ROAD FREIGHT TRANSPORTATION ON TURKISH TOLLWAYS

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ABSTRACT

ROAD FREIGHT TRANSPORTATION ON TURKISH TOLLWAYS

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Truck freight dominates the freight transportation. Motorways are especially important in serving truck freight demand due to more reliable travel times and favorable driving conditions, and result in different mode and route choice behaviors. Thus, it is important to understand the characteristics of truck commodity flows on motorways, which is the objective of this study. In the absence of commodity flow data in Turkey, the major source of freight data is the roadside axle load surveys conducted annually by the Turkish General Directorate of Highways (TGDH). Unfortunately, these surveys do not include observations on/around motorways, except for the year 2005, when 6299 trucks were surveyed at 19 locations on three motorway corridors in Turkey (Northern corridor connecting Edirne-İstanbul-Ankara, Aegean Corridor of İzmir-Aydın and southern corridors connecting Adana-Şanlıurfa). The following data was collected for each surveyed truck: Origin-Destination (O-D), commodity type, truck type, payload and location information. s. Therefore, truck circulation characteristics on different motorways corridors were studied to observe corridor based differences in commodity types, truck types, payloads, loading conditions and O-D patterns. The three motorway corridors serve many O-D pairs in the national level. Differences among the corridors are expected due to differences in regional economics and industries, as well existence of ports

and border gates. The motorways are developed as corridors and are not total connected, yet, which may restrict the national flows on some of them.

Keywords: *Truck Freight Transportation, Motorways, Tollgate Survey Data, Roadside Axle Surveys*

ÖZ

TÜRKİYE OTOYOLLARINDA KARAYOLU YÜK TAŞIMACILIĞI

Mardan, Atabak
Yüksek Lisans, İnşaat Mühendisliği Bölümü
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May 2015, 51 sayfa

Kamyon taşımacılığı, yük taşımacılığında egemendir. Otoyollar, güvenilir seyahat süresi ve uygun sürüş koşulları nedeniyle kamyon yük talebine hizmette büyük önem taşımaktadırlar ve bu durum farklı tür ve güzergah seçim davranışları ile sonuçlanmaktadır. Bu yüzden, bu çalışmanın konusu olan kamyon yük akış özelliklerini incelemek önem taşımaktadır. Türkiye'de yük akış bilgileri olmadığından, yük bilgilerinin ana kaynağı Karayolları Genel Müdürlüğü (KGM) tarafindan yıllık olarak yapılan yol kenarı dingil ağırlık etütleridir ama maalesef bu etütler genelde otoyollar üzerinde yapılmamaktadır. Ancak, 2005 senesinde 3 ana otoyol koridorunda (Edirne-İstanbul-Ankara arasındaki Kuzey Koridoru, İzmir-Aydın arasındaki Ege Koridoru ve Adana-Şanlıurfa'yı bağlayan Güney Koridoru boyunca) 19 noktada 6299 kamyon ile etüt yapılmıştır. Yapılan etüt çalışmasında her bir kamyon için; Başlangıç-Son bilgisi (B-S), yük tipi, kamyon tipi, taşıma kapasitesi, doluluk durumu ve konum bilgisi elde edilmiştir. Bu sayede, farklı otoyol koridorlarında kamyon dolaşım özelliklerinin, yük tipi, kamyon tipi, yükleme durumu ve O-D patternına bağlı olarak koridor bazlı farklılıklar gösterip göstermediği çalışılmıştır. Sonuçlarda görülen odur ki, üç otoyol koridoru birçok B-S çiftine ulusal düzeyde hizmet etmektedir. Koridorlar arasındaki farklılıkların bölgesel ekonomik ve endüstriyel farklılıklar ile liman ve sınır kapısı varlığına bağlı olduğu beklenmektedir. Otoyollar koridorlar olarak yapılmıştır, henüz tamemen birbirine bağlı değildir ve bu durum bazılarında ulusal yük akışını zorlaştırmaktadır.

Anahtar Kelimeler: *Kamyon Yük Ulaşımı, Otoyollar, Turnike Anket Bilgileri, Yol Kenarı Dingil Etütleri*

To My Parents

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I also would like to express my gratitude to the Turkish General Directorate of Highways, which provided the data used in this study; without it, we would not have known much about truck freight in Turkey.

The last but not the least, I would like to thank my parents for giving birth to me at the first place and then supporting me emotionally during the hard times. It was because of their sincere supports that I was able to sail through the difficulties, I had during this study.

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CHAPTER 1

INTRODUCTION

Truck freight dominates the freight transportation. Truck freight transportation captures around 90% of the freight transportation demand and is the predominant manner of cargo transportation in Turkey .There are two primary reasons that make road mode preferable in Turkey. First is the feasibility of the door-to-door service. Second is capacity of vehicles and supply chain management. Furthermore, other modes mostly cannot use individually. They should be part of a multimodal system which first and end chain of that is road mode. As a result, it's hard to compete against road mode.

Motorways are especially important in serving truck freight demand due to more reliable travel times and favorable driving conditions, and result in different mode and route choice behaviors. Motorways despite of their small share in the highway network length, accounted for 22.8% of the demand. Furthermore, freight transportation ton-km in motorways almost tripled in the last 12 years

1.1 Scope of the study

Thus, it is important to understand the characteristics of truck commodity flows on motorways, which is the objective of this study. In the absence of commodity flow data in Turkey, the major source of freight data is the roadside axle load surveys conducted annually by the Turkish General Directorate of Highways (TGDH). Unfortunately, these surveys do not include observations on/around motorways, except for the year 2005, when 6299 trucks were surveyed at 19 locations on three motorway corridors in Turkey (Northern corridor connecting Edirne-İstanbul-Ankara, Aegean Corridor of İzmir-Aydın and southern corridors connecting Adana-Şanlıurfa). The following data was collected for each surveyed truck: Origin-

Destination (O-D), commodity type, truck type, payload and location information. s. Therefore, truck circulation characteristics on different motorways corridors were studied to observe corridor based differences in commodity types, truck types, payloads, loading conditions and O-D patterns. The three motorway corridors serve many O-D pairs in the national level. Differences among the corridors are expected due to differences in regional economics and industries, as well existence of ports and border gates. Further analyzes were made to find out these differences in case of commodity, axle and truck type for each corridor.

1.2 Layout of the thesis

Chapter 2 mainly presents the required background necessary to study motorways and relation between motorways and tolls. In addition, describing truck travel surveys and usage of fathered data in truck freight modeling.

Chapter 3 is presents national freight transportation statistics of Turkey. In addition, describing motorway corridors in Turkey and some truck freight modeling studies in Turkey.

Chapter 4 is the results of descriptive data analyses of motorways surveys data. Trucks are analyzed based on their axle, commodity and truck type in total and individually for each corridor.

CHAPTER 2

LITERATURE REVIEW

2.1 History of tolls on roads

History of collecting tolls on roads goes back to the 5^{th} century, when the Roman army leaved the England. People who lived around the roads made by Romans for military purposes, were put responsible to maintain these roads; but they disregarded this obligation. The local government at that time also failed in maintaining the roads. By the early 14^{th} century, the responsibility of maintaining roads was given to churches until 1663 when first England Turnpike Act passed. The act imposed people who use the roads to pay money (Black, 2003)**.** The rise of metropolitan regions in England at the early 18^{th} century, and the dramatic increase of trade among countries, furthermore the political consolidation of England and Scotland made it necessary to provide improved facilities to carry commercial and governmental functions along these roads. The utilization of turnpikes arrived at its pick in the 19^{th} century. There was a parliament committee report in 1864 that concluded the turnpike tolls were:

- unequal in force
- collection methods were costly
- inconvenient to the public.
- injurious as causing a serious impairment to traffic,

and the abolition of turnpike trusts would be both beneficial and appropriate. As a result, in 1895, turnpike trusts in England dissolved and their responsibility restored to conventional agencies of government (Dearing, 2012)**.**

Between early colonies in America, road transportation was not developed. It is because they lived along the coast, and they used the water transport between them.

Roads were just existed between major cities at that time. Lancaster Pike was the turnpike road between Philadelphia and Lancaster, Pennsylvania that completed in 1794. This road was among these important roads (Black, 2003). There were a significant count of turnpikes and tollways in Nevada. The first major tollway project in Nevada passed on a mountain between Virginia City and California. Between 1850 and 1890, local entrepreneurs financed, built and operated more than one hundred of tollways and turnpikes there. This was a enormous activity in an area with a small population. In this era, both large and small investors, sought their profit not primarily from the tolls. Their revenue was from the indirect profits that a road would bring. These might include anything from faster shipments to more riders for stagecoach lines. People who lived along the road were often the first subscribers of these roads (Beito, 1998). After the World War II, there were major problems with high traffic volume and high cost facilities on roads in some states of the United States. The New Jersey turnpike was authorized and built for such a condition. In contrast, some states such California were negative towards tollways and continued to use other financing methods, such as gasoline tax, license fees and etc., to handle the problems (Dearing, 1961).

2.2 Technical definition of tollways versus motorways

A motorway also is called as throughway, thruway, parkway, freeway, superhighway or expressway. Motorways are major arterials. Motorways designed as divided highways. They have two or more lanes in each direction. They are limited access roads that means there are access to the road only by specially designated on-ramps and off-ramps. Cross-streets, left-turn lanes or traffic lights do not exist on motorways. Motorways have advanced designs. Their designs are not contain steep grades, sharp curves, and other hazards and inconveniences to driving. They mostly pass close to, but not through, large centers of population like big towns. Their advantages include high speed, greater safety, comfort and convenience for drivers and passengers, and lower vehicle operating costs. They may be used as tollways, or not. But, many of these new motorways, especially in the United States, are used as toll roads. Like Interstates, tollways are designed to provide a higher quality of service than ordinary highways (“Expressway,” 2014, “Motorway,” 2004).

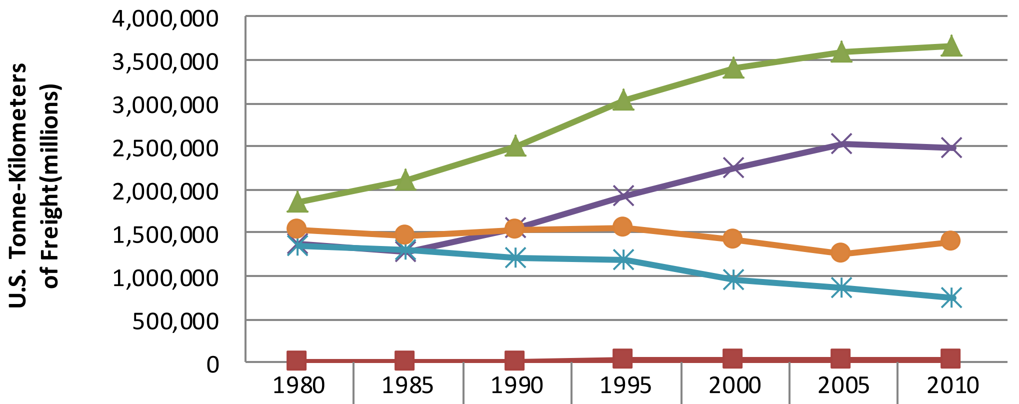
Special Roads Act passed in 1949 in England to construct motorway construction, which provided for appropriation of existing roads for special types of traffic (Ashworth, 1966). Schreiber (1961) mentioned the main problem of building motorways as their cost. The main reason behind this is presented as their utilization by the heavy freight traffic which demand much better road surface resistance such as a railway line. Transportation policy in Europe aims increasingly at recovering construction and maintenance costs of new roads and parking facilities by the use of tolls. This "user pays" trend and the re-emergence on the political agenda of variable road use pricing to manage traffic demand (Hills, 1993).

Tolling or toll collection are terms attributed to the collection of a road use fee on certain roads, bridges, or tunnels, where the toll is levied to recover all or part of the capital, operating, and maintenance costs for that infrastructure. Road user charging, also known as road use pricing or congestion charging, is the levying of some fee or charge for road use that aims to use ‘‘price’’ as a means of influencing a proportion of the road users to change their driving and or travel behavior to manage the demand for the use of the road space to within some predetermined limits. Motorway schemes using electronic devices to automate existing toll collection facilities are quite widespread and include numerous examples in the United States and in many countries in Europe (Pickford & Blythe, 2006).

The contribution of the private sector in infrastructure finance and management is increasing around the world. This growth is taking remarkable relevance in the case of toll motorways. In the last decade, the private sector has increased its participation in the funding and management of the motorways network in Europe, as well as in the United States(Albalate, Bel, & Fageda, 2009; Albalate & Bel, 2009). The growing importance of motorways privatization is response to budget constraints and needs for development. motorways privatization is an emerging infrastructure policy in both the United States and Europe(Albalate et al., 2009).

2.3 Truck freight transportation in the world

Truck ton-kilometers in U.S freight carriage shows a significant increase from 1980 to 2010 as shown in Figure 2.1 (National Transportation Statistics (2013). A similar trend has been observed in intercity rail system, which adds up to 2/3 of the truck freight volume. Table 2.1 summarizes the modal split of European Union (EU) freight transportation between 1995-2010. In 2010, 45% of freight movements were on the roads. Water mode comes in second place by 35% share of the total movement. Despite of the U.S modal split, the rail mode share is less than two other by a 10.2% share. When the change over the years is analyzed, it is seen that road freight had a 36.2% increase between 1995-2010 creating an average of 2.1% per year; however statistics of the last decade (2000-2010) shows a slower increase in the road freight by an average of 1.2% increase per year. Nevertheless, the biggest increase was occurred on road mode from 1995 to 2010 (European Union, 2012).



	1980	1985	1990	1995	2000	2005	2010
Air	6,611	7,527	13,233	18,279	21,875	22,987	18,309
Truck	1,849,24	2,105,14	2,492,71	3,036,79	3,396,66	3,581,81	3,668,07
Railroad	1,360,69	1,279,24	1,554,00	1,922,79	2,257,58	2,530,60	2,491,45
Domestic water transportation	1,345,85	1,303,71	1,216,95	1,179,26	942,848	863,246	733,215
Pipeline	1,530,04	1,467,59	1,519,89	1,564,13	1,412,98	1,263,89	1,395,71

Figure 2.1 U.S ton-kilometer of freight modal split (thousand millions) (National Transportation Statistics, 2013)

Bookbinder (2013) mentioned China became the second largest economy after the second quarter of 2010 with Gross Domestic Product (GDP) increasing at an average rate of 10.8% per year from 2001 to 2010. This large GDP naturally needs significant support from logistics. It was reported that logistics cost took around 18 % of GDP in China; that seems too high because the rate is only about 10 % for developed countries. The road transportation takes the biggest ratio by serving about 76% of the total logistics volume, and air takes the smallest ratio by a 0.02% in 2010. In the same year rail system and water transportation both had a share of 12%. Gasoline and toll payments are the two main fees in transportation cost. The proportion of gasoline in the total transportation cost was 25 % in 2004, increasing to 40 % in 2008 with the rise in oil price.

Table 2.1 European Union ton-kilometer of freight modal split (thousand millions) (European Union, 2012)

Year	Road	Rail	Inland waterways	Pipelines	Sea	Air	Total
1995	1289	386	122	115	1146	2	3060
2000	1519	404	134	127	1314	2	3499
2005	1794	413	139	136	1461	3	3946
2010	1756	390	147	121	1415	3	3831
% Increase 1995-2010	36.2	1.0	20.8	4.9	23.5	27.4	25.2
Per year	2.1	0.1	1.3	0.3	1.4	1.6	1.5
% Increase 2000-2010	15.6	-3.4	10	-4.8	7.7	4	9.5
Per year	1	-0.3	1	-0.5	0.7	0.4	0.9

In Latin America, Argentina is the second largest country, where transportation mainly happens on a road network across the country with a few railway lines. Most of the cargo transportation in Argentina is performed by truck. In Brazil there is a renewed interest in short sea shipping due to a strong bias toward trucking in Brazil's transportation matrix. The Brazilian government intends to increase the current share of water transportation from 13% to 29 % in ton-miles by 2025, while decreasing the share of truck transportation from 58% to 30%.

2.4 Tollways route choice

The size and weight of truck, distance of trip and reliability of addresses affected truck driver decisions about route choice as stated by Feng, Arentze, & Timmermans (2010). In addition, regulations such as speed limit, departure time and road grade have effects on the decisions. Zhou, Burris, Baker, & Geiselbrecht (2009) analyzed many incentives through some web-based and some online surveys. The results showed that some incentives had a positive effect to attract heavy vehicle drivers to use the tollways. For example, in 2004 the Ohio Turnpike Commission raised the speed limit from 55 mph to 65 mph for heavy trucks to lure trucks back to the turnpike, resulting in a 10% increase in truck traffic. While some incentives were not effective because any motivation policy or strategy developed without a detailed analysis of how truck drivers will react would be arbitrary. Since different groups of truck drivers have different characteristics, they might show completely different attitudes toward the same incentive. Toll roads can attract heavy vehicles .This ability will greatly influence the performance of the toll road, both in revenue and in its ability to reduce congestion on alternate routes. Many truckers are reluctant to use toll roads because of tight profit margins. In Texas, Austin that has 2 highways, one tolled bypass road, and other highway runs through Austin, interviews with truck drivers showed that characteristics of companies were important in make decisions about using tolled ways. Big companies prefer the tollways roads to small companies, because after a certain number of paid trips they can use these roads free. Private carriers the companies who transport their own goods were most likely to use toll facilities; it is because they could charge the prices to customers. Also the drivers face tight delivery schedules. Independent owner were least likely to utilize toll facilities because the costs of transportation are in responsibility of carrying. The local and intraregional companies were reluctant to use tolled facilities because they adapted their schedule in order to the congestion.

Wood (2011) after gathering data from surveys and interviews with driver and companies concluded there was not a single segment of the trucking industry, which showed any positive attitudes about tollways or the benefits they might offer, either in congestion relief, time savings or reduced shipping cost. They found the negative believe about toll facilities were so strong, such as,

- "Tollways are too expensive"
- "Tollways exist mainly to make money for the government"
- "Tollways are too expensive for what they provide"
- "I avoid tollways whenever I can"

On the other hand,, there was some positive effect of tollways were found as,

- "Tollways are a fairer way of funding maintenance and construction"
- "Tollways help drivers comply with the hours of service rules"
- "Tollways improve on time performance"

At last, they concluded the drivers perceptions of the value of tollways was likely a direct reflection of the nature of their system of compensation. For most of drivers, there was no reimbursement for tolls paid "out of pocket" and those toll costs cannot be passed on to a shipper or third party broker. On the other hand, there were a great number of smaller trucking firms and independent owner operators, for whom time saving of toll facilities was not important; but in case of converting the time to the money (e.g. payment by the hour), tollways became interesting for them. They also suggested below solutions to break this negative beliefs about tollways:

- Being as flexible as possible in charging trucks for tolls.
- For new toll facilities, developing a multi-year (for example, 10 year) "ramp up" period for truck tolling, where trucks are first charged no tolls to use the facility, but tolls gradually increase overtime to develop the trucking industry's experience.
- Cross subsidies between automobiles and commercial trucks.

Poe (2010) concluded the most important factor influencing truck and freight use of tollways are the industry's own needs and business processes. Texas trucking industry is large and diverse. Some of his observations of what the industry may support include:

- “Tolls on new capacity, not on existing facilities”,
- “Toll in corridors where a free alternative is available”,
- “Tolled facilities that allow for increased speed, size, and weight”,
- “Tolled facilities that are managed to control consistency of speed” and
- “Tax relief where tolls are levied.”

2.5 Truck travel surveys

The demand for goods has grown gradually over the past years so that today a vital ingredient of a successful national economy is a cost effective freight transportation system. This involves the use of multimodal, including intermodal, transportation options (Southworth & Peterson, 2000). Theoretical models, simulation models and various kinds of quantitative and qualitative analyses of road freight transport rely on databases describing the activity of road freight transport systems. These databases contain observations achieved through data collection protocols. Numerous types of data collection protocols exist. They can be grouped into the following categories: roadside intercepts, telephone interviews, mail out/ mail-back, combined telephone and mail-back, personal interviews, internet, focus and stakeholder groups, commercial vehicle trip diaries, Global Positioning System (GPS) vehicle tracking, license plate match, and administrative surveys. Of course, each of these methods has its strengths and weaknesses, and is therefore useful in different ways(Combes & Leurent, 2013).

Roadside interview is one of origin-destination (O-D) survey methods. In this method, vehicles are stopped and drivers are questioned (Ashworth, 1966). In many countries, they are one of the only ways to obtain data on international transit traffic. The immediate purpose of roadside freight surveys is most often to examine commodity flows and vehicle trips together, with the purpose of building origin destination matrices. The interviewers can gather data in two ways:

- By direct observation of the vehicle
- By interviewing the driver

The data gathered during roadside surveys can be categorized into two groups: trip-related data and freight-related data. Table 2.2 is the common gathered information in most surveys(Combes & Leurent, 2013).

Table 2.2 Roadside freight surveys common gathered information

Information type	Description
Number of axles	Observed by the interviewer
Vehicle type	Observed by the interviewer, who identifies a type within a typology
Trip origin	The driver is asked his last compulsory stop, whether was to load or unload freight or to pick up the vehicle
Trip destination.	The driver is asked his next stop. Whether it is to load or unload freight
Trip length	The interviewer asks the length of the trip. The driver's answer is sometimes approximate.
Empty or loaded.	The interviewer asks whether the vehicle contains freight or not.
Commodity type.	In the case of a loaded vehicle, the interviewer asks the nature of the freight.
Freight quantity	The driver is asked how many tons of freight he or she is carrying. This data is also available on the documents accompanying the freight
Hazardous materials	There can be questions regarding specifically hazardous materials

The most common surveys in the past were the roadside interviews, however this method has been discarded in many developed countries, since it is very expensive and frequently impossible to find locations to stop and interview trucks at road side (Allen & Browne, 2008). A roadside survey consists of one or several data collection points, located at strategically chosen locations, matching the specific objectives of the survey. At each of these data collection points, trucks are stopped randomly from the traffic flow, and pulled over to an area where drivers can be interviewed. National surveys of freight transport operations are conducted in many countries such as the Continuing Survey of Road Goods Transport in Britain, and commodity flow studies in the USA (Allen & Browne, 2008; Combes & Leurent, 2013). Origin and destination survey is necessary to anticipate when traffic will be drawn from a number of existing routes onto a new or improved road. Furthermore, by using this survey, it is possible to estimate the number of trips for each of exiting routes that will choose the new routes.

2.6 Truck freight demand modeling

Parameters of Transportation planning change frequently in course of time, results this field to be a dynamic process. There are many modelling concepts applied for estimation of freight transportation in the literature, although they are originally developed for passenger transport (Güler, 2014). Jong et al. (2004) stated that travel demand modeling is vital to provide a reliable forecasting of long-term transportation flows and evaluate alternative policies for future. Travel demand modeling is derived from economic theory of consumer choice. Transport researchers generally agree on the fact that the four-step transport modelling structure adapted from passenger transport can be successfully applied to freight transportation, as well. Nevertheless, there are some important differences within each of the four steps of passenger transport. These differences include the diversity of decision-makers in freight, the diversity of the items being transported and the limited availability of data.

The four-step freight transport modelling system can be summarized briefly as follows.

- Generation and attraction: the amounts of goods generated by and attracted to the defined zones are determined in tonnes.
- Distribution: the flows of goods transported between the defined zones are designated in tonnes
- Modal split: the flows of goods are allocated to transportation modes which are motorways, railways, waterways and combined transportation etc.
- Assignment: freight flows are assigned to transportation network after converting the flows in tonnes to vehicle units.

Jong et al. (2004) added another step of “vehicle/fleet loading” in their attempt to explain freight modeling (see Figure 2.2). An overall model framework for modeling freight travel demand as provided by Pendyala (2006) is presented in Figure 2.3. Origin and destination population and employment characteristics influence total freight flow and modal freight flows between origin-destination pairs. In addition, modal level of service characteristics including travel distance, travel time, and travel cost influence freight flows by mode. The model framework is simple and practical, and therefore can be easily estimated on a database that can be assembled by any public agency that has resources to purchase commercially available databases. Jong et al. (2004) mentioned 222 transport models developed in Europe (with some double counting); 65 of those models are freight transport models and 29 are joint passenger and freight transport models.

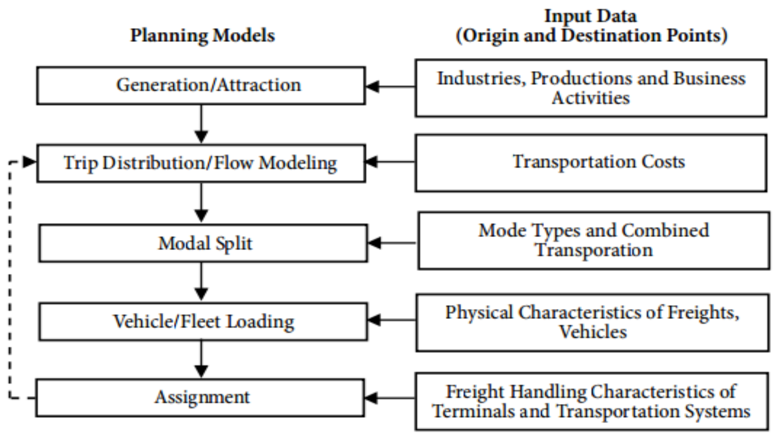


Figure 2.2 Multi-step freight transportation planning mode (Jong et al., 2004)

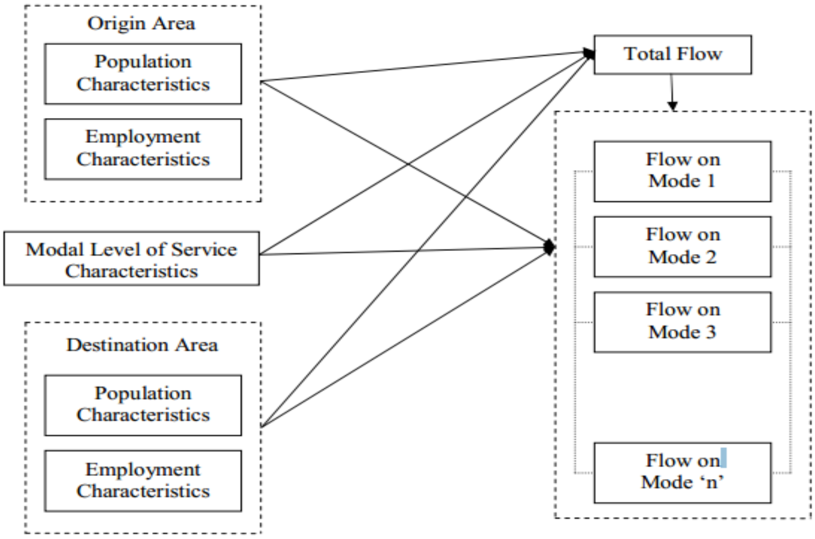


Figure 2.3 Conceptual framework for modeling freight transportation movements (Pendyala, 2006)

CHAPTER 3

TRUCK FREIGHT AND STUDIES IN TURKEY

3.1 Turkey freight transportation

In Turkey, compared to 2001 values, freight transportation has a 44.8% grow up from 174 Billion Ton-Km in the year 2001 to 252 Billion Ton-Km in 2013. In this period road freight and railway freight volume increased 34% and 54% respectively. Despite of a tripling increase in the air mode, share of this mode is negligible. Maritime unlike other modes does not show a constant growth. A reduction from 2001 to 2005 followed by a triple increase in 2013. Even though total freight ton-km volume transported by other modes almost doubled in the late years, highway still captures around 90% of the freight transportation demand and is the predominant manner of cargo transportation in Turkey (TGDH, 2014).

Table 3.1 Freight transportation demand in Turkey (in billion) (TGDH, 2014)

Year	Road		Maritime		Railway		Air		Total
	Ton-km	%	Ton-km	%	Ton-km	%	Ton-km	%	Ton-km
2001	151.4	86.9	15.0	8.6	7.6	4.3	0.3	0.2	174.5
2002	150.9	89.3	10.6	6.3	7.2	4.3	0.3	0.2	169.2
2003	152.2	88.9	10.0	5.8	8.7	5.1	0.3	0.2	171.4
2004	156.9	90.2	7.3	4.2	9.4	5.4	0.4	0.2	174.2
2005	166.8	91.3	6.4	3.5	9.2	5.0	0.4	0.2	182.8
2006	177.4	91.4	7.1	3.6	9.7	5.0	*	*	194.2
2007	181.3	90.3	9.6	4.8	9.9	4.9	*	*	200.8
2008	181.9	89.3	11.1	5.5	10.7	5.3	0.8	0.4	204.5
2009	176.5	89.0	11.4	5.8	10.3	5.2	1.2	0.6	198.8
2010	190.4	88.2	12.6	5.8	11.5	5.3	1.5	0.7	226.0
2011	203.1	87.4	15.9	6.9	11.7	5.0	1.8	0.7	232.5
2012	216.1	88.1	15.8	6.4	11.7	4.8	1.8	0.7	245.4
2013	224.0	88.7	17.3	6.9	11.2	4.4	*	*	252.5

* There is no published data for this year

There are two primary reasons that make road mode preferable in Turkey. First is the feasibility of the door-to-door service. Second is capacity of vehicles and supply chain management. Furthermore, other modes mostly cannot use individually. They should be part of a multimodal system which first and end chain of that is road mode. As a result, it's hard to compete against road mode (Ozen, 2013).

3.2 Highway network in Turkey

Total length of the highway network remained almost constant in the recent years as seen in Table 3.2. Only length of motorways increased by 25%. At the end of 2013, total length of the highway network is 65,623 km in Turkey. State roads constitute a 31,341 km (47.8%) of this network. The length of provincial roads is 32,155 km (49%). On the other hand, the length of motorways is only 2,127 km (3.3%) (TGDH, 2014)

Table 3.2 Highway network statistics in Turkey (TGDH, 2014)

Year	State highways		Provincial roads		Motorways		Total
	Km	%	Km	%	Km	%	Km
2001	31376	49.8	29929	47.5	1696	2.7	63001
2002	31318	49.6	30050	47.6	1714	2.7	63082
2003	31358	49.6	30133	47.6	1753	2.8	63244
2004	31446	49.5	30368	47.8	1662	2.6	63476
2005	31371	49.3	30568	48.1	1667	2.6	63606
2006	31335	49.2	30429	47.8	1908	3.0	63672
2007	31333	49.1	30579	47.9	1908	3.0	63820
2008	31311	49.0	30712	48.0	1922	3.0	63945
2009	31271	48.7	30948	48.2	2036	3.2	64255
2010	31395	48.4	31390	48.4	2080	3.2	64865
2011	31372	48.2	31558	48.5	2119	3.3	65049
2012	31375	48.0	31880	48.8	2127	3.3	65382
2013	31341	47.8	32155	49.0	2127	3.3	65623

3.3 Turkey road freight transportation

State roads captured 69.9% of the road freight demand in last published data by Turkish General Directorate OF Highways (TGDH) in 2014. However, this share decreased from its 81.4% share in 2001. The percentage of provincial roads are only 7.3% and almost constant since 2001. Motorways despite of their small share in the highway network length, accounted for 22.8% of the demand. Furthermore, freight transportation ton-km in motorways almost tripled in the last 12 years (see Table 3.3) (TGDH, 2014). This increasing role itself emphasizes the importance of studies on motorways.

Table 3.3 Road freight transportation demand by classification (in billion)

Year	Vehicle-km				Ton-km			
	Motorways	State roads	Provincial roads	Total	Motorways	State roads	Provincial roads	Total
2001	5.45 10.4%	41.92 79.6%	5.27 10.0%	52.63 100.0%	17.21 11.4%	123.28 81.4%	10.93 7.2%	151.42 100.0%
2002	6.03 11.7%	40.50 78.4%	5.13 9.9%	51.66 100.0%	19.39 12.8%	121.16 80.3%	10.37 6.9%	150.91 100.0%
2003	6.71 12.8%	40.51 77.4%	5.13 9.8%	52.35 100.0%	20.33 13.4%	121.47 79.8%	10.37 6.8%	152.16 100.0%
2004	7.76 13.4%	44.33 76.7%	5.68 9.8%	57.77 100.0%	23.74 15.1%	123.34 78.6%	9.78 6.2%	156.85 100.0%
2005	9.47 15.5%	45.82 75.0%	5.85 9.6%	61.13 100.0%	28.50 17.1%	128.34 76.9%	9.98 6.0%	166.83 100.0%
2006	11.53 17.9%	47.06 72.9%	5.99 9.3%	64.58 100.0%	32.93 18.6%	134.36 75.7%	10.11 5.7%	177.40 100.0%
2007	12.73 18.3%	50.46 72.5%	6.42 9.2%	69.61 100.0%	34.45 19.0%	136.97 75.5%	9.91 5.5%	181.33 100.0%
2008	13.13 18.8%	50.26 72.0%	6.39 9.2%	69.77 100.0%	36.93 20.3%	135.61 74.5%	9.40 5.2%	181.94 100.0%
2009	13.91 19.2%	51.93 71.7%	6.59 9.1%	72.43 100.0%	40.52 23.0%	127.21 72.1%	8.73 4.9%	176.46 100.0%
2010	14.95 18.7%	58.16 72.6%	7.02 8.8%	80.12 100.0%	42.94 22.6%	138.92 73.0%	8.50 4.5%	190.37 100.0%
2011	15.71 18.4%	62.28 72.8%	7.51 8.8%	85.50 100.0%	46.89 23.1%	147.63 72.7%	8.55 4.2%	203.07 100.0%
2012	16.38 17.4%	64.66 68.8%	12.95 13.8%	93.99 100.0%	48.75 22.6%	151.72 70.2%	15.65 7.2%	216.12 100.0%
2013	17.97 18.1%	67.92 68.3%	13.55 13.6%	99.43 100.0%	51.08 22.8%	156.61 69.9%	16.36 7.3%	224.05 100.0%

3.4 Motorway corridors of Turkey

History of tolls for roads in Turkey goes back to 1970 when first law was acted for limited access highways. In third development plan regarding the period of 1973-1977, new roads were anticipated for increased heavy traffic routs. These roads called in Turkish literature as motorways. Motorways specially are designed and built for transit traffic. In addition, they were limited access that means despite of certain places entrance and exit of these roads are not possible. Because of high cost of building these roads Turkey government decide to give construction of these roads to private section by Build-Operate-Transfer model. By this model private section that built the roads would have been responsible for maintain roads and had the right to gain all the income from these roads like roadside facilities and tolls of roads. So motorways could consider as tollways in Turkey literature (Karayolları tarihi, 2007; Tombul, 2010).

In May 1973, the responsibility of planning, construction and maintaining of motorways, and also income from them were given to the TGDH. First finished projects after passing this law were Istanbul Boğaziçi Bridge and Istanbul beltway, which were constructed in 1973. Motorways effected traffic accidents by switching transit traffic from normal ways to them. This effect impact was proved by reducing accident to third in Turkey in first years after construction. Construction of motorways started in 1980's by Gebze-Izmit motorway, which was opened to service in 1984. Same year Tarsus-Pozantı also was opened for service. These were followed by Kapıkule-Edirne motorway opening in 1987. A motorway network of 10,000 km length was planned in 1985; 2000 km of this plan finished until 1992 and 3000 km until year 2000 (Karayolları tarihi, 2007). As of 2013, these goals have not been reached, yet. Figure 3.1 shows three main motorway corridors in Turkey. In this study, from this point on, these three corridors are named as the Northern, the Southern and the Aegean corridors in order to geographical label them. Major segments of these corridors and their length are shown in Table 3.4.

Figure 3.1 Turkey motorway corridors

Table 3.4 Motorway corridor section lengths (TGDH, 2013)

Section	Length (Km)
N.C.	
Edirne -Çerkezköy	139
Çerkezköy -Çatalca	46.0
Çatalca -Çamlica	33.2
Çamlica - Gebze	40.3
Gebze - Sapanca	73.8
Sapanca- Kaynaşli	95.3
Kaynaşli -Akincilar	194.8
Istanbul beltway	47.5
Ankara beltway	98.9
Total	768.8
A.C.	
Şehitlik -Çeşme	71.9
Işikkent - Şevketiye	90.2
Izmir beltway	41.0
Total	203.1
S.C.	
Niğde Güney-Eminlik	167.1
Çeşmeli-İskenderun	151.8
İskenderun-Şanliurfa	293.2
İskenderun Ayr. Bati-Gözeneler	75.7
Total	687.8

The Northern Corridor (N.C.): This corridor Connects Ankara the capital of Turkey to Edirne, which is the border city of Turkey into Greece and Bulgaria. Beltway of Ankara and Istanbul are included also in this corridor. The total length of this corridor is 768.8 km.

The Aegean Corridor (A.C.): This corridor placed on the south- east of Turkey, Starts from Aydın city and continued to the Izmir, Past the Izmir to the Çeşme. The total length of this corridor is 203.1 km. This corridor is the shortest between other corridors.

The Southern Corridor (S.C.): This corridor placed on the southern part of central Turkey. Despite of two previous corridors this corridor is not a straight-line corridor.

The motorways on this corridor are not along each other. They are perpendicular. This corridor connects important cities and ports like Mersin, İskenderun and Şanlıurfa to each other. The total length of this corridor is 687.8 km. Table 3.4 indicates the length of segments of corridors separately.

3.5 Truck travel surveys in Turkey

Truck travel surveys are performed for gathering data about freight transportation on roads. Roadside interviews are one of methods for collecting these data. Roadside interviews are disused in many developed countries because of the difficulty of performing and high cost of them. Also new technologies compensate the role of these surveys (Unal, 2009).

Roadside axle surveys are annually performed by the TGDH on Turkey highways. TGDH is the responsible authority for collecting commodity flow data through roadside axle surveys on roads. TGDH has 17 regional divisions and each regional division (except the 17th regional division) performs truck surveys at least 2-3 stations every year. Annually at more than 40 locations, surveys are performed on state roads. In these surveys, trucks are stopped at the roadside interviewed, and weighed. Survey time is 8 hours daily between 08:00 a.m. to 4:00 p.m. and all surveys are conducted in four days; two days on the east-west (north-south) direction and two days on west-east (south-north) direction. Surveys start on Tuesday and finish on Friday. Each TGDH regional division carries on surveys on different seasons (Ozen, 2013; Unal, 2009). Every year roadside axle load surveys reach upto almost 10,000 trucks in the whole country. The following information is gathered during survey:

- Freight Type
- Origin of the Trip
- Destination of the Trip
- License Plate Number
- Vehicle Type
- Gross Weight
- Axle Type

- Survey Date and Time
- Survey Location
- Others

Unal (2009) mentioned miscoding problems in annual surveys, while some of the data were checked and corrected, others were simply disregarded. The limitations of these surveys are:

- Sampling.
- Time and duration of the surveys.
- Limited number of commodity types.
- Data miscoding.
- Insufficient representation of seasons, links and road types.

Unal (2009) also mentioned one of biggest limitation of modeling freight in Turkey as the absence of performing these surveys on motorways. Therefore, it was asked to TDGH to realize the Origin-Destination (O-D) surveys on motorways at tollgates. In 2005, motorway O-D surveys were performed at 20 tollgates on 6224 trucks (survey locations shown in Figure 3.2) Trucks moving on motorways were interviewed at tollgates, the same questions on state highways were asked and the volume of freight declared by drivers was accepted. Unfortunately, motorway surveys were not conducted periodically.

Figure 3.2 Tollgate surveys on motorways (Unal, 2009)

3.6 Truck freight studies in Turkey

Unal (2009) performed trip generation and trip distribution steps of intercity road freight transportation modeling. In the absence of any commodity flow data for Turkey, aggregated data of 42,164 truck surveys collected between 1996 and 2005 was used in the modeling.. In Figure 3.3 presented locations of these surveys. Unal (2009) produced province level 81x81 O-D base matrices in three dimensions:

- Number of trucks
- Ton-km
- Total tonnage of transport commodities

In result of of lack of data these matrices were not produced for each commodity type. Instead, a single commodity matrix was produced for each dimension based on aggregation of all commodity types. Then, regression analysis was performed to obtain the province level freight trip generation and attraction equations. Table 3.5 represent the annual attraction and production of provinces of Turkey. A set of demographic and socioeconomic variables were tested in regression analysis to find the most significant and uncorrelated ones. Based on the regression analysis, the following production/attraction equations were found as follows:

Freight Trip Production:

Number of Produced Trips = f(Number of Employees)
+ Dummy (International Port Existence) (3.1)
= 70,498.06 + 0.981*(Number of Employees)
+ 302,163.4 (if International Port Exist)

Freight Trip Attraction:

Number of Attracted Trips = f(Population, Passenger Car Ownership per 1000 Households) (3.2)
= -25,454 + 0.287*Population
+ 672.976 *Passenger Car per 1000 Household

Freight Commodity Production:

Tons of Produced Commodity = f(Number of Employees) +
Dummy (International Port Existence) (3.3)
= 1,542,173 + 1.294*(GDP in Million TL)
+ 302,163.4 (if International Port Exist)

Freight Commodity Attraction:

Tons of Attracted Commodity = f(Population, Passenger Car Ownership per 1000 Household) (3.4)
= -333,701 + 3.556 Population
+ 6317.94 Passenger Car per 1000 Household

YEAR		NUMBER OF SURVEYED STATIONS ON STATE ROADS	ON MOTORWAYS	TOTAL	NUMBER OF SURVEYED TRUCKS ON STATE ROADS	ON MOTORWAYS	TOTAL	%
2005	●	10	20	30	2 751	6 041	8 792	20,9
2004	●	39	–	39	11 782	–	11 782	27,9
2003	●	23	–	23	7 498	–	7 498	17,8
2002	●	9	–	9	2 740	–	2 740	6,5
2001	●	6	–	6	1 652	–	1 652	3,9
2000	○	5	–	5	2 037	–	2 037	4,8
1999	●	7	–	7	2 159	–	2 159	5,1
1998	○	11	–	11	5 156	–	5 156	12,2
1996	●	1	–	1	348	–	348	0,8
	TOTAL	111	20	131	36 123	6 041	42 164	

Figure 3.3 Roadside axle survey locations, 1996-2005 (Unal, 2009)

It should be noted here that Unal (2009) used 2004 values of the aforementioned variables. Turkish Statistical Institute published province level "Number of Passenger Car" and "Population" variables for 2004. However, "Gross Domestic Product (GDP)", "Number of Employees", "Number of Households" were not available for 2004. Therefore, unavailable province level variables were estimated by using trend extrapolations for 2004 by Unal (2009). Total freight trip productions and attractions (over 500,000 trips) estimated in this study are presented in Table 3.5 After prediction of province level trip productions and attractions, Unal (2009) used TRANPLAN travel demand software to distribute these trips between province level 81x81 O-D pairs. TRANPLAN uses the following form of gravity model:

$$T_{ij} = \mathrm{k}\frac{O^{\lambda}_{i}D^{\alpha}_{j}}{d^{\beta}_{ij}} \tag{3.5a}$$

Where:

T_{ij} : flow from zone i to zone j ; k a proportionality constant

O_i : flow originating from zone i

D_j flow terminating from zone j

d_{ij} distance between zone i and zone j

β a parameter for friction of flow between two zones

λ potential to generate movements (emissiveness)

α potential to attract movements (attractiveness)

Finally, using initially aggregated 42,164 surveyed truck information, regression results produced the following trip distribution equation:

$$T_{ij} = 0.498\frac{O^{0.641}_{i}D^{0.648}_{j}}{d^{0.894}_{ij}} \tag{3.5b}$$

Ozen (2013) utilized Unal (2009) model to determine road freight demand forecasting and greenhouse gas emissions. A brief summary of the methodology is presented in Figure 3.4. Estimated annual province level truck trip productions or attractions over 500,000 trips are presented in Table 3.6. This study relied on the estimation of survey truck circulation profile, which requires network assignment of the O-D matrix obtained from roadside axle survey data. Additionally, a truck network assignment principle was obtained from the survey O-D matrix, which will be discussed in more detail in the following section.

Table 3.5 Annual province level freight productions and attractions over 500,000 (Unal, 2009)

Code	**Province**	**Produced Trips**	**(%)**	**Attracted Trips**	**(%)**
1	Adana	1,074,224	3.46	1,078,091	3.52
6	Ankara	1,450,695	4.68	1,347,350	4.4
7	Antalya	867,534	2.8	1,152,963	3.76
9	Aydin	695,996	2.24	609,524	1.99
10	Balikesir	545,197	1.76	508,991	1.66
16	Bursa	798,286	2.57	823,244	2.69
21	Diyarbakir	417,246	1.34	522,349	1.7
25	Erzurum	826,407	2.66	875,619	2.86
26	Eskisehir	518,130	1.67	533,597	1.74
27	Gaziantep	559,960	1.8	540,627	1.76
31	Hatay	730,796	2.36	798,286	2.6
33	Mersin	1,293,568	4.17	1313,253	4.28
34	Istanbul	3,379,447	10.89	3160,806	10.31
35	Izmir	1,979,019	6.38	2085,528	6.8
38	Kayseri	782,117	2.52	878,431	2.87
41	Kocaeli	1,435,580	4.63	922,019	3.01
42	Konya	718,844	2.32	660,845	2.16
43	Kutahya	424,276	1.37	512,155	1.67
45	Manisa	727,984	2.35	602,142	1.96
55	Samsun	532,191	1.72	666,469	2.17
59	Tekirdag	523,403	1.69	449,585	1.47
61	Trabzon	597,924	1.93	682,639	2.23
Total		31,025,957	100	30,651,596	100

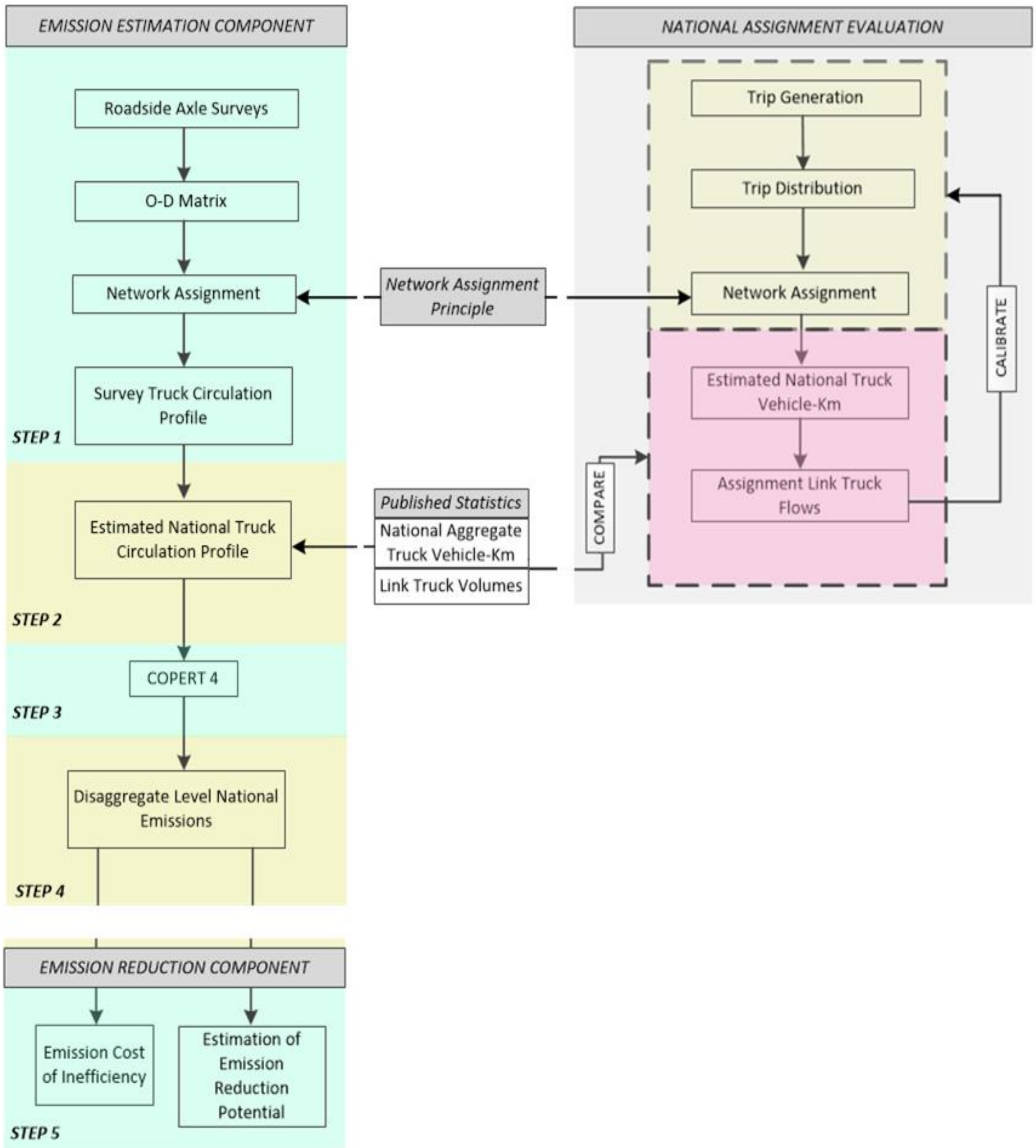


Figure 3.4 A framework to analyze truck freight emissions in Turkey (Ozen, 2013)

Table 3.6 Estimated annual truck trip productions or attractions over 500,000 trips in 2011 (Ozen, 2013)

Code	Province	Produced Trips	(%)	Attracted Trips	(%)
1	Adana	654,386	2.1	859,574	2.3
6	Ankara	1,611,590	5.1	1,840,906	5.0
7	Antalya	1,148,017	3.6	916,126	2.5
9	Aydin	422,856	1.3	516,062	1.4
10	Balikesir	488,948	1.5	543,605	1.5
16	Bursa	969,140	3.1	1,001,482	2.7
20	Denizli	424,294	1.3	544,954	1.5
21	Diyarbakir	411,283	1.3	542,050	1.5
27	Gaziantep	521,839	1.6	737,907	2.0
31	Hatay	788,064	2.5	646,693	1.8
33	Mersin	880,004	2.8	703,990	1.9
34	Istanbul	4,851,892	15.3	4,231,708	11.6
35	Izmir	1,678,055	5.3	1,410,208	3.8
38	Kayseri	431,862	1.4	671,298	1.8
41	Kocaeli	563,296	1.8	660,662	1.8
42	Konya	707,999	2.2	856,870	2.3
45	Manisa	581,295	1.8	596,587	1.6
46	Kahramanmaras	371,764	1.2	505,164	1.4
48	Mugla	407,454	1.3	543,509	1.5
55	Samsun	798,895	2.5	554,173	1.5
61	Trabzon	648,675	2.0	383,041	1.0
63	Sanliurfa	463,652	1.5	666,655	1.8
Total		31,723,037	100	36,795,158	100

Güler (2014) presents a framework, which includes empirical modelling methods to estimate truck transportation among defined O-D's. Observed origin and destination matrices for each type of freight are established based on the link counts and the roadside truck survey data. The selected method is gravity method to forecast the origin and destination matrices by using observed gross domestic product by provinces , link flows and inter-zonal distances. The developed method was applied to find the O-D matrix of the total freight transportation in Turkey. The suggested model was tested to find the O-D matrix, only for the total freight transportation, between 81 provinces in Turkey. The roadside surveys performed on 63 different highway sections by TDGH. Roadside surveys were between 2008 and 2010 years included the O-D information of 58935 trucks. The suggested method proved to be useful to determine the O-D matrices for a wide variety of freight types in case of having available road survey data over time. The highway sections that roadside surveys have been performed are presented in Figure 3.5. However, the study did not provide any concrete results in terms of truck demand forecasting.

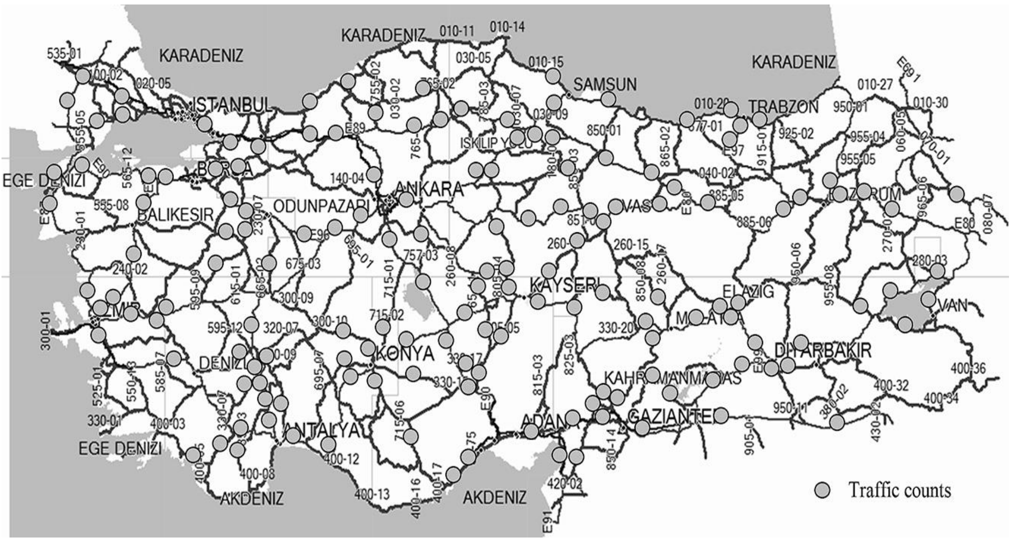


Figure 3.5 The highway sections on which the roadside surveys have been performed (Güler, 2014)

3.7 Shortest path definitions for truck freight transportation

Ozen (2013) defined shortest path (SP) cost for SP calculation so the trucks would be assigned to the network. Two different SP definitions are used. Distance and time are two variable costs to calculate SP between origin and destinations.

Time based SP (TbSP): TbSP is resulted while the cost assigned to network's each link is time. TbSP is calculated by sum of each link travel time of path from each truck origin to destination. Link travel time is the result of each link length division to speed value of it. Speed value is the average speed value separately for each link which TDGH annually is measured and published for provincial and state roads. Motorway average speeds assumed 80 km/hr because TDGH hasn't published any speed value for them.

Distance based SP (DbSP): DbSP is resulted while the cost assigned to network's each link is distance. DbSP is calculated by totalize of each path links length. Used length value is the published value by TDGH for provincial roads, state roads and motorways.

Length of TbSP calculated for Unique OD pairs. Deviation between two SP definitions based on the formula below:

$$\Delta d = \text{Length of TbSP} - \text{DbSP} \qquad (3.6)$$

To evaluate the appropriateness of the proposed SP definitions, survey location and stated O-D information of each truck where used to check whether the former was on the calculated TbSP and DbSP for truck. Survey location of each truck can be on a) both TBSP and DbSP b) only TbSP c) only DBSP and d) none of the TbSP and DbSP. Results indicate in Figure 3.6.

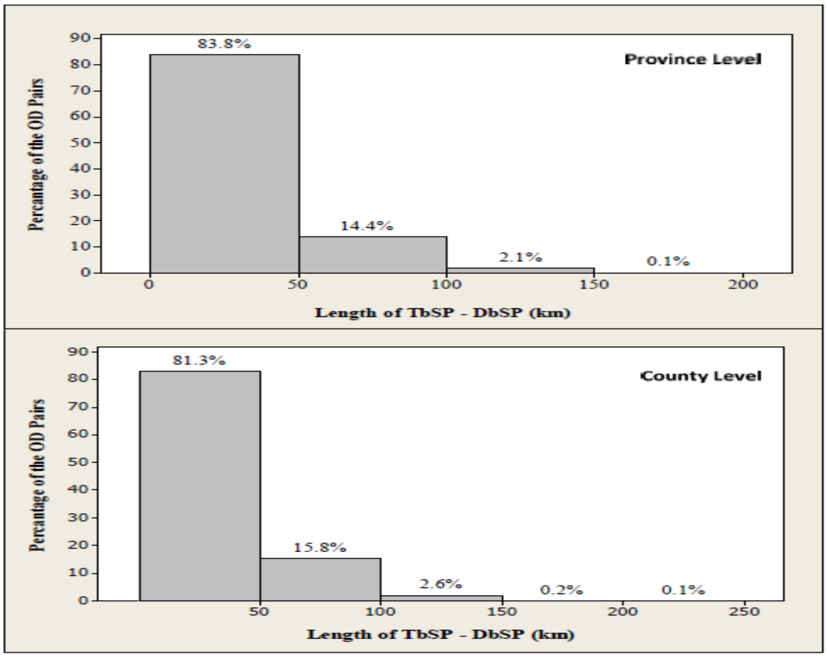


Figure 3.6 Δd distributions for province and county level O-D pairs (Ozen, 2013)

3.8 Gross domestic product of provinces

Most recent gross domestic product of provinces belongs to 2001. Table 3.7 shows the gross domestic product of provinces with current prices in year 2001. Order of table is from the most to the least. As seen as in Table Istanbul is the first province and have 21.3% share of total GDP. There is some changes while consider GDP in per capita scale.

Table 3.7 Gross domestic product of province with current prices in year 2001 (in million) (Turkstat, 2015)

Province	GDP	% of total	Province	GDP	% of total	Province	GDP	% of total
İstanbul	38010	21.3	Kütahya	1447	0.8	Bilecik	611	0.3
Ankara	13537	7.6	Kırklareli	1431	0.8	Burdur	606	0.3
İzmir	13383	7.5	Tokat	1386	0.8	Karaman	597	0.3
Kocaeli	9160	5.1	Bolu	1381	0.8	Uşak	564	0.3
Bursa	6510	3.6	Çanakkale	1319	0.7	Artvin	491	0.3
Adana	5312	3.0	Kırıkkale	1271	0.7	Aksaray	474	0.3
İçel	5040	2.8	Sivas	1270	0.7	Kırşehir	455	0.3
Antalya	4705	2.6	Afyon	1249	0.7	Erzincan	445	0.2
Konya	4237	2.4	Erzurum	1218	0.7	Düzce	438	0.2
Manisa	3769	2.1	Çorum	1191	0.7	Karabük	428	0.2
Muğla	2918	1.6	Elazığ	1185	0.7	Sinop	392	0.2
Hatay	2638	1.5	Edirne	1168	0.7	Çankırı	372	0.2
Balıkesir	2628	1.5	Ordu	1148	0.6	Ağrı	368	0.2
Gaziantep	2535	1.4	Isparta	949	0.5	Siirt	356	0.2
Samsun	2449	1.4	Van	932	0.5	Kars	345	0.2
Aydın	2343	1.3	Giresun	917	0.5	Muş	321	0.2
Kayseri	2335	1.3	Mardin	852	0.5	Bitlis	307	0.2
Diyarbakır	2200	1.2	Rize	842	0.5	Şırnak	279	0.2
Zonguldak	2197	1.2	Kastamonu	802	0.4	Kilis	249	0.1
Denizli	2192	1.2	Nevşehir	797	0.4	Gümüşhane	245	0.1
Eskişehir	2159	1.2	Niğde	757	0.4	Hakkari	244	0.1
K.Maraş	1935	1.1	Yalova	717	0.4	Bingöl	244	0.1
Tekirdağ	1931	1.1	Yozgat	712	0.4	Bartın	234	0.1
Sakarya	1913	1.1	Adıyaman	702	0.4	Iğdır	176	0.1
Trabzon	1809	1.0	Batman	685	0.4	Tunceli	175	0.1
Şanlıurfa	1794	1.0	Osmaniye	656	0.4	Ardahan	135	0.1
Malatya	1482	0.8	Amasya	635	0.4	Bayburt	119	0.1

CHAPTER 4

TRUCK FREIGHT TRANSPORTATION ON TURKEY MOTORWAYS

4.1 Motorway freight surveys

In Turkey, Turkish General Directorate Of Highways (TGDH) performs roadside axle surveys on state roads to collect disaggregate level freight transportation. During these surveys, randomly selected trucks are stopped at the roadsides according to the predetermined sampling ratio, and then they are weighted and interviewed. Unfortunately, it is not possible and safe to perform these surveys on motorways. Instead, TGDH performs interviews with the driver of trucks at toll gates, during which mostly trip based information is collected. As it is not possible to weight trucks on toll locations, the weight of the commodity stated by truck driver is accepted.

The last tollgate survey on motorways was in 2005. The collected information includes origin-destination (O-D), truck type (rigid or articulated), axle type, truck empty weight, stated commodity weight and commodity type. A total of 6242 was surveyed at 19 locations. These trucks surveys are analyzed based on commodity types, axle types, weights and or O-D patterns in this section.

4.2 Axle and truck types distribution on corridors

Majority of surveyed trucks (69.7 %) were rigid and 30.3% of were articulated trucks (Table 4.1). In rigid trucks, majority belongs to 3-axle trucks which followed by 4- and 2-axle ones. In articulated trucks 5-axle trucks are in first place. 3-axle rigid trucks have the biggest number by 47.2% of total surveyed trucks. The total axle type distribution among three corridors has a negligible difference. Rigid trucks share in the Southern Corridor (73%) is more than others and less in Aegean by 67%.

Table 4.1 Axle and truck type distribution by corridors

Truck type and axle number	Number and share of trucks on corridors							
	A.C.		N.C.		S.C.		All	
	#	%	#	%	#	%	#	%
Articulated	323	32.1	1204	31.2	367	26.7	1894	30.3
3	0	0.0	9	0.2	0	0.0	9	0.1
4	35	3.5	111	2.9	23	1.7	169	2.7
5	286	28.4	1077	27.9	344	25.0	1707	27.3
6	2	0.2	7	0.2	0	0.0	9	0.1
Rigid	683	67.9	2658	68.8	1007	73.3	4348	69.7
2	77	7.7	360	9.3	0	0.0	437	7.0
3	461	45.8	1762	45.6	724	52.7	2947	47.2
4	145	14.4	516	13.4	282	20.5	943	15.1
5	0	0.0	20	0.5	0	0.0	20	0.3
6	0	0.0	0	0.0	1	0.1	1	0.0
Total	1006	100	3862	100	1374	100	6242	100

4.3 Axle and truck types average trucks weight

The load weight data as stated by the drivers was not reliable (in some surveys, stated loaded weight of the truck was more than the maximum capacity of the truck). With this concern in mind, the truck weight distribution was studied in relation to truck types to get average loading levels shown in Table 4.2. Total surveyed trucks averagely loaded 19 tons, while their empty, average weight is 11ton, can conclude the average freight weight in these trucks is 8 tons. As mentioned above, most of surveyed trucks were 3-axle rigid and 5-axle articulated trucks. Weight relation between empty, maximum and loaded of them are logical. In 3-axle rigid trucks average weight of loaded minus the empty weight equals 7 tons. It means approximately half of trucks loaded averagely by 7-ton freight. Also in 5-axle articulated trucks this subtraction resulted 10 tons. (Table 4.2)

Table 4.2 Axle and truck type distribution truck weights

Truck types & axles	Average truck weight (Ton)		
	Maximum	Empty	Loaded
Articulated	23.4	14.2	24.2
3	16.5	10.1	18.2
4	21.9	13.4	18.1
5	23.6	14.3	24.8
6	20.7	15.1	27.9
Rigid	22.1	10.1	16.8
2	59.4	14.0	7.6
3	16.9	9.1	16.1
4	21.8	11.4	22.5
5	21.7	10.2	29.9
6	14.1	14.3	37.0
Total	22.5	11.3	19.0

4.4 Commodity types

Table 4.3 shows commodity type classification used in 2005 surveys. Eleven categories were considered for motorways surveys on 2005. But this classification is not sufficient and a detailed classification is necessary for more accurate studies. In United States 39 group classification and in European Union countries 20 groups conducted for freight flow studies (Unal, 2009), which are being used in more recent surveys in Turkey.

Table 4.3 Commodity type numbers

Type	Commodity	Type	Commodity
1	Empty	**7**	Live animals
2	Agricultural products	**8**	Forest products
3	Mineral products	**9**	Petroleum and products
4	Construction materials	**10**	Processed materials
5	Animal products	**11**	Other
6	Textiles and textile products		

4.4.1 Commodity type distribution in corridors

Table 4.4 shows the commodity type distribution of the surveyed trucks for each motorway corridor. Empty trucks (Type 1) constituted the highest share for all corridors by an overall average value of 26.0% . Commodities categorized under "other (Type 11)" accounted for 16.1% of the all surveyed trucks. Agricultural products (Type 2) were among the most observed commodity types for all corridors. On the other hand, animal products (Type 5) and live animals (Type 7) were the least observed commodity types for all corridors. There were significant differences in the share of some commodity types between motorway corridors. For instance, petroleum and products (Type 9) was the most observed commodity type after empty trucks (Type 1) with 15.7% in the Southern Corridor, whereas the share of Petroleum and products (Type 9) in the Aegean corridor is only 1.3%.

Table 4.4 Surveyed trucks by commodity type on corridors

Type	N.C.		A.C.		S.C.		All	
	#	%	#	%	#	%	#	%
1	874	22.6	339	33.7	399	29.0	1612	26.0
2	476	12.3	108	10.7	183	13.3	767	12.4
3	233	6.0	99	9.8	42	3.1	374	6.0
4	373	9.7	120	11.9	101	7.4	594	9.6
5	44	1.1	17	1.7	13	0.9	74	1.2
6	225	5.8	10	1.0	47	3.4	282	4.5
7	24	0.6	8	0.8	2	0.1	34	0.5
8	95	2.5	6	0.6	44	3.2	145	2.3
9	325	8.4	13	1.3	216	15.7	554	8.9
10	436	11.3	174	17.3	198	14.4	808	13.0
11	757	19.6	112	11.1	129	9.4	998	16.1
Total	3862	100	1006	100	1374	100	6242	100

4.4.2 Truck and axle type distribution to commodity type

Analyzing separately, the highest percentage belongs to live animals (Type7), among the surveyed ones, 85% of carried live animals were on rigid trucks. Animal products (Type5) had an 84 % share. (These two types are commodities produced by rural areas). Articulated trucks most carried textile and textile products (Type 6) by a 45% percent. Construction materials (Type 4) with a 39.1% share were the second commodity types that were carried by articulated trucks.

Table 4.5 Each truck and axle type distribution by commodity type

Type	Articulated%					Rigid%						Total %
	3	4	5	6	All	2	3	4	5	6	All	
1	0.2	3.2	22.6	0.1	26.0	8.8	49.5	15.5	0.2	0.0	74.0	100
2	0.0	0.8	28.9	0.3	30.0	4.7	48.3	17.0	0.0	0.0	70.0	100
3	0.0	1.3	29.4	0.0	30.7	3.2	39.8	25.4	0.8	0.0	69.3	100
4	0.2	2.5	36.3	0.2	39.1	3.7	39.0	17.4	0.8	0.0	60.9	100
5	0.0	0.0	16.2	0.0	16.2	14.9	51.4	17.6	0.0	0.0	83.8	100
6	0.0	3.2	42.2	0.4	45.7	12.1	37.2	5.0	0.0	0.0	54.3	100
7	0.0	0.0	14.7	0.0	14.7	2.9	73.5	8.8	0.0	0.0	85.3	100
8	0.0	1.4	22.1	0.0	23.4	4.8	56.6	15.2	0.0	0.0	76.6	100
9	0.2	1.8	21.5	0.2	23.7	5.2	49.4	21.0	0.7	0.0	76.3	100
10	0.2	3.1	35.3	0.1	38.8	6.1	44.5	10.5	0.0	0.1	61.2	100
11	0.2	4.5	22.6	0.2	27.6	8.6	52.1	11.2	0.5	0.0	72.4	100

4.4.3 Commodity type distribution to truck type

Table 4.6 shows the each commodity type percentage carried by each truck type. Empty trucks (Type 1) percentage for rigid trucks by a 27.5 % is more than 22.2% for articulated trucks. In contrast processed materials (Type10) mostly carried by articulated trucks by a 16%, while 11.4% are rigid.

4.4.4 Each corridor truck type distribution for each commodity type

Table 4.7 shows each truck type's percentage in order to commodity type in every corridor. Aim is finding differences in corridor level to total. In the Aegean Corridor, major difference from total is in mineral products (Type3). While in total 70% of mineral products carried by rigid trucks, in this corridor this percentage decreased to 43%. In the Northern Corridor in mineral products (Type3) percentage increased to 81% for rigid trucks. In the Southern Corridor, major difference happened in Textiles and textile products (type6). It increased from 54% in total for rigid trucks to 83% for rigid trucks.

Table 4.6 Commodity type distribution to truck type

Commodity Type	Rigid%	Articulated%
1	27.5	22.2
2	12.4	12.1
3	6.0	6.1
4	8.3	12.2
5	1.4	0.6
6	3.5	6.8
7	0.7	0.3
8	2.6	1.8
9	9.7	6.9
10	11.4	16.5
11	16.6	14.4
Total	100.0	100.0

Table 4.7 Each Commodity type percentage for truck types by corridors (%)

Type	N.C.		A.C.		S.C.		All	
	Art.	**Rigid**	**Art.**	**Rigid**	**Art.**	**Rigid**	**Art.**	**Rigid**
1	21	79	33	67	30	70	26	74
2	35	65	14	86	25	75	30	70
3	19	81	57	43	33	67	31	70
4	37	63	58	42	26	74	40	60
5	16	84	6	94	31	69	16	84
6	52	48	50	50	17	83	46	54
7	8	92	38	63	0	100	15	86
8	26	74	17	83	18	82	23	77
9	28	72	23	77	17	83	24	76
10	47	53	20	80	37	63	39	61
11	29	71	20	80	25	75	28	72

4.5 O-D pattern in regional level

To study motorway O-D patterns in a regional level, TGDH fragmentation for Turkey is used. TGDH divides Turkey to 18 regions for administrative purposes

(17th region is not a geographical region and represent motorway administration instead). The schematic representation of the jurisdiction of these regions is presented in Figure 4.1. (TGDH, 2014).

Figure 4.1Schematic representation of the jurisdictions of TGDH regions (TGDH, 2014)

Table 4.8 summarizes corridor-based regional level O-D matrix of the surveyed trucks. The following findings can be drawn:

- In the Northern Corridor, both of the trip ends were within the Region 1 for 53.1% of the surveyed trucks. Only for 1.6% of the trucks, both of the trip ends were out of the Region 1.
- In the Aegean Corridor, both of the trip ends were within the Region 2 for 84.5% of the trucks. Both of the trip ends were out of the Region 2 only for 2 of the surveyed trucks out of 1006 trucks.
- In the Southern Corridor, both of the trip ends were within the region 5 for 30.9% of the trucks. Only for 4.5% of the trucks, both of the trip ends were out of the Region 5.

As a summary, while the Aegean Corridor was more locally used, the Southern Corridor served highest number of different unique O-D pairs as compared to others.

Table 4.8Corridor-based regional (TGDH Regions) O-D matrix of the surveyed trucks

Origins	Corridor	Destinations																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	N.C.	2050	13	45	268	101	37	19	12	40	15	3	34	43	219	19	5	2923
	A.C.	--	18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	18
	S.C.	--	--	--	--	121	--	--	--	8	--	1	1	--	--	--	--	131
2	N.C.	56	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	56
	A.C.	25	850	2	2	4	--	1	--	--	1	--	2	31	14	--	--	932
	S.C.	--	--	--	--	40	--	--	2	2	--	--	--	1	--	--	--	45
3	N.C.	58	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	59
	A.C.	--	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7
	S.C.	--	--	--	--	48	--	--	--	2	--	--	1	--	--	--	--	51
4	N.C.	208	--	--	21	2	--	1	1	--	--	--	--	--	6	--	--	239
	A.C.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	S.C.	1	--	--	--	37	--	--	--	2	--	--	1	--	--	--	--	41
5	N.C.	203	--	--	--	1	--	--	--	--	5	--	--	--	--	--	--	209
	A.C.	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
	S.C.	44	30	89	48	425	63	4	14	70	1	4	3	6	9	3	8	821
6	N.C.	52	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	53
	A.C.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	S.C.	--	--	--	--	36	--	--	--	--	--	--	--	--	--	--	--	36
7	N.C.	31	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	33
	A.C.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	S.C.	--	--	--	--	13	--	--	--	1	--	--	--	--	--	--	--	14
8	N.C	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6
	A.C.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	S.C.	2	3	3	1	21	--	--	--	--	--	--	--	--	2	--	--	32
9	N.C.	9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9
	A.C.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	S.C.	4	5	4	3	110	--	--	--	--	--	--	--	1	4	--	--	131
10	N.C.	38	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	38
	A.C.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	S.C.	--	--	--	--	6	--	--	--	--	--	--	--	--	--	--	--	6
11	N.C.	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8
	A.C.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	S.C.	--	1	--	--	1	--	--	--	1	--	--	--	--	1	--	--	4
12	N.C.	33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	33
	A.C.	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
	S.C.	--	--	--	--	7	--	--	--	--	--	--	--	--	--	--	--	7
13	N.C.	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	20
	A.C.	1	32	--	1	--	--	--	--	--	--	--	--	--	--	--	--	34
	S.C.	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	5
14	N.C.	115	--	--	3	4	1	5	--	1	3	--	--	--	--	2	--	134
	A.C.	--	10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10
	S.C.	--	--	--	--	34	--	--	3	--	--	--	--	2	--	--	--	39
15	N.C.	34	--	1	--	--	--	--	--	--	--	--	--	--	1	--	--	36
	A.C.	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
	S.C.	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	2
16	N.C.	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6
	A.C.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	S.C.	--	--	--	--	9	--	--	--	--	--	--	--	--	--	--	--	9
Total	N.C.	2927	13	46	295	108	38	25	13	41	23	3	34	43	226	22	5	3862
	A.C.	26	922	2	3	4	--	1	--	--	1	--	2	31	14	--	--	1006
	S.C.	51	39	96	52	915	63	4	19	86	1	5	6	10	16	3	8	1374

4.6 O-D pattern in province level

Turkey is divided into 81 provinces. Around 20% of total population of Turkey are living in Istanbul province. Second province in population is Ankara with a 7% share and third is Izmir with a 6% share of total population. Most recent gross domestic product of provinces belongs to 2001. Table 3.6 shows the gross domestic product of provinces with current prices in year 2001. Order of table is from the most to the least. As seen as in Table 3.6, Istanbul is the first province and have 21.3% share of total GDP.

4.6.1 Northern Corridor

3862 of surveyed trucks were captured in the Northern Corridor survey locations and its 62% of total trucks. This high ratio of surveyed trucks is in this corridor, furthermore inclusion of important and industrial provinces like Istanbul and Kocaeli and Ankara, makes this corridor important than other two for study. Istanbul by far was the major end and start point for surveyed trucks in northern corridor. 45%8 of trucks originated from İstanbul and destination of 36% of total in this corridor belongs to İstanbul. Kocaeli comes in second for both origin and destination with a 21.3% and 15.7% share of surveyed trucks respectively (Table 4.9).

Table 4.9 Major origin and destination provinces for the Northern Corridor

Destination Origin	Bilecik	Edirne	İstanbul	Kocaeli	Sakarya	Other	Total
Tekirdağ	0	45	104	16	7	38	210
Sakarya	3	5	27	50	11	25	121
Kocaeli	80	28	298	63	139	211	819
İstanbul	83	206	370	215	187	477	1538
Edirne	1	1	72	24	5	90	193
Other	6	241	364	239	35	96	981
Total	173	526	1235	607	384	937	3862

Commodity Types: In case of commodity type in provincial level, major provinces of Table 4.9 considered for Northern corridor in Table 4.10. Total percentage of for each commodity type is same for both origin and destination. Standard deviation of each commodity type is calculated. Bigger number indicates more diversity in that commodity group. Originated trucks most diverse numbers are the empty trucks (Type 1) and other commodity type (Type 11). In destination case empty trucks and agricultural products (Type 2) have the most diversity. The least diversity in both origin and destination belongs to animal products (Type 5) and live animals (Type 7) In case of empty trucks (Type 1) while 22.8% is the total percentage, most originated empty trucks were from İstanbul by a 30% and most destined empty trucks were to Sakarya with a 41.4% and Kocaeli with a 35.%. Least of empty destined trucks were to Edirne with a 10.8 %. Edirne is the border province of Turkey and low traffic of empty trucks in this region is logical. In Edirne Processed materials (Type 10) and trucks with other commodity type (Type 11) are in majority in both origin and destination case.

Table 4.10 Major origin and destination cities commodity type distribution for the Northern Corridor

Origin Province	Commodity type %											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Edirne	12.4	13.0	2.1	5.7	1.6	8.8	0.0	1.6	4.7	16.6	33.7	100.0
İstanbul	30.0	7.2	4.7	9.7	0.7	5.1	0.1	1.5	8.3	10.3	22.4	100.0
Kocaeli	25.9	5.3	12.8	8.5	1.3	1.5	0.2	2.6	18.4	7.6	15.9	100.0
Sakarya	29.8	12.4	4.1	22.3	3.3	0.0	1.7	3.3	1.7	9.1	12.4	100.0
Tekirdağ	13.8	16.2	1.9	12.9	0.5	15.2	1.0	2.9	3.8	19.0	12.9	100.0
Other	11.9	25.4	4.3	9.1	1.5	8.7	1.6	3.9	2.8	13.5	17.4	100.0
All	22.8	12.3	6.0	9.7	1.1	5.8	0.6	2.5	8.4	11.3	19.5	100.0
Destination Province	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Edirne	10.8	27.9	1.1	12.0	0.6	13.5	0.6	3.0	7.6	20.5	2.3	100.0
İstanbul	20.4	12.6	5.8	12.6	1.2	6.6	1.0	2.3	8.4	8.3	20.8	100.0
Kocaeli	35.7	15.5	4.4	10.0	0.7	2.5	0.8	3.3	2.5	9.6	15.0	100.0
Sakarya	41.4	3.1	5.7	4.4	1.0	0.3	0.5	1.3	11.7	5.2	25.3	100.0
Bilecik	31.8	1.2	12.7	5.2	0.0	0.0	0.0	0.0	17.9	4.0	27.2	100.0
Other	14.8	6.9	9.0	7.3	1.9	6.0	0.2	2.8	9.6	15.0	26.5	100.0
All	22.8	12.3	6.0	9.7	1.1	5.8	0.6	2.5	8.4	11.3	19.5	100.0

Truck types: Table 4.11 shows the major origin and destination cities truck type distribution for the Northern Corridor. In both destined and originated trucks, rigid trucks are in majority by 68.8%. In Kocaeli originated and Sakarya destined trucks this majority increases to 80.1% and 81.0% respectively. In addition, in Edirne originated and destined articulated trucks are in majority despite of other.

Table 4.11 Major origin and destination cities truck type distribution for the Northern Corridor

Origin			Destination		
Province	**Articulated (%)**	**Rigid (%)**	**Province**	**Articulated (%)**	**Rigid (%)**
Edirne	63.2	36.8	**Bilecik**	20.2	79.8
İstanbul	26.4	73.6	**Edirne**	76.4	23.6
Kocaeli	19.9	80.1	**İstanbul**	23.0	77.0
Sakarya	24.8	75.2	**Kocaeli**	26.4	73.6
Tekirdağ	25.2	74.8	**Sakarya**	19.0	81.0
Other	43.8	56.2	**Other**	26.7	73.3
All	31.2	68.8	**All**	31.2	68.8

4.6.2 Aegean Corridor

1006 trucks were surveyed on this corridor. The Aegean Corridor has the least number of surveyed trucks. Its 16.1% of total surveyed trucks. Izmir and Aydın were the major end and start points of the trucks. 47% of originated and destination of 52% of trucks belong to İzmir. Aydın with 31% and 22% for origin and destination respectively, comes in second place for this corridor. This primacy of İzmir and Aydın in this corridor is another evidence for local usage of this corridor (Table 4.12).

Commodity type: In case of commodity type in provincial level, major provinces in Table 4.13 considered for the Aegean Corridor. Biggest value of standard deviation of every commodity type in originated trucks belongs to mineral products (Type 3). Reason of this should be a 70 % share of this commodity type in Manisa originated trucks compare to 9.8% average share in total. In Denizli originated trucks construction materials (Type 4) with a 43.5% percent are have difference in compare to 13.3% in total.

Table 4.12 Major origin and destination provinces for the Aegean Corridor

Destination / Origin	Antalya	Aydın	Denizli	İzmir	Muğla	Other	Total
Muğla	0	0	0	68	0	12	80
Manisa	1	8	4	0	7	0	20
İzmir	19	173	53	143	53	35	476
Denizli	0	0	0	41	0	5	46
Aydın	1	24	3	255	4	23	310
Other	0	19	5	43	5	2	74
Total	21	224	65	550	69	77	1006

Table 4.13 Major origin and destination cities commodity type distribution for the Aegean Corridor

Origin	Commodity type %											
Province	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Aydin	25.5	18.1	17.7	9.7	0.3	0.3	1.6	0.0	1.0	16.1	9.7	100.0
Denizli	8.7	10.9	8.7	43.5	2.2	13.0	0.0	0.0	0.0	8.7	4.3	100.0
İzmir	45.6	5.9	2.3	7.4	2.1	0.4	0.2	0.6	1.9	20.8	12.8	100.0
Manisa	5.0	0.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	15.0	100.0
Muğla	35.0	10.0	15.0	20.0	2.5	0.0	1.3	0.0	1.3	5.0	10.0	100.0
Other	13.5	14.9	4.1	25.7	4.1	1.4	1.4	4.1	0.0	20.3	10.8	100.0
All	33.7	10.7	9.8	11.9	1.7	1.0	0.8	0.6	1.3	17.3	11.1	100.0
Destination												
Province	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Muğla	13.0	1.4	11.6	20.3	1.4	0.0	0.0	2.9	4.3	26.1	18.8	100.0
İzmir	34.7	14.2	13.1	11.8	1.6	1.1	0.9	0.4	0.9	13.1	8.2	100.0
Denizli	30.8	1.5	16.9	12.3	0.0	1.5	0.0	1.5	1.5	24.6	9.2	100.0
Aydin	44.2	7.6	2.7	9.8	0.4	0.0	0.0	0.4	0.9	17.9	16.1	100.0
Antalya	23.8	0.0	0.0	0.0	19.0	0.0	0.0	0.0	0.0	47.6	9.5	100.0
Other	19.5	14.3	2.6	14.3	2.6	3.9	3.9	0.0	2.6	23.4	13.0	100.0
All	33.7	10.7	9.8	11.9	1.7	1.0	0.8	0.6	1.3	17.3	11.1	100.0

Truck type: Articulated trucks have more share in compare to other corridors in the Aegean Corridor. More than half of originated trucks from Denizli are articulated trucks. In Manisa and Muğla percent is 45%. Also 47% destined trucks to Denizli are articulated trucks. (Table 4.14)

Table 4.14 Major origin and destination cities truck type distribution for the Aegean Corridor

Origin			Destination		
Province	**Articulated(%)**	**Rigid(%)**	**Province**	**Articulated(%)**	**Rigid(%)**
Aydin	33.5	66.5	**Muğla**	31.9	68.1
Denizli	54.3	45.7	**İzmir**	29.1	70.9
İzmir	26.7	73.3	**Denizli**	47.7	52.3
Manisa	45	55	**Aydin**	34.4	65.6
Muğla	45	55	**Antalya**	4.8	95.2
Other	29.7	70.3	**Other**	41.6	58.4
All	32.1	67.9	**All**	32.1	67.9

4.6.3 The Southern Corridor

1374 of surveyed trucks are on this corridor. Its 21.8% of total surveyed trucks. As same as regional level origin and destination of trucks seems more scattered in order to number of other in Table 4.15. Also top 5 provinces don't show a major difference between them. Among them, Mersin has the biggest share.

Table 4.15 Major origin and destination cities for the Southern Corridor

Destination Origin	Adana	Hatay	Konya	Mersin	Şırnak	Other	Total
Adana	3	47	13	64	4	75	206
Gaziantep	2	16	2	38	0	29	87
Hatay	0	15	15	37	39	54	160
İstanbul	28	19	0	16	2	14	79
Mersin	39	28	42	7	8	198	322
Other	48	106	7	245	7	107	520
Total	120	231	79	407	60	477	1374

Commodity type: the Southern Corridor major provinces commodity distributions are shown in Table 4.16. Petroleum and products (Type 9) have the biggest number of standard deviation in both origin and destination case. 43.8 % of trucks that originated from Mersin carried petroleum and products. 68.3% of Şırnak destined trucks carried the same commodity. In empty trucks case (type1) diversity also can see. 54% of trucks that came from Gaziantep are empty in compare to 29% in total. Also Mersin with 45.9% and Hatay 4.16% empty destined trucks.

Truck type: Table 4.17 is the major provinces of southern corridor truck type distribution. Truck type percentages don’t change too much in this corridor. They obey the same paradigm of total trucks.

Table 4.16 Major origin and destination cities commodity type distribution for the the Southern Corridor

Origin	Commodity type %											
Province	1	2	3	4	5	6	7	8	9	10	11	Total
Adana	32.5	20.9	3.4	7.3	0	1.9	0	6.3	2.9	17.5	7.3	100
Gaziantep	54	9.2	0	0	2.3	11.5	0	1.1	1.1	8	12.6	100
Hatay	16.9	7.5	9.4	10	0.6	2.5	0	0.6	30.6	20	1.9	100
İstanbul	10.1	3.8	0	8.9	1.3	1.3	1.3	0	7.6	26.6	39.2	100
Mersin	20.8	5.9	1.9	5.6	0.3	0.3	0	1.2	43.8	13.7	6.5	100
Other	35.2	18.8	2.7	8.7	1.5	5.2	0.2	4.8	2.5	11.2	9.2	100
All	29	13.3	3.1	7.4	0.9	3.4	0.1	3.2	15.7	14.4	9.4	100
Destination												
Province	1	2	3	4	5	6	7	8	9	10	11	Total
Adana	28.3	13.3	0	7.5	1.7	0	0.8	3.3	8.3	18.3	18.3	100
Hatay	41.6	18.2	6.1	3.9	0	0	0	3.9	4.8	10.8	10.8	100
Konya	13.9	10.1	5.1	7.6	1.3	0	0	2.5	34.2	16.5	8.9	100
Mersin	45.9	16.5	1.2	13.3	2	3.9	0	4.9	0.7	7.1	4.4	100
Sirnak	3.3	1.7	0	0	0	0	0	0	68.3	18.3	8.3	100
Other	14.5	10.3	4	4.8	0.4	6.5	0.2	1.9	26	20.5	10.9	100
All	29	13.3	3.1	7.4	0.9	3.4	0.1	3.2	15.7	14.4	9.4	100

Table 4.17 Major origin and destination cities truck type distribution for the the Southern Corridor

Origin			Destination		
Province	Articulated(%)	Rigid(%)	Province	Articulated(%)	Rigid(%)
Adana	28.2	71.8	Adana	23.3	76.7
Gaziantep	18.4	81.6	Hatay	32.5	67.5
Hatay	28.1	71.9	Konya	17.7	82.3
İstanbul	29.1	70.9	Mersin	27.3	72.7
Mersin	22.7	77.3	Şırnak	25.0	75.0
Other	29.2	70.8	Other	26.0	74.0
All	26.7	73.3	All	26.7	73.3

CHAPTER 5

CONCLUSION

Despite of small share of motorways to total highway network, they play an important role in freight transportation in Turkey. However, so far, motorways do not have a well-connected network; they serve mostly as three main corridors (Northern, Aegean and Southern corridors). There is still a motivation to increase the total length of the motorway network is Turkey; however, it is important to forecast the truck demand that can be attracted. Thus, it is important to understand the factors affecting choice of motorways.

In the absence of commodity flow data, it was possible to analyze the some of their characteristics using the only available tollgate survey data performed in the year 2005. This data included a total 6242 trucks with classified information on commodity types and origin-destination (O-D). Based on the O-D patterns, it can be concluded that Northern and Southern corridors were fed by the demand mostly from Region 1 and Region 5, respectively; and serve destinations scattered throughout the whole country. On the other hand, Aegean Corridor was used by more localized truck movements. Parallel to overall statistics, 26% of the surveyed trucks were empty runs; however, a slightly higher ratio was observed on the Aegean Corridor, which may be due to a relatively shorter travel distances in the localized demand.

There were some differences between corridors in types of commodities. For instance, petroleum products percentage had a significant differential in the Aegean and Southern corridors.

A more detailed analysis is required, including value of time based on commodity type. Furthermore, a new motorway project under construction such as İzmit-İzmir

Motorway, may drastically change the localized behavior of the Aegean Corridor. Any potential project connecting Northern and Southern corridors may also create an added value in the motorway usage. Idealistically, a commodity based data and truck freight modeling must be done for both motorway and state highways jointly. It may also provide a more realistic planning of the intermodal freight transportation for Turkey.

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