İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE ENGINEERING AND TECHNOLOGY

A STUDY OF THE GEOGRAPHICAL DISTRIBUTION AND CHARACTERISTICS OF LOGISTICS CLUSTERS IN TURKEY

M.Sc. THESIS

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Department of Management Engineering

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TÜRKİYE'DEKI LOJİSTİK KÜMELERİN COĞRAFİ DAĞILIMININ VE İŞLEMSEL ÖZELLİKLERİNİN BELİRLENMESİ

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Majd MOHAMMAD, a M.Sc. student of ITU Graduate School of Science Engineering and Technology 507131025 successfully defended the thesis entitled "A STUDY OF THE GEOGRAPHICAL DISTRIBUTION AND CHARACTERISTICS OF LOGISTICS CLUSTERS IN TURKEY", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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FOREWORD

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ABBREVIATIONS

DHMI	: Devlet Hava Meydanları İşletmesi Genel Müdürlüğü General Directorate of State Airports Authority
DTGM	: Deniz Ticareti Genel Müdürlüğü Maritime Trade General Directorate
HCLQ	: Horizontal Clustering Location Quotient
HHI	: Herfindahl–Hirschman Index
ISIC	: International Standard Industrial Classification
KGM	: Karayolları Genel Müdürlüğü General Directorate of Highways
LEP	: Logistics Establishments Participation Index
LGC	: Locational Gini Coefficient
LQ	: Location Quotient
NAICS	: North American Industry Classification System
NUTS	: Nomenclature of Territorial Units for Statistics
TCDD	: Türkiye Cumhuriyeti Devlet Demiryolları Turkish State Railway
TEU	: Twenty-foot Equivalent Unit
TUIK	: Türkiye İstatistik Kurumu Turkish Statistical Institute
UND	: Uluslararası Nakliyeciler Derneği International Transport Association
UTIKAD	: Uluslararasi Taşımcılık ve Lojistik Hizmet Üretenleri Derneği Association of International Forwarding and Logistics Service Providers

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A STUDY OF THE GEOGRAPHICAL DISTRIBUTION AND CHARACTERISTICS OF LOGISTICS CLUSTERS IN TURKEY

SUMMARY

Clusters are defined as a number of organizations which are located in the same geographical area, whıch provide related services, and whıch are linked by a number of interdependencies (Porter, 1998). There is a rising interest in the development of logistics clusters among governments around the world to the extent where they are investing significant money and resources in that field.

Logistics clusters can lead to various economies of scale. The benefits of logistics clusters are discussed in a number of studies. Those include job creation, labor pooling, the sharing of resources, cost reduction, sharing of information and knowledge spillovers. Moreover, clusters can lead to economic growth for the regions they are located in.

There are a number of indexes to identify logistics clusters and their geographical distribution. Among which are the Location Quotient (LQ), the Horizontal Clustering Location Quotient (HCLQ) the Logistics Establishments Participation index (LEP) and a number of other indexes such as the Locational Gini Coefficient (LCG) and the Herfindahl–Hirschman Index (HHI).

This thesis utilizes the Horizontal Clustering Location Quotient (HCLQ) and the Logistics Establishments participation index (LEP) in combination with statistical data about the transport and warehousing employment and number of establishments to identify the main geographical areas of logistics clustering. It also studies the growth of those areas between 2002 and 2014.

The study also addresses the characteristics of those regions by investigating (1) the physical infrastructure in terms of airports, sea ports, road and railway density, (2) the operational infrastructure in terms of number of establishments, employment and available freight transport vehicles and (3) the logistics potential for all the provinces of Turkey in terms of freight volumes, import and export volumes and proximity to markets as indicators of demand.

The results show the main regions of logistics clustering. It indicates that those regions are experiencing growth in terms of employment and number of establishments. Moreover, it provides evidence that areas with logistics clusters are characterized with excellent transportation infrastructure, an advanced operational infrastructure and high demand for logistics services as indicated by high freight and import and export volumes.

TÜRKİYE'DEKİ LOJİSTİK KÜMELERİN COĞRAFİ DAĞILIMININ VE İŞLEMSEL ÖZELLİKLERİNİN BELİRLENMESİ

ÖZET

Kümelenme, aynı coğrafi bölgelerde bulunan, ilgili hizmetleri sağlayan ve göreceli olarak bağlantılı olan, çok sayıda kurumun bir araya gelmesi olarak tanımlanabilir (Porter, 1998). Günümüzde devletlerinin yapmış olduğu yatırım ve kaynak ayırımı doğrultusunda, dünyada lojistik kümelerin gelişiminde artış gözlemlenmektedir.

Lojistik kümelerin önemli bir avantajı ölçek ekonomisine öncülük etmeleridir. Lojistik kümelerin faydalarına birçok çalışmada değinilmiştir. Bu çalışmalarda ortaya çıkan faydalar, açılabilecek yeni iş alanları, oluşan iş gücü havuzu, kaynak paylaşımı, maliyetlerin azalımı, bilgi ve politik etkilerin paylaşımı olarak belirlenmiştir. Bunlara ek olarak, lojistik kümeler bulundukları alanlarda, bölgesel ekonomik kalkınmaya da katkı sağlayabilmektedir.

Lojistik kümelerin tanımlanması ve coğrafi dağılımının belirlenmesi için birçok endeks geliştirilmiştir. Bunlara örnek olarak Location Quotient (LQ), the Horizontal Clustering Location Quotient (HCLQ), the Logistics Establishments Participation index (LEP), Locational Gini Coefficient (LCG) ve Herfindahl–Hirschman Index (HHI) gibi endeksler gösterilebilir.

Bu çalışmada HCLQ ve LEP endeksleri ele alınarak, nakliye ve depolama istihdamı istatistikleri üzerinden Türkiye'de lojistik kümelerin bulunduğu ana coğrafi bölgeleri ortaya çıkarılmış ve incelenmiştir. Çalışmada aynı zamanda 2002 ve 2014 arasında bu lojistik kümelerin gelişimi de araştırılmıştır.

Yukarıda değinilenlere ek olarak Türkiye'nin tüm bölgelerinde (1) fiziki altyapı açısından hava alanlarının, limanların, karayollarının ve demir yollarının yoğunluğuna, (2) operasyonel altyapı açısından kurumların sayısının, istihdam verilerinin ve mevcut nakliye araçlarının sayısına ve (3) lojistik potansiyel açısından yük miktarları ve ithalat ve ihracat hacimlerinin göstergelerine odaklanılmıştır.

Sonuçlar lojistik kümelerin bulunduğu başlıca bölgeleri göstermektedir. Lojistik kümelerin oluştuğu bu bölgelerde, kuruluşların sayısı ve istihdam açısından bir büyüme yaşandığı gözlenmiştir. Bunlara ek olarak, bu çalışmanın bulguları lojistik kümelere sahip bölgelerin gelişmiş ulaşım altyapısı, ileri düzeyde operasyonel hizmet kalitesi ve ithalat, ihracat işlemleri sonucu oluşan yüksek nakliye talebi sonucunda ortaya çıktığını ve geliştiğini göstermektedir.

1. Introduction

1.1 Background and Context

A large body of spatial theory has been developed in respect to transportation costs or trade areas however the freight sector appears to be relatively neglected in contemporary regional science. Until recently the focus in regional studies was mainly passenger transportation and individual mobility issues (Hesse and Rodrigue, 2004).

The concept of logistics clusters is relatively new in the global economy and few studies can be found regarding this topic within the academic literature. Clusters are defined by Porter (1998) as a number of organizations which are located in the same geographical area, provide related services, and are linked by a number of interdependencies. Governments around the world are investing in the development of new logistics clusters or the expansion of existing ones due to the advantages expected as a result of the existence of such logistics clusters (Rivera at al., 2014).

It is cited that among the advantages of industry agglomeration or clustering is labor market pooling. Specialized labor is said to gravitate toward those clusters where a larger number of job opportunities is available. Another advantage is the knowledge spill over and the sharing of resources among the agglomerated firms. In addition to that clustering of firms can lead to input sharing and the creation of a local supply base (Marshal, 1956).

The Turkish transportation ministry has set a target to have established 18 freight villages spread out across Turkey by 2023 according to the Turkish State Railways (TCDD). Those freight villages are meant to integrate railway transportation to other logistics systems and it is a matter of debate whether those freight villages will actually cause a major shift of logistics to freight villages (Uysal, 2013). With a small number of exceptions there is little information available about the geographical distribution, clustering, or lack thereof, of logistics firms within Turkey. This thesis aims to contribute to the literature about this subject by

consolidating and analyzing the available data about the sector and providing an overall preview of the patterns of logistics firms' geographical distribution and clustering as well as shedding some light on the available transport infrastructure and capacity for growth in the logistics sector in each of the respective regions of study.

1.2 Research Objectives

The main purpose of this study is to provide a general overview of the logistics sector within Turkey in geographical terms. The provinces of Turkey are all studied individually according to the available statistical data in terms of the employment levels and number of establishments. It is attempted to identify the existing logistics clusters over a number of indexes, namely the Horizontal Clustering Location Quotient (HCLQ) and the Logistics Establishments Participation index (LEP).

The second objective of this study is to investigate the attractiveness of different provinces for logistics firms by measuring it against location decisions criteria available in the literature such as freight accessibility measures, infrastructure, and proximity to major markets (Lipscomb, 2010). Light is shed on the level of synergy between transportation infrastructure and the clustering of firms geographically.

Last but not least a comparison is performed to study the possible growth of clusters in time by investigating employment levels and the number of firms in the subject geographical areas in the years 2002-2003 and the most recent years with available statistical data 2013-2014.

1.3 Hypothesis

Logistics clusters are expected to be found within regions that offer excellent transportation conditions such as good roads and intermodal infrastructure. The availability of large ports and airports plays a big role in logistics firms' location decisions as explained by Rodrigue at al., (2013). This is tested within Turkey by identifying the existing logistics firms agglomeration based on the available data and clustering indexes and comparing the results with the transport infrastructure of the respective regions.

Due to the numerous advantages, claimed but not measured in the existing literature, of the agglomeration of firms it is expected that logistics clusters will grow in time. Firms are said to have a tendency for co-location due to economies of scale that help reduce costs.

On the other hand, some researchers argue that there are negative externalities, such as traffic congestion, resulting from clustering that could cause the dispersion of like-businesses instead. (Cairncross, 1997; Polenske 2001, 2003; Henderson and Shalizi, 2001). In addition, following the hypothesis that clusters grow in time, Bowen (2008) found that faster growth rate was found in suburban areas and non-core cities rather than metropolitan areas, possibly another result of negative externalities of clustering. This study tests this by comparing the clustering indexes for 2 reference years across time to identify whether they grow in time and indicate which regions have the fastest growth rates.

1.4 Structure of The Thesis

This study begins with an introduction about the topic. Section two includes a literature review of the articles published about the geographical aspect of freight, distribution and warehouses. The findings of various articles regarding the topic are summarized. Secion three discusses the data collection process and the limitations in the collection of logistics data. Section four is about the identification of possible logistics clusters in Turkey using a two index method. A time comparison is also done between two reference years to understand the growth trend of logistics clusters.

Section four addresses the issue of transportation infrastructure in relation to the results of the previous sections. Accessibility measures are discussed for road, rail, sea and air transportation. In addition, the freight volumes for each province are investigated along with its respective capacity, imports and exports and proximity to major markets. The effects of those measures on the number of logistics establishments and employment rates are studied. Section 5 provides a summary of the results of the study, while section 6 provides the conclusions and suggestions for future research.

2. Literature Review

2.1 Definition of Logistics Clusters

Geographical concentration of firms providing similar services or products is referred to as agglomeration or clustering. Co-location of firms providing logistics services such as 3rd party logistics, transportation, warehousing and freight forwarding is what basically defines logistics clustering (Rivera at al., 2014). Not to be confused with freight villages, Sengpiehl (2010) makes the distinction by stating that freight villages are elements of intermodal transport chains providing infrastructure and logistics services. While both terms are similar in terms of the geographical grouping of firms, a freight village incorporates at least one terminal and offers accompanying services such as storage, maintenance and repair (UNECE, 2001).

Logistics clusters can possibly develop within regions of freight villages because of the advantages that would be prevalent in those regions. Logistics firms are expected to base their locational decisions according to availability of good infrastructure and logistics services, which are indeed provided in regions within freight villages. Rodrigue at al., (2013) explain the rationale behind the emergence of logistic villages stating that the recent developments in both logistics and physical distribution arise as a result of a number of economic structural changes and related corporate strategies. Among those changes are the rise of service economies, the introduction of new information and communication technologies, the appearance of global trade and global production networks. This has resulted in the emergence of a network of global flows and hubs that are highly dependent on efficient transport systems and infrastructure (Walters, 2010).

Logistics clusters are more than just a value chain or a network of companies. They are holistic systems with value adding activities that can create operational efficiencies and give space for innovative logistics solutions (Notteboom & Rodrigue, 2005).

In an attempt to further clarify the main characteristics of logistics clusters, Wang et al (2007) identified three main features: (1) Multilevel functions regarding space and distance, (2) open networks which gather information about the demand and provides communication with outside areas, and (3) agglomeration of logistics firms and their respective supplementing activities and last but not least the insurance of economies of scale and innovation.

Ma & Huang (2008) identified seven important sub-systems for the development of logistics clusters. The first sub-system is demand which would in turn require logistics activities and encourage firms to locate within proximity of it. Second is the innovation sub-system where agglomerated firms would have knowledge spillovers leading to higher levels of innovation. The third sub-system is identified as manpower. Specialized manpower is clearly needed to perform the logistics activities with their varying levels of complexity. The fourth is the sharing of resources which serves as the major constituent of economies of scale and overall cost reduction. Fifth subsystem is the government support in areas such as infrastructure provision and tax incentives. The last and sixth sub-system deals with access to capital.

2.2 Geographical Outlooks

The academic literature contains a small number of articles that are concerned with logistics clusters and there is little mention of their prevalence. Studies about the geography and spatial distribution of logistics clusters are even less available. In their paper about the spatial concentration and location dynamics in logistics, Heuvel et al. (2013) analyze the location dynamics of logistics establishments in relation to spatial clustering for the case of a Dutch province. They used empirical data on logistics establishments and drew six general conclusions on spatial concentration and location decisions of logistics firms.

Heuvel et al., (2013) observed that logistics employment is concentrated in particular areas and big logistics establishments quite often located relatively within those areas of concentration. In addition, they observed that in their re-location decisions, logistics firms also chose to move to those concentration areas or from one area of concentration to another. Those observations stress the correlation between the levels

of logistics employment within a region and the emergence of clusters. It is also observed in the same study that intermodal terminals attract logistics employment which in turn attracts logistics establishment. This can be a possible explanation for why firms choose proximity to intermodal terminals for location decisions.

Among the geographical studies of the sector, Hesse and Rodrigue (2004) provide an overview of the transport geography of logistics and freight distribution. They showed that logistical requirements underline transportation as a component of integrated demand, hence challenging the idea that transportation is a derived demand. They analyze the evolution of logistics as it relates to the main dimensions of transport geography. They conclude that a deeper geographical investigation is needed and a more comprehensive insight into the nature of distribution and the geographical dimensions it is related to should be favored.

Bowen (2008) makes a connection between warehousing in the USA and accessibility measures of transportation networks. He examines the changing geography of warehousing, which is an important component of logistics, between 1998 and 2005. In his study he shows the degree to which the expansion of warehousing has gravitated towards regions with better transportation accessibility. Conclusions are made stating that the growth of the number of warehousing establishments across the regions under investigation was strongly correlated with measures of accessibility in air and highways and to a lower level to rail networks.

Another interesting study is done by Rivera et al., (2014) where they define logistics clusters, explain their advantages, and then use a two-index metric to identify the locations of logistics clusters in the US using data from 1998 and 2008. They provide evidence that within the United States, logistics clusters seem to be agglomerating rather than dispersing over time.

2.3 Identifying Logistics Clusters

A number of indexes have been developed to measure an industry's geographical concentration. Among the most important ones are the Location Quotient (LQ), the

Horizontal Clustering Location Quotient (HCLQ), the Locational Gini Coefficient (LGC), the Herfindahl–Hirschman Index (HHI), and the Ellison–Glaeser Index (EGGCI).

2.3.1 The location quotient (LQ)

The Location Quotient is a measure used as an analytical statistic for the industrial specialization of a specific region in comparison with a larger geographical unit, quite often the entire country. It is a very widely used index for clustering thanks to the fact that it does not require complex data. It can be measured as the ratio of the industry's employment in the region of interest to the total employment in the reference area. It has been used in different studies from Paige and Nenide's (2008) analysis of the trends of agglomeration in California to De Langen's (2004a) study of Maritime clusters. An LQ of 1 in a certain industry shows that the region and the nation are equally specialized in that specific industry. A value greater than one, however, shows that the region has a higher level of specialization than the nation as a whole.

2.3.2 The horizontal cluster location quotient (HCLQ)

The horizontal cluster location quotient was proposed by Fingleton et al. (2004) as an improvement to LQ in order to give an indication about the absolute size of the industry not just the relative size compared to the country as a whole. The HCLQ provides information about the number of jobs available in the region of study which exceeds the number of jobs that would be available given an LQ which is equal to 1 thereby making it possible to compare not just the relative but also the absolute sizes of different regions in the industry of interest.

The HCLQ index was used by Echeverri-Carroll and Ayala (2010) in their paper about gender wage differentials and the spatial concentration of high-technology industries. They studied the wage differentials in some cities in the United States which happened as a result of the clustering of high-technology establishments.

Rivera, Sheffi and Welsch, (2014) used the horizontal clustering location quotient in their study about the logistics agglomeration in the United States. They first

identified the characteristics of the indicator that would be most desirable for identifying clusters stating that it should be able to identify concentration of activities, point out the location of the concentration and provide an idea about the size of said concentration. In addition to possessing the above characteristics they mention that it should also work with the available data since logistics data is considered quite hard to quantify, be replicable and finally guarantee that the concentration resulted from external economies of scale rather than from the existence of one large logistics provider.

In order to address the necessity of the index guaranteeing external economies of scale, Rivera at al., (2014) developed a measure called the Logistics Establishments Participation Index.

2.3.3 The logistics establishments participation index (LEP)

The logistics establishments' participation index serves to measure the industry's share of the number of establishments in the entire country. It can be used as an indication about whether the concentration in a certain geographical area is the result of external economies of scale i.e: a large number of agglomerated establishments or a result of a small number of large establishments with a big share in employment. It is measured as the ration of the number of the industry's establishments within the region to the number of establishments in the reference area, possibly the country.

The larger the value of the LEP is, the larger the region's share of logistics establishments. However, the LEP does not come with a natural cutoff value. Meaning that in order to determine at which value of LEP the region can be considered a cluster Rivera et al., (2014) had to use the group validity method (Babbie, 2009) where they decreased the cut off value starting at 1 until all known clusters appeared. Following that they attempted to reduce the false positives by starting with a small value and increasing until false positives started to show up. Based on the results in combination with the known clusters data, the value was chosen.

2.3.4 Other measuring indexes

Heuvel et al (2013) use a measure called the Locational Gini Coefficient (LCG) proposed by Krugman (1991) to test whether the logistics sector concentrates spatially and how logistics employment concentration employment develops over time. The Locational Gini Coefficient is used as a concentration index to measure the level to which the percentage distribution of employment in an industry corresponds to the percentage distribution of national employment within certain locations. It basically captures the distribution of one industry's employment in a certain region as compared to the distribution of total employment. The LCG is considered one of the oldest concentration indexes.

Another important measure is the Herfindahl–Hirschman Index (HHI). This index was defined by Kim el al. (2000) as the aggregation of the industrial shares of all areas in an overall area, usually the country. It is calculated as the sum of squares of the difference between the industrial employment shares in all regions and the total employment shares in those same regions. Both HHI and the LCG are mainly concentration indexes rather than cluster identification indexes. They measure concentration in a reference area but they do not give information about the location of that concentration hence they are not often used to locate clusters. The HHI for example is most widely used in measuring the size of firms and giving an indication about the competition between them.

2.4 Criteria for Evaluating Logistics Agglomeration Locations

A number of factors can affect the agglomeration of logistics firms. A firm's location decision is one of the most important factors to reduce the costs for both short term and long term investments which leads companies to devote much effort for the study of such a crucial decision. The reason why firms tend to co-locate is the significant benefits that the entire society as well as the firms themselves can reap such as economies of scale reducing the costs and job creation (Heuvel et al, 2013).

The most widely discussed factor affecting agglomeration is the freight accessibility of the region. Traditionally freight was concentrated near production areas but currently it is more and more noticeable that it is more often located next to gateways

and hubs (Rodrigue et al., 2013). The European Spatial Planning Observation Network (ESPON) did a study where they investigated Europe's transportation infrastructure and geographical potential thereby defining specific criteria to measure the physical infrastructure of different regions. While physical infrastructure plays an important role it is not sufficient for logistics sectoral studies. For that reason Zorlu (2008) summarized some additional criteria for operational infrastructure as well as the logistics potential by which the sectoral specialization of regions can be overall more appropriately measured.

2.4.1 Physical infrastructure

Physical infrastructure is referred to in almost every paper concerned with the locational decisions of logistics firms or agglomeration. For example, regions of logistics agglomeration in China were all found to have developed transportation networks. (Yang et al, 2007). Rodrigue et al., (2013) mention inter-modality of transportation as a major key to freight centers giving an example of the logistics clustering in Netherland, which is characterized by a high level of accessibility, good transport infrastructure and the existence of an international port and an airport in close proximity.

In his paper about accessibility measures and warehouse locations, Bowen (2008) found a positive correlation between warehousing growth and road and air accessibility. He also found that once an intermodal terminal is established it tended to attract logistics establishments, which highlights the importance of transport infrastructure for the location of logistics firms. A well-established infrastructure makes firms more efficient and brings benefits to both service quality as well as the firm's competitiveness.

Physical infrastructure usually studied for locational decisions includes the railway systems, airports, international ports and the road network available, all referred to as accessibility measures. Railroad accessibility can be defined as the railroad density of the region calculated as the length of railroad within the region per unit of area. Zorlu (2008) used being on a national or international railway corridor to measure railroad accessibility.

The freight accessibility for sea and air is investigated by checking whether a region contains an international port or an international airport within its borders or in close proximity. Ports and airports are usually considered intermodal terminals since the freight moves between land to sea transport and land to air. Heuval et al (2014) calculated growth in areas with a terminal and areas without a terminal and found that areas with an intermodal terminal experience faster growth in logistics establishments. Zorlu (2008) investigated whether the region is located over international maritime transport corridors or within close proximity to high capacity ports and considered it a measure of the logistics expertise of the region under study.

Road infrastructure is referred to as one of the most important aspects of physical infrastructure. Rodrigue et al., (2013) explain that by stating that there is a shift from rail-water freight to truck and air because trucks and air allow for smaller and more frequent freight. The popularity of just in time inventories is adding more pressure on the freight transportation system because it demands higher flexibility and quick responsiveness. Truck transportation is considered the most flexible while air transportation is considered the fastest. The only downside is that road and air transportation require higher per unit cost of transporting goods when you compare them with rail and sea freights (Lipscomb, 2010).

Road infrastructure can be measured by measuring the road density within the region. Road density is defined as the number of kilometers of road per 100 square kilometer of land areas. A higher road density would allow smoother and faster road transport. It indicates the degree to which the area is able to answer to the logistics needs for frequent fast transport. Well-established road infrastructure is especially important in the case of inland hubs since they are mainly affiliated with interstate networks and airports (Rodrigue et al., 2013).

2.4.2 Operational infrastructure

The operational infrastructure can be investigated by (1) looking at the number of logistics establishments within the regions of study, (2) the employment levels in the logistics sector, and (3) the total number of trucks available for the carriage of

freight. (Zorlu, 2008) The number of firms located within a geographical area can be an indication of the desirability of the location. The logistics employment level will naturally increase in areas where the number of logistics firms is high because a high number of firms leads to job creation.

Holmes and Stevens (2002) noticed that in the areas with high concentration of employment the size of logistics firms tends to be larger. This leads to the question of whether high levels of employment found in an area is a result of a few large firms with a large number of employees or a high number of medium/small sized firms. This question is addressed by Rivera et al., (2014) who developed the Logistics Establishments Participation Index specifically to provide the answer. Small to medium size firms contribute significantly to external economies of scale in logistics clusters which means that it's important to make sure that high levels of employment are a result of a high number of firms (Henderson, 2003).

2.4.3 Logistics potential

In order to have an idea about the logistics potential for the regions under investigation the following criteria were used by Zorlu (2008) First, the volumes of exports and imports, Second, the number of firms and employment in the manufacturing industry. Freight was traditionally concentrated near production areas, which means that the number of manufacturing establishments can be looked into as an incentive for logistics firms to locate within close proximity (Rodrigue et al., 2013). The third criterion was the total production in agriculture and the fourth main criterion was market reach. He investigated the accessibility of a region to cities with high populations.

Additionally, the proximity to market was mentioned as an important criterion in the locational decision for inland freight hubs by Lipscomb (2010). All the above mentioned criteria is meant to measure the potential for logistics growth in a region. In other words its purpose is to give an idea about the available demand within the regions of study.

2.5 Benefits of Agglomeration

Many benefits are mentioned in the literature for the agglomeration or clustering of firms in general and of logistics firms specifically. The agglomeration of logistics inclusive establishments in a certain location provides advantages not just for the establishments themselves but also for the economy of the region as a whole. Some of the factors that Sheffi (2013) considered to be the root behind the economic advantage of clusters are: (1) Job creation and (2) diversification which are explained as follows.

Firstly, clusters contribute to job creation since the increasing number of firms consistently requires labor. There is a traditional criticism that logistics jobs involve low level jobs at minimum wage but it is now considered an outdated view since logistics firms consist of a variety of jobs that vary in level and complexity (Sheffi, 2013). Rodrigue et al., (2013) also agree with this view stating that agglomeration leads to network building and job creation which further mobilizes its economic impacts.

On the other hand, diversification refers to the fact that a logistics cluster could result in an efficient infrastructure which can be utilized by other sub-clusters of different industries which require strong logistics services. This set-up leads to the development of those clusters due to the positive feedback mechanism where there's an exchange of tacit knowledge and an ability to complete deals more easily (Sheffi, 2013).

Wu, Yue and Sim (2006) discussed the cost advantage that supply clusters provide for China. They state that companies can benefit from joint marketing campaigns such as trade fairs. Co-location also makes it more attractive for buyers to purchase from the cluster since they can get in touch with many vendors in the same region in one trip without the added trouble of going to various locations.

Another way that clusters reduce the costs is by facilitating the sharing of resources between different firms in close proximity. This can make individual companies more responsive and allows them to manage their supply chains more effectively. (Wu, Yue and Sim, 2006) It is also possible for co-located firms to be able to

combine their transport flows, which reduces the corresponding costs. (Heuvel et al, 2013)

Wu, Yue and Sim, (2006) also mention an important advantage which is the sharing of information and process improvements within clusters. Technological know-how is also shared which leads to more innovations within clusters. Even when the knowledge is not directly shared, there are always spillovers to co-located firms. (De Further to knowledge spillovers, De Langen (2002) states that agglomeration also leads to a broad supplier and customer base and a joint labor pool.

One of the earliest studies done by Marshal (1956) talks about agglomeration economies and mentions the same benefits mentioned above, namely: Labor market pooling, knowledge spillovers and input sharing among the co-located firms. In their study about the reasons that cause companies to agglomerate Ellison, Glaeser and Kerr (2010) actually confirmed all of Marshal's findings.

2.6 Agglomeration Growth Over Time

Since many advantages for the agglomeration of logistics firms are cited and confirmed in literature, it is expected that those clusters will grow over time thus making further use of those advantages. Rivera et al., (2014) found that clusters increased in size over time by comparing data from 1998 and 2008 for counties in the United States. They verified their findings by conducting interviews with private sector executives, government representatives, members of academia, and Chambers of Commerce around the world.

There have been studies which focused on where the growth of logistics has the fastest rates. Heuval et al (2014) for instance focused on whether growth rate is faster in areas with an intermodal terminal or without one and found that the former had faster rates. Cidell (2010) found that core cities showed significant growth, while Bowen (2008) came up with the conclusion that distribution firms prefer metropolitan areas but that the fastest growth rates were in outer suburban areas and non-core cities.

The reason that non-core cities and suburban areas may experience faster growth rate is the diseconomies of scale. While there are many benefits for agglomeration sometimes the high number of firms co-locating could create congestion which results in high traffic and longer delivery times. In order for a cluster to grow the region should have the ability to expand. New logistics developments will most probably require more land and infrastructure. Land availability is a main criterion for establishments when making locational decisions (Lipscomb, 2010).

3. Data Collection

Finding the data required for a study regarding logistics activities within a country is a very challenging task. Logistics encompass complex operations starting from sourcing of raw materials through manufacturing and moving those materials during various stages until reaching the final customer. Looking for publically available annual statistical data that represents the logistics sector is considered very difficult due to the fact that it is hard to place logistics with its wide span of operations within a macroeconomic perspective. Logistics activities relate to everything from the sourcing of raw materials, through all stages of production along the supply chain to the warehousing and distribution to final buyers. It is hard to classify all those activities into one sector under which macroeconomic statistical data could be collected and provided. The following sections explain in better detail the problems that arise while attempting to collect logistics data.

3.1 Logistics Data in Statistics

Candemir and Celebi (2015) discuss treatment of logistics in national accounts which is highly relevant in our study since the data collected was majorly sourced from governmental statistical annual data reports. They discuss the problems faced when establishing a boundary between logistics activities and other business activities is attempted.

There are two main activities that compose logistics: (1) Physical distribution which is composed of both transportation services (trucking, air, rail and marine.) and warehousing services and (2) materials management which includes all the activities related to the manufacturing of merchandise in all its stages of production along the supply chain (often called in-house logistics) (Rodrigue et al., 2013).

The main problems are (1) that excluding transportation and warehousing many logistics operations are not actually classified as logistics functions under standard

classifications such as the International Standard Industrial Classification of All Economic Activities (ISIC) and North American Industry Classification System (NAICS). The second problem is that when the current industrial classification is used many logistics activities will fall under sectors that will not fall entirely under logistics (Candemir and Celebi, 2015).

As the result of the problems mentioned, this study takes into account the nationally available data for transport and warehousing which are the only logistics activities classified by a standard classification scheme separately therefore falls entirely under logistics data.

Data was collected for regional employment and the number of establishments in transport and warehousing for years 2002-2014 from the Turkish Statistical Institute (TUIK). Logistics firms and freight forwarders headquarters and regional offices data was obtained from the Association of International Forwarding and Logistics Service Providers (UTIKAD) while information about road transporters was obtained from the International Transport Association (UND).

For freight accessibility measures the road density data was taken from the General Directorate of Highways (KGM), railway information was taken from the Turkish State Railway website (TCDD), Seaports data was obtained from the Maritime Trade General Directorate (DTGM) and airports distribution data was acquired from the General Directorate of State Airports Authority (DHMI).

3.2 NUTS Statistical Regions of Turkey

The Nomenclature of Territorial Units for Statistics (NUTS) defined the statistical regions of Turkey used in this study. The regions were defined in 2002 by Eurostat and the Turkish authorities only because Turkey is considered a candidate for the European Union. There are 3 levels defined for Turkey: (1) NUTS – 1 which includes 12 regions. (2) NUTS – 2 which includes 26 regions and (3) NUTS – 3 which includes the 81 provinces of Turkey. Data used in this thesis is according to the NUTS-2 and NUTS-3 levels.

4. Logistics Clusters within Turkey

4.1 Operational Infrastructure

Studying the existence and the distribution of logistics clusters within Turkey requires exploring the various aspects that could be related to the formation and growth of those clusters. Among these aspects are the employment levels in the sector. Employment levels data can be used in its raw form in addition to being the input to calculate clustering indexes such as the horizontal clustering location quotient, which is used in this study.

The number of logistics establishments is then used to calculate the logistics establishments' participation index, which is taken as an indication of external economies of scale. It goes to show whether the employment concentration calculated by HCLQ is representative of one big logistics company hiring a large number of people or whether the high concentration comes from an actual agglomeration or high number of logistics establishments in the region of study. Transportation infrastructure, freight accessibility as well as freight volumes within each region are investigated to shed some light on the potential of the provinces for being logistics clusters locations. This study explores the mentioned indicative aspects in accordance with the available statistical data hence giving a general idea about the logistics clusters or potential for the development of such clusters within Turkey.

4.1.1 Transportation and warehousing employment distribution

Employment within the field of logistics in the region of study is an important factor. Higher employment in logistics within a certain region is a direct indicator of possible agglomeration or clustering. Since statistics about the number of people employed in the field of logistics as a whole is not entirely available or accounted for within Turkey, this study looks at employment in the fields of transport and warehousing as a partial indicator.

Data obtained from the Turkish statistical Institute reveals the number of people employed in transportation and warehousing across the 26 NUTS statistical regions

mentioned in this study. The data reveals the highest levels of transport and warehousing employment in major cities led by Istanbul with a substantially higher number than the rest of the sub regions. Istanbul is followed by Ankara then Izmir, which is closely followed by the other sub regions shown in Figure 1 and Figure 2 below.

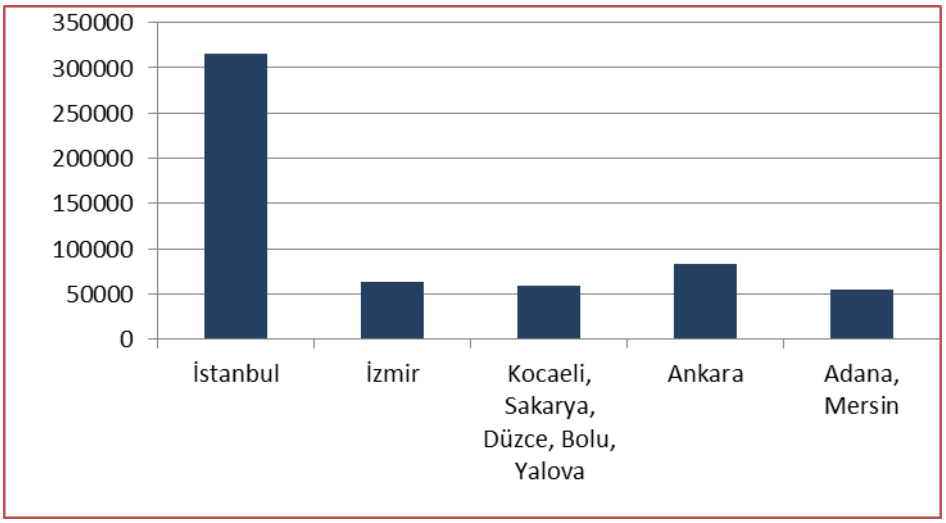

Figure 1: Highest numbers of people employed in transportation and warehousing in the sub regions of Turkey (NUTS-2) 2014.

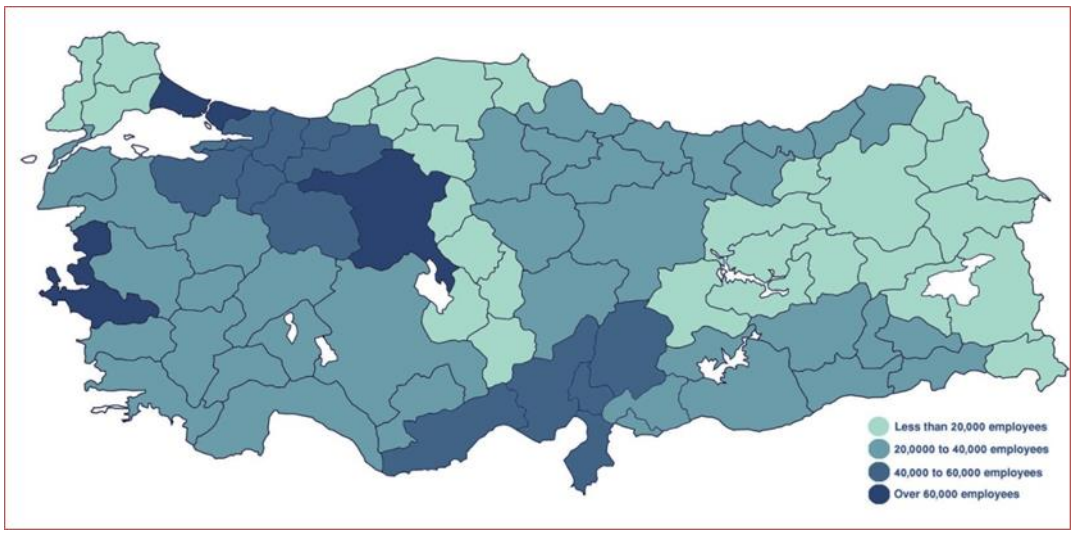

Figure 2: Transportation and warehousing employment distribution 2014.

4.1.2 Horizontal clustering location quotient (HCLQ)

The Horizontal Clustering Location Quotient (HCLQ), which was proposed by Fingleton et al. (2004) was used as a measure for the clustering of logstics establishments within the (NUTS-2) regions of Turkey. HCLQ takes into account relative and absolute importance of the industry over the ratio of the logistics share of employment in the region and its share in the country. The value of HCLQ gives an indication of magnitude by showing how much higher the level of logistics employment is, in a certain region, than the expected level based on total employment. The values of HCLQ for the 26 regions were calculated as follows:

$$\boldsymbol{HCLQ} = L - Le \tag{4.1}$$

Where **L** is the number of employees in transportation and warehousing in the region and **Le** is the expected number of employees in transportation and warehousing in the region. The expected number is calculated as the number of employees in the industry that would produce a LQ equal to one.

$$\boldsymbol{LQ} = \frac{\boldsymbol{ei/e}}{\boldsymbol{Ei/E}} \tag{4.2}$$

LQ is the Location quotient for transportation and warehousing in the region.

ei is the employment in transportation and warehousing in each region.

e is the total employment in each region.

Ei is the employment in transportation and warehousing in the country.

E is the total employment in the country.

$$\boldsymbol{Le} = \frac{\boldsymbol{e}}{\boldsymbol{E}} \times \boldsymbol{Ei} \tag{4.3}$$

Based on the transportation and warehousing employment, an HCLQ value larger than zero indicates agglomeration. Taken over a period of 5 years starting from 2009 and ending in 2014 the HCLQ values calculated showed the following regions as possible logistics clusters. Expectedly Istanbul showed the highest index dwarfing every other region; hence, the following graph represents the highest agglomeration in the warehousing and transportation sector according to HCLQ excluding Istanbul. Table 1 shows the results for all regions.

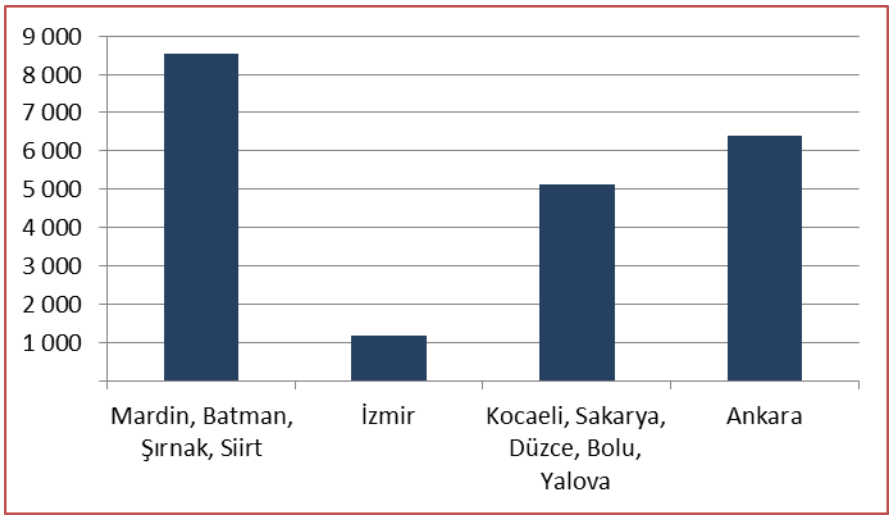

Figure 3: Regions with HCLQ levels exceeding zero for 2009-2014 excluding Istanbul.

Region	HCLQ (2009-2014)
Erzurum, Erzincan, Bayburt	-3809.88
Ağrı, Kars, Iğdır, Ardahan	-4698.92
Malatya, Elazığ, Bingöl, Tunceli	-6946.00
Van, Muş, Bitlis, Hakkari	-3445.15
Gaziantep, Adıyaman, Kilis	-3480.01
şanlıurfa, Diyarbakır	-196.03
Mardin, Batman, Şırnak, Siirt	**8530.57**
İstanbul	**105940.42**
Tekirdağ, Edirne, Kırklareli	-9146.77
Balıkesir, Çanakkale	-3987.14
İzmir	**1193.94**
Aydın, Denizli, Muğla	-10739.51

Manisa, Afyon, Kütahya, Uşak	-14318.62
Bursa, Eskişehir, Bilecik	-9667.15
Kocaeli, Sakarya, Düzce, Bolu, Yalova	**5117.86**
Ankara	**6393.24**
Konya, Karaman	-8649.21
Antalya, Isparta, Burdur	-4886.25
Adana, Mersin	-382.27
Hatay, Kahramanmaraş, Osmaniye	-1.35
Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir	-6135.113059
Kayseri, Sivas, Yozgat	-4152.76
Zonguldak, Karabük, Bartın	-4653.41
Kastamonu, Çankırı,Sinop	-4168.02
Samsun, Tokat, Çorum, Amasya	-14458.99
Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane	-9253.44

Table 1: HCLQ results for thw 26 NUTS regions of Turkey.

4.1.3 Logistics establishments participation index (LEP)

The logistics establishments' participation index was developed by L. Rivera, Y. Sheffi and R. Welsch (2014) as a sign of the share of logistics Establishments that a region has within the country. It's an indicator for external economies of scale in that it demonstrates the existence of a number of firms rather than one big firm with high logistics employment. LEP is defined as the number of logistics establishments in the region divided by the number of logistics establishments in the country of that region.

$$LEP = \frac{esj}{ES} \quad \textbf{(4.4)}$$

Where **esj** is the number of logistics establishments in region **j** and **ES** is the number of logistics establishments in the country.

The LEP was calculated for the 81 provinces of Turkey based on the number of logistics establishments in each province for the most recent data available which is year 2013. Table 2 shows LEP results for all 81 provinces.

Region Name	LEP	Region Name	LEP
Erzurum	0.009053	Bitlis	0.004072
Erzincan	0.002859	Hakkari	0.002032
Bayburt	0.001303	Gaziantep	0.018257
Agri	0.004796	Adiyaman	0.006662
Kars	0.0037	Kilis	0.001852
Igdir	0.004343	**Sanliurfa**	**0.030019**
Ardahan	0.0018	Diyarbakir	0.014131
Malatya	0.00893	Mardin	0.010073
Elazig	0.006295	Batman	0.00411
Bingöl	0.00265	Sirnak	0.009702
Tunceli	0.001301	Siirt	0.002074
Van	0.017827	**Istanbul**	**0.185775**
Mus	0.003766	Tekirdag	0.01316

Table 2: LEP results 2013 (1/2)

Edirne	0.005936	Hatay	0.020347
Kirklareli	0.005104	Kahramanmaras	0.012035
Balikesir	0.015649	Osmaniye	0.005218
Çanakkale	0.007312	Kirikkale	0.003342
Izmir	**0.045144**	Aksaray	0.004404
Aydin	0.013758	Nigde	0.00452
Denizli	0.011969	Nevsehir	0.00507
Mugla	0.021288	Kirsehir	0.002675
Manisa	0.017606	Kayseri	0.012391
Afyonkarahisar	0.008401	Sivas	0.007767
Kütahya	0.007277	Yozgat	0.006521
Usak	0.004484	Zonguldak	0.009841
Bursa	**0.029529**	Karabük	0.004028
Eskisehir	0.009886	Bartin	0.002853
Bilecik	0.003393	Kastamonu	0.007439
Kocaeli	0.02317	Çankiri	0.001755
Sakarya	0.013144	Sinop	0.003817
Düzce	0.005234	Samsun	0.017243
Bolu	0.004537	Tokat	0.006933
Yalova	0.003739	Çorum	0.006391
Ankara	**0.05775**	Amasya	0.005083
Konya	0.023282	Trabzon	0.013461
Karaman	0.002679	Ordu	0.013252
Antalya	**0.03641**	Giresun	0.009859
Isparta	0.003682	Rize	0.008626
Burdur	0.004536	Artvin	0.004243
Adana	0.02127	Gümüshane	0.002246
Mersin	0.021931		

Table 2: LEP results 2013 (2/2)

Due to the fact that the LEP doesn't have a natural cutoff value like the other indexes L. Rivera et al. (2014) found that when using a small critical LEP value, the number of logistics clusters explodes while using a high LEP value results in higher restriction and the number of logistics clusters goes to zero. In order to define the critical value they used a method where Type I error was minimized by reducing the LEP critical value from 1 until all the known clusters were identified. Following that, the false positives were minimized by gradually raising the LEP critical value until false positives started to appear resulting in 61 identified logistics clusters in the USA (Rivera et al., 2014).

In this study where the set of data is considerably smaller -81 Turkish provinces as opposed to 3095 US counties- the critical value for the LEP was chosen as the value after-which the number of identifiable logistics clusters rapidly increases. It was found that at an LEP value of 0.025 the number of identifiable clusters, defined as provinces that show a higher than usual concentration of logistics establishments, reaches up to 6, whereas if the value was decreased further to 0.02 the number of clusters jumps up doubling to 12 and continues to increase reaching up to 50 at 0.005. Hence, the critical value was chosen at 0.025. Table 1 shows the number of clusters obtained from different values of LEP as the cutoff value changes. Meanwhile, figure 4 below demonstrates the chosen cutoff point of 0.025 and the rapid increase of the resulting identifiable clusters if said value was decreased further.

The 6 provinces which were identified by their LEP values to possess a higher than average concentration of logistics establishments were: Istanbul, Ankara, Izmir, Antalya, Bursa and Sanliurfa. Istanbul being one of the most largely populated provinces and with its location encompassing the bosphorus strait expectedly dwarfed all other provinces being identifiable as a cluster even at an LEP of 0.1 and having over 18.5% of the transportation and warehousing establishments in Turkey as of 2013. Ankara followed in second place hosting 5.7% of the establishments in Turkey while Izmir, Antalya, Sanliurfa and Bursa each had 4.5%, 3.6%, 3% and 2.9% respectively.

LEP Value	0.1	0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.025	0.02	0.015	0.01	0.005
Number of Clusters	1	1	1	1	1	2	3	5	6	12	17	27	50

Table 3: LEP values vs. number of identified clusters

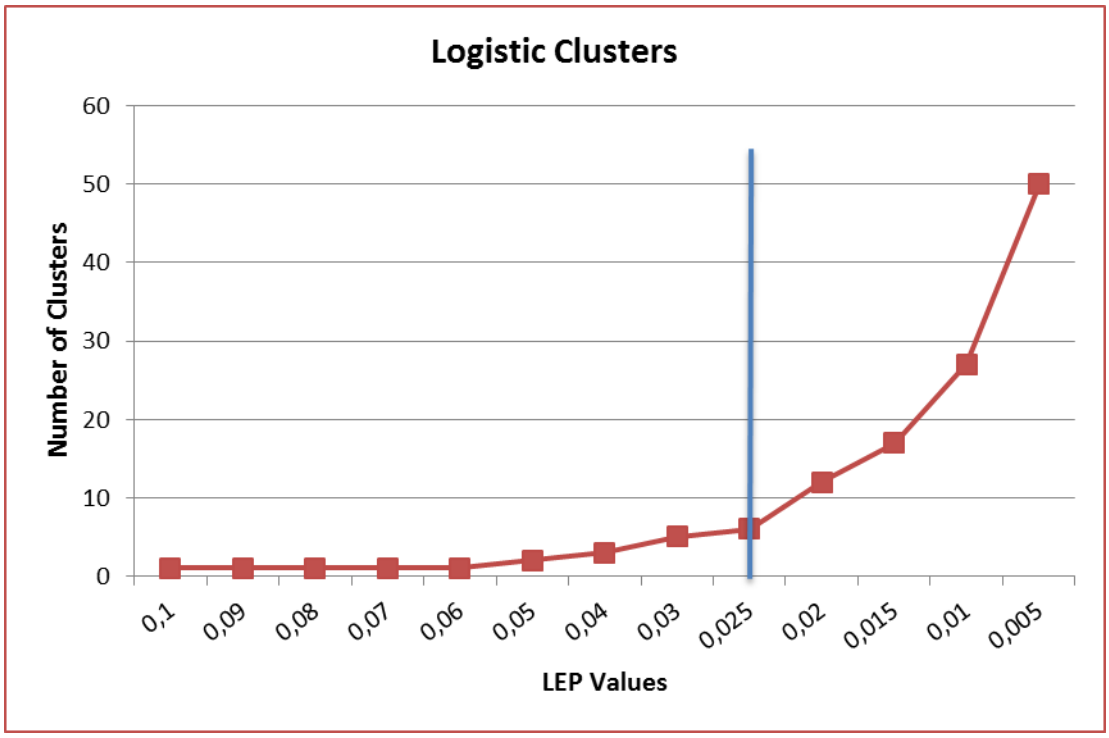

Figure 4: Determination of LEP cutoff value

Figure 5: Identifiable clusters based on LEP Value

4.1.4 Logistics firms' density distribution

In order to further study the geographical distribution of the logistics firms around Turkey. Data was collected from the Association of International Forwarding and Logistics Service Providers in Turkey (UTIKAD). The association has around 430 member firms, which collectively own around 95% stakes in air and rail, and 65% in ocean and road forwarding activities (Utikad.org.tr, 2016).

4.1.4.1 UTIKAD members' headquarters' distribution

Among the 430 members of UTIKAD the vast majority had their headquarters in Istanbul. Izmir, Mersin and Kocaeli also had a number of companies with headquarters located in their regions whereas the rest of the companies were scattered as shown in figure 6 below where the size and color of the pins is representative of the number of firms with headquarters in the region.

Figure 6: UTIKAD member firms' headquarters' distribution

4.1.4.2 Major logistics firms' regional directorates' distribution

In addition to the locations of the headquarters of logistics firms, the location of the regional directorates of some of the major international logistics and cargo companies was investigated. The firms chosen as a representative sample were Aramex, Aras kargo, DHL Logistics, EKOL logistics, MNG Kargo, Horoz Kargo, as well as Yurt ici kargo. The data was obtained from the companies' respective official websites and represented on the map where the pins represent the locations of the regional directorates and the size of the subject pins represents the number of directorates within the region of study.

The distribution of the chosen major companies' respective regional directorates is illustrated in figure 7. It is clear that Istanbul again leads all other provinces having the highest number of regional directorates located within its area. Istanbul is followed by Izmir, Ankara and Kocaeli. Bursa and Adana also have a considerable number of regional directorates compared with the rest of the provinces as shown below.

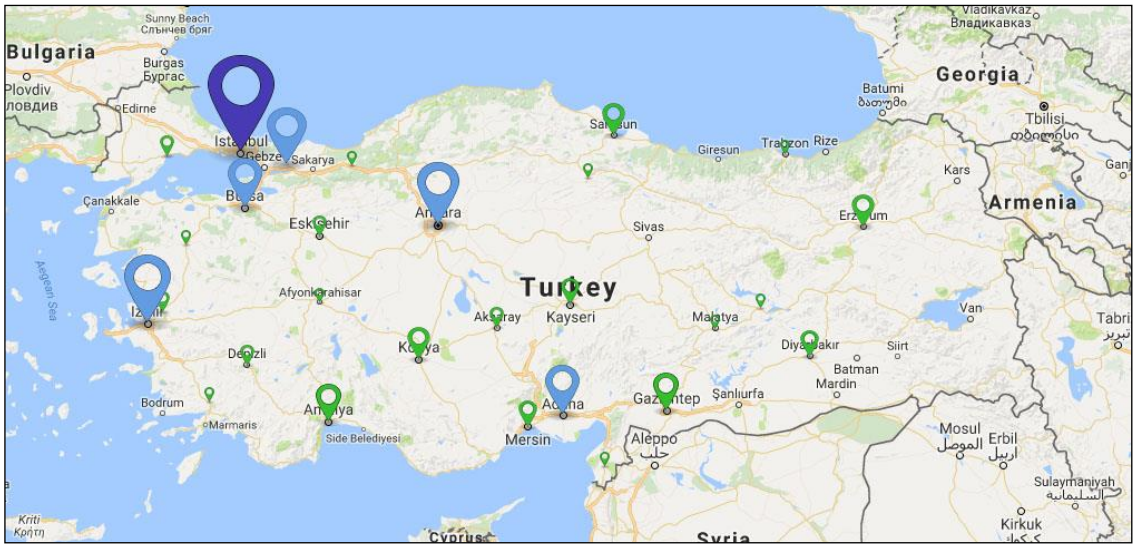

Figure 7: Major firms' regional directorates' geographical distribution. (Pin size is representative of number of regional directorates)
(Aramex, Aras kargo, DHL Logistics, EKOL logistics, MNG Kargo, Horoz Kargo, Yurt ici kargo.)

4.1.4.3 International transport association members (UND)

The international transport association was established in 1974 to be a representative of the Turkish road transport sector on a national and an international level. The number of member firms in each province was obtained and represented in the figure below for the provinces which possess the highest number of firms within their borders to give an indication of the operational infrastructure of the subject regions.

It can be noticed that the major provinces that had the highest employment distribution and that had the highest HCLQ values in Turkey, such as Istanbul, Ankara, Izmir and Kocaeli show a high number of road transport firms. An investigation of the fleet sizes in the provinces follows to investigate the capacity that is available in those provinces. Table A.1.1 in Appendix 1 shows the number of UND members in each province.

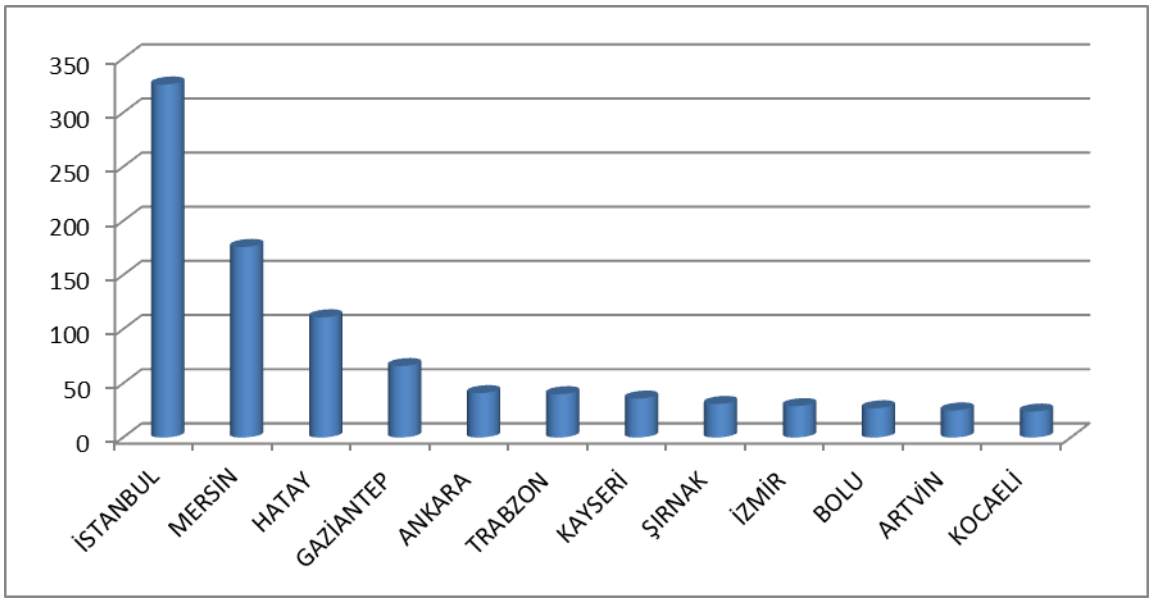

Figure 8: Highest number of UND members in provinces

4.1.5 Regional fleet sizes

The number of the members of the international transport association is indicative of the size of specialization in road transports for a region but is not enough on a stand-alone basis. There is a need to investigate the size of the firms in each region. In order to shed some light of the size and corresponding capacities of road transport firms in different regions. Data about the fleet sizes of trucks and semi-trucks used for the carriage of freight is collected.

The results point out that there is a correlation between the provinces that have the highest number of road transport establishments and those that have the biggest fleet sizes. However, the number of establishments is not a direct indication of the size of fleets. The provinces that had the biggest fleet sizes were mainly the core-cities of the country where there is a combination of high number of transport and warehousing establishments, high employment, good transport infrastructure and key geographical locations.

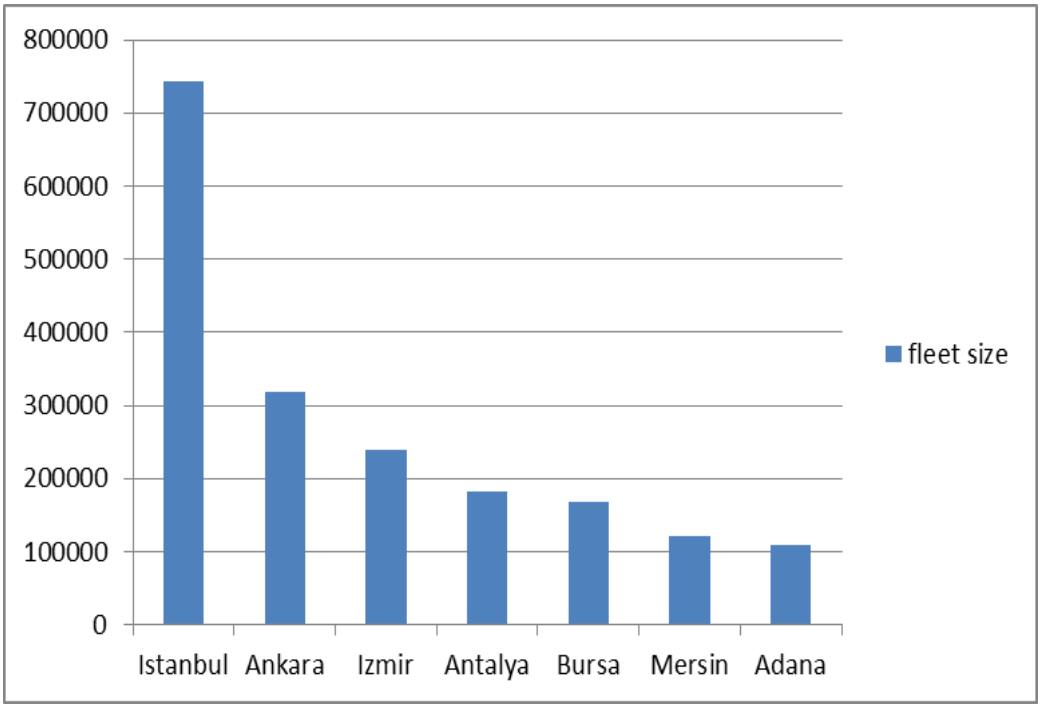

Figure 9: Provinces with the highest numbers of road transport vehicles.

4.2 Growth of Clusters Over Time

4.2.1 Transport and warehousing employment growth

In order to investigate the possible growth of clusters, data about the transport and warehousing employment of provinces was compared in two reference years 2003 and 2014. It was observed that all identified clusters experienced significant growth in terms of employment as illustrated in Figure 10 below.

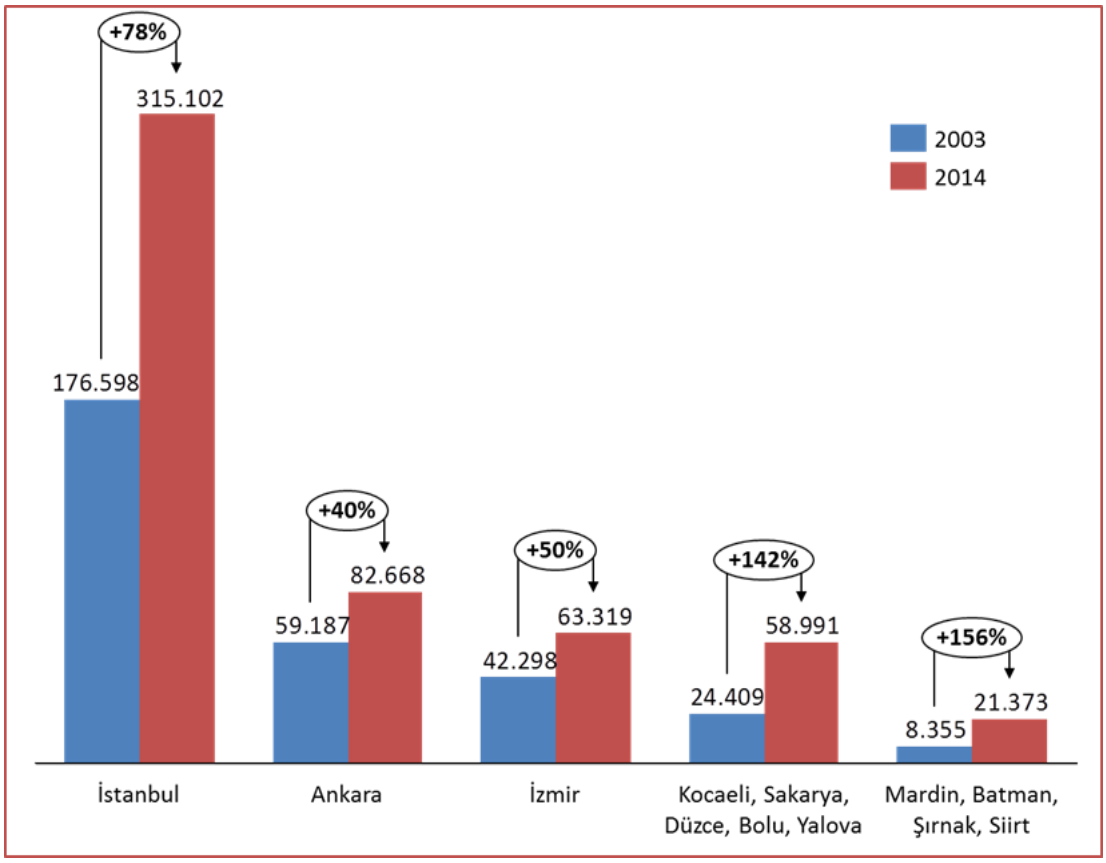

Figure 10: Cluster growth in terms of employment over time (2003-2014)

4.2.2 Transport and warehousing number of establishments' growth

The growth in the number of transport and warehousing establishments was also calculated between the two base years 2002 and 2013. Previous findings of clusters growth were also confirmed in that all identified clusters experienced growth in the number of establishments. The results are shown in figure 11.

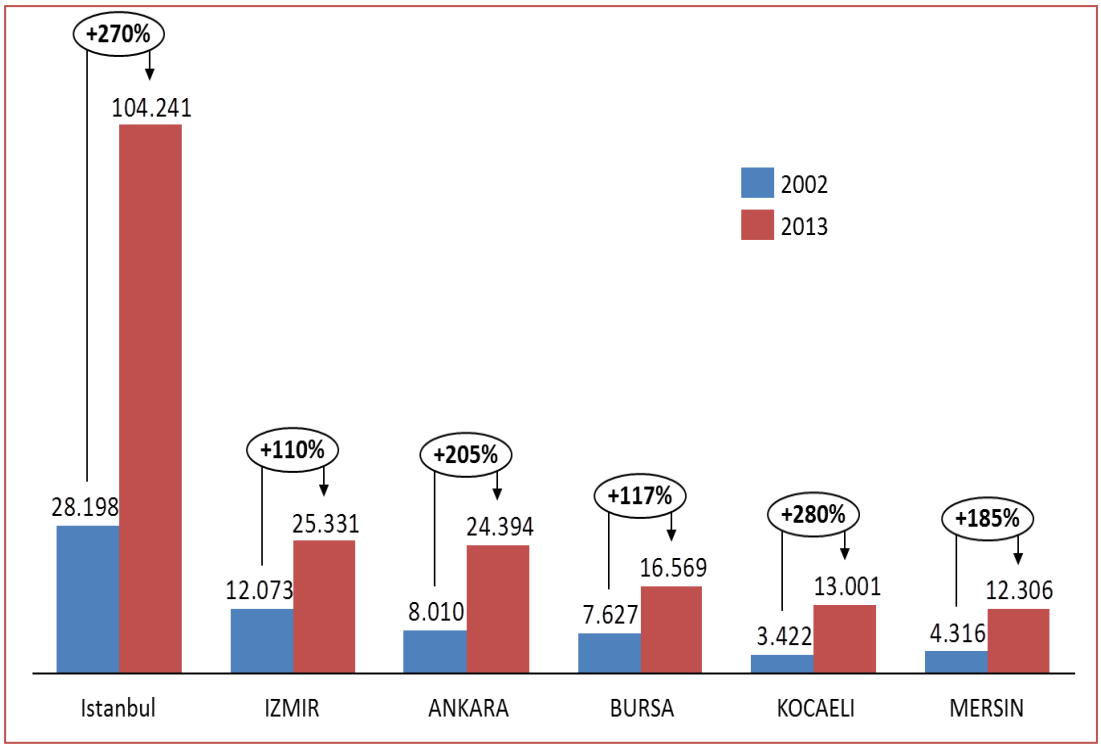

Figure 11: Clusters growth in terms of the number of logistics establishments (2002-2013)

An interesting observation was made however. Even though the identified areas all experienced significant growth, the fastest growth rates were observed in non-core cities instead of the main ones. This observation can be explained by the possible diseconomies of scale that result from the agglomeration of firms. As the number of firms increases, the land availability and resources are put under pressure which leaves little space for further growth, so while clusters in core cities do expand in time, growth in non-core areas can experience faster rates which agrees with the findings of Bowen (2008).

Ege region was further investigated to observe the growth rates of non-core provinces compared to Izmir as one of the identified core cities. It can be observed that while Izmir experienced significant growth it was not the fastest in terms of growth rate. Figure 12 illustrates this observation.

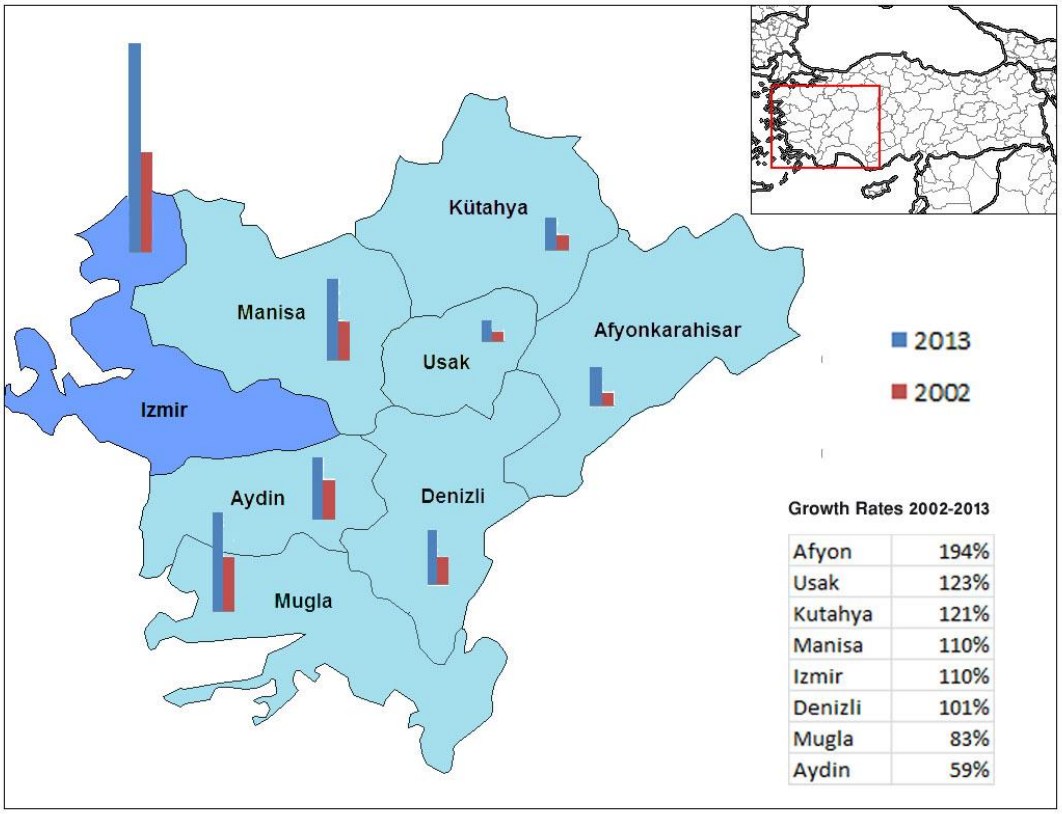

Figure 12: Growth rates in Ege region (2002-2013)

4.3 Physical Infrastructure

Freight Accessibility

The transportation infrastructure is an important factor to consider while studying the location decision of logistics companies. Since companies seek for the best cost structure upon the beginning of their operations, a well-developed transportation infrastructure helps significantly decrease the company's costs and gives it better and faster reach to the market and its customers. It is therefore expected that logistics companies will be attracted to locations with good road networks, airports, seaports and railway systems.

In this section, the transportation infrastructure of the 81 provinces of Turkey was studied in terms of (1) airports' geographical distribution across the country, (2) availability of seaports within the borders of the province, (3) road density distribution and (4) railroad accessibility. The better the transportation infrastructure

that the province has, the more likely it is to have a higher concentration of logistics establishments or have the potential to attract such establishments in the future.

4.3.1 Airports distribution

Data about the geographical distribution of airports was obtained from the General directorate of States Airports Authority (DHMI). Figure 13 below shows the distribution of international and domestic airports within the 81 Turkish provinces. It is evident that within every major city identified as a cluster there is an international airport.

The number of flights in each airport was also investigated to give an indication about the concentration of activiy in each province in terms of air transport. Figure 14 shows the provinces with the highest number of flights in 2014. Istanbul has the highest number of flights, as expected, given the huge number of passengers and the high volumes of flight passing through each year, which is another indication of the degree of concentration. Major cities such as Antalya, Ankara, Izmir, Mugla and Adana also rank very high in comparison with the rest of the provinces. The freight volumes in these airports are further discussed in the next section.

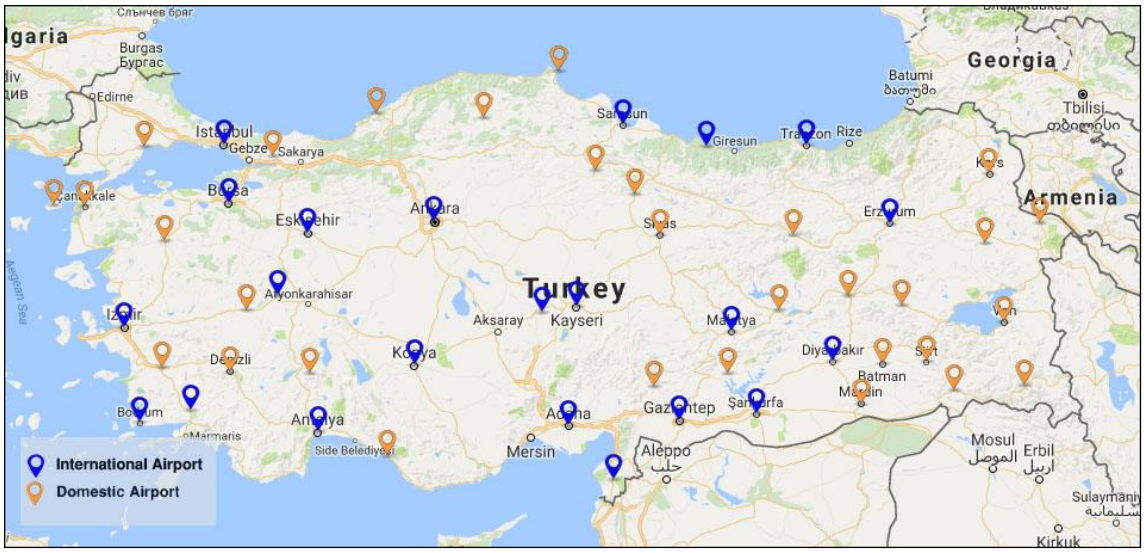

Figure 13: Domestic and International airports geographical distribution.

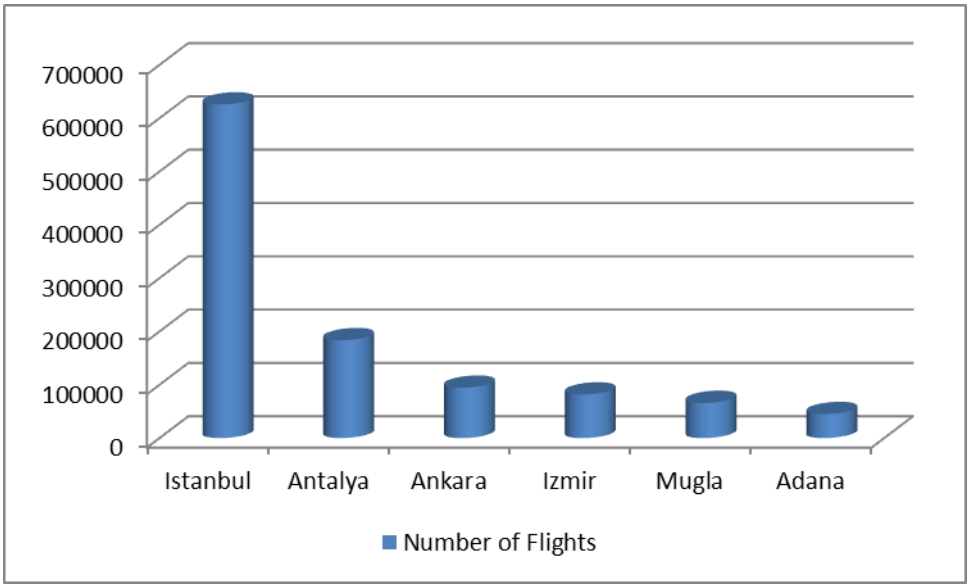

Figure 14: Highest number of flights 2014

Ranked according to capacity, the top five airports in Turkey are located within those major provinces. Istanbul serves as the third largest and busiest airport in Europe and by far the largest in capacity within Turkey. Antalya, Ankara and Izmir have the highest capacity airports in Turkey after Istanbul. The table below shows their corresponding capacities in terms of passenger traffic.

Airport name	Capacity
Atatürk International Airport	61,322,729
Sabiha Gökçen International Airport	28,112,438
Antalya Airport	27,724,249
Esenboğa International Airport - Ankara	12,326,869
Adnan Menderes Airport - Izmir	12,139,788

Table 4: Highest capacity airports 2015.

4.3.2 Seaports distribution

Data about the sea ports around Turkey was obtained from the general directorate of Maritime trade. Figure 15 below represents the major seaports distribution in the black sea, Marmara Sea as well as the Mediterranean region. Areas with high capacity international ports usually attract a higher number of logistics companies since being in close proximity to them leads to a reduction in the transportation costs for a lot of firms.

Figure 15: Major seaports distribution (En.wikipedia.org, 2016)

According to a report issued by Earnst & Young (2011) the number of ports in Turkey according to the regional directorates is listed in Table 5. Of those ports 22 are public ports, 27 are municipality ports and 125 are private ports. Freight volumes are investigated and discussed in following sections.

Turkey's biggest ports are Mersin, Ambarli, Bandirma, Iskenderun, Samsun, Izmir, Derince, Trabzon and Haydarpasa ports. The cargo handling capacities of port regions in Turkey are listed in Table 6.

Regional directorate	Number of ports
Istanbul	78
Canakkale	24
Izmir	22
Mersin	18
Samsun	16
Trabzon	9
Antalya	7

Table 5: Number of ports according to regional directorates.

	Capacity	
	Containers (TEU)	General & bulk (Ton)
Marmara region	6.100.000	124.185.000
Ege region	1.760.000	46.330.810
Mediterranean region	2.720.000	68.886.052
Black sea region	505.000	37.450.000

Table 6: Cargo handling capacities of port regions 2015.

4.3.3 Road density distribution

The density of the road network was calculated for all provinces as the ratio of the length of roads within the province and the area of that province multiplied by a 100. The length of roads per 100 km of geographical area defined as the road density was taken as an indication of road freight accessibility. Data for the road lengths was collected from the Turkish statistical Institute (TUIK) for the most recent available data 2014.

$$\boldsymbol{Road\ Density} = \frac{Length\ of\ roads\ within\ a\ province}{Area\ of\ province} \times 100 \qquad \textbf{(4.5)}$$

We found that the road density is well distributed around the 81 provinces with no specific province showing a noticeably smaller density than the rest. There are however some provinces that show a noticeably higher density than the rest, as demonstrated in Figure 16. The results show that the provinces identified as clusters tend to show high road density. The results for the density of all provinces are represented in Figure 17. Table A.1.2 in Appendix A.1 provides the full results for provincial road densities.

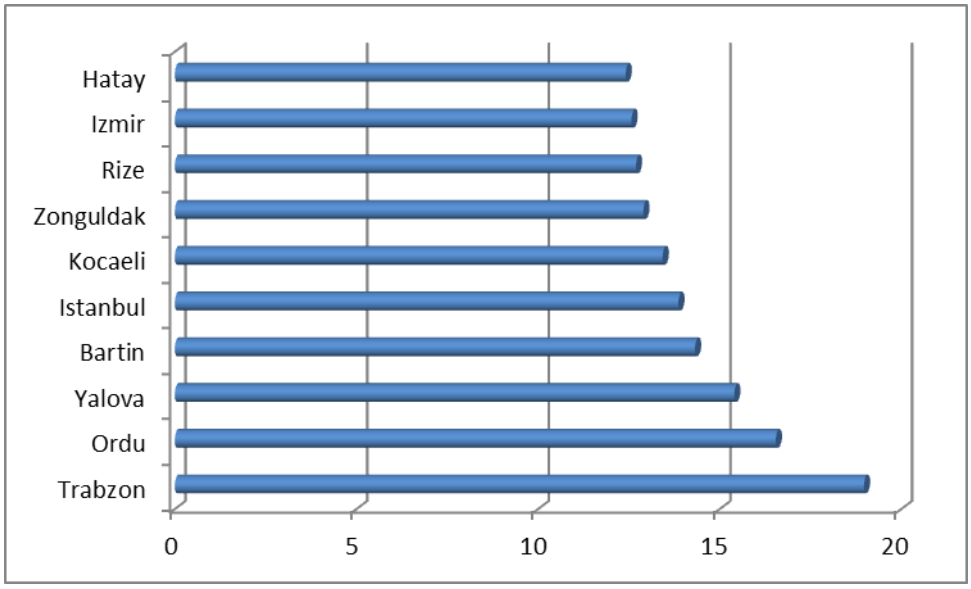

Figure 16: Highest road density values among the provinces of Turkey. (2014)

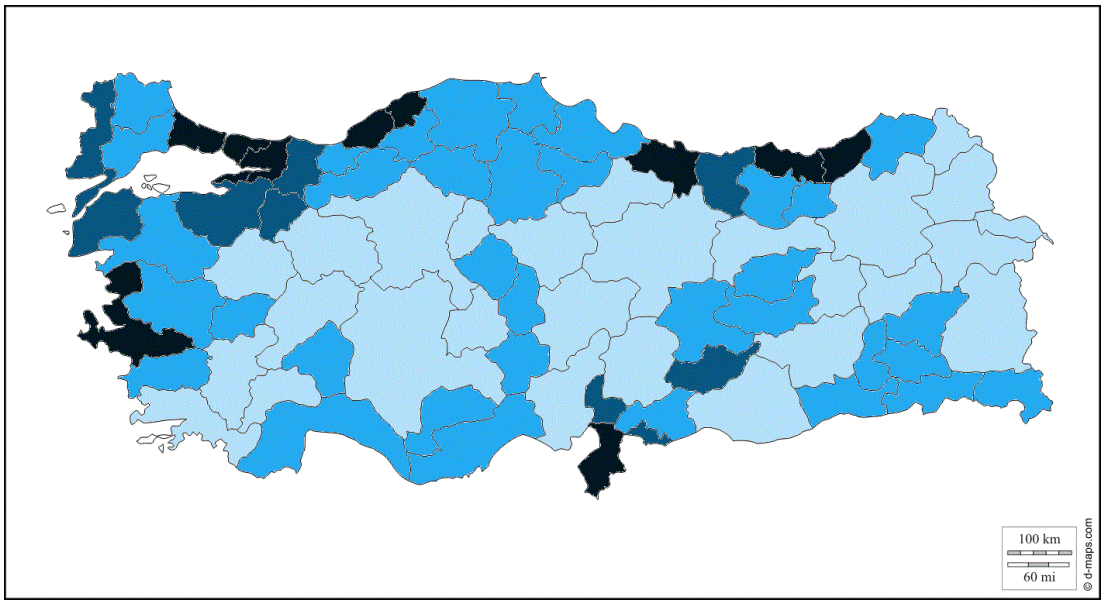

Figure 17: Map representing the road density distribution across Turkey 2014.

4.3.4 Rail accessibility

The rail accessibility measure was taken as the rail density. Density within the province was calculated as the length of all railroads within the province divided by that province's area multiplied by a thousand which means km of railroad per 1000 km squared of area. The railroad network in Turkey is not as well developed as other modes of transportation. Whereas there are some known freight terminals, they are government owned and a part of the State Railways of the Turkish Republic (TCDD) which is not very highly utilized and currently mostly limited to mining and containers. Data for the rail lengths in each province was obtained from the Turkish statistical institute (TUIK) and the highest provincial rail density is represented in Figure 18. Table A.1.3 in

$$Rail\ density = \frac{Length\ of\ railroads\ within\ province}{Area\ of\ province} \times 100 \qquad \textbf{(4.6)}$$

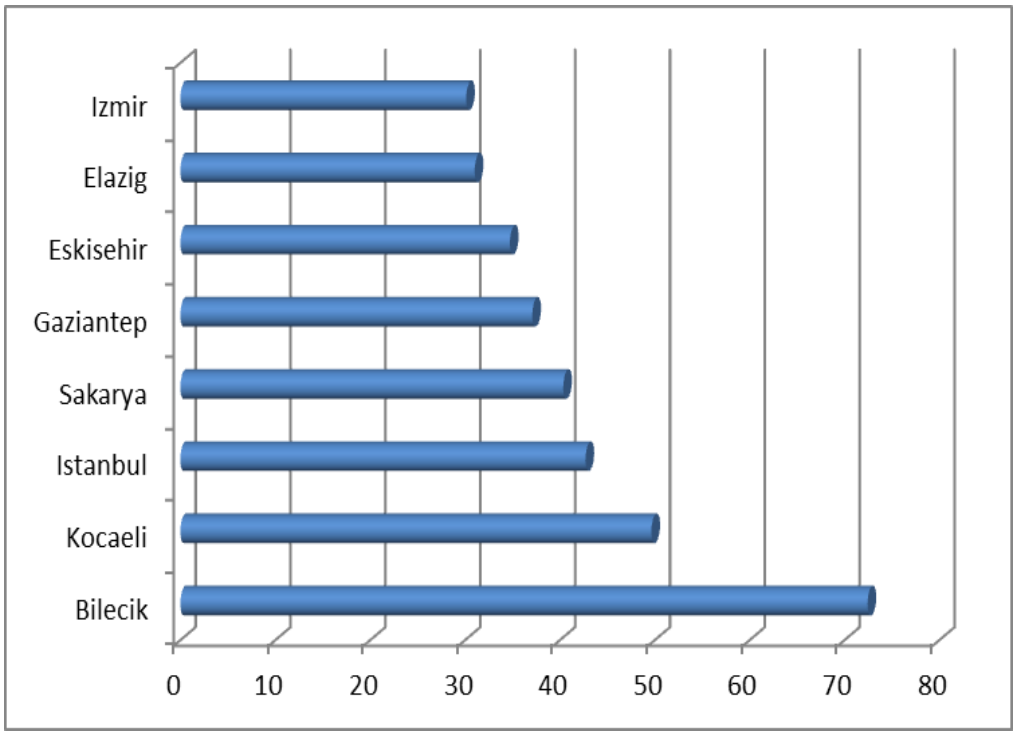

Figure 18: Highest rail density values among the provinces of Turkey. (2014)

According to the Turkish State Railways (TCDD) The Turkish transportation ministry has set a target to have established 18 railway logistics centers spread out across Turkey by 2023. Investment in the Turkish railway system, whether by urbanization or incentives, could bring about positive effects to an otherwise under-developed system. It has been promised that by the same year 9000km of new high speed train lines will have been constructed bringing the total rail length to 26,000km. It was also announced in April 2016 that private operators will finally have access to Turkey's rail network which is currently controlled only by TCDD. This move could result in rail freight increasing rapidly once private firms get the ability to utilize the network in return for a fee. (Transport-exhibitions.com, 2016)

4.4 Regional Logistics Potential

The regional logistics potential is investigated by studying a number of factors: (1) The freight volumes and capacities in terms of air, railway and maritime transport, (2) The imports and exports of each region and (3) the proximity of regions to major markets.

4.4.1 Freight volumes and capacity

High freight volumes give an indication of the logistics potential of a region or the existence of demand for logistics services since the movement of freight constitutes a major part of logistics functions. Freight volumes for air, and maritime transport were investigated and the results summarized accordingly.

4.4.1.1 Airborne freight volumes

Regional airborne freight volumes for the provinces of Turkey were obtained from the website of the Turkish Statistical Institute (TUIK) for the year 2014. Provinces with the highest airfreight volumes, excluding Istanbul which far exceeds any other province, are represented in Figure 19 below.

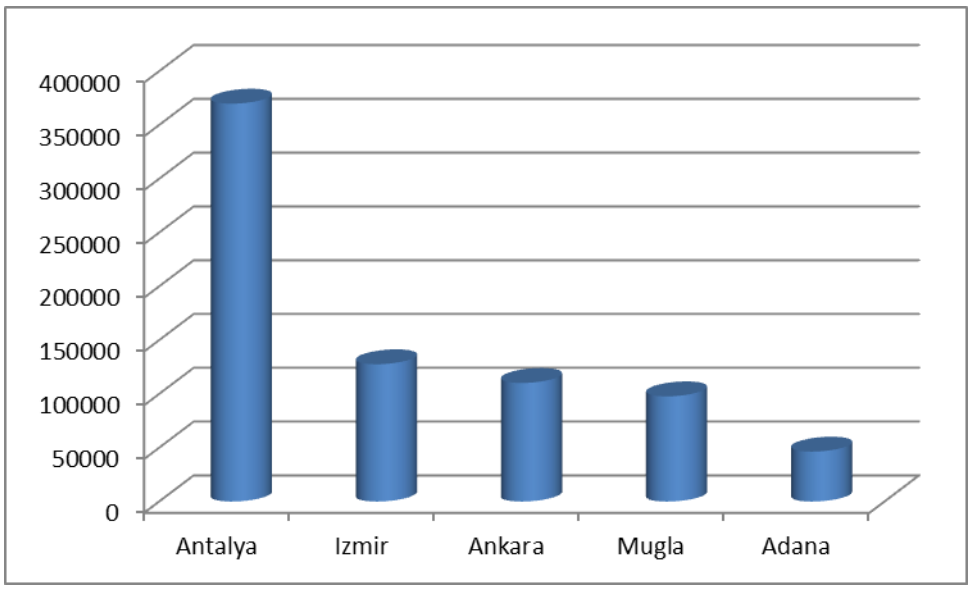

Figure 19: Provinces with the highest airfreight volumes

4.4.1.2 Maritime freight volumes

The data for the regional maritime freight volumes was obtained from the Maritime Trade General Directorate (DTGM) annual statistics report for 2015. Unit of measure is tons. Figure 20 clarifies the regions with the highest maritime freight volumes.

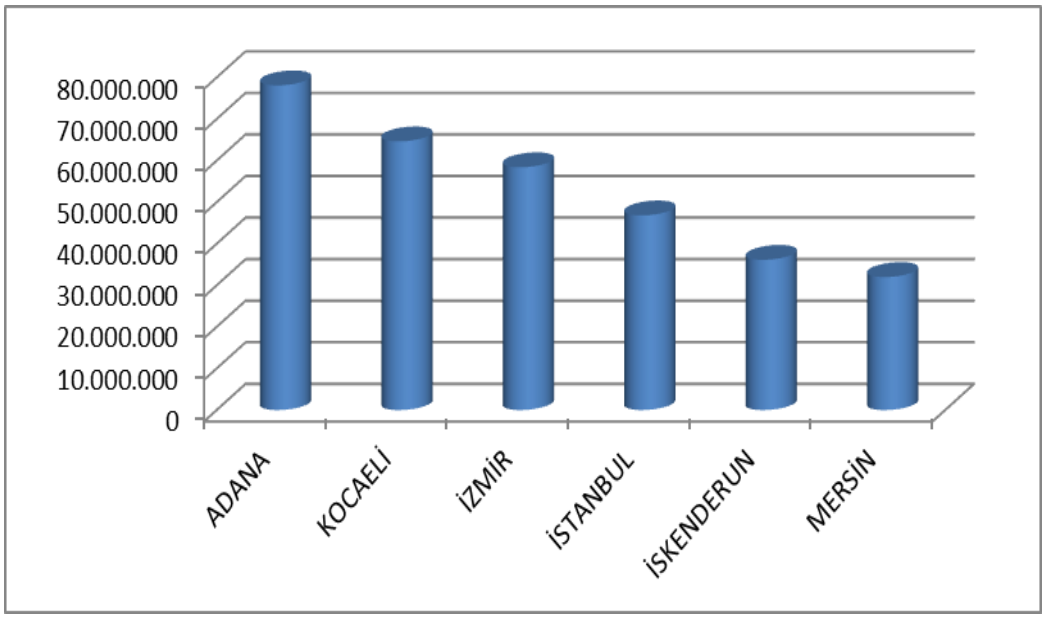

Figure 20: Regions with highest maritime freight volumes

4.4.2 Regional import and export volumes

Another sign of the logistics potential or demand for logistics services is the export and import volumes of each region. Regional imports and exports data measured in 1000 dollars is obtained from the Turkish Statistical Institute (TUIK) for 2014. The following map represents the distribution of exports and imports across Turkey excluding Istanbul.

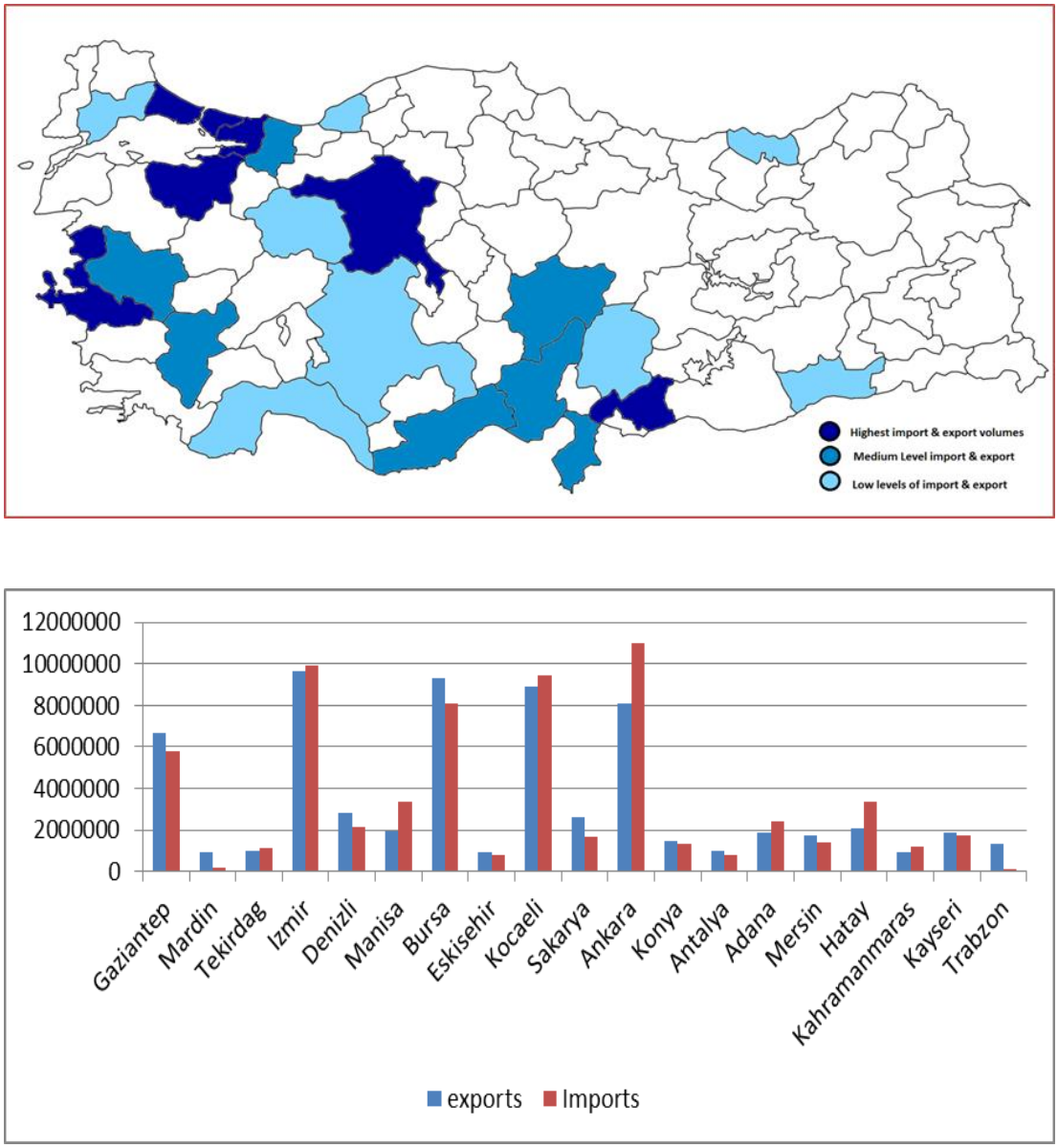

Figure 21: Regional imports and exports 2014

4.4.3 Proximity to markets

The proximity to major markets is one of the major determinants of how logistics firms make their locational decisions. Locating in a region that is close to major markets reduces time needed to reach customers and the corresponding costs. Market reach was studied in terms of accessibility to large urban centers. Zorlu (2008) utilized TUIK data as well as the Turkish roads map and classified regions according to the time it takes from that region's center to urban centers with high populations. Ranked according to the mentioned criterion the following provinces ranked highest in market reach:

Istanbul	Market reach of over 10 million people within 1 hour distance
Ankara, Izmit, Tekirdag	Market reach of over 5 million people within 1 hour distance
İzmir, Manisa, Bursa, Adana, Mersin, Antalya, Konya, Gaziantep, Kayseri, Diyarbakır.	Market reach of over 1 million people within 1 hour distance

Table 7: Market reach of provinces

It is evident that since Istanbul has the biggest population the accessibility to large urban centers is highest. It is then followed by provinces which are in close proximity to it. This indicates that the market reach criterion is always higher for the most highly populated provinces and the provinces close by.

5. Results and Key Findings

5.1 Clusters Distribution and Characteristics

Using the Horizontal Clustering Location Quotient (Fingleton et al, 2004) in combination with the Logistics Establishments Participation Index (Rivera et al., 2014), the logistics agglomeration in Turkey was investigated. The results show that the main areas of concentration are mainly Istanbul, Ankara and Izmir followed closely by Kocaeli. Adana and Mersin also had some of the highest levels of employment and scored relatively high across most of the criteria but were not identified as clusters.

The areas identified as clusters were the areas that have an HCLQ, which is higher than zero and an LEP value, which is higher than the cutoff value of 0.025. Accordingly, Istanbul, Izmir and Ankara were identified as the most prevalent clusters while Kocaeli had high HCLQ but an LEP value of 0.023, which is slightly lower than the cutoff value.

The growth of those clusters was then investigated. Between 2002 and 2014 all the subject clusters experienced growth in terms of both employment and the number of establishments coinciding with the findings of Rivera et al. (2014). The growth rate in the number of establishments was highest in Kocaeli at 280%. Istanbul experienced a growth rate of 270% while Ankara had the third highest growth rate among the identified clusters of 205%.

In terms of transportation and warehousing employment growth, Kocaeli again far exceeded the other identified clusters with a growth rate of 142%. Istanbul had the second highest growth rate at 78% while Ankara and Izmir had growth rates of 50% and 40% respectively. The increasing levels of employment are in line with Rodrigue et al. (2013) who discussed the benefits of agglomeration in terms of job creation.

The study also shows that core-cities have experienced significant growth which is in agreement with Cidell's (2010) findings yet it also notes that the fastest growth rates were experienced by non-core cities in accordance with what Bowen (2008) stated in

his study. Kocaeli, being the emerging cluster, has the highest growth rates in terms of both employment levels and number of establishments. This can be explained in terms of the diseconomies of scale that could emerge once the clusters have grown past a certain limit where there is less availability of land and resources in the regions of clustering.

Coinciding with Rodrigue at al. (2013) findings, the identified clusters were also characterized with excellent transportation infrastructure. Istanbul, Izmir and Kocaeli had some of the highest densities in terms of roads and railways. In fact, they have all been targeted by the Turkish railway for the establishment of freight villages thus highlighting their importance. Lipscomb (2010) states that clusters not only have high road density but also a high number of road transport vehicles which agrees with the results of this thesis. Istanbul, Ankara and Izmir have the largest fleet sizes among all Turkish provinces. The synergy between the identified clusters and transportation infrastructure was evident.

In addition the identified clusters all have international airports which have the highest capacities in Turkey. With the exception of Ankara all identified clusters also have large international seaports. The corresponding freight volumes in terms of air and maritime transport are very high. All identified clusters rank highest among Turkish provinces, which confirms the results of Heuvel (2013) & Sheffi et al (2014).

In terms of the import and export volumes, the results confirm that logistics clusters see high demand for logistics services given the fact that Istanbul, Ankara, Izmir and even Kocaeli have significantly high levels of import and export volumes. All in all, the identified clusters were characterized with an advanced transport infrastructure, advanced operational infrastructure and high logistics potential in terms of the demand for logistics services.

6. Conclusion and Research Opportunities

Logistics agglomeration and clustering is a relatively new concept in the global economy as evident by the lack of extensive literature addressing the topic. This study contributes to the available literature by attempting to identify existing clusters within Turkey. The regions of Turkey are then studied in detail in terms of the physical infrastructure, operational infrastructure, the logistics potential and growth in time.

The results showed that the identified clusters had excellent transportation infrastructure in terms of the availability of ports and airports and the density of the roads and railway networks. It also shows the high operational capabilities of those regions in terms of available freight transport vehicles, the number of establishments, and the employment levels. It further confirms the results by representing the logistics firms density distribution based on data collected from Turkish associations such as Association of International Forwarding and Logistics Service Providers in Turkey (UTIKAD and the international transport association (UND).

The logistics potential is also shown to have played a role in the clustering of logistics firms since it serves as an indication of demand. (Zorlu 2008). Clusters had high import and export volumes, they had high freight volumes and were all located in close proximity to highly populated urban centers.

Given the fact that logistics data is very hard to acquire in terms of annual statistics this study took transport and warehousing data as a reference, which means that only the physical distribution aspect of logistics was studied. Materials management aspect which includes all the activities related to the manufacturing of merchandise in all its stages of production along the supply chain (often called in-house logistics) was not considered (Rodrigue et al.,2013). Future research can possibly address this problem, where reclassification of data is required in order to consider all the activities of logistics into one industry (Candemir & Celebi, 2015). Thus finding a way to more accurately measure the clustering of logistics as a sector.

Another issue that could be further studied is the measurement of the benefits of logistics clusters. Ways for quantifying those benefits can be developed and applied to verify the academic studies which are mostly based solely on expert opinions.

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APPENDICES

APPENDIX A.1 :

Table A.1.1: Number of road transport firms in Turkish provinces (UND)

Province	Number of members
ADANA	9
AĞRI	8
ANKARA	41
ANTALYA	6
AKSARAY	2
ARTVİN	25
BOLU	27
BURSA	12
BURDUR	2
ÇORUM	1
DENİZLİ	4
DÜZCE	16
EDİRNE	2
ESKİŞEHİR	5
ERZURUM	1
GAZİANTEP	66
GİRESUN	3
HATAY	111
IĞDIR	19
ISPARTA	0
İSTANBUL	326
İZMİR	29
KARABÜK	1
KARS	1
KAYSERİ	36
KİLİS	2
KOCAELİ	24
KONYA	23
MALATYA	1
MARDİN	23
MANİSA	5
MERSİN	176

NEVŞEHİR	0
ORDU	4
OSMANİYE	1
RİZE	11
SAKARYA	5
SAMSUN	8
SİVAS	0
ŞIRNAK	31
TEKİRDAĞ	1
TRABZON	40
ZONGULDAK	1
Total:	1109

Table A.1.2: Provincial road density results

Province	**Road density**
Adana	5.973418
Adiyaman	9.242509
Afyonkarahisar	6.963963
Agri	4.409206
Amasya	8.485601
Ankara	6.538871
Antalya	7.777568
Artvin	7.940709
Aydin	8.729282
Balikesir	7.752511
Bilecik	10.65764
Bingol	6.748644
Bitlis	8.189443
Bolu	7.532988
Burdur	7.834673
Bursa	9.663451
Canakkale	10.54226
Cankari	7.728357
Corum	8.19774
Denizli	6.836555
Diyarbakir	6.550903
Edirne	11.06937
Elazig	8.263795
Erzincan	6.864179
Erzurum	6.336135
Eskisehir	6.107022
Gaziantep	7.319382
Giresun	10.94915

Gumushane	8.637551
Hakkari	6.170879
Hatay	10.46068
Isparta	7.947172
Mersin	8.199971
Istanbul	9.425567
Izmir	10.48636
Kars	7.032189
Kastamonu	9.606338
Kayseri	6.45262
Kirklareli	8.587601
Kirsehir	8.070049
Kocaeli	10.84051
Konya	7.252499
Kutahya	7.624711
Malatya	8.750114
Manisa	8.254904
Kahramanmaras	6.419151
Mardin	8.380611
Mugla	7.16646
Mus	7.301206
Nevsehir	8.958313
Nigde	6.381283
Ordu	14.73333
Rize	11.21882
Sakarya	10.26599
Samsun	8.094745
Siirt	9.263167
Sinop	9.593316
Sivas	7.641594
Tekirdag	8.498494
Tokat	6.919749
Trabzon	16.05904
Tunceli	7.416409
Sanliurfa	6.128398
Usak	8.763605
Van	4.924246
Yozgat	7.702097
Zonguldak	12.41744
Aksaray	6.164075
Bayburt	7.969875
Karaman	8.411415
Kirikkale	8.074822
Batman	7.812483
Sirnak	7.299097

Bartin	14.18024
Ardahan	7.206656
Igdir	5.713792
Yalova	14.22759
Karabuk	9.443146
Kilis	10.36589
Osmaniye	9.011292
Duzce	7.057598

Table A.1.3: Provincial rail density results

Province	**Rail density**
Erzurum	8.329747463
Erzincan	19.1003236
Bayburt	0
Agri	0
Kars	16.96404707
Igdir	0
Ardahan	0
Malatya	19.66503342
Elazig	31.02963438
Bingöl	11.631415
Tunceli	0.650562216
Van	6.026535298
Mus	10.66050506
Bitlis	7.470575798
Hakkari	0
Gaziantep	37.10824504
Adiyaman	5.916257349
Kilis	11.20636522
Sanliurfa	11.37761743
Diyarbakir	9.865818294
Mardin	14.53547792
Batman	10.08754703
Sirnak	0
Siirt	6.39469131
Istanbul	42.70666167
Tekirdag	22.38935402
Edirne	15.74309887
Kirklareli	17.46092721
Balikesir	19.34673002
Çanakkale	0
Izmir	30.12747584
Aydin	18.47065506

Denizli	11.52133268
Mugla	0
Manisa	19.95691121
Afyonkarahisar	26.293208
Kütahya	22.8075418
Usak	29.27416844
Bursa	1.469726392
Eskisehir	34.74312744
Bilecik	72.44408222
Kocaeli	49.65120032
Sakarya	40.36728078
Düzce	0
Bolu	0
Yalova	0
Ankara	25.70669799
Konya	14.45599399
Karaman	11.95187678
Antalya	0
Isparta	9.468971084
Burdur	2.662947883
Adana	13.02902839
Mersin	6.833309159
Hatay	9.260275476
Kahramanmaras	10.23743942
Osmaniye	21.27666232
Kirikkale	21.22649767
Aksaray	0
Nigde	21.85928864
Nevsehir	3.523974153
Kirsehir	1.837582232
Kayseri	12.62469074
Sivas	19.95285525
Yozgat	9.378936755
Zonguldak	20.84680319
Karabük	29.20560748
Bartin	0
Kastamonu	0
Çankiri	22.95815876
Sinop	0
Samsun	15.80504266
Tokat	13.60122788
Çorum	0
Amasya	12.09724078
Trabzon	0
Ordu	0

Giresun	0
Rize	0
Artvin	0
Gümüshane	0

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