. The size of each *Wait* block is multiplied by the unit weight of each type of container and they all are summed up to determine the total weight of the containers. The code commands *Hold25* to get blocked as soon as the total weight reaches 750 tons, which is the maximum carrying capacity of a freight train in the corridor.

Figure 39: Rail Transportation of Import Containers



event6, *event7*, and *event8* manage train departures. At most three train departures are possible from and to the dry port. If there is a demand, the three event elements simulate three departures. The departures take place if there is a demand. The three *event* elements are identical except their activation times. *event6* activates a code on every day at 01:00 (it is the train departure time). The code reads as:

```
if (Sunday == 0 && (Wait4.size() + Wait5.size() + Wait6.size()
+ Wait7.size()) >= 5)
ImpTrain.inject(1);
```

The code first checks if *Sunday* equals to 0 (checks if it is Sunday or not). Sunday variable was explained previously (in section 3.5.1.7.1.2.3.). If it is not Sunday and the sum of sizes of *Wait4*, *Wait5*, *Wait6*, and *Wait7* equals to or more than 5, one train is created from *ImpTrain*. Because at most three train departures are possible if there is a demand, *event7* activates the same code on every day at 01:30 for the second train departure and *event8* activates the same code on every day at 02:00 for the third train departure.

Before the import train leaves *ImpTrain*, it activates a code. The code reads as:

```
Wait4.freeAll();
Wait5.freeAll();
Wait6.freeAll();
Wait7.freeAll();
Hold25.unblock();
```

The code frees all containers in *Wait4, Wait5, Wait6, and Wait7* and unblocks *Hold25* to let the containers for the next train enter. When the containers are freed, they enter *SelectOutput23*, where they are separated in terms of their arrival location: the seaports of Aliaga and the seaport of Alsancak. Since the containers that arrive from the seaports of Aliaga start rail transportation from Bicerova rail station, they enter *Queue46*. The containers that arrive from the seaport of Alsancak enter *Queue47*.

The train picks up containers from *Queue46* by *Pickup22* and enters *Delay30* where it gets delayed for a duration of rail transportation between Bicerova rail station and the seaport of Alsancak. In *SelectOutput24*, a certain percentage of the trains enter *Delay31* that simulates unexpected delays on the railway.

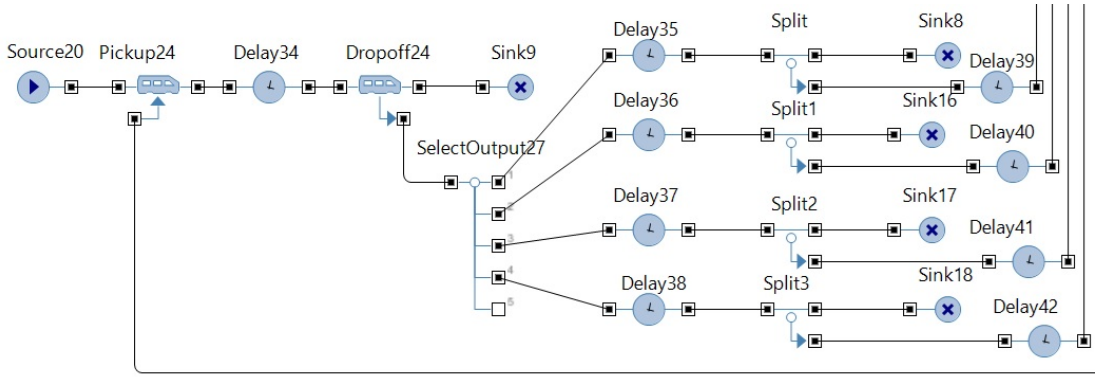
The train picks up the containers from *Queue47* by *Pickup23*. Then, it is delayed at *Delay32* for the duration of container loading on train cars. Then, it enters *Delay33* where it is delayed for the duration of rail transportation between the seaport of Alsancak and the dry port in Denizli. All containers are dropped off at *Dropoff23* and the train goes in *Sink7* to get disposed.

When the containers are dropped at *Dropoff23*, they enter *SelectOutput25* where full and empty containers are separated. The empty containers are separated in terms of their types at *SelectOutput25* and go to empty container storages (illustrated in Figure 29). The full containers enter *Queue48* to get transported by road to the locations of importers.

3.5.7.2.2.4. Road Transportation between the Dry Port and Denizli

Figure 40 illustrates the simulation of road transport from the dry port to the location of the importers. As explained in the previous section, when the containers arrive to the dry port, they enter *Queue48* (illustrated in Figure 39) to get picked up by trucks and get transported to the importers. As soon as a container enters *Queue48*, it activates a code: `Source20.inject(1)`. The code commands *Source20* to create one truck. At *Pickup24*, the trucks pick up the full containers from *Queue48*. Then, they go in *Delay34* where they are delayed for the duration of road transportation from the dry port to the locations of the importers. The containers are dropped off at *Dropoff24* and

Figure 40: between the Dry Port and Denizli



the trucks are disposed at *Sink9*.

The dropped of containers enter *SelectOutput27*, where they are separated in terms of their types and origins. Then, they enter *Delay35*, *Delay36*, *Delay37*, and *Delay38* to get delayed for the duration of container unstuffing. Split blocks split full containers in two: the empty containers and the cargoes. The cargoes are disposed at *Sink8*, *Sink16*, *Sink17*, and *Sink18* while the empty containers enter *Delay39*, *Delay40*, *Delay41*, and *Delay42* where they are delayed for the road transportation time between the importers and the dry port. At last, the empty containers go in the *Queue10*, *Queue16*, *Queue24*, and *Queue27* (they are illustrated respectively in Figure 29, Figure 30, Figure 31, and Figure 32) where the import empty containers are stored as explained in the previous section (Section 3.5.1.7.1.2.2.).

3.5.8. Performance Measures

The simulation model is developed for evaluating impacts of demand increase in the rail-based dry port, which resulted from the alterations in the service attributes of both inland transportation alternatives: direct road alternative and rail-based dry port alternative. The impact of the demand increase needs to be evaluated considering certain performance measures. The measures include total ton kilometers of road and rail, average utilization of export and import trains, and total inland container transportation costs of shippers.

3.5.8.1. Total Ton Kilometers of Rail and Road

Ton kilometer is described as transportation of one metric ton of containerized goods or empty containers over a distance of one kilometer. Ton-kilometers of rail and road is calculated separately. Below equations show the formula:

$$Rail_{TKM} = \sum_{n=1}^{n} P_{ijn} D_{ijr}$$

$$Road_{TKM} = \sum_{n=1}^{n} P_{ijn} D_{ijt}$$

$Rail_{TKM}$ stands for total rail tonne-kilometers, P_{ijn} tonnage of the empty or the full container (including tare weight of the container) carried in the nth shipment between i and j, D_{ijr} is the rail distance between i and j in terms of kilometers. $Road_{TKM}$ represents total road tonne-kilometers, P_{ijn} represents the tonnage of the empty or the full container (including tare weight of the container) carried in the nth shipment between i and j. D_{ijr} stand for the road distance between i and j.

3.5.8.2. Average Export and Import Train Utilization

Average utilization of the trains is the average used capacity of the trains. The average train utilization is calculated separately for the import containers, which are transported from the seaports of Izmir to Denizli and export containers, which are transported from Denizli to the seaports of Izmir.

$$U_{Exp} = \frac{\sum_{n=1}^{n} \frac{V_{ijn} * 100}{750}}{n}$$

$$U_{Imp} = \frac{\sum_{n=1}^{n} \frac{V_{jin} * 100}{750}}{n}$$

U_{Exp} stands for the utilization of export trains, V_{ijn} represents the tonnage carried in the nth train shipment between i and j. Since the maximum carrying capacity of a freight train in the corridor is 750 tons, the tonnage V_{jin} is divided by 750 and multiplied by 100 to find the used capacity as a percentage. U_{Imp} is the utilization of import trains,

V_{jin} is the tonnage carried in the nth train shipment and n stands for the number of the train shipments.

3.5.8.3. Total Transportation Costs of Shippers

Total inland container transportation cost is calculated as the total of the prices that the shippers pay to the logistics service providers for the transportation of containers between the seaports of Izmir and Denizli. The formula for the total costs presented as:

$$C = \sum_{n=1}^{n} W_{jin} + \sum_{n=1}^{n} Y_{jin}$$

Where C stands for the total costs, W_{jin} is the price of nth road shipment between i and j, Y_{jin} stands for the price of nth shipment through rail-based dry port between i and j.

3.5.9. Verification

Verification of a simulation model is described as testing the model to determine if it works as intended (Rossetti, 2015). Model verification process consists of determining if the model is correctly constructed. Tests and guidelines put forward by the researchers to verify that a computer simulation model works according to the specifications of its design. In this thesis, various techniques are used for verification of the simulation model. First, the debugger of the AnyLogic simulation program is used to for checking if there are inconsistencies and misspecification in the code of the model. Second, using trace feature entities are traced through the simulation process. Additionally, entity flow is observed visually during the simulation runs to determine any inconsistencies. Two different tests described by Altiok and Melamed (2010) is applied: (1) finding the throughput with different methods; (2) applying Little's formula to find average entities in the system.

3.5.9.1. Analyzing the Throughput with Different Methods

The throughput of the system will be determined in various ways and compared if they are compatible. Altiok and Melamed (2010) provides various ways to find the system throughput.

$$\hat{O_1}(r) = \frac{D(r)}{T(r)}$$

$\hat{O_1}(r)$ represent the throughput estimator for the replication r, $D(r)$ denotes the number of entities processed during replication r and $T(r)$ denotes the duration of the replication r.

The throughputs of export and import flows that went through dry port will be calculated separately.

Export throughput calculated as:

$$\hat{O_1}(r) = \frac{6,326}{365 * 24} = 0.722$$

$6,326$ is the number of the full export containers that went through the dry port, divided by the duration of the simulation which is one year.

Import throughput calculated as:

$$\hat{O_1}(r) = \frac{1,170}{365 * 24} = 0.134$$

$1,170$ is the number of the full import containers that pass through the system and it is divided by the duration of the simulation.

$$\hat{O_2}(r) = \lambda p(r)$$

λ denotes the arrival rate of the full containers and p denotes the probability of the containers to use the rail-based dry port during replication r. $\hat{O_2}(r)$ is the effective arrival rate which equals to hourly throughput (Altiok and Melamed, 2010).

$$\lambda = 1.883 + 2.166 + 1.184 + 1.363 = 6.546$$

λ is equal to sum of all arrival rates of full export containers which are described in Table 46.

$$p = \frac{6,326}{6,326 + 51,554} = 0.109$$

6,326 is the number of full containers that use the dry port and 51,554 is the number of full containers that use the direct road.

$$\hat{O_2}(r) = 6.546 * 0.109 = 0.714$$

Import throughput calculated as:

$$\lambda = 0.084 + 0.097 + 0.488 + 0.561 = 1.23$$

λ is equal to sum of arrival rates of full import containers which are described in Table 46.

$$p = \frac{1,170}{1,170 + 9,538} = 0.109$$

1,170 is the number of full import containers that use the dry port and 8,656 is the number of the full import containers that use the direct road.

$$\hat{O_2}(r) = 1.23 * 0.109 = 0.134$$

Table 49: Calculation of Hourly Throughput with Different Methods

Hourly Throughput	Export	Import
$\hat{O_1}(r)$	0.722	0.134
$\hat{O_2}(r)$	0.714	0.134

The throughput is calculated with two different methods for both export and import shipments. Table 49 shows the results of the calculations. The results are very close to each other. It verifies that the simulation model works properly.

3.5.9.2. Applying Little's Formula to Find Average Full Containers in the System

$$\overline{N_S} = \lambda_{eff}\overline{W_S}$$

$\overline{N_S}$ denotes the average number in the system, λ_{eff} is the effective arrival rate and $\overline{W_S}$ is the average time an entity spends in the system.

Average full containers in the system is calculated for export module as:

$$\hat{\lambda_{eff}}\hat{W_S} = 0.714 * 54.221 = 38.714$$

Average number of export full containers in the system is also gathered as an output of simulation run. It equals to 39.32.

Average full containers in the system is calculated for import module as:

$$\hat{\lambda_{eff}}\hat{W_S} = 0.134 * 55.764 = 7.472$$

Average number of import full containers in the system is also gathered as an output of simulation run. It equals to 7.845.

Table 50: Calculation of Average Full Containers in the System

Average Full Containers	Export	Import
$\overline{N_S}$	38.714	7.472
$\hat{N_S}$	39.32	7.845

$\overline{N_S}$ denotes number of average full containers calculated by Little's Formula
$\hat{N_S}$ denotes number of average full containers gathered from the simulation output

The average number of the full containers in the system is calculated by using Little's formula. The results are compared with the output values of the simulation model. These values are also very close to each other. The calculation shows compatibility and further verify the simulation model.

3.5.10. Experiment Design

The simulation run length is determined as one year since the inter-arrival rates of containers are determined by using the statistics for a period of one year. Additionally, the warm-up period is determined to eliminate the bias resulted from the initiation phase. The simulation model runs for a period of time, the warm-up period, until its statistics reach a steady state so that results of the simulation analysis avoided from getting affected by the statistic of initiation phase. The warm-up period is determined by observing the graph of moving average of the number of entities in the system. It is determined that the system statistics reaches steady state in between 1 and 2 months. In order to be on the safe side, it is decided that three months of a warm-up period is adequate for the simulation model.

The simulation analysis will be conducted based on various scenarios where the attributes of transportation modes altered to achieve mode shift towards the rail-based dry port alternative. The scenarios reflect current developments. Now, Turkish railway sector is in a deregulation process. After the private parties are involved in the transportation of freight in the Turkish railways, it is likely that the railway service will be less expensive because the free competition is expected to increase efficiencies. Therefore, it is expected that deregulation of Turkish railways would decrease the costs of rail-based dry port service and increase its service quality by reducing the percentage of delayed shipments. Additionally, because of the environmental externalities, some countries apply an additional tax to road transportation to encourage environmentally friendly alternative modes. The scenarios are based on possible impacts of these developments on the attributes of transportation modes in the hinterland corridor.

3.5.11. Findings

As mentioned previously, the aim of this section was to evaluate the impacts of mode shift from road to rail-based dry port resulting from variations in the attributes of those transport modes. The first section of this chapter revealed how the variations in the attributes of inland transport modes affect the hinterland transportation mode choice.

This section combined the outcomes of the first section by developing a simulation model to conduct scenario analysis.

The scenarios are discussed by comparing them with the base case. The base case reveals the impacts of current levels of the transport mode attributes on the inland container logistics. Three scenarios were developed. Scenario-1 evaluates the impacts of decreases in the cost of rail-based dry port service. Scenario-2 evaluates the effects of increases in the cost of road transport service. Scenario-3 evaluates decreases in the delays of the rail-based dry port service. Free time attribute is excluded from the scenario development since the dry port currently provides 30 days of free time. The interviewees indicated that 30 days of free-time is adequate for the shippers.

The base case describes the current situation. Table 51 shows that share of rail-based dry port service is 11% in the base case that reveals considerably low percentage of the containerized freight is carried by intermodal-rail through the dry port. Currently, average 6.1 train departures per week are provided from the dry port to the seaports of Izmir for export containers. And 6 train departures per week is provided from the seaports of Izmir to the dry port for import containers. Average utilization of export train capacity is fairly low, it is only 53%. This shows that trains are currently working with idle capacity. Average capacity utilization of import trains is 18%. This is even lower than the average utilization of the export trans capacity. This causes an extensive idle capacity in import trains.

Total costs define the total amount paid for inland container transportation in the corridor by the shippers. It includes both the amount paid for direct road transportation and rail-based dry port. Currently, as of base case, total inland container transportation cost is TRL 67,267,750 in the corridor. Total road ton-km includes total ton-km resulted from direct road transportation and road transportation between the dry port and shippers' location and road transportation between seaports of Aliaga and Bicerova rail station. Total road ton-km has particular importance since rail transportation is environmental friendlier and fewer accidents occur in railways. Shifting inland container transportation mode from road to rail-based dry port service can help to reduce environmental emissions and accidents. Therefore, the smaller total road ton-km means fewer emissions and accidents. The result of the base scenario suggests that current

road ton-km in the corridor equals to 397,971,551 ton-km. Total rail ton-km in the base case equals to 40,923,607. The mode shift from road to rail increases the total ton-km of rail transportation since tonnage of the containers shifted from road to rail is added in the rail ton-km.

3.5.11.1. Scenerio 1–Decrease in the Cost of Intermodal Rail

The first scenario evaluates decrease in the cost of rail-based dry port service while the other attributes stay at their current level. The decrease in the cost of rail-based dry port service might be associated with the subsidies to rail transport, efficiency improvements, and adaptation of better organizational management practices. In this scenario, the effects of incremental decrease of respectively 5%, 10%, 15%, 20% in the cost of rail-based dry port service are evaluated.

Table 51 summarizes Scenario 1. 5% decrease in the cost of rail-based dry port service is the lowest increment that causes a 45% increase in the demand for the rail-based dry port. This considerably high demand increase resulted from only a 5% decrease in the costs of the rail-based dry port service because the transport service users are highly sensitive to costs as described in the previous section where elasticities of the attributes were discussed. This demand increase did not impact train frequencies, only train capacity utilization increased because the trains already had plenty of idle capacity. Small decreases occurred in the total transportation cost and total road ton-km, respectively 1.7% and 4.6 %.

10% decrease in the cost of rail-based dry port increases its share almost two-fold, 91%. Because the volume of export shipments is higher than the import shipments, the increase required an increase in the average export train frequency from 6 to 7.6 while average import train frequency remains the same. Total transportation costs of shippers decreased 4.1%. The decrease in the total cost is minuscule since the share of the rail-based dry port is still very low comparing to road transportation. But, the increase in the share of rail-based dry port reduced the total road ton-km 10.3%.

The third increment simulates a 15% decrease in the cost of rail-based dry port. Even though it is only 5% higher than the previous decrease, it resulted in substantial

mode shift towards rail-based dry port increasing its share 218%. To deal with this demand increase, average export train frequency increased to 12.9 trains per week. Import train frequency still has not affected by the demand increase since it was working with a plenty of idle capacity. Additionally, total costs considerably decreased with 9.4% and total road ton-km decreased in a great deal with 23.4%, more than two-fold of the previous increment.

Table 51: Scenerio 1–Decrease in the Cost of Rail-based Dry Port

		Decrease in the Cost of Rail-based Dry Port			
	Base Case	-5%	-10%	-15%	-20%
Share of Dry Port(%)	11	16 (+45%)	21 (+91%)	35 (+218%)	46 (+318%)
Average Export Train Frequency (per week)	6.1	6.8	7.6	12.9	15.7
Average Export Train Utilization(%)	53	69	84	83	93
Average Import Train Frequency (per week)	6	6	6	6	6
Average Import Train Utilization(%)	18	26	34	51	67
Total Transport Costs (TRL)	67,267,750	66,120,917 (-1.7%)	64,490,090 (-4.1%)	60,880,320 (-9.4%)	56,894,300 (-15.4%)
Total Rail Ton-Kms	40,923,607	58,438,494 (+42.7%)	79,608,854 (+94.5%)	129,805,440 (+217%)	175,070,059 (+328%)
Total Road Ton-Kms	397,971,551	379,356,426 (-4.6%)	356,962,042 (-10.3%)	304,656,675 (-23.4%)	257,796,651 (-35.2%)

Table 51 illustrates that 20% decrease in the cost of rail-based dry port increases the share of the rail-based dry port to 46% with a very substantial increase of 318%. To meet the increased demand average 15.7 export train departures per week is provided. Although the train capacity was increased more than two-fold, capacity utilization of export trains reached to 93%. Because of the lower import container volume, 6 train departures per week was enough to meet the increased demand. Total transportation costs also reduced significantly with a 15.4%. The highest reduction in the total road ton-km resulted from the 20% decrease in the cost of rail-based dry port by reaching a

35.2% decrease. Therefore, negative environmental impacts of road transportation can be significantly eliminated.

3.5.11.2. Scenario 2–Increase in the Cost of Road Transport

The second scenario investigates the increase in the cost of road transport while the other attributes stay at their base levels. The increase in the cost of road transport might be resulted from the introduction of environmental taxes because of negative environmental impacts of road transport or increase in the fuel cost. As described in Table 52, this scenario evaluates the effects of 5%, 10%, 15%, and 20% increase in the cost of road transport.

The first case in this scenario simulates a 5% increase in the cost of road transport. Table 52 shows that it caused a 36.3% increase in the share of rail-based dry port. Because the capacity utilization in the base case is small, it requires a little increase in the average frequency of export train departures while average import train frequency has not been affected. However, the increase resulted in a 3% increase in the total transportation costs. Additionally, a 4.5% decrease occurred in the total road ton-km.

The second case in this scenario simulates a 10% increase in the cost of road transport. Table 52 illustrates that the simulation of 10% increase in the cost of road transport increases the demand for the rail-based dry port to 21% with an increase of 90.9%. Average export train frequency requires increasing to 7.6 shipments per week while average import trans frequency still has not been affected. However, the increase in the cost of road transport resulted in a considerable increase in the total transportation costs with an 5.4%. Additionally, the total road ton-km is reduced 10.2%.

The third case simulates a 15% increase in the cost of road transport. In Table 52, a 15% increase in the cost of road transport has been shown to result in an enormous mode shift with an increase of 200% towards the rail-based dry port service. This demand requires an average of 12.8 export train frequencies per week, but the average import train frequency is not affected. In addition to the demand for rail-based dry port, a significant decline of 22.2% in the total road ton-km is also observed. However, total transport costs increased by 5.1%.

Table 52: Scenerio 2–Increase in the Cost of Road Transport

		Increase in the Cost of Road Transport			
	Base Case	+5%	+10%	+15%	+20%
Share of Dry Port(%)	11	15 (+36.3%)	21 (+90.9%)	33 (+200%)	44 (+300%)
Average Export Train Frequency (per week)	6.1	6.7	7.6	12.8	14.8
Average Export Train Utilization(%)	53	68	83	81	93
Average Import Train Frequency (per week)	6	6	6	6	6
Average Import Train Utilization(%)	18	24	33	49	63
Total Transport Costs (TRL)	67,267,750	69,290,925 (+3%)	70,958,555 (+5.4%)	70,726,222 (+5.1%)	69,908,850 (+3.9%)
Total Rail Ton-Kms	40,923,607	56,174,452 (+37.2%)	78,228,309 (+91.1%)	125,164,485 (+206%)	165,702,300 (+305%)
Total Road Ton-Kms	397,971,551	379,939,233 (-4.5%)	357,265,172 (-10.2%)	309,596,822 (-22.2%)	266,728,700 (-32.9%)

The last case in this scenario simulates a 20% increase in the cost of road transport. 20% increase in the cost of road transport results in a great deal of mode shift towards rail-based dry port by 300%. Average export train frequency per week become 14.8 to meet the increased demand, but average import train frequency is not affected, only import train utilization is increased. The increased cost of road transport comes with a negative outcome as well; the total transportation costs in the corridor increased 3.9%. On the other hand, total road ton-km is reduced substantially by 32.9%.

3.5.11.3. Scenario 3–Decrease in the Delays of Intermodal Rail

The third scenario analyses the impacts of a decrease in the delays of rail-based dry port while the other attributes stay at their base levels. The decrease in the delays of rail-based dry port might be caused by the introduction of better management practices or improvements in the efficiency of the operations through infrastructural investments. Table 53 summarizes analysis results which show effects of 25%, and 50% decrease in the delays of rail-based dry port service.

The first case under this scenario simulates a 25% decline in the percentage of delayed shipments that are transported through the dry port. Table 53 shows that the decrease in the delayed shipments has a considerable impact on the demand for the rail-based dry port service. The share of the rail-based dry port increased from 11% to 15% with an increase of 36.3%. To meet the increased demand, the frequency of the train departures increased to 6.8 departures per week. However, only 67% of the export train capacity is utilized. The increase in the demand for rail-based dry port service have a little impact on the total costs by 0.1% but caused a 4% reduction in the total road ton-km.

The second case of this scenario evaluates a 50% decrease in the delays of rail-based dry port service. The outcome in Table 53 illustrates that the share of the rail-based dry port service increased to 22% with a substantial increase of 100%. This increase is met by increasing the frequency of train departures to 8 departures per week. The export train capacity utilization became 83%. However, increase in the import train capacity utilization does not require to increase the train frequency. Even though

Table 53: Scenerio 3–Decrease in the Delays of Rail-based Dry Port

		Decrease in the Delays of Rail-based Dry Port	
	Base Case	-25%	-50%
Share of Dry Port(%)	11	15 (+36.3%)	22 (+100%)
Average Export Train Frequency (per week)	6.1	6.8	8
Average Export Train Utilization(%)	53	67	83
Average Import Train Frequency (per week)	6	6	6
Average Import Train Utilization(%)	18	24	34
Total Transport Costs (TRL)	67,267,750	66,692,450 (-0.1%)	65,896,100 (-2%)
Total Rail Ton-Kms	40,923,607	56,475,616 (+38%)	81,039,866 (+98%)
Total Road Ton-Kms	397,971,551	381,827,547 (-4%)	357,386,669 (-10.1%)

the cost of rail-based dry port service remained at the base level, the total costs of inland container transportation decreased 2%, because the cost of the rail-based dry port service is still lower than the cost of road transportation. The highest impact of increased rail-based dry port demand was in total road ton-km which is a decrease of 10.1%.

3.6. DISCUSSION

This thesis studied the effects of rail-based dry port usage considering the influence of transportation attributes on mode choice in inland container logistics. The study is conducted in two parts: in the first part, stated choice experiment was applied to analyze the effects of transportation attributes on the mode choice in the inland transport corridor between seaports of Izmir and city of Denizli; in the second part, a discrete event simulation modeling was applied by incorporating the outcomes of the first part to analyze the effects of variations in the transportation attributes on mode shift towards

rail-based dry port service and inland container logistics.

Results of the first part, which analyzed mode choice in the inland transport corridor, show that besides transit time attribute, all the attributes including transport cost, delays, train frequency, and free time are statistically significant. This is in line with Feo-Valero et al. (2011) where they found that transit time attribute has a minimal impact on the inland transport mode choice. These results also confirm Patterson et al. (2008)'s study on Quebec City-Windsor Corridor. They underlined that in a short distance corridor, transit times of different transportation modes are identical so that transit time can be excluded in the survey of the stated choice experiment.

The elasticity analysis of stated choice experiment indicates that the transportation cost attribute has the biggest impact on the mode choice. 1% increase in the cost of road transport resulted with a 1.61% decrease in the mode choice probability of the road alternative while causing a 5.38 % increase in the choice probability of rail-based dry port alternative. Additionally, 1% increase in the cost of the rail-based dry port alternative causes a 1.13 % increase in the mode choice probability of road alternative while reducing its share 3.77%. These results are in good agreement with Feo-Valero et al. (2016b) and Vermeiren and Macharis (2016). Their findings also showed that transport cost is the most influential attribute influencing in freight transport mode choice.

Results of simulation analysis show that mode shift towards rail-based dry port cause a significant reduction in ton-km of road transportation in the corridor. Since rail transportation is environmentally friendly and fewer accidents occur in railways, shifting inland container transportation mode from the road to rail-based dry port can help to reduce environmental emissions and accidents. Therefore, increase in the usage of the rail-based dry port means fewer emissions and accidents confirming previous research which investigated the impacts of dry port usage in inland freight transport (i.e. Lättilä et al. (2013), Regmi and Hanaoka (2015), Roso (2007), and Henttu and Hilmola (2011)).

Simulation results suggest that both Scenario-1, decreasing the cost of rail-based dry port service, and Scenario-2, increasing the cost of road transportation are very effective ways for creating mode shift from road to rail-based dry port. The decrease in

the cost of rail-based dry port service might be accomplished by introducing subsidies to rail transport, improving the efficiency of the railway, or introducing better organizational and management practices. The best case of Scenario-1 shows that 20% decrease in the cost of rail-based dry port decreases the road ton-km up to 35.2% and decrease the total inland transportation costs up to 15.4%. These results provide compelling evidence for benefits of increasing rail-based dry port usage and suggest that policies and practices for decreasing the cost of rail-based dry port service in the inland corridor appear to be effective in both eliminating negative environmental impacts of road transportation and decreasing the total inland transportation costs of shippers.

Results of Scenario-2 suggest that increase in the cost of road transport has almost the same impact as decreasing the cost of rail-based dry port service. This increase in the cost of road transport might be resulted from the increased taxes and tariffs on road transportation because of its negative environmental impacts or increase in the fuel prices. The highest boundary of the scenario indicates that 20% increase in the cost of road transport results with a 32.9% decrease in the road ton-km. However, this causes a 3.9% increase in the total inland transportation cost. These outcomes suggest that although policies and practices for increasing the road transportation costs are effective for reducing negative impacts of road transport, they result in a considerable increase in total inland transportation costs that can cause an overall increase in the cost of goods thus causing negative economic and social impacts.

The results of Scenario-3 confirm the effectiveness of decreasing the delays of rail-based dry port service creating the mode shift towards it. However, this scenario is not as effective as the other two. The results indicated that up to 50% decrease in the delays of rail-based dry port service decreases the road ton-km up to 10.1% and decreases total inland transportation costs 2%. This reduction in the delays of rail-based dry port can be accomplished by improving the efficiency of operations through infrastructural investments or adaptation of better management practices. Since decreasing the delays of rail-based dry port service is not as effective as the other two scenarios, it can be more useful to adopt a comprehensive approach which combines policies and practices that decrease delays of rail-based dry port service and decreasing its cost.

The scenario analysis of the simulation model also provides an understanding of the importance of available train capacity and adequate train frequency. Increasing mode shift to rail-based dry port service increases the need for additional train frequency. The highest mode shift is achieved by decreasing the rail-based dry port service cost by 20% which resulted in the necessity of increasing the export train frequency from 6 shipments per week to 15.7 shipments per week. Increasing the train frequency requires improvements in the infrastructure of the railway line and the infrastructure of the dry port. Currently, the railway has a single line that puts a restriction on train operations. Construction of an additional railway line will enable two directional train operations so that it can be possible to increase the train frequency. Besides enabling more frequent train services, improvements in the rail infrastructure can help to reduce delayed shipments through the dry port. Infrastructural improvements require investments which can be provided either by public funding or encouraging the private investment with supportive government policies.

Infrastructural and superstructural improvements in the dry port are also necessary for both reducing handling costs and providing comprehensive value-added logistics services. Analysis results of the stated choice experiment suggest that free-time is statistically significant in the inland transportation mode choice of decision makers in the corridor. This indicates that longer free time of the dry port increases the probability of the rail-based dry port service to be chosen. Availability of comprehensive value-added services can increase the influence of free-time in the dry port. Making necessary infrastructure available for logistics service providers and manufacturing companies will encourage them to relocate their facilities inside and around the dry port area to ensure the provision of value-added logistics services and some level of freight volume to be transported.

Besides infrastructure, business strategies can also significantly affect mode shift to rail-based dry port service. Effective organization of container movement in the railway and the dry port is necessary for cost reduction as well as decreasing delayed shipments. This can be accomplished by collaboration among the actors such as railway operators, shipping lines, logistics service providers, dry port operators and shippers who involved in inland container transportation. Collaboration can play a significant

role in the facilitation of efficient container movement through operational integration and information sharing. Furthermore, the collaboration of actors is essential to ensure a level of demand for rail-based dry port services.

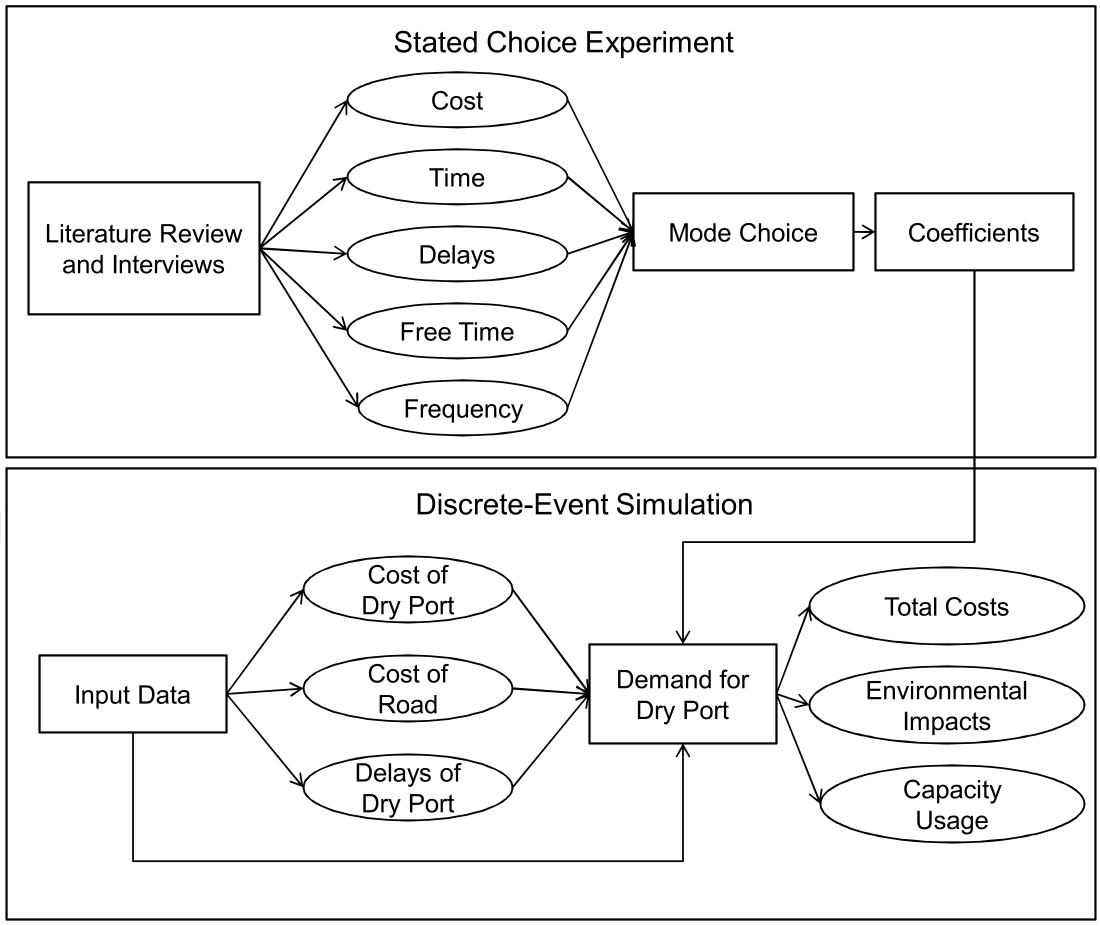
3.7. CONTRIBUTION

Figure 41 shows the relationship among the variables in the findings of both parts of the research application: Stated choice experiment and discrete-event simulation. With the help of literature review and semi-structured interviewing the attributes and their levels to be used in the stated choice experiment were identified. Using the outputs of semi-structured interviews, the stated choice experiment was designed. The analysis of the data revealed the coefficients of the impacts of inland transportation service attributes on the inland transportation mode choice. The coefficients were used for the evaluating the demand for the dry port in the discrete-event simulation model. The discrete-event simulation analyzed the impact of three policies, which are decreasing costs of dry port usage, increasing costs of road transport, and decreasing the delays of dry port usage, on creating demand for dry port and how this increased demand effected total inland transportation costs, environment, and capacity usage (railway frequency and train capacity utilization).

This thesis empirically investigates the effects of dry ports on inland container logistics in Turkish context. Turkey is strategically located on the center of international freight transportation corridors. Dry ports in Turkey can be enablers of international trade connecting main seaports with international road and rail transportation corridors. Empirical investigation of dry port development in Turkeys has a great importance for policy development concerning initiatives such as TRACECA and OBOR. With that regard this thesis evaluates the impacts of a dry port located in Turkey taking preferences of dry port users into account while evaluating scenarios of increasing demand for the dry port.

Previous research has inspected impacts of rail-based dry port usage in inland transportation of maritime freight and documented the effectiveness of rail-based dry port usage in improving inland access, reducing transportation costs, and environmental

Figure 41: Relationship among Variables and Methodological Applications



externalities in inland container logistics. Roso (2007), for instance, reports that dry port usage in inland container logistics significantly reduces environmental externalities by %25, including queues at seaport terminals. However, these studies have either considered that transportation cost is the only factor that intervening the decision of inland transportation mode selection or has not considered any railway capacity limitations in their analyses. Lättilä et al. (2013) evaluated impacts of dry ports using discrete-event simulation in Finland: They assumed that transportation cost is the only factor that impacts decision of inland transport mode selection and has not considered railway capacity constraints. In another study, although Regmi and Hanaoka (2015) considers transit time and delays besides transportation cost in inland transport mode selection while analyzing the impacts of dry port development between Laos and seaports of Thailand, they have not included railway capacity limitations.

Results of this thesis extend the findings of previous research, since the analysis includes not only conventional attributes such as transport costs, transit time, delays, and frequency in inland transport mode selection but also free time attribute that has not been used in previous research.

Additionally, this thesis took into account the capacity constraints of railways to inspect frequency of railway service per week required for meeting the created mode shift towards rail-based dry port service and utilization of train capacities to see the average percentage of used capacities.

Besides extending the findings of the previous research, this thesis also extends the methodological approaches of the previous research. This is the first study to the author's knowledge to integrate stated choice experiment with discrete-event simulation. The discrete choice model generated through stated choice experiment incorporated into the mode choices in the discrete-event simulation model, therefore, the impacts of the variations in the transport mode attributes on the inland container logistics can be evaluated by the scenario analysis.

CONCLUSION AND RECOMMENDATION

Growth in the World economy and international trade have created an increasing demand for international transportation of maritime containers. This growing demand for freight transport has caused capacity problems in seaports and inland transportation of maritime containers, as well as creating negative environmental impacts. To cope with these issues and increase their efficiencies, container terminals adopted technological innovations such as automated operations systems and new generation handling equipment. However, land requirements for capacity expansion can only be provided by physical expansion. For most seaports, landward expansion is out of the question because they are surrounded by a city. The seaward expansion is too much expensive for the most of the container terminals.

The dry port concept has emerged to deal with capacity constraints of seaports, inefficient inland access and negative environmental impacts resulting from inland transportation of maritime containers. A dry port is defined as an inland terminal located in the hinterland of a seaport and directly linked to a seaport with high capacity land transportation modes such as highways and/or railways. In addition to creating efficient freight flow, dry ports enhance hinterlands of seaports and allow penetrating the hinterlands of rival seaports.

The significant role of dry ports in flawless inland access, overcoming capacity constraints as well as the competitiveness of seaports has drawn the attention of industry practitioners in the maritime freight transportation chain. This attention of the industry triggered academic interest towards dry ports. Much scholarly research has investigated dry ports in recent years. However, studies empirically investigating the impacts of dry ports in inland logistics of maritime containers are rather scarce. Additionally, existing studies either consider transportation cost as the only factor that determines dry port usage or does not include railway capacity constraints in their analyses. The research area of this thesis is located in Turkey. Turkey is a country which is strategically positioned in the international freight transportation corridors between Europe, Central-Asia, and Middle-East. Considering road, rail, and air transportation networks, Turkey is in the center for international transportation projects such as TRACECA and OBOR. Dry ports

in Turkey can be enablers for flawless freight transportation through the international corridors. Therefore, government agencies and private establishments are increasingly interested in the construction of dry ports in Turkey. In this regard, there is a need to investigate the effects of dry ports on inland container logistics in Turkey.

This thesis aims to evaluate the effects of dry ports on inland container logistics in Turkey. The analysis takes into account attributes besides transportation costs that affect the rail-based dry port usage in an inland transport corridor between the seaports of Izmir and city of Denizli. To meet the aim, two interlinked objectives were put forward. The first objective is to investigate how the inland transportation service attributes affect the mode choice in the inland transportation corridor. The second objective is to evaluate how the variations in inland transportation service attributes affect rail-based dry port usage and inland container logistics. The results of the first objective were integrated into the second objective and effects of variations in the attributes on the inland container logistics were revealed.

The research process of this thesis was designed as two parts considering the two objectives. To meet the first objective, the first part investigated how the variations in the attributes affect inland transportation mode choice probabilities in the corridor using a method called stated choice experiment. First of all the attributes and the attribute levels included in the stated choice experiment were identified by a qualitative research using literature review and semi-structured interviewing method. Five attributes were identified to include the stated choice experiment. The four of the attributes, which are cost, transport time, delays, and frequency, is the most widely used attributes in the related literature. The interview showed that they are also important for mode choice in the inspected inland freight transport corridor. The fifth attribute named the free time that is specific to inland container transportation is identified through the interviews. Free time is defined as the duration a container stays in a seaport or a dry port free of container storage charge.

After the attributes and their levels were determined, stated choice experiment was conducted. Analysis of the discrete choice models showed that all of the attributes except transport time attribute is statistically significant meaning that shippers and logistics service providers do not consider transportation time while selecting transportation

mode in the corridor. Additionally, the random coefficient mixed logit estimate provided better model fit than conditional logit estimate. The elasticity analysis showed that the transportation cost attribute has the most substantial impact on the mode choice. 1% increase in the cost of road transport resulted with a 1.61% decrease in the mode choice probability of the road alternative while causing a 5.38 % increase in the choice probability of rail-based dry port alternative. Additionally, 1% increase in the cost of the rail-based dry port alternative causes a 1.13 % increase in the mode choice probability of road alternative while reducing its share 3.77%.

The second part of the research investigated how the variations in inland transportation service attributes affect rail-based dry port usage and inland container logistics using discrete event simulation modeling. The results suggested that both Scenario-1, decreasing the cost of rail-based dry port service, and Scenario-2, increasing the cost of road transportation are very effective ways for creating mode shift from road to rail-based dry port. Scenario-1 showed that 20% decrease in the cost of rail-based dry port service decreases the road ton-km up to 35.2% and decrease the total inland transportation costs up to 15.4%. Results of Scenario-2 indicated that 20% increase in the cost of road transport results with a 32.9% decrease in the road ton-km. However, this causes a 3.9% increase in the total inland transportation cost. Scenario-3 results confirmed this scenario was not as effective as the other two. The results indicated that up to 50% decrease in the delays of rail-based dry port service decreases the road ton-km up to 10.1% and decreases total inland transportation costs 2%. These results suggest increasing the road transportation costs is effective for reducing negative impacts of road transport but it resulted with a considerable increase in total inland transportation costs that can cause an overall increase in the cost of goods thus causing negative economic and social impacts. Results also suggested that it can be more useful to adopt a comprehensive approach which combines policies and practices that decrease delays of rail-based dry port service and decreasing its cost.

The scenario analysis also showed the significance of available train frequency. Increasing mode shift to rail-based dry port service increase the need for additional train frequency, for example, decreasing the rail-based dry port service cost by 20% which resulted in the necessity of increasing the export train frequency from 6 shipments

per week to 15.7 shipments per week. Provision of more train frequency necessitates infrastructural improvements.

The impact of dry ports usage on inland container logistics depends on how well the customers' preferences are met. The increase in the use of rail-based dry ports, in any case, reduces the ton-km of road transport thus reducing the environmental impacts. However, the decline in total inland container transportation costs is depend on the ways to increase demand for rail-based dry port use. When the usage of rail-based dry port is increased by lowering the cost of the rail-based dry port service, the total inland container logistics cost is reduced. Additionally, increasing the demand for dry port usage by reducing the percentage of delayed shipments also decreases total inland container logistics costs. However, if the demand for the rail-based dry port is increased by increasing road transportation costs, the total inland container logistics costs are increased. The frequency of railway transport between dry port and seaport also has a significant impact on the inland container logistics. When the demand for rail-based dry port service increases, it is necessary to increase the carrying capacity by increasing the frequency of the railway transportation to meet the demand. Increasing the carrying capacity prevents the congestion that may occur and increases customer satisfaction by decreasing the possible delays.

The results revealed the positive role played by dry ports reducing environmental impacts and inland transportation costs. Therefore, supportive policies for dry port development within TRACECA or OBOR projects can help to strengthen links of the freight transportation corridors. However, location of dry port should be carefully assessed to ensure availability of demand and the impacts of the dry ports on transportation corridor should be assessed with the methodological approach proposed in this thesis to determine which policies and practices are more effective and creates desired impacts on both environment and total transportation costs. Additionally, required capacity to meet the demand for railway corridor to be built within TRACECA or OBOR projects can be assessed by the methodological approach of this thesis.

The scope of this thesis is limited to inland transportation corridor between seaports located in Izmir and Denizli. And, only containerized shipments were included in the analysis. Future work should study other regions and other dry ports in Turkey.

Additionally, dry ports which are located in the countries that have excess dry port capacity such as USA and EU, should be analyzed using the methodological approach presented in this thesis to determine effective demand creation policies for decreasing total transportation costs and negative environmental impacts. It would be interesting to include cargo types other than containerized cargo. The length of the inland transportation corridor studied in this thesis is less than 250 kms. Further investigations should study longer distances to reveal the changes in the impacts of dry port usage regarding the distance between dry ports and seaports. Dry ports can significantly affect seaport operations and urban traffic. Hence, it would be useful to enhance the scope of the analysis to include the impacts of dry ports usage on operations and efficiency of seaports as well as urban traffic flow.

REFERENCES

Abdelwahab, W. and Sargious, M. (1992). Modelling the demand for freight transport: a new approach. *Journal of Transport Economics and Policy*, pages 49–70.

Akhtar, S. (2010). Faisalabad dry port: brief history and achievements. Retrieved from http://fp.brecorder.com/2010/01/201001261012609/, (13.02.2018).

Akçay, N. (2017). Yeni İpek yolu projesi kapsamında türkiye Çin İlişkileri. *Bölgesel Araştırmalar Dergisi*, 1(3):73–96.

Alonso, L. G., Pardo, A. M., and Pinto, J. A. V. (2016). Analysis of the spatial development of the hinterland of ports: A case study. *International Journal of Shipping and Transport Logistics*, 8(2):111.

Altiok, T. and Melamed, B. (2010). *Simulation modeling and analysis with Arena*. Academic press.

Ankara Lojistik Ussu (2018). Proje. Retrieved from http://www.ankaralojistikussu.com/, (12.01.2018).

Arencibia, A. I., Feo-Valero, M., García-Menéndez, L., and Román, C. (2015). Modelling mode choice for freight transport using advanced choice experiments. *Transportation Research Part A: Policy and Practice*, 75:252–267.

Awad-Núñez, S., González-Cancelas, N., Soler-Flores, F., and Camarero-Orive, A. (2015). How should the sustainability of the location of dry ports be measured? a proposed methodology using bayesian networks and multi-criteria decision analysis. *Transport*, 30(3):312–319. cited By 1.

BAAS International Group (2013). Riyadh dry port. Retrieved from http://www.riyadhdryport.com/03-RDP.php, (13.02.2018).

Bahçıvan, S. (2017). Tcdd yenice lojistik merkezi tüm hızıyla devam ediyor. Retrieved from http://tarsusnethaber.com/tcdd-yenice-lojistik-merkezi-tum-hiziyla-devam-ediyor/, (12.01.2018).

Ballou, R. (1973). *Business Logistics Management*. Prentice-Hall international editions. Prentice Hall.

Ballou, R. (1992). *Business Logistics Management*. Prentice-Hall international editions. Prentice Hall.

Ballou, R. (2004). *Business Logistics/supply Chain Management: Planning, Organizing, and Controlling the Supply Chain*. Pearson International edition. Pearson Prentice Hall.

Ballou, R. H. (2007). The evolution and future of logistics and supply chain management. *European Business Review*, 19(4):332–348.

Banks, J. (1991). Selecting simulation software. In *IEEE*, pages 15–20.

Banks, J., Carson, J. S., Nelson, B. L., and Nicol, D. M. (2010). *Discrete-Event System Simulation*. PrenticeHall.

Bask, A., Roso, V., Andersson, D., and Hämäläinen, E. (2014). Development of seaport-dry port dyads: Two cases from Northern Europe. *Journal of Transport Geography*, 39:85–95.

Benson, D. (1997). Simulation modeling and optimization using promodel. In *Proceedings of the 29th conference on Winter simulation*, pages 587–593. IEEE Computer Society.

Berawi, M. A., Zagloel, T. Y. M., Berawi, A. R. B., and Abdurachman, Y. (2015). Feasibility analysis of trans-sumatera toll road using value engineering method. *International Journal of Technology*, 6(3):388.

Beresford, A. and Dubey, R. (1991). *Handbook on the management and operation of dry ports*. UNCTAD, Geneva, Switzerland.

Beresford, A., Pettit, S., Xu, Q., and Williams, S. (2012). A study of dry port development in China. *Maritime Economics & Logistics*, 14(1):73–98.

Bergantino, A. S., Bierlaire, M., Catalano, M., Migliore, M., and Amoroso, S. (2013). Taste heterogeneity and latent preferences in the choice behaviour of freight transport operators. *Transport Policy*, 30:77–91.

Bichou, K. and Gray, R. (2005). A critical review of conventional terminology for classifying seaports. *Transportation Research Part A: Policy and Practice*, 39(1):75–92.

Bilim, Sanayi ve Teknoloji Bakanlığı (2018). Denizli İlinde bulunan organize sanayi bölgeleri. Retrieved from https://osbbs.sanayi.gov.tr/citydetails.aspx?dataID=210, (12.01.2018).

Bird, J. H. (1963). *The major seaports of the United Kingdom*. Hutchinson.

Borsodi, R. (1927). *The Distribution Age*. D. Appleton and Company.

Bowersox, D., Closs, D., and Cooper, M. (2007). *Supply Chain Logistics Management*. McGraw-Hill/Irwin series operations and decision sciences. McGraw-Hill/Irwin.

Bowersox, D. J. (1969). Physical distribution development, current status, and potential. *The Journal of Marketing*, pages 63–70.

Casas, J., Ferrer, J. L., Garcia, D., Perarnau, J., and Torday, A. (2010). Traffic simulation with aimsun. In *Fundamentals of traffic simulation*, pages 173–232. Springer.

Cetin, I. B. (2007). *Deniz ticaretinin geliştirilmesinde ulaştırma ağları için ilgi analizleri: Türkiye-Almanya-Çin uygulaması*. PhD thesis, DEÜ Sosyal Bilimleri Enstitüsü.

Chang, Z., Notteboom, T., and Lu, J. (2015). A two-phase model for dry port location with an application to the port of Dalian in China. *Transportation Planning and Technology*, 38(4):442–464.

Chen, S.-L. S. L., Jeevan, J., and Cahoon, S. (2016). Malaysian Container Seaport-Hinterland Connectivity: Status, Challenges and Strategies. *Asian Journal of Shipping and Logistics*, 32(3):127–138.

Choi, B. K. and Kang, D. (2013). *Modeling and simulation of discrete event systems*. John Wiley & Sons.

Christopher, M. (2016). *Logistics & supply chain management*. Pearson UK.

Clark, F. E. (1922). *Principles of marketing*. Macmillan Co.

Clark, F. E. (1924). *Readings in marketing*. The Macmillan Company.

Clott, C., Hartman, B. C., Ogard, E., and Gatto, A. (2015). Container repositioning and agricultural commodities: Shipping soybeans by container from US hinterland to overseas markets. *Research in Transportation Business and Management*, 14:56–65.

Cochran, J. (2016). Nepal birgunj dry rail port. Retrieved from http://dlca.logcluster.org/display/public/DLCA/2.1.2+Nepal+Birgunj+Dry+Rail+Port;jsessionid=48B7190BE770E78D786FE6A6B1380E50, (13.02.2018).

Converse, P. D. (1954). The other half of marketing. In *The other half of marketing*, pages 22–25. Harper and Brothers Publishers Boston, MA.

Corlu Ticaret ve Sanayi Odası (2014). Çorlu tso´dan "Çorlu lojistik köy" projesi. Retrieved from http://www.corlutso.org.tr/haber-275-corlu_tsoacutedan_quotcorlu_lojistik_koyquot_projesi.html, (12.01.2018).

Costa, V., Souza, K. R., Teixeira, L. R., Hedlund, C. J., Fernandes Filho, L. A., and Cardoso, L. S. (2015). Health and Labour from the Perspective of Railway Dock workers in Rio Grande do Sul, Brazil. *Ciencia e Saude Coletiva*, 20(4):1207–1216.

Crainic, T. G., Dell'Olmo, P., Ricciardi, N., and Sgalambro, A. (2015). Modeling dry-port-based freight distribution planning. *Transportation Research Part C: Emerging Technologies*, 55:518–534.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3):297–334.

Crowell, J. F. (1901). *Report of the industrial commission on the distribution of farm products*, volume 6. US Government Printing Office.

CSCMP (2013a). Cscmp celebrates 50 years. Retrieved from http://www.cscmpchicago.org/cscmp-celebrates-50-years/, (12.01.2018).

CSCMP (2013b). *CSCMP Supply Chain Management Definitions and Glossary*. Council of Supply Chain Management Professionals.

Danielis, R. and Marcucci, E. (2007). Attribute cut-offs in freight service selection. *Transportation Research Part E: Logistics and Transportation Review*, 43(5):506–515.

de Cerreño, A. L. C., Shin, H.-S., Strauss-Wieder, A., and Theofanis, S. (2008). Feasibility of Freight Villages in the NYMTC Region. *Center for Advanced Infrastructure and Transportation Freight and Maritime Program. Rutgers, The State University of New Jersey and NYU Rudin Center for Transportation and Management*.

Denizli Sanayi Odası (2018). Denizli sanayi odası meslek gruplarına göre Üye sayıları (2018). Retrieved from http://www.dso.org.tr/images/file/istatistik/2009/dso1.pdf, (12.01.2018).

Department of Customs (2018). Government of nepal ministry of finance department of customs dry port office. Retrieved from http://www.customs.gov.np/district/en/dryport/homepage.html, (13.02.2018).

Dicken, P. (1998). *Global shift: Transforming the world economy*. SAGE Publications.

Do, N., Nam, C., and Le, Q. (2011). A consideration for developing a dry port system in Indochina area. *Maritime Policy and Management*, 38(1):1–9.

Domenich, T. and McFadden, D. (1975). *Urban Travel Demand: A Behavioral Analysis*. North-Holland Publishing Co., Amsterdam, Netherlands.

Drucker, P. F. (1962). The economy's dark continent. *Fortune*, 65(103):265–270.

Dupuit, J. (1844). On the measurement of the utility of public works. *International Economic Papers*, 2(1952):83–110.

Ekinci, I. (2013). 17 lojistik köyün 7'sinde ilk etap inşaatlar bitti. Retrieved from https://www.dunya.com/sektorler/teknoloji/17-lojistik-koyun-7039sinde-ilk-etap-insaatlar-bitti-haberi-207163, (12.01.2018).

Emrich, S., Suslov, S., and Judex, F. (2007). Fully agent based. modellings of epidemic spread using anylogic. In *Proc. EUROSIM*, pages 9–13.

ESCAP (2006). *Cross Cutting issue for managing globalization related to trade and transporte: promoting dry ports as a means of sharing the benefits of globalization with inland location*. UN.

Eskilstuna Logistik och Etablering (2017). Intermodal terminal. Retrieved from https://www.eskilstunalogistik.se/en/intermodal-terminal/, (12.02.2018).

Europa Press (2015). El puerto seco santander-ebro da servicio a más del 60nacional. Retrieved from http://www.europapress.es/cantabria/puerto-santander-00660/noticia-puerto-seco-santander-ebro-da-servicio-mas-60-mercado-nacional-20101118145128.html, (12.02.2018).

Europe Container Terminals (2016). Tct venlo. Retrieved from http://www.ect.nl/en/node/209, (12.02.2018).

Europlatforms, E. (2004). Logistics Centres Directions for Use. *site: www. unece. org/trans/main/eatl/docs/EN-REV-What is a Freight VillageFinalcorretto. pdf*.

Faisalabad Dry Port (2009a). About us. Retrieved from http://www.faisalabaddryport.com/aboutus.html, (13.02.2018).

Faisalabad Dry Port (2009b). Services. Retrieved from http://www.faisalabaddryport.com/services.html, (13.02.2018).

Fanti, M. P., Iacobellis, G., Ukovich, W., Boschian, V., Georgoulas, G., and Stylios, C. (2015). A simulation based Decision Support System for logistics management. *Journal of Computational Science*, 10:86–96.

Fawcett, S. E. and Magnan, G. M. (2002). The rhetoric and reality of supply chain integration. *International Journal of Physical Distribution & Logistics Management*, 32(5):339–361.

Feng, X., Zhang, Y., Li, Y., and Wang, W. (2013). A location-allocation model for seaport-dry port system optimization. *Discrete Dynamics in Nature and Society*, 2013.

Feo, M., Espino, R., and García, L. (2011). An stated preference analysis of Spanish freight forwarders modal choice on the south-west Europe Motorway of the Sea. *Transport Policy*, 18(1):60–67.

Feo-Valero, M., Arencibia, A. I., and Román, C. (2016a). Analyzing discrepancies between willingness to pay and willingness to accept for freight transport attributes. *Transportation Research Part E: Logistics and Transportation Review*, 89:151–164.

Feo-Valero, M., García-Menéndez, L., and del Saz-Salazar, S. (2016b). Rail freight transport and demand requirements: an analysis of attribute cut-offs through a stated preference experiment. *Transportation*, 43(1):101–122.

Feo-Valero, M., García-Menéndez, L., Sáez-Carramolino, L., and Furió-Pruñonosa, S. (2011). The importance of the inland leg of containerised maritime shipments: An analysis of modal choice determinants in Spain. *Transportation Research Part E: Logistics and Transportation Review*, 47(4):446–460.

Ferrari, C., Parola, F., and Gattorna, E. (2011). Measuring the quality of port hinterland accessibility: The Ligurian case. *Transport Policy*, 18(2):382–391.

Flämig, H. and Hesse, M. (2011). Placing dryports. Port regionalization as a planning challenge - The case of Hamburg, Germany, and the Süderelbe. *Research in Transportation Economics*, 33(1):42–50.

García-Menéndez, L., Martínez-Zarzoso, I., and Pinero De Miguel, D. (2004). Determinants of mode choice between road and shipping for freight transport: Evidence for four Spanish exporting sectors. *Journal of Transport Economics and Policy*, 38(3):447–466.

Guerrero, D. (2014). Deep-sea hinterlands: Some empirical evidence of the spatial impact of containerization. *Journal of Transport Geography*, 35:84–94.

Haaijer, R., Kamakura, W. A., and Wedel, M. (2001). The'no-choice'alternative in conjoint choice experiments. *International Journal of Market Research*, 43.

Haberler.com (2017). Kars lojistik merkezi'nin yüzde 25'i tamamlandı. Retrieved from https://www.haberler.com/kars-lojistik-merkezi-nin-yuzde-25-i-tamamlandi-9980559-haberi/, (12.01.2018).

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., and Tatham, R. L. (2007). *Multivariate data analysis*. Prentice hall Upper Saddle River, NJ.

Hanaoka, S. and Regmi, M. B. (2011). Promoting intermodal freight transport through the development of dry ports in Asia: An environmental perspective. *IATSS Research*, 35(1):16–23.

Handfield, R. B. and Nichols, E. L. (1999). *Introduction to supply chain management*. Univerza na Primorskem, Znanstveno-raziskovalno središče.

Haralambides, H. and Gujar, G. (2011). The Indian dry ports sector, pricing policies and opportunities for public-private partnerships. *Research in Transportation Economics*, 33(1):51–58.

Haralambides, H. and Gujar, G. (2012). On balancing supply chain efficiency and environmental impacts: An eco-DEA model applied to the dry port sector of India. *Maritime Economics & Logistics*, 14(1):122–137.

Hauber, A. B., González, J. M., Groothuis-Oudshoorn, C. G., Prior, T., Marshall, D. A., Cunningham, C., IJzerman, M. J., and Bridges, J. F. (2016). Statistical Methods for the Analysis of Discrete Choice Experiments: A Report of the ISPOR Conjoint Analysis Good Research Practices Task Force. *Value in Health*, 19(4):300–315.

Hayuth, Y. (1981). Containerization and the load center concept. *Economic Geography*, 57(2):160–176.

Hayuth, Y. (1988). Rationalization and deconcentration of the united-states container port system. *Professional Geographer*, 40(3):279–288.

He, T. (2011). Inte'l "dry" port to be built in kunming. Retrieved from http://en.kunming.cn/index/content/2011-03/15/content_2447739.htm, (14.02.2018).

Hensher, D. A. (1994). Stated preference analysis of travel choices: the state of practice. *Transportation*, 21(2):107–133.

Hensher, D. A., Rose, J. M., and Greene, W. H. (2005). *Applied Choice Analysis: A Primer*. Cambridge University Press, New York, New York.

Henttu, V. and Hilmola, O. P. (2011). Financial and environmental impacts of hypothetical Finnish dry port structure. *Research in Transportation Economics*, 33(1):35–41.

Henttu, V., Lättilä, L., and Hilmola, O. P. (2011). Optimization of relative transport costs of a hypothetical dry port structure. *Transport and Telecommunication*, 12(2):12–19.

Heskett, J. L. (1964). *Business logistics: management of physical supply and distribution*. Ronald Press Co.

Higgins, C. D., Ferguson, M., and Kanaroglou, P. S. . (2012). Varieties of logistics centers. *Transportation Research Record*, 2288(-1):9–18.

Himalayan Terminals (2017). About htpl. Retrieved from http://www.customs.gov.np/district/en/dryport/homepage.html, (13.02.2018).

Hoffman, S. D. and Duncan, G. J. (1988). Multinomial and Conditional Logit Discrete-Choice Models in Demography. *Source: Demography*, 25(3):415–427.

Holtgen, D. (1996). Intermodal terminals in the trans-european network. In *24th European Transport Forum. Proceedings of Seminar A: Pan- European Transport Issues*.

Hongyan, L. and Fan, Y. (2015). Railway container center. Retrieved from http://en.itl.gov.cn/2015-11/05/content_22381119.htm, (14.02.2018).

Hou, H., Chaudhry, S., Chen, Y., and Hu, M. (2017). Physical distribution, logistics, supply chain management, and the material flow theory: a historical perspective. *Information Technology and Management*, 18(2):107–117.

Hoyle, B. S. (1968). East african seaports: An application of the concept of 'anyport'. *Transactions of the Institute of British Geographers*, 44:163–183.

http://www.karsolay.com (2017). Kars'ta lojistik köyün temeli atıldı. Retrieved from http://www.karsolay.com/haber/karsta-lojistik-koyun-temeli-atildi/579/, (09.06.2018).

Hurriyet.com (2017). Lojistik köy projesi nisan'da start alacak. Retrieved from http://www.hurriyet.com.tr/lojistik-koy-projesi-nisanda-start-alacak-40375686, (12.01.2018).

Iannone, F. (2012). The private and social cost efficiency of port hinterland container distribution through a regional logistics system. *Transportation Research Part A: Policy and Practice*, 46(9):1424–1448.

IMF (2018). Gross domestic product (gdp). Retrieved from http://www.imf.org/external/datamapper/NGDP_RPCH@WEO/WEOWORLD, (12.01.2018).

Jadrić, M., Ćukušić, M., and Bralić, A. (2014). Comparison of discrete event simulation tools in an academic environment. *Croatian Operational Research Review*, 5(2):203–219.

Janelle, D. G. and Beuthe, M. (1997). Globalization and research issues in transportation. *Journal of Transport Geography*, 5(3):199–206.

Jaržemskis, A. and Vasiliauskas, A. V. (2007). Research on dry port concept as intermodal node. *Transport*, 22(3):207–213.

Jeevan, J., Chen, S. L., and Cahoon, S. (2017). Determining the influential factors of dry port operations: Worldwide experiences and empirical evidence from Malaysia. *Maritime Economics & Logistics*, pages 1–19.

Jeevan, J., Chen, S. L., and Lee, E. S. (2015). The challenges of Malaysian dry ports development. *Asian Journal of Shipping and Logistics*, 31(1):109–134.

Jieru, G. (2014). Yunnan's biggest warehousing and logistics port to open. Retrieved from http://www.chinadaily.com.cn/m/yunnan/kunmingsciencepark/2014-10/16/content_18772255.htm, (14.02.2018).

Ka, B. (2011). Application of fuzzy AHP and ELECTRE to China dry port location selection. *Asian Journal of Shipping and Logistics*, 27(2):331–354.

Karadeniz, V. and Akpınar, E. (2011a). Türkiye'de lojistik köy uygulamalari ve yeni bir lojistik köy Önerisi. *Marmara Coğrafya Dergisi*.

Karadeniz, V. and Akpınar, E. (2011b). Türkiye'de lojistik köy uygulamaları ve yeni bir lojistik köy önerisi. *Marmara Coğrafya Dergisi*.

Kargohaber.com (2010). Ankara lojistik Üssü törenle açıldı. Retrieved from http://www.kargohaber.com/ankara-lojistik-ussu-torenle-acildi-474h.htm, (12.01.2018).

Kelle, P. and Jin, M. (2016). A Simulation Model for Intermodal Freight Transportation in Louisiana. Technical report, National Center for Intermodal Transportation for Economic Competitiveness (NCITEC).

Kent Jr, J. L. and Flint, D. J. (1997). Perspectives on the evolution of logistics thought. *Journal of Business Logistics*, 18(2):15.

Klojgaard, M. E., Bech, M., and Sogaard, R. (2012). Designing a stated choice experiment: The value of a qualitative process. *Journal of Choice Modelling*, 5(2):1–18.

Kokkinogenis, Z., Passos, L. S., Rossetti, R., and Gabriel, J. (2011). Towards the next-generation traffic simulation tools: a first evaluation. In *6th iberian conference on information systems and technologies*, pages 15–18.

Komchornrit, K. (2017). The selection of dry port location by a hybrid cfa-macbeth-promethee method: A case study of southern thailand. *The Asian Journal of Shipping and Logistics*, 33(3):141–153.

Kopytov, E. and Abramov, D. (2012). Multiple-criteria analysis and choice of transportation alternatives in multimodal freight transport system. *Transport and Telecommunication*, 13(2):148–158.

Korovyakovsky, E. and Panova, Y. (2011). Dynamics of Russian dry ports. *Research in Transportation Economics*, 33(1):25–34.

Kramberger, T., Rupnik, B., Štrubelj, G., and Prah, K. (2015). Port hinterland modelling based on port choice. *PROMET-Traffic&Transportation*, 27(3):195–203.

Kroes, E. P. and Sheldon, R. J. (1988). Stated Preference Methods - an Introduction. *Journal of Transport Economics and Policy*, 22(1):11–25.

Kronbak, J. and Cullinane, K. (2011). *International Handbook of Maritime Economics*, chapter Captive and contestable port hinterlands: Modelling and visualization using GIS, pages 348–362. Edward Elgar Publishing Ltd.

Kuby, M. and Reid, N. (1992). Technological change and the concentration of the u.s. general cargo port system: 1970-88. *Economic Geography*, 68(3):272–289.

Kuder, G. F. and Richardson, M. W. (1937). The theory of the estimation of test reliability. *Psychometrika*, 2(3):151–160.

Kuhfeld, W. (2010). *Marketing research methods in SAS*. SAS Institute Inc.

Lambert, D. M., Cooper, M. C., and Pagh, J. D. (1998). Supply chain management: implementation issues and research opportunities. *The international journal of logistics management*, 9(2):1–20.

Lambert, D. M., Robeson, J. F., and Stock, J. R. (1978). An appraisal of the integrated physical distribution management concept. *International Journal of Physical Distribution & Materials Management*, 9(1):74–88.

Larranaga, A. M., Arellana, J., and Senna, L. A. (2016). Encouraging intermodality: A stated preference analysis of freight mode choice in Rio Grande do Sul. *Transportation Research Part A: Policy and Practice*, 102:202–211.

Last, J. M., Abramson, J. H., and Freidman, G. D. (2001). *A dictionary of epidemiology*, volume 4. Oxford university press, New York, New York.

Lättilä, L., Henttu, V., and Hilmola, O. P. (2013). Hinterland operations of sea ports do matter: Dry port usage effects on transportation costs and CO2 emissions. *Transportation Research Part E: Logistics and Transportation Review*, 55(SI):23–42.

Lee, P. T., Hu, Z., Lee, S., Choi, K., and Shin, S. (2017). Research trends and agenda on the Belt and Road (B&R) initiative with a focus on maritime transport.

Leitner, S. J. and Harrison, R. (2001). The identification and classification of inland ports. Technical report, Texas Department of Transportation.

Leveque, P. and Roso, V. (2002). *Dry Port concept for seaport inland access with intermodal solutions*. PhD thesis, Chalmers University of Technology.

Lewis, H. T., Culliton, J. W., and Steele, J. D. (1956). Role of air freight in physical distribution. *The Journal of the Royal Aeronautical Society*.

Li, Y., Dong, Q., and Sun, S. (2015). Dry port development in china: Current status and future strategic directions. *Journal of Coastal Research*, pages 641–646.

Li, Z. and Hensher, D. (2012). Accommodating Risk Attitudes in Freight Transport Behaviour Research. *Transport Reviews*, 32(2):221–239.

Lihoussou, M. and Limbourg, S. (2012). Network design model for intermodal transport: the case of the hinterland of the Port of Cotonou. In *4th International Conference on Information Systems, Logistics and Supply Chain*, page 7.

Logent (2017). Hallsberg. Retrieved from http://logent.se/en/services/port-hub/intermodal-terminals/hallsberg/, (12.02.2018).

Louviere, J. J., Flynn, T. N., and Carson, R. T. (2010). Discrete choice experiments are not conjoint analysis. *Journal of Choice Modelling*, 3(3):57–72.

Maciejewski, M. (2010). A comparison of microscopic traffic flow simulation systems for an urban area. *Transport Problems*, 5:27–38.

Margulis, R. (2018). Savannah gateway industrial hub certified a market-ready site by georgia department of economic development. Retrieved from https://www.businesswire.com/news/home/20180201006079/en/Savannah-Gateway-Industrial-Hub-Certified-Market-Ready-Site, (13.02.2018).

Maria, A. (1997). Introduction to modeling and simulation. In *IEEE Computer Society*, pages 7–13.

Masiero, L. and Hensher, D. A. (2010). Analyzing loss aversion and diminishing sensitivity in a freight transport stated choice experiment. *Transportation Research Part A: Policy and Practice*, 44(5):349–358.

Masiero, L. and Hensher, D. A. (2011). Shift of reference point and implications on behavioral reaction to gains and losses. *Transportation*, 38(2):249–271.

Masiero, L. and Hensher, D. A. (2012). Freight transport distance and weight as utility conditioning effects on a stated choice experiment. *Journal of Choice Modelling*, 5(1):64–76.

McFadden, D. (1973). *Conditional logit analysis of qualitative choice behavior*, pages 105–142. Academic Press.

McFadden, D. (1974). The Measurement of Urban Travel Demand. *Journal of Public Economics*, 3(4):303–328.

McFadden, D. (1975). The revealed preferences of a government bureaucracy: Theory. *The Bell Journal of Economics*, pages 401–416.

Meers, D., Macharis, C., Vermeiren, T., and van Lier, T. (2017). Modal choice preferences in short-distance hinterland container transport. *Research in Transportation Business and Management*, 23:46–53.

Meidute, I. (2004). The Development and Perspectives of Logistics Centres in Lithuania. *Reliability and statistics in transportation and communication*, 4:323–328.

Meidute, I. (2005). Comparative analysis of the definitions of logistics centres. *Transport*, 20(February 2015):106–110.

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., and Zacharia, Z. G. (2001). Defining supply chain management. *Journal of Business logistics*, 22(2):1–25.

Mentzer, J. T., Gomes, R., and Krapfel Jr, R. E. (1989). Physical distribution service: a fundamental marketing concept? *Journal of the academy of marketing science*, 17(1):53–62.

Merkuryeva, G. and Bolshakovs, V. (2010). Vehicle schedule simulation with anylogic. In *12th International Conference on Computer Modelling and Simulation (UKSim), 2010*, pages 169–174. IEEE.

Mid-America Freight Coalition (2018). Bnsf logistics park—chicago. Retrieved from http://midamericafreight.org/rfs/network-inventory/rail/intermodal-facilities/bnsf-logistics-park-chicago/, (12.02.2018).

Monios, J. (2011). The role of inland terminal development in the hinterland access strategies of Spanish ports. *Research in Transportation Economics*, 33(1):59–66.

Monios, J. (2016). *Institutional challenges to intermodal transport and logistics: governance in port regionalisation and hinterland integration*. Routledge.

Monios, J. and Wilmsmeier, G. (2012a). Giving a direction to port regionalisation. *Transportation Research Part A: Policy and Practice*, 46(10):1551–1561.

Monios, J. and Wilmsmeier, G. (2012b). Port-centric logistics, dry ports and offshore logistics hubs: strategies to overcome double peripherality? *Maritime Policy and Management*, 39(January 2015):37–41.

Morgan, D. (2017). Xi'an port: A dry port shines on silk road. Retrieved from http://www.chinadaily.com.cn/m/shaanxi/itl/2017-04/24/content_29062892.htm, (14.02.2018).

MOS Lojistik (2015). Hakkımızda. Retrieved from http://www.moslojistik.com/hakkimizda30, (12.01.2018).

Munford, C. (1980). Buenos Aires-congestion and the dry port solution. *Cargo Systems International: The Journal of ICHCA*, 7(10):26–27.

Muravev, D. and Rakhmangulov, A. (2016). Environmental Factors' Consideration at Industrial Transportation Organization in the «seaport-Dry port» System. *Open Engineering*, 6(1):476–484.

Murphy, K. R. and Davidshofer, C. O. (1988). *Psychological testing*. Pearson Education International.

Mustafa, B., Turkmen, M., and Duygu, K. (2017). Denizli-kaklık lojistik köyünün swot analizi ile değerlendirmesi. *Mehmet Akif Ersoy Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 9(22):555–574.

Neufville, R. D. and Tsunokawa, K. (1981). Productivity and returns to scale of container ports. *Maritime Policy & Management*, 8(2):121–129.

Ng, A. and Gujar, G. (2009a). The spatial characteristics of inland transport hubs: Evidences from Southern India. *Journal of Transport Geography*, 17(5):346–356.

Ng, A. K. Y. and Cetin, I. B. (2012). Locational characteristics of dry ports in developing economies: Some lessons from northern india. *Regional Studies*, 46(6):757–773.

Ng, A. K. Y. and Gujar, G. (2009b). Government policies, efficiency and competitiveness: The case of dry ports in India. *Transport Policy*, 16(5):232–239.

Ng, A. K. Y. and Gujar, G. (2009c). The spatial characteristics of dry ports in India. *Development of Dry Ports*, page 102.

Ng, A. K. Y., Padilha, F., and Pallis, A. A. (2013a). Institutions, bureaucratic and logistical roles of dry ports: The Brazilian experiences. *Journal of Transport Geography*, 27:46–55.

Ng, A. K. Y. and Tongzon, J. L. (2010). The transportation sector of india's economy: Dry ports as catalysts for regional development. *Eurasian Geography and Economics*, 51(5):669–682.

Ng, A. K. Y., Wang, T., Yang, Z., Li, K. X., and Jiang, C. (2016). How is Business Adapting to Climate Change Impacts Appropriately? Insight from the Commercial Port Sector. *Journal of Business Ethics*, pages 1–19.

Ng, A. Y., Hall, P. V., and Pallis, A. A. (2013b). Guest editors' introduction: Institutions and the transformation of transport nodes. *Journal of Transport Geography*, 27:1–3.

Nguyen, L. C. and Notteboom, T. (2016). A multi-criteria approach to dry port location in developing economies with application to vietnam. *Asian Journal of Shipping and Logistics*, 32(1):23–32.

Notteboom, T. (1997). Concentration and load centre development in the European container port system. *Journal of Transport Geography*, 5(2):99–115.

Notteboom, T. (2010). Concentration and the formation of multi-port gateway regions in the European container port system: An update. *Journal of Transport Geography*, 18(4):567–583.

Notteboom, T. and Rodrigue, J. (2007). Re-assessing port-hinterland relationships in the context of global supply chains. *Ports, Cities, and Global Supply Chains*, pages 51–66.

Notteboom, T. and Rodrigue, J. P. (2004). Inland freight distribution and the sub-harborization of port terminals. In *Proceedings of the 1st International Conference on Logistics Strategies for Ports*.

Notteboom, T. and Rodrigue, J. P. (2005). Port regionalization: Towards a new phase in port development. *Maritime Policy & Management*, 32(3):297–313.

Notteboom, T. and Rodrigue, J.-P. (2008). Containerisation, Box Logistics and Global Supply Chains: The Integration of Ports and Liner Shipping Networks. *Maritime Economics & Logistics*, 10(1-2):152–174.

Notteboom, T. and Rodrigue, J. P. (2009). Inland terminals within north american and european supply chains. *Transport and Communications Bulletin for Asia and the Pacific*, 78(78.):39p.

Notteboom, T. and Yang, Z. (2017). Port governance in China since 2004: Institutional layering and the growing impact of broader policies. *Research in Transportation Business and Management*, 22:184–200.

Notteboom, T. E. (2008). The Relationship between Seaports and the Intermodal Hinterland in light of Global Supply Chains. *OECD/ITF Joint Transport Research Centre Discussion Papers*.

Nugroho, M. T., Whiteing, A., and de Jong, G. (2016). Port and inland mode choice from the exporters' and forwarders' perspectives: Case study — Java, Indonesia. *Research in Transportation Business & Management*, 19:73–82.

Nunally, J. (1978). Psychometric Theory. *Auflage, New York ua: Mc Graw-Hill*.

Oey, E. and Setiawan, V. (2017). Evaluating import cargo performance through Tanjung Priok sea port vs. Cikarang dry port - a case study in a FMCG company in Indonesia. *International Journal of Logistics Systems and Management*, 26(3):379.

Oliver, R. K. and Webber, M. D. (1982). Supply-chain management: logistics catches up with strategy. *Outlook*, 5(1):42–47.

Orme, B. K. (2010). *Getting started with conjoint analysis: strategies for product design and pricing research*. Research Publishers, Madison, USA.

Ortúzar S, J. d. D. and Willumsen, L. G. (2011). *Modelling transport*. Wiley, New Delhi, India.

Padilha, F. and Ng, A. (2012). The spatial evolution of dry ports in developing economies: The Brazilian experience. *Maritime Economics & Logistics*, 14(1):99–121.

Paixão, A. C. and P., B. M. (2003). Fourth generation ports – A question of agility? *International Journal of Physical Distribution & Logistics Management*, 33(4):355–376.

Panova, Y. (2011). Potential of connecting eurasia through trans-siberian railway. *International Journal of Shipping and Transport Logistics*, 3(2):227.

Panova, Y. and Hilmola, O.-P. P. (2015). Justification and evaluation of dry port investments in Russia. *Research in Transportation Economics*, 51:61–70.

Patterson, Z., Ewing, G. O., and Haider, M. (2008). The potential for premium-intermodal services to reduce freight CO2 emissions in the Quebec City-Windsor Corridor. *Transportation Research Part D: Transport and Environment*, 13(1):1–9.

Pearce, D. and Özedemiroglu, E. (2002). *Economic valuation with stated preference techniques* . Department for Transport, Local Government and the Regions.

Pegden, C. D. (2011). Introduction to simio. In *Winter Simulation Conference, 2011*. IEEE.

Pegden, C. D. and Sturrock, D. T. (2014). *Rapid modeling solutions: introduction to simulation and simio*. Simio Forward Thinking.

Port of Santander (2007). Dry ports. Retrieved from http://www.puertosantander.es/ing/puertos_secos.aspx, (12.02.2018).

Porter, M. E. (1985). *Competitive advantage: Creating and sustaining superior performance*. Simon and Schuster.

ProModel (2017). Product home. Retrieved from https://www.promodel.com/products/promodel/, (14.02.2018).

PTV Group (2018). Ptv vissim. Retrieved from http://vision-traffic.ptvgroup.com/en-us/products/ptv-vissim/, (15.02.2018).

Puerto Seco Azuqueca (2015). Características técnicas. Retrieved from http://www.intermodalcentro.com/caracteristicas-tecnicas, (12.02.2018).

Puerto Seco de Madrid (2017). Terminal owner. Retrieved from http://www.puertoseco.com/ingles/terminalowner.html, (12.02.2018).

Qiu, X., Lam, J. S. L., and Huang, G. Q. (2015). A bilevel storage pricing model for outbound containers in a dry port system. *Transportation Research Part E: Logistics and Transportation Review*, 73:65–83.

Rail Turkey (2017). Türkiye'nin lojistik merkezleri – hangileri açıldı? Retrieved from https://tr.railturkey.org/2017/10/06/turkiyenin-lojistik-merkezleri-hangileri-acildi/, (12.01.2018).

Rakotonarivo, O. S., Schaafsma, M., and Hockley, N. (2016). A systematic review of the reliability and validity of discrete choice experiments in valuing non-market environmental goods. *Journal of Environmental Management*, 183:98–109.

Rana, I. (2017). Faisalabad dry port being reactivated, says customs official. Retrieved from https://tribune.com.pk/story/1511959/faisalabad-dry-port-reactivated-says-customs-official/, (13.02.2018).

Rathnayake, J., Jing, L., and Wijeratne, A. W. (2013). Dry ports: A lacuna in Sri Lanka. *International Journal of Process Management and Benchmarking*, 3(4):441.

Rayhaber (2013). Lojistik köylerinde son durum. Retrieved from http://www.rayhaber.com/2013/04/lojistik-koylerinde-son-durum/, (12.02.2018).

Rayhaber (2016). Karamanda lojistik ve yük merkezi için imzalar atıldı. Retrieved from http://www.rayhaber.com/2016/10/karamanda-lojistik-yuk-merkezi-icin-imzalar-atildi/, (12.01.2018).

Regan and Garrido, R. (2001). Modeling Freight Demand and Shipper Behavior: State of the Art, Future Directions. *Travel behaviour research–The leading edge*.

Regmi, M. B. and Hanaoka, S. (2012). Assessment of intermodal transport corridors: Cases from North-East and Central Asia. *Research in Transportation Business and Management*, 5:27–37.

Regmi, M. B. and Hanaoka, S. (2015). Assessment of modal shift and emissions along a freight transport corridor between laos and thailand. *International Journal of Sustainable Transportation*, 9(3):192–202.

Rimiene, K. and Grundey, D. (2007). Logistics centre concept through evolution and definition. *Inzinerine Ekonomika - Engineering Economics*, 4(4):87–95.

Rimmer, P. and Comtois, C. (2009). China's container-related dynamics, 1990-2005. *GeoJournal*, 74(1):35–50.

Rimmer, P. J. (1967a). The changing status of new zealand seaports, 1853–1960. *Annals of the Association of American Geographers*, 57(1):88–100.

Rimmer, P. J. (1967b). The search for spatial regularities in the development of Australian seaports 1861-1961/2. *Geografiska Annaler. Series B, Human Geography*, 49(1):42–54.

Rimmer, P. J. (2007). Port dynamics since 1965: Past patterns, current conditions and future directions. *Journal of International Logistics and Trade*, 5(1):75–97.

Robinson, R. (2002). Ports as elements in value-driven chain systems: The new paradigm. *Maritime Policy & Management*, 29(3):241–255.

Robinson, S., Brooks, R., Kotiadis, K., and Van Der Zee, D.-J. (2010). *Conceptual modeling for discrete-event simulation*. CRC Press.

Rodrigue, J. P., Comtois, C., and Slack, B. (2016). The geography of transport systems. *The Geography of Transport Systems*, 18(2):1–440.

Rodrigue, J. P., Debrie, J., Fremont, A., and Gouvernal, E. (2010). Functions and actors of inland ports: European and North American dynamics. *Journal of Transport Geography*, 18(4):519–529.

Rodrigue, J. P. and Notteboom, T. (2006). Challenges in the maritime-land interface: Port hinterlands and regionalization. *The Master Development Plan for Port Logistics Parks in Korea*.

Rodrigue, J. P. and Notteboom, T. (2012). Dry ports in European and North American intermodal rail systems: Two of a kind? *Research in Transportation Business and Management*, 5:4–15.

Rodrigue, J.-P. J.-P. and Notteboom, T. (2009). The terminalization of supply chains: Reassessing the role of terminals in port/hinterland logistical relationships. *Maritime Policy and Management*, 36(2):165–183.

Román, C., Arencibia, A. I., and Feo-Valero, M. (2017). A latent class model with attribute cut-offs to analyze modal choice for freight transport. *Transportation Research Part A: Policy and Practice*, 102:212–227.

Roso, V. (2007). Evaluation of the dry port concept from an environmental perspective: A note. *Transportation Research Part D: Transport and Environment*, 12(7):523–527.

Roso, V. (2008). Factors influencing implementation of a dry port. *International Journal of Physical Distribution and Logistics Management*, 38(10):782–798. cited By 41.

Roso, V. (2009). The emergence and significance of dry ports: the case of the Port of Goteborg. *World Review of Intermodal Transportation Research*, 2(4):296.

Roso, V. (2013). Sustainable intermodal transport via dry ports - importance of directional development. *World Review of Intermodal Transportation Research*, 4(2/3):140.

Roso, V. and Lumsden, K. (2010). A review of dry ports. *Maritime Economics & Logistics*, 12(2):196–213.

Roso, V., Russell, D., Ruamsook, K., and Stefansson, G. (2015). Seaport-inland port dyad dynamics: an investigation of service provisions and intermodal transportation linkages. *World Review of Intermodal Transportation Research*, 5(3):263–280.

Roso, V., Woxenius, J., and Lumsden, K. (2009). The dry port concept: Connecting container seaports with the hinterland. *Journal of Transport Geography*, 17(5):338–345.

Rossetti, M. D. (2015). *Simulation modeling and Arena*. John Wiley & Sons.

Rotaris, L., Danielis, R., Sarman, I., and Marcucci, E. (2012). Testing for nonlinearity in the choice of a freight transport service. *European Transport - Trasporti Europei*.

Rozic, T., Rogic, K., and Bajor, I. (2016). Research trends of inland terminals: A literature review. *Promet - Traffic & Transportation*, 28(5):539–548.

Sabah, M. (2014). Boğazköprü lojistik köyü'nde açılış 2015'e kaldı. Retrieved from http://www.tcdd.gov.tr/content/33, (12.01.2018).

Saidallah, M., El Fergougui, A., and Elalaoui, A. E. (2016). A comparative study of urban road traffic simulators. In *EDP Sciences*, volume 81, page 05002.

Santos, T. A. and Guedes Soares, C. (2017). Development dynamics of the Portuguese range as a multi-port gateway system. *Journal of Transport Geography*, 60:178–188.

Sarayköy Kaymakamlığı (2012). Lojistik merkez hizmete açıldı. Retrieved from http://www.saraykoy.gov.tr/lojistik-merkez-hizmete-acildi, (12.01.2018).

Saudi Gazette (2014). Riyadh dry port activity to double with a new terminal. Retrieved from http://saudigazette.com.sa/article/89961/Riyadh-Dry-Port-activity-to-double-with-a-new-terminal, (13.02.2018).

Savannah Gateway Industrial Hub (2018). About. Retrieved from https://savannahgatewayindustrialhub.com/2018/02/02/savannah-gateway-industrial-hub-certified-market-ready-site-georgia-department-economic-development/, (13.02.2018).

Sharman, G. (1984). The rediscovery of logistics. *Harvard Business Review*, 62(5):71–79.

Shaw, A. W. (1912). Some problems in market distribution. *The Quarterly Journal of Economics*, 26(4):703–765.

Slack, B. (1990). Intermodal transportation in North America and the development of inland load centers. *Professional Geographer*, 42(1):72–83.

Slack, B. (1999). Satellite terminals: A local solution to hub congestion? *Journal of Transport Geography*, 7(4):241–246.

Smykay, E. W. (1973). *Physical distribution management*. Macmillan.

Southern, R. N. (2011). Historical perspective of the logistics and supply chain management discipline. *Transportation Journal*, 50(1):53–64.

Stewart, W. M. (1965). Key to improved volume and profits. *Journal of Marketing*, 20:65–70.

Stock, J. R. and Lambert, M. (2001). Strategic logistics management. *McGraw-Hill, New York*.

Stopford, M. (2009). *Maritime economics*. Routledge.

Swain, J. J. (2015). Simulation software survey-a brief history of discrete-event simulation and the state of simulation tools today. *OR/MS Today*, 38(5):56.

Taaffe, E. J., Morrill, R. L., and Gould, P. R. (1963). Transport expansion in underdeveloped countries: A comparative analysis. *Geographical Review*, 53(4):503–529.

Talley, W. K. and Ng, M. W. (2017). Hinterland transport chains: Determinant effects on chain choice. *International Journal of Production Economics*, 185(April 2016):175–179.

Tao, X., Wu, Q., and Zhu, L. (2017). Mitigation potential of CO 2 emissions from modal shift induced by subsidy in hinterland container transport Hinterland container transport Modal shift CO 2 emissions Random coefficient logit Semi-life cycle assessment Activity-based method. *Energy Policy*, 101:265–273.

Taylor, D. H. (1997). *Global cases in logistics and supply chain management*. Cengage Learning EMEA.

TCDD (2015). Balıkesir (gökköy) lojistik merkezi hizmete girdi. Retrieved from http://www.tcdd.gov.tr/haberler/BALIKES%C4%B0R%20(G%C3%96KK%C3%96Y)%20LOJ%C4%B0ST%C4%B0K%20MERKEZ%C4%B0%20H%C4%B0ZMETE%20G%C4%B0RD%C4%B0/950, (09.06.2018).

TCDD (2016). Turkish state raiways annual statistics. Technical report, Turkiye Cumhuriyeti Devlet Demiryolları.

TCDD (2018). Lojistik merkezler. Retrieved from http://www.tcdd.gov.tr/content/33, (12.01.2018).

Terzi, N. and Bolukbas, O. (2016). An analysis of logistics villages in turkey: Halkalı and yenice. *Journal of Management Marketing and Logistics*, 3(3).

Timeturk.com (2017). Konya kayacık lojistik merkezinin yapım ihalesi sonuçlandı. Retrieved from https://www.timeturk.com/konya-kayacik-lojistik-merkezinin-yapim-ihalesi-sonuclandi/haber-566235, (12.01.2018).

TRACECA (2018). Traceca. Retrieved from http://www.traceca-org.org/en/traceca/, (08.06.2018).

Train, K. E., van der Spoel, E., Rozing, M. P., Houwing-Duistermaat, J. J., Eline Slagboom, P., Beekman, M., de Craen, A. J. M., Westendorp, R. G. J., and van Heemst, D. (2009). *Discrete choice methods with simulation*. Cambridge university press.

Trenhaber (2017). Kahramanmaraş türkoğlu lojistik merkezi açıldı. Retrieved from https://www.trenhaber.com/tcdd/kahramanmaras-turkoglu-lojistik-merkezi-acildi-h2296.html, (12.01.2018).

Tsamboulas, D. A. and Dimitropoulos, I. (1999). Appraisal of investments in european nodal centres for goods - freight villages: A comparative analysis. *Transportation*, 26(4):381–398.

UBAK (2016a). Konteyner İstatistikleri. Retrieved from https://atlantis.udhb.gov.tr/istatistik/istatistik_konteyner.aspx, (12.01.2018).

UBAK (2016b). Limanlar geri saha karayolu ve demiryolu bağlantıları master plan Çalışması sonuç raporu. Technical report, Türkiye Cumhuriyeti Ulaştırma Denizcilik ve Haberleşme Bakanlığı.

UNCTAD (1982). Multimodal transport and containerisation. Technical report, UNCTAD.

UNCTAD (2017). Review of maritime transport. Technical report, United Nations Conference on Trade and Development.

UNECE (1998). *Un/Locode Codes for Ports and other Locations*. UN.

UNECE (2001). Terminology on combined transport. Technical report, The United Nations Economic Commission for Europe.

UNESCAP (2009). Policy framework for the development of intermodal interfaces as part of an integrated transport network in asia. Technical report, The United Nations Economic and Social Commission for Asia and the Pacific.

UNESCAP (2012). Introduction to the development of dry ports in asia. Technical report, The United Nations Economic and Social Commission for Asia and the Pacific.

UTIKAD (2013). 17 lojistik köyün 7'sinde İlk etap İnşaatlar bitti. Retrieved from http://www.utikad.org.tr/haberler/?id=10969, (09.06.2018).

UTIKAD (2015). İzmir kemalpaşa lojistik köyü'nün açılışı 2018 yılına ertelendi. Retrieved from http://www.utikad.org.tr/haberler/?id=12827, (12.01.2018).

UTİKAD (2015). Lojistik merkez değerlendirme Çalişmasi: Eskişehir hasanbey lojistik merkezi. Retrieved from http://www.utikad.org.tr/images/HizmetRapor/hasanbeylojistikmerkezraporu-4663.pdf, (09.06.2018).

Uysal, O. (2015). Bozüyük lojistik merkezi. Retrieved from https://tr.railturkey.org/2015/06/12/bozuyuk-lojistik-merkezi/, (12.01.2018).

Uzumcu, A. and Akdeniz, S. (2014). Yeni İpek yolu: Traceca ve bakü-tiflis-kars demiryolu projesi. *Avrasya Etüdleri*, 45(1):11–39.

Van den Berg, R. and De Langen, P. W. (2011). Hinterland strategies of port authorities: A case study of the port of Barcelona. *Research in Transportation Economics*, 33(1):6–14.

Vanden Bossche, M. and Gujar, G. (2010). Competition, excess capacity and pricing of dry ports in India: Some policy implications. *International Journal of Shipping and Transport Logistics*, 2(2):151–167.

Veenstra, A., Zuidwijk, R., and Van Asperen, E. (2012). The extended gate concept for container terminals: Expanding the notion of dry ports. *Maritime Economics and Logistics*, 14(1).

Vermeiren, T. and Macharis, C. (2016). Intermodal land transportation systems and port choice, an analysis of stated choices among shippers in the Rhine–Scheldt delta. *Maritime Policy & Management*, 43(8):1–13.

Wang, C., Chen, Q., and Huang, R. (2018). Locating dry ports on a network: a case study on tianjin port. *Maritime Policy and Management*, pages 1–18.

Wang, G. W. Y., Zeng, Q., Li, K., and Yang, J. (2016). Port connectivity in a logistic network: The case of Bohai Bay, China. *Transportation Research Part E: Logistics and Transportation Review*, 95:341–354.

Wanzala, W. G., Zhihong, J., Werikhe, G. W., and Jin, Z. H. (2015). Integration of the Extended Gateway Concept in Supply Chain Disruptions Management in East Africa-Conceptual Paper. *International Journal of Engineering Research in Africa*, 20:235–247.

Wei, H. and Sheng, Z. (2017). Dry ports-seaports sustainable logistics network optimization: Considering the environment constraints and the concession cooperation relationships. *Polish Maritime Research*, 24(S3):143–151.

Wei, H. and Sheng, Z. (2018). Logistics connectivity considering import and export for Chinese inland regions in the 21st-Century Maritime Silk Road by dry ports. *Maritime Policy and Management*, 45(1):53–70.

Wei, H., Sheng, Z., and Lee, P. T.-W. (2017). The role of dry port in hub-and-spoke network under Belt and Road Initiative. *Maritime Policy and Management*, pages 1–18.

Weld, L. D. H. (1916). *The marketing of farm products*. Macmillan.

Wiegmans, B. W., Masurel, E., and Nijkamp, P. (1999). Intermodal freight terminals: An analysis of the terminal market. *Transportation Planning and Technology*, 23(2):105–128.

Wilmsmeier, G., Bergqvist, R., and Cullinane, K. (2011a). Ports and hinterland - evaluating and managing location splitting. *Research in Transportation Economics*, 33(1):1–5.

Wilmsmeier, G., Monios, J., and Lambert, B. (2011b). The directional development of intermodal freight corridors in relation to inland terminals. *Journal of Transport Geography*, 19(6):1379–1386.

Winston, C. (1983). The demand for freight transportation: models and applications. *Transportation Research Part A: General*, 17(6):419–427.

Woxenius, J., Roso, V., and Lumsden, K. (2004). The dry port concept – connecting seaports with their hinterland by rail. In *Proceedings of the 1st International Conference on Logistics Strategies for Ports*, pages 22–26.

Xie, Y., Liang, X., Ma, L., and Yan, H. (2017). Empty container management and coordination in intermodal transport. *European Journal of Operational Research*, 257(1):223–232.

Yapıcı, E. (2015). Lojistik Üs olma yolunda samsun. Retrieved from www.emo.org.tr/ekler/50d8c4e76716b73_ek.doc?tipi=2&turu=X&sube=9, (09.06.2018).

Zamparini, L., Layaa, J., and Dullaert, W. (2011). Monetary values of freight transport quality attributes: A sample of Tanzanian firms. *Journal of Transport Geography*, 19(6):1222–1234.

Zeng, Q., Maloni, M. J., Paul, J. A., and Yang, Z. (2013). Dry port development in China: Motivations, challenges, and opportunities. *Transportation Journal*, 52(2):234–263.

Zheng, Q., Chen, S. F., Shen, J., Liu, Z. Q., Fang, K., and Xiang, W. (2010). Simulation modeling of the operating room based on simio. In *Applied Mechanics and Materials*, volume 37, pages 1162–1166. Trans Tech Publ.

APPENDICES

APPENDIX 1: Interview Questions

Interview Questions for Freight Forwarders and Logistics Service Providers

- Which transportation mode do you usually use for inland container logistics between Seaports of Izmir and City of Denizli? Road transport or intermodal-rail?
- Which criteria do you consider choosing transportation modes for your inland container logistics between Seaports of Izmir and City of Denizli?
- What advantages do you gain from the transportation mode that you already use for your inland container logistics between Seaports of Izmir and City of Denizli?
- What qualities does a transport mode need to have so that you can use it for your inland container logistics between Seaports of Izmir and City of Denizli?
- How much is the average port-to-door road transport cost of one TEU between Seaports of Izmir and City of Denizli?
- How much is the average port-to-door intermodal-rail cost of one TEU between Seaports of Izmir and City of Denizli?
- How long does it take port-to-door transportation of containers by road for your inland container logistics between Seaports of Izmir and City of Denizli?
- How long does it take port-to-door transportation of containers by intermodal-rail for your inland container logistics between Seaports of Izmir and City of Denizli?
- What is the percentage of delayed shipments of intermodal-rail transport in your inland container logistics between Seaports of Izmir and City of Denizli?
- What is the percentage of delayed shipments of road transport in your inland container logistics between Seaports of Izmir and City of Denizli?
- What is the frequency of train departures between Seaports of Izmir and Sarayköy dry port?

- Do you think this frequency is enough? How many train departures per week need to be provided?
- Is there any other factor that you consider for your inland container logistics between Seaports of Izmir and City of Denizli?
- Do you have any other comments?

Interview Questions for the Rail Operator

- Which criteria do you think shippers consider choosing transportation modes for their inland container logistics between Seaports of Izmir and City of Denizli?
- What advantages does shippers gain from using intermodal-rail transportation for their inland container logistics between Seaports of Izmir and City of Denizli?
- What advantages does intermodal-rail transportation need to have so that shippers can use it for their inland container logistics between Seaports of Izmir and City of Denizli?
- How much is the average port-to-door road transport cost of one TEU between Seaports of Izmir and City of Denizli?
- How much is the average port-to-door intermodal-rail cost of one TEU between Seaports of Izmir and City of Denizli?
- How long does it take port-to-door transportation of containers by road for inland container logistics between Seaports of Izmir and City of Denizli?
- How long does it take port-to-door transportation of containers by intermodal-rail for inland container logistics between Seaports of Izmir and City of Denizli?
- What is the percentage of delayed shipments of intermodal-rail transport in inland container logistics between Seaports of Izmir and City of Denizli?
- What is the percentage of delayed shipments of road transport in inland container logistics between Seaports of Izmir and City of Denizli?

- What is the frequency of train departures between Seaports of Izmir and Sarayköy dry port?
- Do you think this frequency is enough? How many train departures per week need to be provided?
- Is there any other factor that should be considered for inland container logistics between Seaports of Izmir and City of Denizli?
- Do you have any other comments?

Interview Questions for the Dry Port Operators

- **Questions related to the dry port**
- What kind of services do you provide in your dry port?
- How much container storage capacity does your dry port have?
- How much total area does your dry port have?
- Can you please explain the inland container logistics process provided through your dry port?
- How many TEUs does your dry port handle per year?
- How is your dry port managed? Which companies does your management involve?
- **Questions related with inland container transportation mode choice**
- Which criteria do you think shippers consider choosing transportation modes for their inland container logistics between Seaports of Izmir and City of Denizli?
- What advantages does shippers gain from using intermodal-rail transportation for their inland container logistics between Seaports of Izmir and City of Denizli?
- What advantages does intermodal-rail transportation need to have so that shippers can use it for their inland container logistics between Seaports of Izmir and City of Denizli?

- How much is the average port-to-door road transport cost of one TEU between Seaports of Izmir and City of Denizli?
- How much is the average port-to-door intermodal-rail cost of one TEU between Seaports of Izmir and City of Denizli?
- How long does it take port-to-door transportation of containers by road for inland container logistics between Seaports of Izmir and City of Denizli?
- How long does it take port-to-door transportation of containers by intermodal-rail for inland container logistics between Seaports of Izmir and City of Denizli?
- What is the percentage of delayed shipments of intermodal-rail transport in inland container logistics between Seaports of Izmir and City of Denizli?
- What is the percentage of delayed shipments of road transport in inland container logistics between Seaports of Izmir and City of Denizli?
- What is the frequency of train departures between Seaports of Izmir and Sarayköy dry port?
- Do you think this frequency is enough? How many train departures per week need to be provided?
- Is there any other factor that should be considered for inland container logistics between Seaports of Izmir and City of Denizli?
- Do you have any other comments?

APPENDIX 2: Questionnaire for Exporters and Importers

Dry Port Usage in Inland Container Transportation between the Seaports of İzmir and Denizli Region

This questionnaire is carried out within the scope of doctorate thesis titled "The Effects of Dry Ports on Inland Container Logistics" conducted in Dokuz Eylül University, Graduate Scholl of Social Sciences, Maritime Business Administration Doctorate Program.

Dry Ports are logistics centers located in the hinterlands of seaports, they provide all the services given at seaports and they are directly connected to sea ports by rail or highway.

The aim of the study is to reveal the effects of transportation service attributes (transportation cost, transportation time, delays, frequency and free time) on transportation mode choice in inland container logistics.

Your answers to questions will be used for scientific purposes only and will not be shared with any person or organization.

Thank you for your valuable time and contributions.

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I. Please indicate the importance of factors that you consider when choosing the mode of transportation for your containerized cargo in inland logistics between Seaports of Izmir and Denizli region.

Factor	(1) Very Low Importance	(2) Low Importance	(3) Moderately Importance	(4) Highly Importance	(5) Very Highly Importance
1. Port-to-door transportation cost	☐	☐	☐	☐	☐
2. Port-to-door transportation time	☐	☐	☐	☐	☐
3. Compliance with the previously declared transport time	☐	☐	☐	☐	☐
4. Frequency of the transportation service	☐	☐	☐	☐	☐
5. Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	☐	☐	☐	☐	☐

II. Please indicate the frequency of transport modes you are using for the shipments of your containerized cargo between the seaports of Izmir and your factory or warehouse.

Transportation Mode	(1) Never	(2) Rarely	(3) Sometimes	(4) Frequently	(5) Always
1. Road Transport	☐	☐	☐	☐	☐
2. Through the Dry Port (Rail + Road)	☐	☐	☐	☐	☐

III. Please assume that you have a containerized cargo to be shipped between the Seaports of Izmir and Denizli region. Port-to-door transportation cost, port-to-door transportation time, percentage of delayed arrivals, frequency of transportation and free time are given in the following scenarios. Select your preference between two transport alternatives in the scenarios.

Please mark the containerized freight type that you mostly transport and answer the scenarios according to this cargo type.

Dry Food ☐ Fresh Fruit and Vegetable ☐ Electronics ☐ Textile☐ Machinery☐ Minerals☐ Marble/Natural Stone ☐

Iron-Steel Products ☐ Plastics ☐ Paper Products ☐ Other.....

1. Scenario	**Through the Dry Port (Rail + Road)**	**Road Transport**
Port-to-door transportation cost	TRL 850	TRL 1,150
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	5%	3%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

2. Scenario	**Through the Dry Port (Rail + Road)**	**Road Transport**
Port-to-door transportation cost	TRL 750	TRL 1,150
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	10%	5%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

3. Scenario	**Through the Dry Port (Rail + Road)**	**Road Transport**
Port-to-door transportation cost	TRL 950	TRL 1,300
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	5%	5%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

4. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 750	TRL 1,300
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	5%	3%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

5. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 950	TRL 1,150
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	5%	7%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

6. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 950	TRL 1,150
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	10%	3%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

7. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 950	TRL 1,300
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	15%	3%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

8. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 950	TRL 1,000
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	10%	7%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

9. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 750	TRL 1,150
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	15%	7%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

10. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 750	TRL 1,300
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	10%	7%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

11. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 950	TRL 1,000
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	15%	5%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

12. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 850	TRL 1,150
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	15%	5%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

13. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 850	TRL 1,300
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	15%	7%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

14. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 850	TRL 1,300
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	10%	5%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

15. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 750	TRL 1,000
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	15%	3%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

16. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 850	TRL 1,000
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	10%	3%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

17. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 850	TRL 1,000
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	5%	7%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

18. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 750	TRL 1,000
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	5%	5%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

IV. Profile Questions

1.	Please write which department you are working in……..
2.	Please write the position you are working……
3.	Your experience in the industry ……..years
4.	Does your company have a logistics department? yes ☐ no☐
5.	How many employees does your company have? 0-10☐ 11-50 ☐ 51-250☐ 251+☐
6.	Please mark the foreign trade activity that your company performs. Export☐ Import☐ Both ☐
7.	Please write the type of good your company exports?…….(i.e. textile, electronics, marble, machinery vb.)
8.	Please mark the transportation mode that you use for your export shipments. Road transport ☐ Rail transport☐ Maritime transport☐
9.	Please write the type of good your company imports?…….(i.e. textile, electronics, marble, machinery vb.)
10.	Please mark the transportation mode that you use for your import shipments. Road transport ☐ Rail transport☐ Maritime transport☐

APPENDIX 3: Questionnaire for Shipping Lines and Freight Forwarders

Dry Port Usage in Inland Container Transportation between the Seaports of İzmir and Denizli Region

This questionnaire is carried out within the scope of doctorate thesis titled "The Effects of Dry Ports on Inland Container Logistics" conducted in Dokuz Eylül University, Graduate Scholl of Social Sciences, Maritime Business Administration Doctorate Program.

Dry Ports are logistics centers located in the hinterlands of seaports, they provide all the services given at seaports and they are directly connected to sea ports by rail or highway.

The aim of the study is to reveal the effects of transportation service attributes (transportation cost, transportation time, delays, frequency and free time) on transportation mode choice in inland container logistics.

Your answers to questions will be used for scientific purposes only and will not be shared with any person or organization.

Thank you for your valuable time and contributions.

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Dokuz Eylül University
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I. Please indicate the importance of factors that you consider when choosing the mode of transportation for your containerized cargo in inland logistics between Seaports of Izmir and Denizli region.

Factor	(1) Very Low Importance	(2) Low Importance	(3) Moderately Importance	(4) Highly Importance	(5) Very Highly Importance
1. Port-to-door transportation cost	☐	☐	☐	☐	☐
2. Port-to-door transportation time	☐	☐	☐	☐	☐
3. Compliance with the previously declared transport time	☐	☐	☐	☐	☐
4. Frequency of the transportation service	☐	☐	☐	☐	☐
5. Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	☐	☐	☐	☐	☐

II. Please indicate the frequency of transport modes you are using for the shipments of your containerized cargo between the seaports of Izmir and your factory or warehouse.

Transportation Mode	(1) Never	(2) Rarely	(3) Sometimes	(4) Frequently	(5) Always
1. Road Transport	☐	☐	☐	☐	☐
2. Through the Dry Port (Rail + Road)	☐	☐	☐	☐	☐

III. Please assume that you have a containerized cargo to be shipped between the Seaports of Izmir and Denizli region. Port-to-door transportation cost, port-to-door transportation time, percentage of delayed arrivals, frequency of transportation and free time are given in the following scenarios. Select your preference between two transport alternatives in the scenarios.

Please mark the containerized freight type that you mostly transport and answer the scenarios according to this cargo type.

Dry Food ☐ Fresh Fruit and Vegetable ☐ Electronics ☐ Textile☐ Machinery☐ Minerals☐ Marble/Natural Stone ☐

Iron-Steel Products ☐ Plastics ☐ Paper Products ☐ Other.....

1. Scenario	**Through the Dry Port (Rail + Road)**	**Road Transport**
Port-to-door transportation cost	TRL 850	TRL 1,150
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	5%	3%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

2. Scenario	**Through the Dry Port (Rail + Road)**	**Road Transport**
Port-to-door transportation cost	TRL 750	TRL 1,150
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	10%	5%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

3. Scenario	**Through the Dry Port (Rail + Road)**	**Road Transport**
Port-to-door transportation cost	TRL 950	TRL 1,300
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	5%	5%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

4. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 750	TRL 1,300
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	5%	3%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

5. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 950	TRL 1,150
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	5%	7%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

6. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 950	TRL 1,150
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	10%	3%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

7. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 950	TRL 1,300
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	15%	3%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

8. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 950	TRL 1,000
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	10%	7%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

9. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 750	TRL 1,150
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	15%	7%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

10. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 750	TRL 1,300
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	10%	7%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

11. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 950	TRL 1,000
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	15%	5%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

12. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 850	TRL 1,150
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	15%	5%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	30 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

13. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 850	TRL 1,300
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	15%	7%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

14. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 850	TRL 1,300
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	10%	5%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

15. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 750	TRL 1,000
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	7 hours
Percentage of delayed shipments	15%	3%
Frequency of the transportation service	9 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

16. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 850	TRL 1,000
Port-to-door transportation time	14 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	10%	3%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

17. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 850	TRL 1,000
Port-to-door transportation time	18 hours (Reservation must be made at least one work day before departure)	6 hours
Percentage of delayed shipments	5%	7%
Frequency of the transportation service	12 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	5 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

18. Scenario	Through the Dry Port (Rail + Road)	Road Transport
Port-to-door transportation cost	TRL 750	TRL 1,000
Port-to-door transportation time	16 hours (Reservation must be made at least one work day before departure)	5 hours
Percentage of delayed shipments	5%	5%
Frequency of the transportation service	6 trains per week	Shipment is made upon request.
Free Time (The duration a container stays in a seaport or a dry port without paying a container storage charge)	15 days (In the Dry Port in Denizli)	5 days (In the Seaports of Izmir)
Please mark your preference in the box.	☐	☐

IV. Profile Questions

1.	Please write which department you are working in…….			
2.	Please write the position you are working……..……			
3.	Your experience in the industry ……..years			
4.	How many employees does your company have?	0-10☐	11-50 ☐	51-250☐	251+☐