A NETWORK DESIGN PROBLEM FOR A POST SALE SERVICES DISTRIBUTION SYSTEM

by

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Submitted to the Graduate School of

Engineering and Natural Sciences

in partial fulfillment of the requirements for the degree of

Master of Science

Sabancı University,
January, 2015

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DATE OF APPROVAL: 05.02.2015

ACKNOWLEDGEMENTS

I am using this opportunity to express my gratitude to everyone who supported me throughout my thesis. First, I want to thank my supervisors Assoc. Prof. Dr. Güvenç Şahin and Asst. Prof. Dr. Tevhide Altekin for their endless support, guidance, encouragement, and feedback during thesis process. By means of my supervisors I learned not only technical and academic aspects but also positive perspective on life.

I want to express my gratitude my thesis committee for spending their valuable time on my thesis. I give my sincere thanks to academic staff in Sabanci University and Dokuz Eylül University which I took my bachelor degree. I am in debt to all teachers that I have during whole my life for the values and knowledge they have added me.

I would particularly like to thank to the company which this thesis is implemented. I am thankful to Zeynep Didem Demir, Hakan Alıcı, Pınar Enberker Çavuşoğlu, Özgür Ak, Serdar Aynacı, Serkan Karaca, Özgür Çakmak, Birsen Sancar. They gave me chance to implement my study and they never hesitate to share information.

I owe my deepest gratitude to parents and other my family members. My father Sefer Aylı is always inspiring and leading; my mother Fatma Aylı is patient and supportive to me.

My completion of this thesis could not have been accomplished without the support of Orkun Berk Yüzbaşıoğlu, Fardin Dashty, Ümmühan Akbay, Merve Keskin, Burcu Atay, Özge Arabacı, Kadriye Kahraman and Emre Uysal. I am grateful to them for endless support and belief.

Finally, I want to thank to people and organizations that have established Sabanci University and provide financial support for the graduate students.

A NETWORK DESIGN PROBLEM FOR A POST SALE SERVICES DISTRIBUTION SYSTEM

Ezgi Aylı

Industrial Engineering, Master's Thesis, 2015

Thesis Supervisor: Assoc. Prof. Dr. Güvenç Şahin

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Keywords: Distribution network, facility location, location-routing problem, network design, post sale services, spare parts supply chain

Abstract

Post sale services network design problem addresses the design of the customer support network. This includes determination of the number and capacity of the facilities, assignment of repair vendors to these facilities, transportation mode between facilities and repair vendors and hierarchical structure of the network. In this study, a household appliance manufacturer's post sale network design problem is addressed. We present a mixed integer linear programming problem formulation with the single objective of minimizing the total network cost which includes the opening and operating costs of facilities and transportation costs. Using 2013 data provided by manufacturer, we estimate the parameters and scale down the input data of the problem by various aggregation and consolidation techniques. We propose three alternative scenarios to test different configurations of the network and compare them with the existing scenario in terms of total cost and applicability. The scenario with minimum total cost among three scenarios is proposed. The improvement of the proposed scenario is 12% reduction in total costs.

SATIŞ SONRASI SERVİSLERİ DAĞITIM SİSTEMİ İÇİN AĞ TASARIM PROBLEMİ

Ezgi Aylı

Endüstri Mühendisliği, Yüksek Lisans Tezi, 2015

Tez Danışmanı: Doç. Dr. Güvenç Şahin

Tez İkinci Danışmanı: Yard. Doç. Dr. Tevhide Altekin

Anahtar Kelimeler: Ağ tasarımı, satış sonrası hizmetleri, tesis yer seçimi, yedek parça tedarik zinciri, yer-seçimi rotalama problemi

Özet

Satış sonrası servis ağı tasarım problemi, müşteri destek ağının tasarımıyla ilgilidir. Bu problem ağ içinde olması gereken tesis sayısı ve kapasiteleri, satış sonrası hizmet verecek servis taleplerinin hangi tesisler tarafından karşılanacağı, tesisler ve servis noktaları arası taşıma yönteminin belirlenmesi, ağın hiyerarşik yapısı belirlenmesi kararlarını içerir. Bu çalışmada, bir elektrikli ev eşyası üreticisinin satış sonrası servis ağı tasarımı problemi hedef alınmıştır. Tek amaç fonksiyonlu karışık tamsayılı doğrusal programlama formülü ağın toplam maliyetini en küçükleme için oluşturulmuştur. Oluşturulan modelde toplam ağ maliyeti taşıma maliyetleri, tesis kurulum ve işletme maliyetlerinin toplamı ile bulunur. Model için ihtiyaç duyulan parametreler çeşitli toplama ve birleştirme yöntemleri kullanılarak kestirilmiş ve girdi verisi daraltılmıştır. Firmanın var olan uygulamalarına ek olarak farklı şekilde yapılandırılmış ağ tasarımlarının uygulanabilirliğini test etmek ve toplam maliyetlerini karşılaştırmak için 3 alternatif senaryo oluşturuldu. Bu üç senaryodan en düşük maliyete sahip olanı önerilmiştir. Önerilen senaryonun toplam maliyet üzerinde iyileştirmesi %12'dir.

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Chapter 1

1. Introduction

Post sale support service is provided to end users after merchandise such as household appliances or electronics has been sold. End users expect that the product will perform satisfactorily over its useful life when operated properly. This is achieved through post sale support provided by the manufacturer. Post sale support services include installation, warranties, extended warranties, maintenance service contracts, provision of spares, training programs and product upgrades to name a few (Murty *et al*., 2004).

From end users' perspective, the performance of the services depends on the timeliness and fitness to the needs. On the other hand, the service provider is concerned with cost and efficiency of the services they provide. As expected, the service provider aims to use their resources in the most efficient way possible. One dimension of efficiency is associated with the configuration of the service network.

The manufacturer needs a dispersed network of service facilities that store spare parts and act as a base for field services. Configuration of the network of service facilities is concerned with the hierarchical structure of the facilities and the spatial network design where number of various types of facilities and their locations are the most dominating decisions in this context. Such decisions are in the scope of strategic planning for the service provider.

Location decisions lie in the core of network design. The facility location problem has been discussed in a multitude of studies. The first formal introduction was by Alfred

Weber (1909). A location problem can be defined as a spatial resource allocation problem where one tries to determine the location of one or more service facilities to serve a spatially distributed set of demands. The objective is to locate facilities and allocate customers to the servers with an objective function such as the minimization of the average travel time (Brandeau and Chiu, 1989). According to Owen and Daskin (1998), the optimal location of the servers is an important aspect of the company's strategy because of its long term nature and its financial impact.

The network design must take into account the transportation time and cost for moving parts between facilities and the cost of operating the facilities while honoring the capacity of facilities and transportation links with respect to the demand for commodities. In the case of a post sale service network, the facilities may include distribution centers, warehouses, service centers and/or third party repair vendors.

We work with a household appliances manufacturer in Turkey. The company engages in the production and marketing of durable goods, components, and consumer electronics. Their post sale network consists of repair vendors, warehouses, distribution centers and suppliers. Efficient and cost-effective access between facilities will improve efficiency of the network and response times. The company wants to determine optimum number of facilities, capacity of these facilities, hierarchical structure of the network of facilities, assignment of repair vendors to facilities, transportation mode between facilities in order to minimize the overall costs of delivery of the spare parts to the repair vendors.

In order to optimize the spare parts delivery network, we define a static single-period multi-commodity multi-level network design problem. We develop a mixed integer linear mathematical programming formulation to solve this problem with given locations of suppliers and repair vendors. Objective function of the formulation is the minimization of the total network cost. In addition to the location decisions associated with the distribution center and warehouses, we are also concerned with the assignment of repair vendors to facilities and transportation mode selection.

Our contribution can be summarized as follows:

- We develop a generic mathematical model which can be configured to represent a variety of network configuration and transportation schemes using a scenario-based approach.
    - We formulate a mathematical programming model considering real life policies and restrictions.
    - In addition to facility location issues in the network design problem, we address transportation mode selection and delivery strategy decisions.
- We work with an extremely large data set and transform this data into a smaller scale through aggregation and consolidation without sacrificing the accuracy, and solve managable size optimization problems.
    - We suggest a set of assumption and approximation techniques to deal with the missing information.
- We work with the real data of the household appliances manufacturer. We compare their current distribution network with different network configurations under different constraints.

The remainder of the thesis is organized as follows: Chapter 2 presents a literature review. In Chapter 3, we give details about the existing post sale distribution network of the household appliances manufacturer, data collection and parameter estimation. Furthermore, we give a mathematical programming formulation of the network design problem for post sale services of the company. We present detailed results of different network configuration scenarios in Chapter 4. Finally, Chapter 5 concludes the thesis with remarks and directions of future research.

Chapter 2

2. Literature Review

There are two major issues in a network design problem: (i) establishment of facilities and (ii) establishment of transportation links. We are interested in establishment of facilities aspect of the problem. We suppose that transportation links are already existing or constructed according to the location of the facilities. We are concerned with the configuration of the transportation links subsequently by considering the locations of the facilities. We consider alternative configurations of the transportation network.

Post sale network design problem is not studied extensively in the literature. However the context is not too different from the traditional facility location and network design problem. It may be considered as a particular application area of the distribution network design problem. Therefore, we mainly focus on the particular practicality issues and managerial insight gained in the literature rather than the methodological content of the literature.

Lele (1997) addresses cost effective service strategies such as product design based strategies, support system related strategies, reducing or minimizing customer risk strategies for post sale systems. They work on different cost items of post sale service. Bachetti *et al*. (2010) present a detailed literature survey on spare part management. They propose spare parts classification methods, demand and inventory management techniques in different operation frameworks. Importance of demand frequency of parts,

spare part demand forecasting criteria, analysis of response lead time to the customers, critical part selection processes, part value analysis are investigated in the study.

Murty *et al*. (2004) discuss different issues of warranty logistics in the scope of post sale. They classify the managerial issues in warranty logistics into subgroups such as strategic, operational and tactical. In the scope of warranty logistics strategic issues they elaborate on the importance of facility locations in the network and service channels. According to Murty *et al.* (2004), optimal locations take into account transportation time and cost for moving parts between facilities, the cost of operating the warehouses and the capacity of facilities.

Considering both the endusers' perspective and the service provider's goals, the post sale network design problem shoul indeed hace multiple objectives. In this respect, publications on post sale network design may be clustered according to characteristic of the objective function: single objective versus multi-objective.

2.1. Single Objective Models

Single objective models are concerned with minimizing total cost of the network. Most of the papers address the problem as a mixed integer mathematical programming linear formulation. Tsiakis *et al*. (2001) study a multi-product multi-echelon supply chain network of spare parts under demand uncertainty. They determine the number of facilities and capacity of warehouses and distribution centers to be established. Transportation links are set-up according to a given set of manufacturing centers and demand points. They illustrate the use of their solution approach on distribution systems with and without demand uncertainty using two different case studies. In terms of their decision variables and constraints, their formulation can be considered a generic representation of the spare part distribution within a post sale network design problem.

In addition to the generic model proposed by Tsiakis *et al.* (2001), Landrieux and Vandaele (2012) combine two different types of post sale service problems: facility location and spare parts inventory control. Objective function of their mixed integer linear problem formulation minimizes total cost which includes setup costs and fixed costs of the facilities, transportation costs and storage costs of goods. They focus on holding cost and lead time analysis in order to determine economic order quantities and reorder points which are the most important decisions of the relevant inventory system.

They illustrate the use of their theoretical findings on a case study for a digital camera projector producer on various scenarios.

Piplani and Saraswat (2011) determine the facilities to operate and the transportation links of a post sale service network of a computer manufacturer. They validate the model with real life data. A min-max robust optimization model is also solved to address uncertainties in demand. These two papers are good examples of the implementation of different scenarios with real life data of the companies.

2.2. Multi-objective Models

In addition to minimizing total cost of the network, some of the papers in the literature also consider minimization of the delivery times of the post sale service.

Zegordi *et al.* (2011) propose a bi-objective mixed integer linear programming model. The model considers minimizing total network cost and minimizing total weighted tardiness of part deliveries to the disposal centers. Their problem setting consists of collection centers, repair facilities, production plants, and disposal centers. The ε-constraint method is used to obtain Pareto optimal solutions. They present a numerical example to show the applicability of proposed method.

Eskandarpour *et al*. (2014) study a multi-product four layer post sale reverse logistics network design problem. They propose a bi-objective mixed integer linear mathematical model to minimize the total network cost and the tardiness for the returning products to customers. They propose a novel multi-start-variable-neighborhood search heuristic that incorporates nine different neighborhood structures and three new encoding-decoding mechanisms.

Du and Evans (2007) propose a closed loop reverse logistics network design problem of a manufacturer. Return flows start from customer areas, go through distribution network and service facilities, and then go back to customers, accompanied by spare parts flows between manufacturers to the service facilities. The decisions involve location selection for facilities and their capacities, and how to arrange the transportation flows among these facilities. Their objective functions include minimization of the overall costs and minimization of the total tardiness of cycle time. They combine three different algorithms scatter search, the dual simplex method and the constraint method. They also

investigate the tradeoff between these two objectives. As a result of the model, differences of centralized and decentralized post sale networks are demonstrated in terms of costs and times.

Eskandarpour *et al*. (2013) aim to develop a post sale network model considering strategic and tactical decisions as well as conflicting objectives for third party logistics (3PL) companies. In order to create a network which comprises of customers, collection centers, recovery facilities, suppliers, and disposal centers, they propose a multi-objective post sale network design problem. Besides minimizing total cost and total tardiness, minimizing the environmental pollution is one of their objective functions of their mixed integer linear mathematical model. In order to solve the problem, a parallel multi-objective heuristic based on variable neighborhood search is developed to find Pareto optimal solutions. The efficiency of the heuristic is compared with a multi objective Memetic algorithm. Furthermore, they compare the results with those of a branch and bound algorithm.

We work with the real data of the household appliances manufacturer for post sale distribution network optimization. We develop a mathematical model and solve the problem using real life data of the company. Our objective function is to minimize total network cost which includes facility opening and operating costs and transportation costs. We do not explicitly consider service time minimization as an objective function. However, we take it into account as a hard constraint by enforcing a maximum allowable time between successive deliveries of spare parts to the repair vendors.

Chapter 3

3. A Network Design Problem for Post Sale Services of a Household Appliances Manufacturer

In this chapter, post sale network design is exemplified with the spare part distribution system of a leading Turkish household appliances manufacturer. First, we present company information and the existing distribution system and motivation of the study. Next, we explain data collection and parameter estimation stages of the study. Then we present a mathematical model for the problem.

3.1. Industry and Company Information

Companies in this industry manufacture large appliances such as stoves, ovens, refrigerators, washers and dryers, and also small appliances including vacuum cleaners, fans, humidifiers and dehumidifiers, and toaster ovens. The global household appliances industry is expected to reach an estimated 3.8% growth in the next 3 years (www.freedoniagroup.com/World-Major-Household-Appliances.html).

The profitability of individual companies in this industry depends on efficient operations and effective marketing. Large companies have economies of scale in production, marketing, distribution and post sale services. Small companies can compete effectively by producing specialty products, subcontracting to larger manufacturers, or producing name brand goods under contract. The industry is highly concentrated; the top 20 companies generate about 90 percent of the revenue. Major

product categories are refrigerators and freezers; washers and dryers; and ovens and ranges. Other leading sources of revenue include dishwashers, fans, microwave ovens, vacuum cleaners, and water heaters (www.hoovers.com/industry-facts.household-appliance-manufacturing.1168.html).

Table 3.1 Customer Appliances Penetration Rates in Turkey

	Historic Data				Forecasts				
Appliance	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Dishwashers	41.9	45.2	48.2	51.3	54.5	56.5	58.5	59.5	60.2
Automatic Tumble Dryers	2	2.7	3.1	3.7	4.3	5.1	5.9	6.1	6.2
Automatic Washer Dryers	6.3	6.9	7.6	8.4	9.2	10.1	11	11	10.5
Automatic Washing Machines	93.3	94	94.2	95.1	96.2	97.1	98.1	98.9	99.2
Semi-Automatic Washing Machines	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0
Built-In Hobs	31.6	33.8	35	35.7	36.8	38.5	40.1	42.2	44.5
Ovens	45.9	49	50.1	52.9	56	58.5	61	63	65.2
Cooker Hoods	25.4	26.5	27.5	28.5	29.6	32.1	34.6	36.4	38.1
Cookers	62.1	63.3	64.7	66.1	67.4	68.6	69.7	70.3	71.2
Microwaves	5.3	5.4	5.5	5.7	5.9	6.3	6.7	7.1	7.5
Freezers	2.3	2.2	2.1	2	1.9	1.8	1.7	1.6	1.5
Fridge Freezers	96.2	96.4	96.4	96.4	96.5	96.6	96.6	96.7	96.8
Fridges	24	22.7	21.3	20.1	19	17.3	15.6	14.3	14.1
Room Air Conditioners	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Split Air Conditioners	11.1	12	12.2	12.4	12.5	12.7	12.9	13.1	13.3
Food Preparation Appliances	59.2	59.6	60	60.5	61	63	65	67	69
Coffee Machines	14.9	15	15	15.1	15.1	15.3	15.4	15.6	15.8
Freestanding Hobs	53.4	56	58.8	61.8	64.9	68.1	71.3	73.7	75.6
Mini Ovens	23.5	25.9	28.5	31.3	34.5	37.9	41.4	43.5	45.6
Cylinder Vacuum Cleaners	90.9	91.8	92.9	94.1	95.1	96	97	97	98
Handheld Vacuum Cleaners	8.8	8.8	8.8	8.9	9.1	9.4	9.8	10.3	11.1
StickVacuum Cleaners	1.7	1.8	1.9	2	2	2.1	2.2	2.3	2.5
Upright Vacuum Cleaners	5.9	6	6.1	6.2	6.4	6.4	6.4	6.5	6.6
Wetand Dry Vacuum Cleaners	8.8	8.8	8.9	9	9	9.6	10.3	11.1	11.2

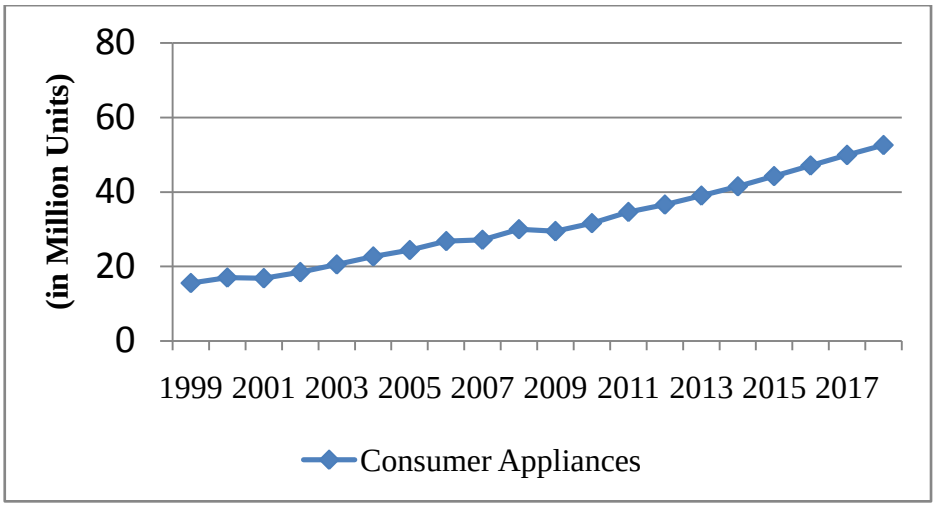

Figure 3.1 Turkey Consumer Appliances Market Size (Source: Market research provider, Euromonitor International)

Household appliances industry trends in Turkey act very similar as the world trends. However, the market in Turkey has not reached saturation yet. Table 3.1 represents the household appliances industry penetration rates according to different appliance types between 2010 and 2013 and forecasted penetration rates between 2014 and 2018. Therefore, expected growth for the next year is more than 3.8%. Figure 3.1 shows customer appliances industry growth in Turkey from 1999 to 2014 and demonstrates the expected growth between 2015 and 2018.

For household appliances industry, post sale activities have a significant role especially in a competitive market. Post sale activities start with delivery and installation of the sold product. It also predominantly includes repair and maintenance of the products based on customer needs. Besides the replacement of an unrepairable product, it also includes collecting unusable ones and handling them according to Turkey's environmental legislation.

Repair and maintenance has a major share in the post sale operations. In order to fix problems, a corrective might be sufficient. However, it is usually necessary to replace parts that have broken down. In this context, procurement of the required spare part in a short time window is essential. To achieve this goal, one obvious option is to maintain high levels of inventory of spare parts at many locations. For this option, not only inventory holding cost of spare parts but also operational costs and fixed costs of facilities would increase drastically. Second option is a responsive distribution network and timely transportation services. For this option, transportation costs would

significantly increase. Hence, the company should be aware of the tradeoff between transportation costs and inventory holding costs. Accordingly, they need to decide optimum stocking and transportation policies.

In Turkey, "customer satisfaction" is a new phenomenon which has been emphasized more in the household appliances industry recently. An efficient customer service system is a competitive advantage. In order to increase their market share, companies have to provide effective post sale services, which bear additional costs. Post sale services are getting critical day by day for household appliances manufacturers.

We work with a household appliances manufacturer in Turkey. The company engages in the production and marketing of durable goods, components, consumer electronics and post sale services. Its products include electronic products, small home appliances and small kitchen accessories, such as refrigerators, freezers, washing machines, dishwashers, aspirators, vacuum cleaners, coffee makers and blenders. The company offers products and services around the world with its 24,000 employees, has 14 different production plants in five countries (Turkey, Romania, Russia, China and South Africa), and executes its sales and marketing companies all over the world with its 10 brands.

In Turkey, around 15 million households use the company's products. The performance indicators regarding their remarkable conducts are also supported by many international quality and technology awards, and other prizes. In the last four years, it has been consistently selected the most admired Turkish company in all sectors.

3.2. The Existing Post Sale Operations of Company

Since the company is in the household appliances industry, its market can be identified as business to consumer (B2C) market. Holding a big share of the market and having increasing number of customers are success indicators of a B2C market.

Apart from increasing sales, the company's focus is also keeping the existing customers satisfied by responsive post sale service. By means of consistent post sale activities, they do not only manage to gain new customers but also succeed in customer retention.

The company's post sale service objectives can be summarized as

- fast delivery and installation of product,

- consumers' easy access to the company's call center,
- quick diagnostic and solution by well-equipped maintenance crew,
- case closing in 10 days,
- effective replacement decision for unsolvable breakdowns by providing the consumer a new product.

Due to company's customer satisfaction policies and future goals within the scope of customer services, effective and efficient delivery of spare parts is crucial. Responding to customers in tighter time windows is important for the company. In the future, the company is determined to respond to 100% of the customers within shorter response times. They also aim to decrease the share of post sale service operational costs.

Considering the post sale priorities of the company, distribution network activities are essential. This network consists of repair vendors, warehouses, a distribution center and suppliers. Quick and less costly access between facilities, can improve both the efficiency of network and the customer response times.

The post sale service process of a customer is initiated by the customer calling the customer services to report a problem with their product. The call center assigns the customer to a repair vendor. Repair vendor visits the customer and diagnoses the problem. If the problem can be solved by changing a part, the repair vendor firstly checks the inventory on hand for a spare part. If it is not available in inventory, they place an order for this spare part to the warehouse to which this repair vendor is assigned to. If the warehouse does not have inventory of this spare part, either they order it from the distribution centre. Furthermore, if on hand inventory of the distribution center does not contain this spare part, it is procured from the supplier.

As of 2013, the company's spare part distribution network contains 44,408 different Stock Keeping Units (SKUs). Overseas countries and 531 domestic repair vendors require these parts which are procured from 83 domestic suppliers, company owned production plants and imports. Repair vendors place orders for the spare parts in response to an actual demand for the end customer. Distribution center and warehouses deliver spare parts to repair vendors. Warehouses are located at 8 different places in Turkey. Repair vendors keep stocks for an anticipated demand level. In case of stockouts, they request spare parts from the facility they are assigned to; it can be a warehouse or a distribution center depending on the location of the repair vendor. 135

repair vendors that are very close to the distribution center in İstanbul are not assigned to a warehouse as the distribution center provides the spare parts directly to these repair vendors. Moreover, the distribution center is responsible for the import and export activities of the spare part distribution system.

3.2.1. Suppliers and Variety of Spare Parts

In the post sale distribution system of the company, there are three sources for the procurement of spare parts. These are import from overseas countries, external suppliers and internal suppliers. Internal suppliers are production plants of the company. Each internal supplier produces only one product type including its spare parts. External suppliers are local manufacturers which also provide spare parts to the post sale services of the company. Procurement proportions from these sources are shown in Figure 3.2. For a distribution network analysis, the most important comparison criterion is the volume of the distributed quantity. As it can be seen in Figure 3.2, procurement from internal suppliers has the highest proportion of the total procurement in 2013.

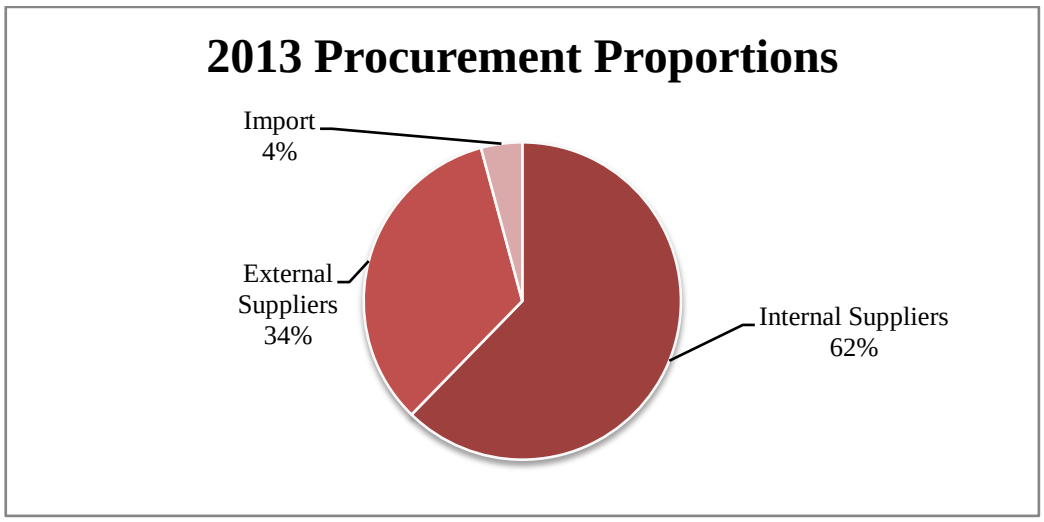

Figure 3.2 Procurement Proportions According to Suppliers

Overall, there are 83 different external suppliers. In addition to these external suppliers, there are 9 internal suppliers and one supplier for import activities. Totally, 93 different suppliers provide the network with spare parts. Each spare part has a unique supplier. This means one spare part cannot be procured from more than one supplier.

In the existing system, which is highly centralized, each supplier sends the parts to the distribution center. Transportation costs from external suppliers and import location to

the distribution center has no cost on the company as they are paid by these suppliers. But, the company has to pay transportation costs for transportation starting from the internal suppliers to the distribution center, and all the way down to the repair vendors.

3.2.2. Distribution Centers and Warehouses

Currently, the post sale service system includes three distribution centers. These distribution centers are located very close to each other: 27 km in between them. As each distribution center keep stock of different spare parts, a single SKU cannot be stored in two different distribution centers. Therefore, these three distribution centers can be treated as a single facility.

Along with the representative distribution center, there are currently 8 warehouses. 531 domestic repair vendors are spread all over Turkey. They are divided into 10 regions: namely, Adana, Ankara, Antalya, Bursa, Çayırova, Elazığ, Eskişehir, İstanbul, İzmir, and Samsun.

In the existing system, all suppliers send their spare parts to the distribution center. The distribution center transfers the parts to the warehouses and repair vendors of İstanbul and Çayırova. Available information on the size and the number of SKUs of the warehouses are presented in Table 3.2.

Table 3.2 Warehouse Size and Total Number of Stored SKUs, in Region's Warehouses

Region warehouse	Bursa	İzmir	Ankara	Eskişehir	Antalya	Adana	Samsun	Elazığ
Warehouse Size (m^2)	2,268	2,122	1,776	1,080	2,220	1,260	1,500	1,780
Total number of stored SKUs	15,484	14,161	13,435	12,256	15,035	12,536	13,048	12,000

Each region is assigned to a single warehouse, and all repair vendors in that region can only be served by that particular warehouse. As noted before, İstanbul region and Çayırova region are assigned directly to the distribution center because of their proximity. Figure 3.3 shows the locations of distribution center and warehouses in Turkey.

Distribution Center Warehouses

Figure 3.3 Locations of Distribution Center and Warehouses

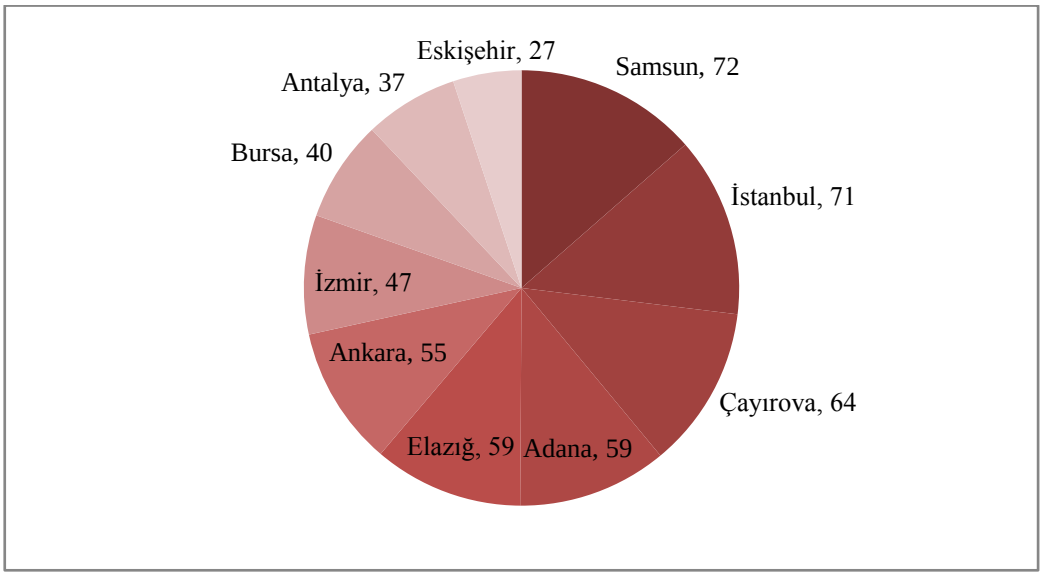

Figure 3.4 Number of Repair Vendors in Different Regions

Figure 3.4 shows clearly that the number of repair vendors changes by region and the distribution of vendors among the regions. Note that the number of repair vendors cannot be the sole indicator about region's size. Demand of each region, warehouses and repair vendors should be analyzed in detail. The warehouses and repair vendors ship the ordered spare parts two times a week. Therefore, each warehouse is served once every three days and on the same days of each week.

3.2.3. Repair Vendors

As of 2013, there are 531 active repair vendors in the post sale distribution system. While providing repair and/or maintenance service, they may replace any part on the final product.

Repair vendors are divided in two categories: inner-city and suburban. Delivery strategies are based on the repair vendor's category. 171 repair vendors out of 531 are inner-city repair vendors. All deliveries are carried out with routes which are pre-determined by the company. For suburban repair vendors, pre-determined delivery routes are fixed. However, some inner-city routes may change depending on the demand from the repair vendors. For each route, deliveries are carried out twice a week (i.e. there are 3 days between subsequent deliveries to the same location).

In post sale spare parts supply chains, demand fluctuations for parts exist. These fluctuations usually do not have any trends or cycles. Kalchschmidt *et al.* (2003) study uncertainty of spare parts' demands, and they demonstrate that demand for spare parts cannot be forecasted by traditional methods. For this reason, companies hold inventory of the frequently replaced parts so as to respond to such problems quickly. When a spare part is not in stock, a repair vendor requests the part from the distribution center or its designated warehouse.

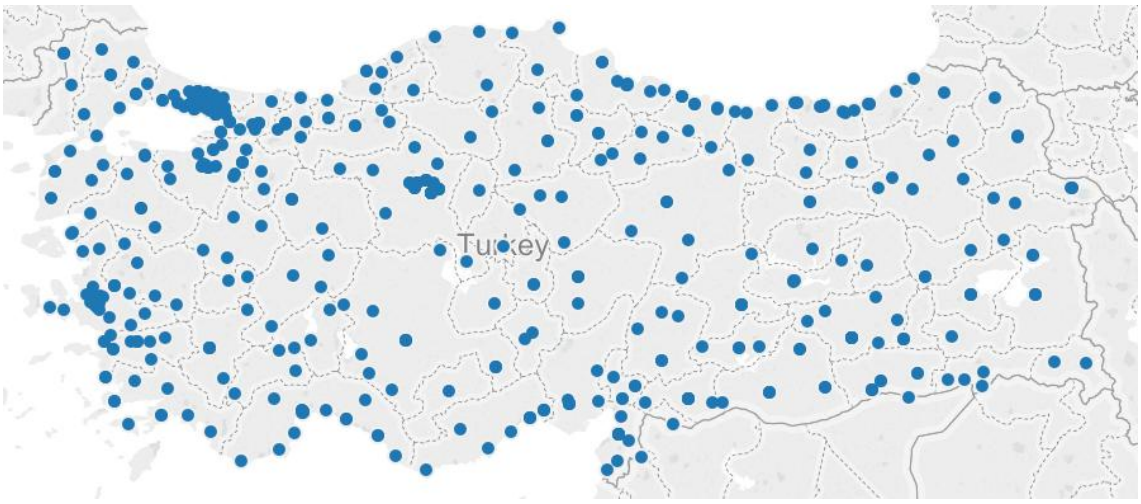

Figure 3.5 Locations of Repair Vendors

Locations of the 531 repair vendors are provided in Figure 3.5. As expected, in the regions where population is high, the number of repair vendors is also high. Repair vendors are located according to demand, population density, and quantity of retail sales

stores. In the near future, the company is not considering significant changes in their existing repair vendors.

3.3. Motivation

For a household appliances manufacturer, high customer satisfaction is one of the key competitive advantages. End user satisfaction is not only related with satisfaction from the final product, but also with post sale services. An efficient post sale service is possible through timely service dispatch, availability of sufficient level of inventory of spare parts at the facilities and an efficient distribution network.

Efficient post sale distribution network is believed to result in several direct benefits, including improved customer satisfaction, decreased resource investment levels and reductions in storage and distribution costs (Andel, 1997). If a post sale network is designed and managed properly, it can be a cost-driving area for improving profitability and customer satisfaction (Du and Evans, 2008).

A post sale network's first objective is minimization of the total cost of the distribution network, whereas the second is the minimization of the tardiness of parts to the repair vendors. In the scope of our study, service delivery by designing an efficient distribution network is the main focus.

Indeed, one of the reasons for focusing on the distribution network optimization is company's commitment to serve customers within 3 days. This particular service requirement is at the core of their post sale services operations. We do not enforce this service constraint explicitly; however we will implicitly reflect this issue into our modeling approach.

Furthermore, costs associated with the distribution system represent a high percentage compared to the other operational costs. In this context, there is a tradeoff between cutting down the inventory holding costs with minimum inventory and minimizing transportation costs.

The decisions of the post sale network design problem include:

- number of distribution centers and warehouses,
- location of the new facilities if necessary along with the closing down the existing facilities,

- assignment of the suppliers to facilities and
- assignment of repair vendors to facilities and the choice of transportation mode between vendors and facilities.

3.4. Data Collection and Parameter Estimation

The ERP system of the company tracks all activities regarding the post sale operations at the warehouse-to-customer level. Therefore, the inventory position by location and time can be tracked from the system in detail. However, within the scope of our study, we only need to analyze the flow of commodities by consolidating for a pre-specified length of time period and aggregating with respect to parts and with respect to locations. In this respect, the level of both aggregation and consolidation is important as we do not want to sacrifice from accuracy of the data used within the mathematical model. The mathematical model considers a static single-period multi-commodity flow over a multi-level network and is presented in Section 3.5.

The company provided us with the relevant data including the SKU info of the spare parts, their suppliers and weekly volumetric demand for the parts, locations of existing facilities, locations of repair vendors, operational costs, transportation costs and opening costs for candidate locations.

Next step in data collection is consolidating the data so as to estimate the parameters. Data is aggregated with respect to part, time and location. The aggregation and disaggregation techniques offer promise for solving large-scale optimization models, supply a set of promising methodologies for studying the underlying structure of both univariate and multivariate data sets, and provide a set of tools for manipulating data for different levels of decision makers (Rogers *et al.*, 1991). The company could not provide the complete required data. To deal with the missing data, basic imputation methods such as weighted mean substitution, single regression and model-based methods such as multiple imputations are used (Howell, 2012). Methods used for aggregation are explained in detail for estimating parameters associated with suppliers and repair vendor demands, existing distribution centers and existing and candidate warehouses, locations and distances and various cost items.

3.4.1. Part Aggregation

We have extracted the demand data of 44,408 distinct SKUs for year 2013. The number of parts is too high and it unfortunately complicates the problem. Therefore, the problem cannot be solved in a reasonable time with network optimization methods, if the stock location for each part is chosen separately.

In the existing setting different suppliers do not consolidate their parts. Therefore; we use item based aggregation for spare parts according to their suppliers to reduce the problem size. All parts supplied by the same supplier are aggregated as one spare part. Number of spare part, hence; reduces to 93 from 44,408.

3.4.2. Supplier Aggregation

The amount of spare parts is supplied by a total of 93 different suppliers. Internal suppliers have 62% of total procured volume. Firstly, this includes 9 internal suppliers that have an important role in the distribution system. Secondly, this also includes imports. Finally, external suppliers, which have 34% of procurement volumes, are also included. However, this category includes 83 different suppliers of spare parts. We also observe that some of these external suppliers have pretty small proportion in total procured volume. Although internal suppliers and import suppliers cannot be ignored in any stage of the analysis and optimization process, some of external suppliers can be aggregated as a single external supplier as their transportation costs are paid by the external suppliers.

Figure 3.6 indicates that 56 external suppliers (out of 83) contribute with only 1% of the total spare part procurement. As a result, 67% of the external suppliers are directly aggregated as a fictive external supplier. The volume-wise largest supplier provides 33% of the total volume. The Pareto analysis demonstrates that few external suppliers have significant contribution to spare part procurement operations.

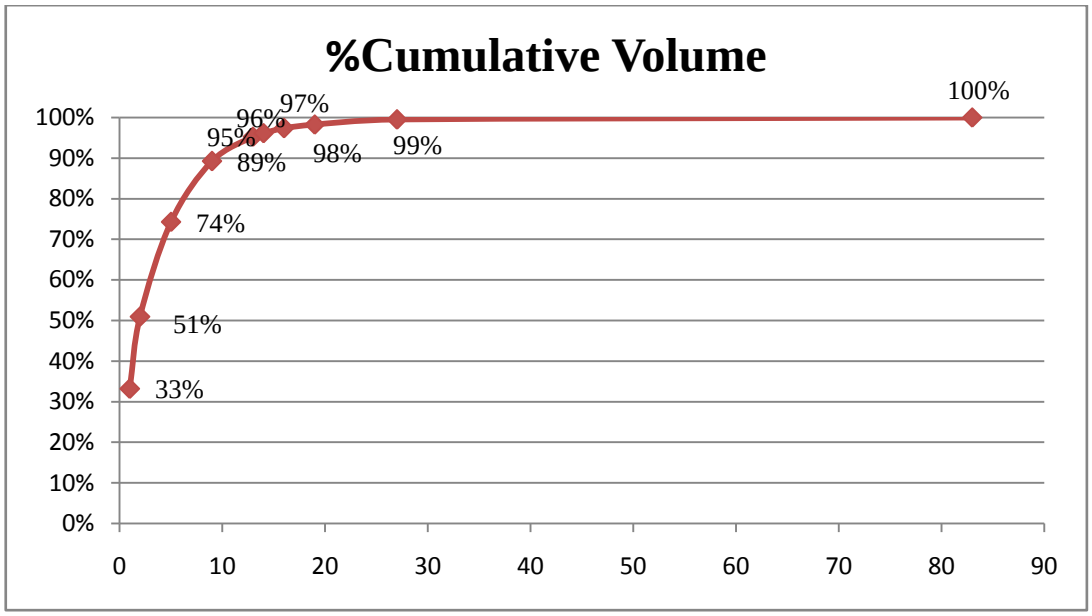

Figure 3.6 Cumulative Percent Distribution of External Suppliers

In Figure 3.7 blue bars represent the volume from the associated external supplier, the red line indicates the percentage of each external supplier in the total procurement volume and the green line shows the 80% cut-off level.

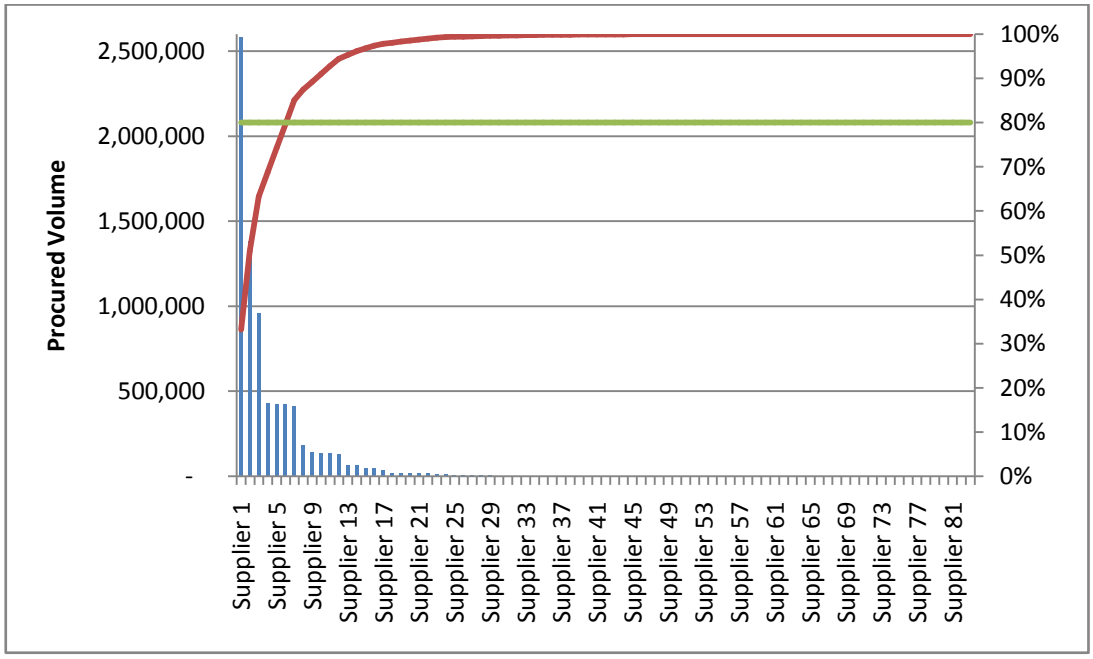

Figure 3.7 Pareto Analysis of External Suppliers According to Procured Volume

Figure 3.7 shows that the largest six external suppliers have 80% of total volume for spare parts. These external suppliers provide different parts such as cable, paper filter, copper wire, heat exchangers, evaporators and air conditioners.

Annual TL usage (i.e. procurement cost) based Pareto analysis is shown in Figure 3.8; red bars show the total TL value of the external supplier. Figure 3.8 shows that; 7 external suppliers are covering 80% of total spare parts' procurement costs. One of these external suppliers was not included according to the former volume based Pareto analysis. Yet it turned out to be a major external supplier according to total procurement costs. This supplier's part is small appliances motors. Hence, all of the major external suppliers' parts are different which further increases the variety of the selected external suppliers.

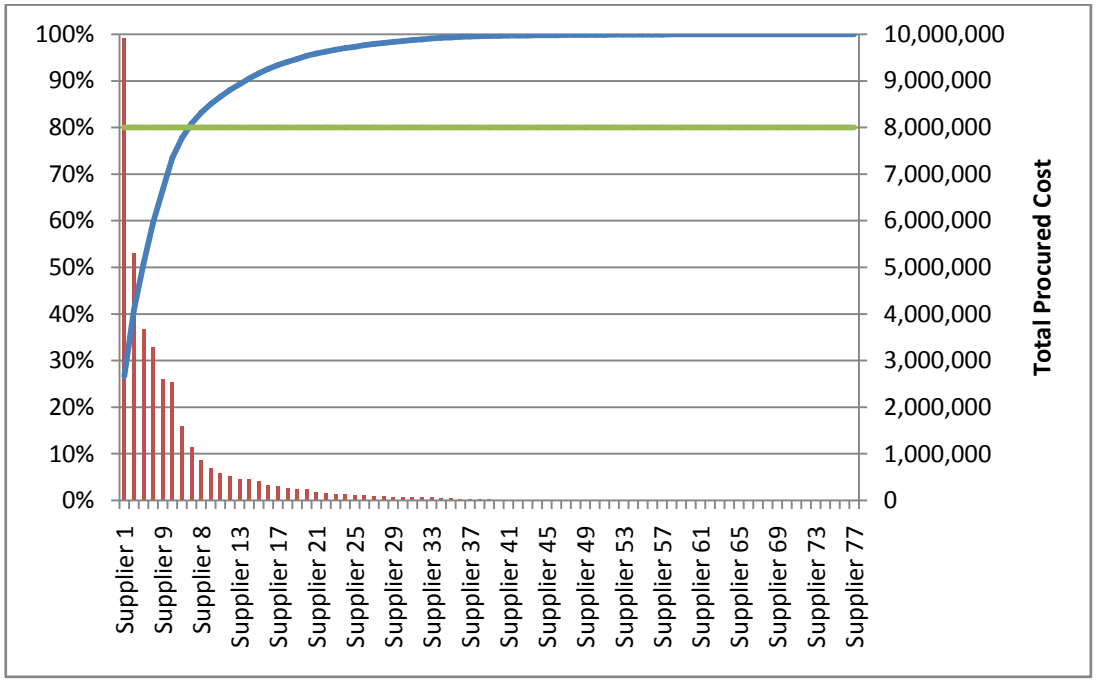

Figure 3.8 Pareto Analysis According to Total Procurement Cost

On top of the Pareto analysis study with two different measures, we also calculate the coefficient of variation (CoV) in the 2013 annual volume data for each major external supplier and other suppliers which are likely to be included in the major external supplier set. The CoV of a sample is calculated as the ratio of the standard deviation to the mean, i.e. $CoV = \frac{\sigma}{\mu}$.

Using Table 3.3, the 8 major external supplier candidates can be categorized in three different CoV levels. Supplier 4 and 7 have the low level CoV value. Supplier 2, 3, 5 and 6's CoVs are considered as moderate. Finally, Supplier 1 and 8 have high level CoV. Hence, we have selected external major suppliers with high, moderate and low

demand variability. CoV of 8 major suppliers are calculated according to their weekly demand and provided in Table 3.3.

Table 3.3 8 Major External Candidate Supplier's Demand Analysis

Supplier	**Total demand**	**Expected value of demand**	**Standard deviation**	**Coefficient of variation**
Supplier 1	2,577,751	49,572	51,925	1.05
Supplier 2	1,381,403	26,565	11,766	0.44
Supplier 3	956,296	18,390	8,340	0.45
Supplier 4	428,814	8,246	2,275	0.28
Supplier 5	425,728	8,187	6,898	0.84
Supplier 6	423,786	8,150	5,780	0.71
Supplier 7	415,280	7,986	1,722	0.22
Supplier 8	181,735	3,495	3,212	0.92

By choosing 8 major external suppliers out of 83, we leave out a considerable number of the external suppliers. As noted before, we consolidate the rest of the external suppliers into one fictive supplier co-located with the distribution center. As a result our supplier aggregation analysis, 9 internal suppliers, 8 major external suppliers, one fictive external supplier and one import supplier represent the suppliers of our post sale network design problem.

Also note that; three internal suppliers are located at the same place in Çerkezköy. They consolidate outbound transportation activities and send parts to the distribution center together. Therefore, these three internal suppliers' locations are considered as the same. Hence, from now on they will be consolidated into a single major internal supplier. (i.e. namely KMI/TMI/ESI). Eventually, we have 16 different major suppliers and their locations are depicted in Figure 3.9. In Figure 3.9, blue nodes represent internal suppliers and green nodes represent external suppliers along with the fictive external supplier.

Figure 3.9 Locations of Major Suppliers

3.4.3. Demand Aggregation

Based on the type of spare parts, the major suppliers are summarized in Table 3.4. Note that, the imports are excluded in Table 3.4. Each supplier can be seen as providing one particular spare part. Therefore, we may distinguish the items either based on the product type or the supplier.

Table 3.4 Major Suppliers and Descriptions

Supplier	**Description**
BI	Refrigerator spare parts
BMI	Dish washer spare parts
BTVI	Television spare parts
CMI	Washing machine spare parts
KMI/TMI/ESI	Small house appliance spare parts
MDI	Imported spare parts
PCI	Oven repair parts
External Supplier 1	Pipe and heat exchanger parts
External Supplier 2	Air conditioner parts
External Supplier 3	Copper wire parts
External Supplier 4	Paper filter parts
External Supplier 5	Cable parts
External Supplier 6	Metal parts
External Supplier 7	Small house appliances parts
External Supplier 8	Sheet metal parts
Fictive External Supplier	Consolidated other spare parts

Figure 3.10 presents the total demand (in volume) of each major supplier. Figure 3.10 depicts vividly the significant differences among suppliers in terms of the total demand.

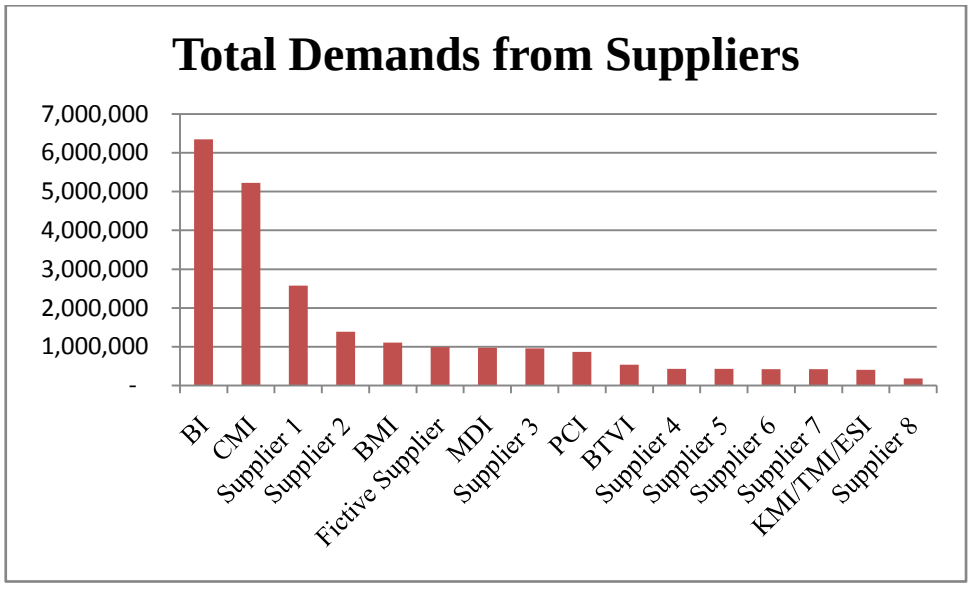

Figure 3.10 Total Demands (in volume) of Major Suppliers

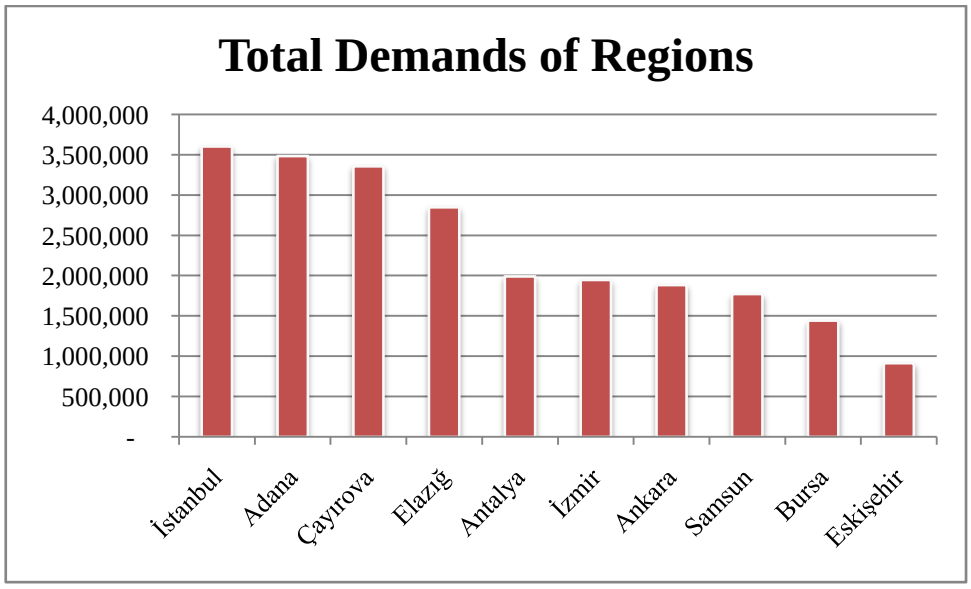

Figure 3.11 Total Demands of Regions

When we depict the total demand (in volume) of the ten regions (see Figure 3.11), the differences in total demands of the regions are easily observable.

Figure 3.12 and 3.13 shows volumetric weekly demand of each major supplier during 2013. It is evident that the demand for none of them is constant throughout the year. Unfortunately, one year data is not sufficient to recognize any other particular pattern or seasonality in the demand (Gooijer, 1997). Note that the weeks in which the demand drops to zero represent national/regional holidays for the year 2013.

3.4.4. Repair Vendor Demand Estimation

Recall the company ships spare parts two times a week due to the existing policy. Hence, we need to calculate the expected value for the half-week volumetric demand for each repair vendor. Due to the random fluctuations in the demands, data for each 532 repair demand points (531 repair vendors and one for export) for the 16 spare parts (representing major suppliers), the expected value can be calculated as the simple arithmetic average.

Let D_{ri} denote the expected half-week volumetric demand of repair vendor r for spare part i. For spare part i let d_{rit} represent the demand of the repair vendor r for item i during week t. Considering, there are 104 half-weeks in a year, the expected volumetric demands can be calculated as

$$D_{ri} = \frac{\sum_{t=1}^{52} d_{rit}}{104}$$

Appendix A presents expected half-week volumetric demands of 16 different items for each demand point.

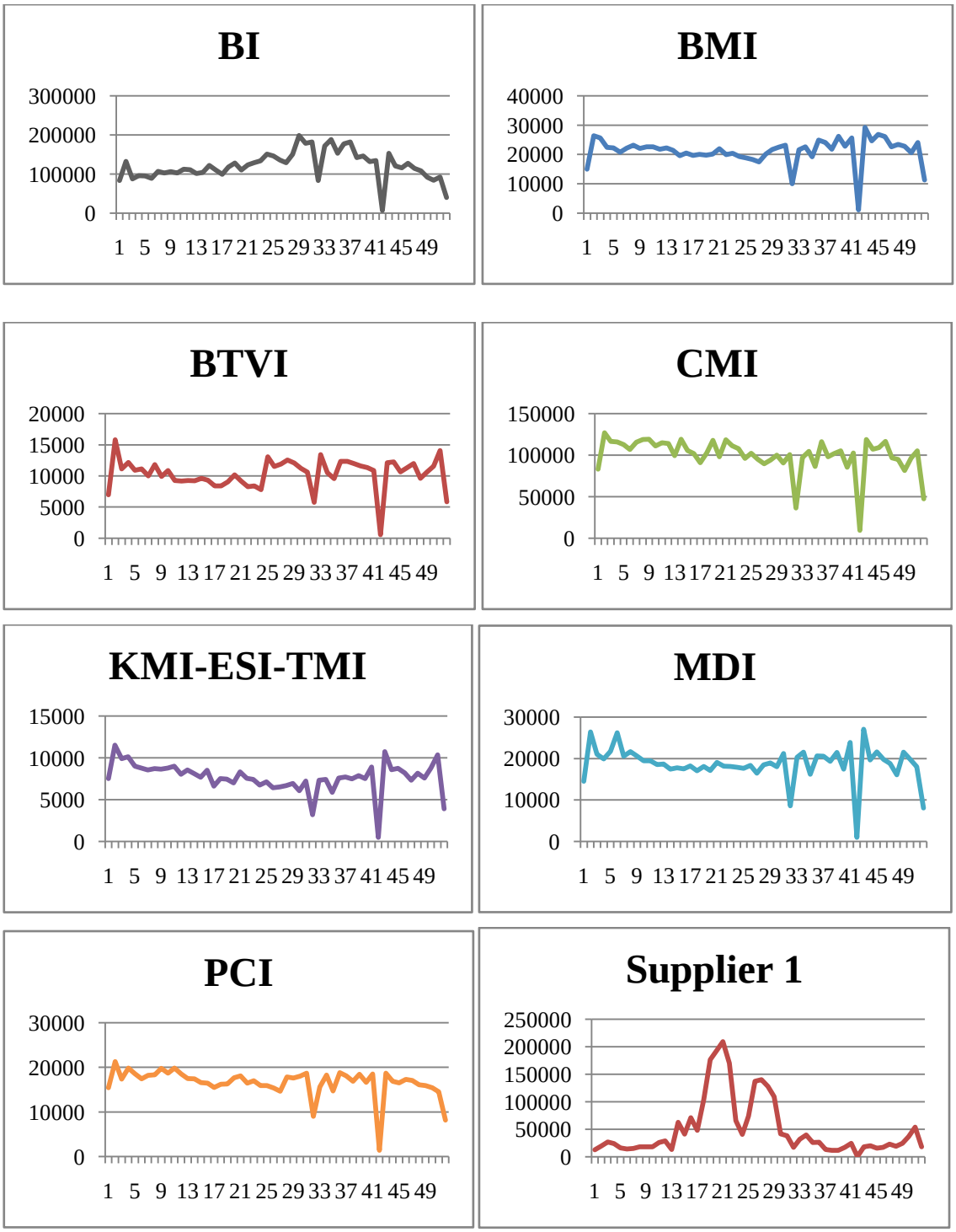

Figure 3.12 Total Weekly Volumetric Demands of Major Suppliers-Part 1

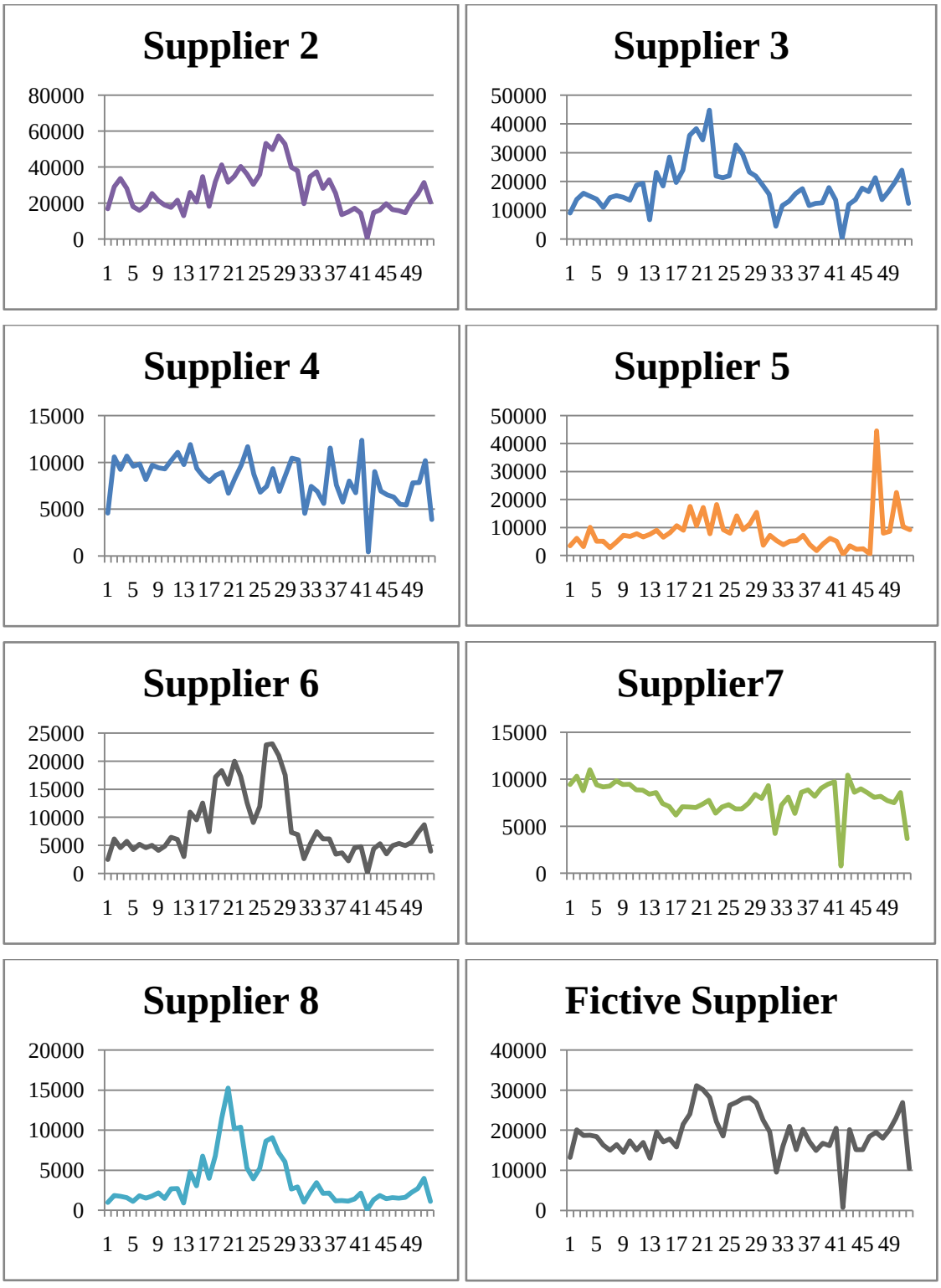

Figure 3.13 Total Weekly Volumetric Demands of Major Suppliers- Part 2

3.4.5. Pre-determined Route Demand Estimation

Recall that the company's existing spare part distribution system is operated using 73 pre-determined routes. Appendix B represents these routes.

Hence, we aggregate demands of repair points at given pre-determined route level. In this aggregation for each spare part, the expected half-week volumetric demands of all repair vendors in same route are summed up. With this aggregation, there are 73 different routes serving as repair demand points in the existing system.

For each route o, we are given the number of repair vendors on this route denoted by n_o. Let D_{oi} represent the expected half-week volumetric demand of route o for item i. Recall D_{ri} is the expected half-week volumetric demand of repair vendor r for item i.

$$D_{oi} = \sum_{r=1}^{n_o} D_{ri}$$

Figure 3.14 illustrates how we calculate the expected half-week volumetric demand for a sample route.

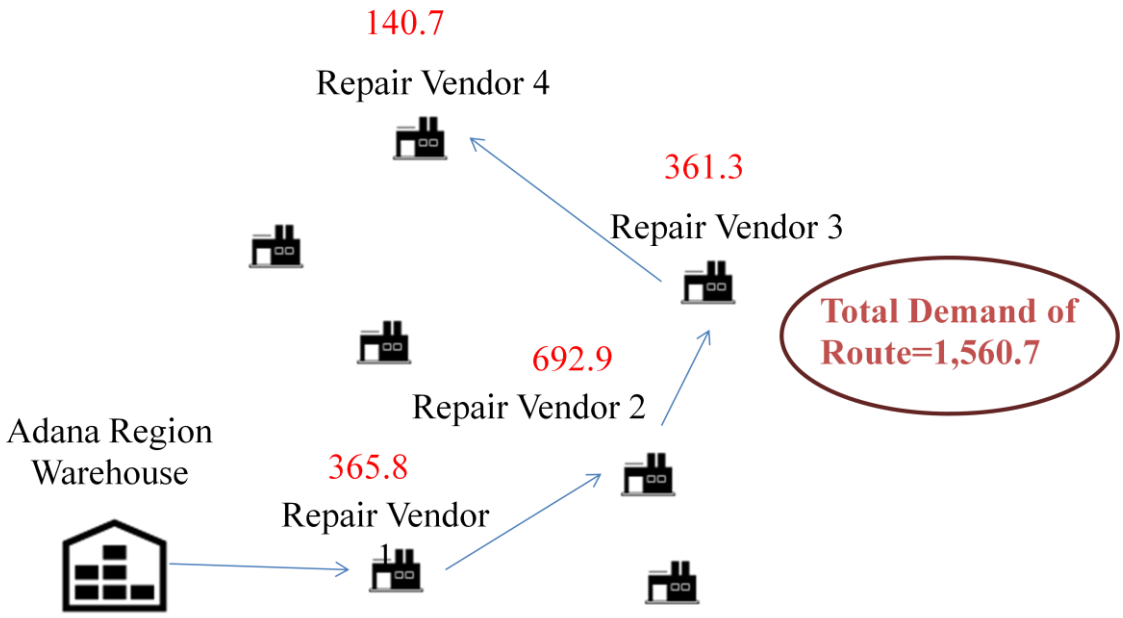

Figure 3.14 Calculation of Route's Total Demand

3.4.6. Locations of Distribution Center and Warehouses

The existing spare part network comprises of one distribution center (consisting of 3 very close distribution centers combined together) and 8 warehouses. We propose 15 candidate locations for the new warehouses; Aydın, Çanakkale, Denizli, Diyarbakır, Erzurum, Gaziantep, Kayseri, Konya, Malatya, Manisa, Ordu, Sakarya, Şanlıurfa, Trabzon and Van. Figure 3.15 shows existing distribution center (as the bold big building), warehouses (as the small buildings) and candidate warehouses locations (indicated with orange triangles). These candidate locations are determined by considering the major cities in Turkey which do not have a warehouse. They are selected based on factors such as the existing repair vendors, spatial density of the warehouses in a region, development of related industry, rate of population growth and land availability.

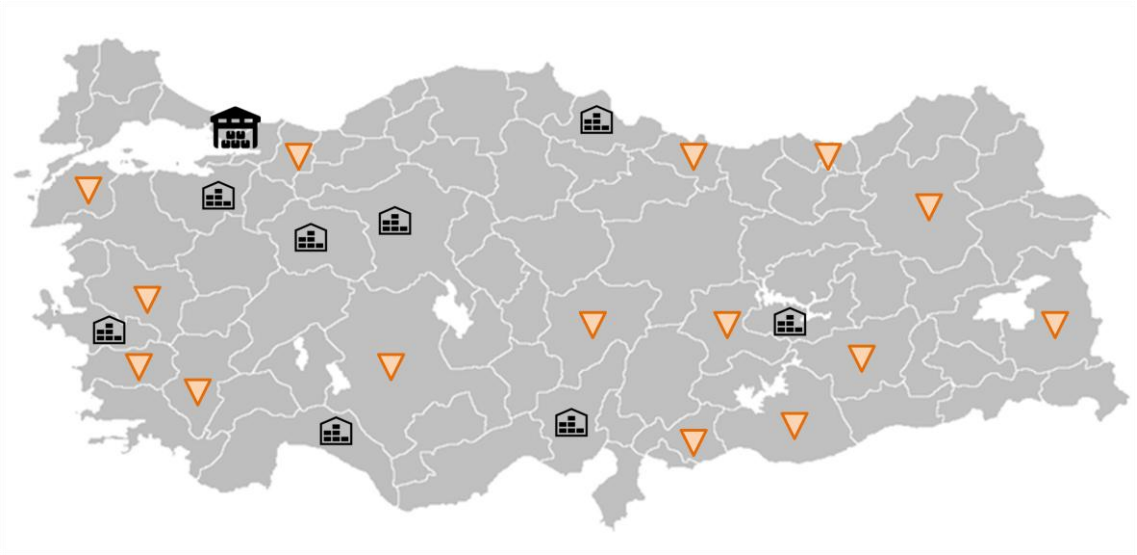

Figure 3.15 Locations of Existing and Candidate Warehouses and Distribution Center

3.4.7. Capacities of Distribution Center and Warehouses

One important parameter about facilities (i.e. distribution center and warehouses) is the capacity level. The distribution center and warehouse capacities are presented by upper bounds on their material inbound handling capacity.

For each existing facility, volumetric inbound handling quantities need to be calculated. The inbound handing capacity utilization is assumed to be 100%.

Let c_d denote the half-week volumetric handling capacity of the distribution center. To estimate c_d using the 2013 weekly inbound volumetric flows through the distribution center, for each week we sum up the volumetric flow from the major suppliers and import point to the distribution center. Over the calculated 52 weekly volumetric inbound flows, we take the maximum to represent the upper bound weekly handling capacity. Then, we simply divide it by two to get the half-week estimated c_d. Let q_{st} represent the volumetric flows from major supplier s to the distribution center in week t of 2013.

$$c_d = \frac{\max_t \left\{ \sum_s q_{st} \right\}}{2}$$

The half-week volumetric handling capacities of existing warehouses are estimated in a similar fashion. Let q_{wt} represent the inbound volumetric flow from distribution center to warehouse w in week t of 2013. Then, c_w the half-week volumetric handling capacity of warehouse w, can be estimated as an upper bound by dividing the maximum weekly inbound volumetric flow by two. Hence,

$$c_w = \frac{\max_t \{q_{wt}\}}{2}$$

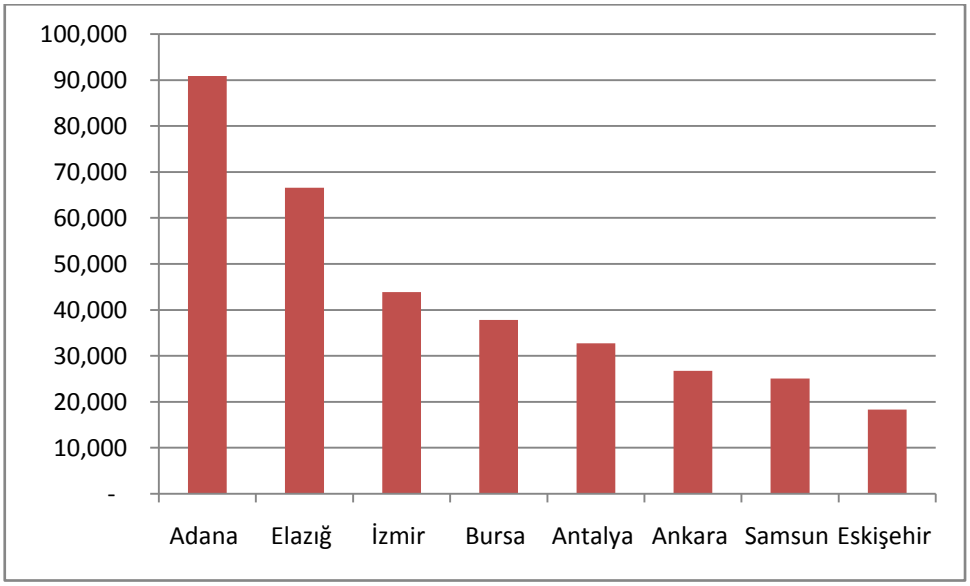

Figure 3.16 Warehouses Inbound Handling Capacities

Figure 3.16 presents calculated half-week volumetric inbound handling capacities for existing warehouses.

Table 3.2 and Figure 3.16 clearly demonstrate the differences in existing warehouses. While inquiring the new warehouse attributes, the company suggested the use of Elazığ warehouse as a prototype. Therefore, for all candidate warehouses inbound handling capacities are set the same with Elazığ warehouse's capacity.

3.4.8. Locations and Generation of Distance Matrix

In the existing system, there are

- 83 external suppliers
- 9 internal suppliers
- 1 distribution center
- 8 warehouses
- 15 candidate warehouses
- 531 repair vendors
- 1 import/export location

Following the product based aggregation, aggregation based on major external suppliers, location based aggregation at pre-determined route level, to represent the existing system we have

- 16 suppliers
- 1 distribution center
- 8 warehouses
- 15 candidate warehouses
- 531 repair vendors and 1 export location
- 73 pre-determined routes

Longitude and latitude information of all locations on the network is found by using online mapping service with their open addresses. ARCGIS software is used to find the actual ground travel distance between each pair of nodes. Hence, the distances between major suppliers-distribution center, distribution center-warehouses, distribution center-repair vendors, warehouses-repair vendors, repair vendors-repair vendors are estimated.

In the existing system, recall 73 pre-determined routes are used for delivery to the repair vendors. Hence, we need to calculate the total distance from designated warehouses to visit each repair vendor on the route. For this purpose the nearest neighbor algorithm is used and implemented in VBA.

The nearest neighbor algorithm is one of the first algorithms used to determine a solution to the travelling salesman problem: the salesman starts at a random city and repeatedly visits the nearest city until all have been visited. It quickly yields a short tour, but usually not the optimal one (Ghiani *et al.*, 2004).

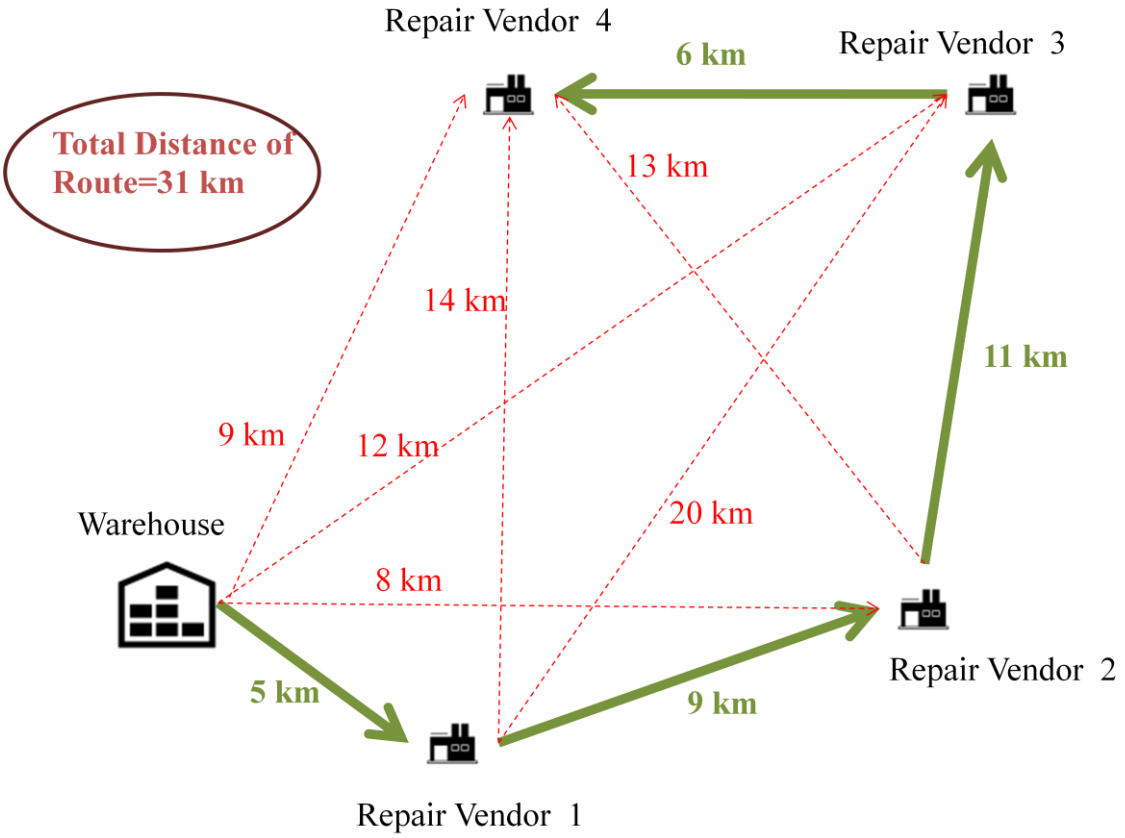

Figure 3.17 Calculating Distance of a Sample Route by Nearest Neighbor Algorithm

Figure 3.17 illustrates the calculated warehouse-route total distance over a sample route with four repair vendors. However, recall that there is a different routing system for the six inner-city routes. These repair vendors' total demands are usually higher than the others. Therefore, even a vehicle with maximum volume capacity, which is used for urban logistics, cannot meet the total demand on such a route. When vehicle capacity is full, new sub-routes are generated by the specialists. Each route consists of a fixed number of sub-routes. For each sub-route a different vehicle is assigned to meet the

demand of the repair vendors. So, there is one to one correspondence between the number of sub-routes and the number of vehicles. However, these sub-routes are updated routinely. Therefore, distances of these six inner-city routes are treated differently and are calculated by a modified nearest neighbor algorithm. Numbers of sub-routes of each inner-city route are presented in Table 3.5.

Table 3.5 Sub-routes of Inner-city Routes

Route Number	**Region of Route**	**Number of Random Sub-Routes**
Route 27	Antalya	2
Route 32	Bursa	3
Route 34	Bursa	3
Route 40	Çayırova	7
Route 54	İstanbul	13
Route 61	İzmir	3

Since sub-routes are being updated dynamically, the original routes are not split into pre-determined sub-routes. Therefore, a new algorithm is developed in order to approximate the inner-city route lengths for these six routes. The steps of the algorithm are as follows:

1. Apply nearest neighbor algorithm and find total route length d_r
2. Find out the shortest edge connecting the warehouse/distribution center and a repair vendor, mark this edge's distance as d_e
3. Subtract d_e from d_r
4. Divide the value by number of sub-routes of the route.
5. Add d_e to the calculated value and multiply with number of sub-routes of the route

The main idea of this algorithm is to come up with an average distance to be covered by trucks to arrive at each repair vendor location. Once we have completed calculating the inner-city route distance for these six routes, we have all the necessary distance-based data we need for the network. Appendix C presents all the calculated distances.

Next, we will present the determination of facility opening and operating costs and transportation cost parameters that are required to solve our network design problem.

3.4.9. Opening and Operating Costs for Distribution Centre and Warehouses

These costs are fixed costs and they are independent of the amount of product handled by the facility. For the existing distribution center and the existing 8 warehouses, only operating costs are considered. Besides operating costs, opening costs are estimated for the 15 candidate warehouses.

Operating costs include the following cost items: Staff salaries (staff includes 10 employees), electricity expenditure, gas expenditure, maintenance expenditure and rent expenditure (valid for distribution center, Adana, Antalya, Bursa warehouses and candidate warehouses as the other warehouses are owned by the company).

Monthly operating cost is provided by the company only for the Elazığ warehouse. In order to calculate the operating costs for the other warehouses and the distribution center, we assume that operating costs and the size (m^2) of facilities are directly proportional.

We assume, rent cost is independent of the location or any other property of the warehouse. This cost item is directly proportional with the facility size (m^2) rented. We calculate the half-week rental cost for each facility as

$$R_f = \frac{r_f \times A_f}{8}$$

where R_f is half-week rental cost of the facility f, r_f is the monthly unit m^2 rent calculated using Elazığ warehouse data, A_f is the size of facility f and 8 represents the number of half-week in one month.

Cost items used to calculate the opening cost include; moving costs of spare parts, installment costs of new warehouse, new premises and equipment costs, staff recruitment and training costs. The opening cost of warehouses is recovered over the specified life time of 20 years by straight-line deprecation (http://accountinginfo.com/study/dep/depreciation-01.htm).

Appendix D presents the calculated operating and opening costs for the facilities in spare parts distribution network.

3.4.10. Transportation Costs from Internal Suppliers to the Distribution Center

In the existing highly centralized system, suppliers can send the spare parts only to the distribution center by trucks. Recall that external suppliers pay the transportation costs to the distribution center. The company only covers transportation costs from the internal suppliers to the distribution center.

Transportation costs for one trip from each internal supplier to the distribution center with one truck are given in Table 3.6. Volumetric truck capacities are all 14,000 volumetric units. Historical truck utilization was given as 70% by the company. The used volumetric capacity u_c is calculated as the multiplication of the volumetric vehicle capacity and truck utilization.

Table 3.6 Transportation Costs Between Internal Suppliers and Distribution Center

Trip (*e*)	**Origin**	**Destination**	**Volumetric Capacity of Vehicle (Volumetric Unit)**	**Truck Utilization**	**Actual Capacity of Vehicle (Volumetric Unit)**	**(T_e)**	**(d_e)**	**(w_e)**
1	BI	DC	14,000	0.7	9,800	339.08	228.79	0.68
2	PCI	DC	14,000	0.7	9,800	373.12	206.09	0.10
3	BMI	DC	14,000	0.7	9,800	581.93	353.07	0.12
4	BTVI	DC	14,000	0.7	9,800	300.05	84.21	0.05
5	CMI*	DC	14,000	0.7	9,800	57.48	0	0
6	ESI/KMI/TMI	DC	14,000	0.7	9,800	450.00	157.20	0.05

*The company does not cover the transportation cost of deliveries from CMI. Hence CMI is excluded from this calculation by setting w_e=0.

We calculate a weighted average transportation cost from internal suppliers to the distribution center. Transportation cost per km per volumetric unit is estimated as

$$T_{avg}^{d} = \sum_{e} \left[w_e \frac{T_e / d_e}{u_c} \right]$$

where T_e is the total cost of the trip e, d_e represents the total distance of trip and w_e is the proportion of spare parts supplied by trip e.

The transportation cost for each internal supplier per volumetric unit t_{sd} is, then calculated by multiplying the weighted average cost T_{avg}^{d} with the distance from the internal supplier to the distribution center.

3.4.11. Transportation Costs between Distribution Centre and Warehouses

Transportation cost between the distribution center and warehouses are different for each warehouse and distribution center pair and for each vehicle type.

Table 3.7 Transportation Costs Between Distribution Center and Warehouses

Trip	Origin (d)	Warehouse (w)	Truck Type (v)	Volumetric Capacity of Vehicle (c_v)(volumetric unit)	Truck Utilization	Used Capacity of Vehicle (cu_v)(volumetric unit)	Trip Cost (TL)(T_{wdv})	Trip Distance (d_w)
1	DC1	Adana	Truck 1	14,000.00	0.70	9,800.00	1,272.39	838.51
2	DC1	Adana	Truck 2	30,543.33	0.70	21,380.33	1,819.62	838.51
3	DC1	Ankara	Truck 1	14,000.00	0.70	9,800.00	568.49	363.24
4	DC1	Ankara	Truck 2	30,543.33	0.70	21,380.33	964.64	363.24
5	DC1	Antalya	Truck 1	14,000.00	0.70	9,800.00	925.48	603.28
6	DC1	Antalya	Truck 2	30,543.33	0.70	21,380.33	1,535.38	603.28
7	DC1	Bursa	Truck 1	14,000.00	0.70	9,800.00	361.47	180.02
8	DC1	Bursa	Truck 2	30,543.33	0.70	21,380.33	615.49	180.02
9	DC1	Elazığ	Truck 1	14,000.00	0.70	9,800.00	1,740.18	1,078.74
10	DC1	Elazığ	Truck 2	30,543.33	0.70	21,380.33	2,961.08	1,078.74
11	DC1	Eskişehir	Truck 1	14,000.00	0.70	9,800.00	339.08	226.94
12	DC1	Eskişehir	Truck 2	30,543.33	0.70	21,380.33	581.93	226.94
13	DC1	İzmir	Truck 1	14,000.00	0.70	9,800.00	615.49	487.08
14	DC1	İzmir	Truck 2	30,543.33	0.70	21,380.33	1,047.46	487.08
15	DC1	Samsun	Truck 1	14,000.00	0.70	9,800.00	970.24	686.56
16	DC1	Samsun	Truck 2	30,543.33	0.70	21,380.33	1,941.60	686.56
17	DC2	Adana	Truck 1	14,000.00	0.70	9,800.00	1,322.74	838.51
18	DC2	Adana	Truck 2	30,543.33	0.70	21,380.33	1,903.55	838.51
19	DC2	Ankara	Truck 1	14,000.00	0.70	9,800.00	618.85	363.24
20	DC2	Ankara	Truck 2	30,543.33	0.70	21,380.33	1,048.57	363.24
21	DC2	Antalya	Truck 1	14,000.00	0.70	9,800.00	952.34	603.28
22	DC2	Antalya	Truck 2	30,543.33	0.70	21,380.33	1,619.30	603.28
23	DC2	Bursa	Truck 1	14,000.00	0.70	9,800.00	411.81	180.02
24	DC2	Bursa	Truck 2	30,543.33	0.70	21,380.33	699.42	180.02
25	DC2	Elazığ	Truck 1	14,000.00	0.70	9,800.00	1,790.52	1,078.74
26	DC2	Elazığ	Truck 2	30,543.33	0.70	21,380.33	3,045.02	1,078.74
27	DC2	Eskişehir	Truck 1	14,000.00	0.70	9,800.00	389.43	226.94
28	DC2	Eskişehir	Truck 2	30,543.33	0.70	21,380.33	668.09	226.94
29	DC2	İzmir	Truck 1	14,000.00	0.70	9,800.00	665.85	487.08
30	DC2	İzmir	Truck 2	30,543.33	0.70	21,380.33	1,131.39	487.08
31	DC2	Samsun	Truck 1	14,000.00	0.70	9,800.00	1,020.60	686.56
32	DC2	Samsun	Truck 2	30,543.33	0.70	21,380.33	2,025.52	686.56

Two different types of trucks are used for distribution center to warehouse transportations. There are 3 distribution centers located extremely close (27 km apart from each other). The company provided transportation costs to the warehouses only for two of these distribution centers. We calculate an average unit transportation cost for both existing and candidate warehouses as

$$T_{avg}^{w} = \sum_{v} v_v \times \sum_{d} \left(f_d \times \frac{\frac{T_{wdv}}{d_w}}{cu_v} \right)$$

where T_{avg}^{w} is the average transportation cost from distribution center to warehouse per km per volumetric unit, T_{wdv} is the total cost of the trip, d_w is the total distance of to warehouse w, cu_v is the used volumetric capacity of vehicle v used during trip, f_d is proportion of flow originating from the distribution center d, v_v is the percentage of truck v used. f_d is calculated as flow proportion of distribution center d, note that, the percentage of truck v usage (v_v) were calculated using the 2013 data provided in Table 3.8.

Table 3.8 Number of Trucks

	Truck type		**Total number of trucks**	**Percentage of flow from distribution center *d* (f_d)**
Origin (*d*)	**Truck 1**	**Truck 2**		
DC1	451	1,087	1,538	68%
DC2	299	437	736	32%
Total number of trucks	750	1,524		
Percentage of truck *v* usage (v_v)	33%	67%		

As a result, we calculate a unit transportation cost per volumetric unit between the distribution center and each of the 8 existing warehouses. For the candidate warehouses, unit transportation cost (t_{dw}) is assumed the same as that of a warehouse with a similar distance to the distribution center.

3.4.12. Transportation Costs to Repair Vendors Using Truck Transportation Mode

Transportation costs of deliveries to the inner-city repair vendors and suburban repair vendors are different. The company provided transportation cost per km for each region's repair vendors which are provided in Table 3.9.

Table 3.9 Transportation Costs Between Any Facility and Repair Vendors

Destination (Region's Repair Vendors)	**Repair Vendor Type**	**Cost (TL) per km (t_r)**	f_r
Adana	Suburban	1.21	20%
Ankara	Suburban	1.37	5%
Antalya	Suburban	1.25	10%
Bursa	Suburban	1.26	6%
Çayırova	Suburban	1.15	10%
Elazığ	Suburban	1.54	20%
Eskişehir	Suburban	1.35	5%
İstanbul	Suburban	1.19	4%
İzmir	Suburban	1.30	6%
Samsun	Suburban	1.27	13%
Adana	Inner-City	2.58	9%
Ankara	Inner-City	2.41	12%
Antalya	Inner-City	2.11	6%
Bursa	Inner-City	2.28	7%
Çayırova	Inner-City	2.26	21%
Elazığ	Inner-City	2.52	1%
Eskişehir	Inner-City	2.20	2%
İstanbul	Inner-City	2.29	31%
İzmir	Inner-City	2.21	11%
Samsun	Inner-City	0	0%

Transportation cost to the repair vendors does not change according location of origin.

For suburban repair vendors, flow rate of repair vendors in region r f_{ru} is calculated as $f_{ru} = \frac{D_{ru}}{D_{tu}}$ where D_{ru} is the total demand of suburban vendors of region r, D_{tu} is the total demand of all suburban vendors.

We calculate t_u as the weighted transportation cost per km for suburban repair vendors as $t_u = \sum_r f_{ru} \times t_{ru}$ where t_{ru} is the per km transportation rate given for region r.

There is an exception for İstanbul Region's suburban transportation rates. The company prefers to use the exact urban transportation rate for this region which is 1.19 TL per km for truck. Transportation cost from warehouse w to the repair vendor r which is suburban repair vendor (p_{wrm}) is calculated by multiplying t_u with distance between warehouse and repair vendor for truck transportation mode. We use the same calculation approach for inner-city repair vendors. We calculate f_{ri} and t_i according to inner city repair vendors' per km transportation costs and demands. In the term p_{wrm}, r represents both suburban and inner-city repair vendors.

3.4.13. Transportation Costs Using Freight Transportation Mode

The company is currently using only truck transportation mode. The second alternative transportation mode that can be used is freight carrier service. For freight option, the company provided the data and is presented in Appendix E. Data includes 4 different distance ranges for each discrete integer volume ranging between 1 and 150 volumetric units. We use a simple linear regression model to calculate the cost of freight service per km per volumetric unit for each distance range. The results are given in Table 3.10.

Table 3.10 Regression Equations for Deliveries with Freight

Distance Range	Linear Regression Equations for Freight Costs	R^2
0-200 km	y = 0.2294volume + 1.4846	R^2 = 0.9997
200-600 km	y = 0.2281volume + 1.6975	R^2 = 0.9993
600-1000 km	y = 0.2278volume + 1.8057	R^2 = 0.9991
1000+ km	y = 0.2281volume + 1.8904	R^2 = 0.999

In order to verify consistency between real cost values (r_h) and values obtained from the regression (y_h) differences of these values for 150 data point and percentage deviations are calculated as $\frac{|y_h - r_h|}{r_h}$.

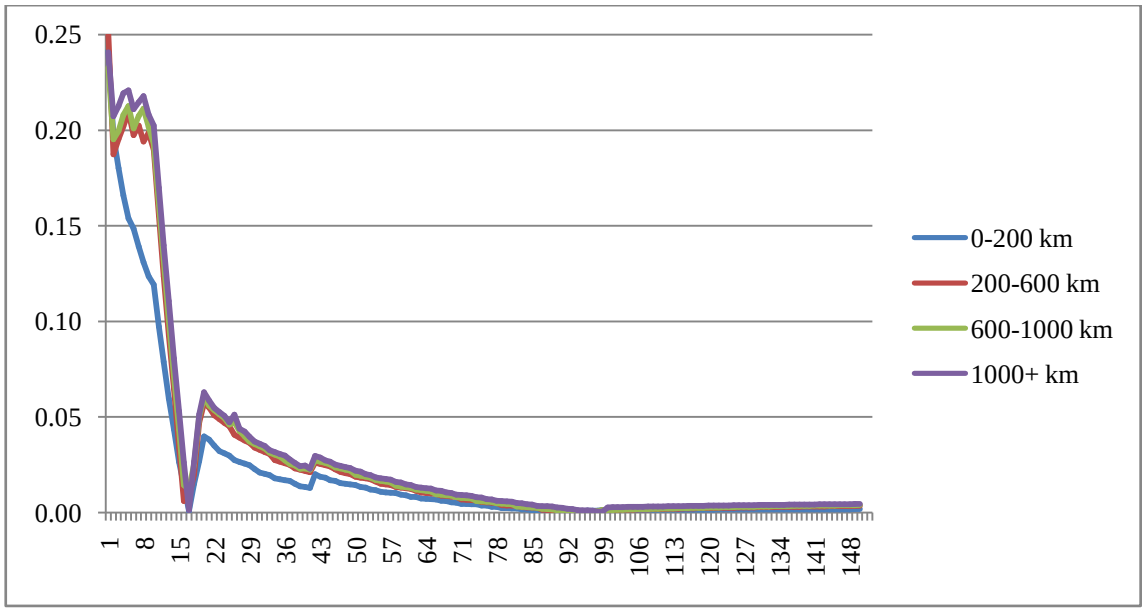

Figure 3.18 Percentage Deviations of Regression Equations

Figure 3.18 shows that percentage deviations decrease when volume increases. When the volume is higher than 70 volumetric units, the percentage deviations reach zero for each distance range regression. Also, only 2% of the repair vendors' expected half-week demand is lower than 70 volumetric units. We suppose that the linear regression model can be used to calculate the cost of freight services even when the volume is larger than 150 volumetric units.

In order to investigate if there is a significant deviation between different distance ranges for the same volume; we calculate the freight transportation cost of each repair vendor for their half-week demand volume with the four regression equations. We, then, calculate the percentage deviation as $\frac{\max(y_k) - \min(y_k)}{\min(y_k)}$ for each repair vendor. Average of these percentage deviations for 532 repair vendors is 0.53% while the maximum of percentage deviation is %5.62.

This value shows that the difference between minimum and maximum values determined by different equations is sufficiently small. Using the half-week volumetric demand of each repair vendor for each spare part, freight service transportation costs are calculated as the average of the estimated freight costs from four different regression equations. Finally, for the freight transportation mode transportation costs between warehouse w and repair vendor r, p_{wrm} is calculated by regression equations according

to repair vendors demand. Then we calculate the average of the four different distance range regression equations' to obtain the transportation costs.

3.5. Mathematical Model and Assumptions

We now develop a mathematical programming formulation of the post sale services distribution system problem. This formulation represents a single objective mixed integer linear programming formulation of a multi echelon network design problem. We first define the notation necessary for the formulation in Table 3.11 and Table 3.12.

Table 3.11 Sets

D	distribution Center	D={Distribution Center}
W	warehouses	W={Adana, Ankara,…,Van}
S	suppliers	S={BI,BMI,…,Fictive External Supplier}
R	repair vendors	R={1,2,…,532}
I	spare parts	I={BI,BMI,…,Fictive External Supplier}
M	transportation mode	M={Truck, Freight Service}
A_i	supplier which produces spare part i	A_i={BI,BMI,…,Fictive External Supplier}

Table 3.12 Parameters

f_d	operating cost for distribution center d
f_w	operating and setup cost for warehouse w
t_{sd}	transportation rate cost from supplier s to distribution center d
t_{sw}	transportation rate from supplier s to warehouse w
t_{dw}	transportation rate from distribution center d to warehouse w
p_{drm}	transportation cost from distribution center d to repair vendor r by transportation mode m
p_{wrm}	transportation cost from warehouse w to repair vendor r by transportation mode m
C_d	inbound handling capacity of distribution center d
C_w	inbound handling capacity of warehouse w
D_{ri}	demand of repair vendor r for spare part i
S_i	supply for spare part i

We use the following decision variables:

$$X_d = \begin{cases} 1, & \text{if distribution center } d \text{ is open} \\ 0, & \text{otherwise} \end{cases}$$

$$X_w = \begin{cases} 1, & \text{if warehouse } w \text{ is open} \\ 0, & \text{otherwise} \end{cases}$$

Q_{sd} =amount of product shipped from supplier *s* to distribution center *d*

Q_{sw} =amount of product shipped from supplier *s* to warehouse *w*

Q_{dw}^i =amount of product *i* shipped from distribution center *d* to warehouse *w*

Q_{drm}^i =amount of product *i* shipped from distribution center *d* to repair vendor *r* by transportation mode *m*

Q_{wrm}^i =amount of product *i* shipped from warehouse *w* to repair vendor *r* by transportation mode *m*

$$Y_{drm} = \begin{cases} 1, & \text{if repair vendor } r \text{ is served by distribution center } d \text{ by transportation mode } m \\ 0, & \text{otherwise} \end{cases}$$

$$Y_{wrm} = \begin{cases} 1, & \text{if repair vendor } r \text{ is served by warehouse } w \text{ by transportation mode } m \\ 0, & \text{otherwise} \end{cases}$$

The resulting formulation is

Minimize
$$f_d X_d + \sum_{w \in W} f_w X_w + \sum_{s \in S} Q_{sd} t_{sd} + \sum_{s \in S} \sum_{w \in W} Q_{sw} t_{sw} + \sum_{w \in W} \sum_{i \in I} Q_{dw}^i t_{dw} + \sum_{r \in R} \sum_{m \in M} Y_{drm} p_{drm} + \sum_{w \in W} \sum_{r \in R} \sum_{m \in M} Y_{wrm} p_{wrm} \quad (1)$$

subject to
$$\sum_{s \in A_i} Q_{sd} - \sum_{w \in W} Q_{dw}^i - \sum_{r \in R} \sum_{m \in M} Y_{drm} D_{ri} = 0 \qquad \forall i \in I \quad (2)$$

$$\sum_{s \in A_i} Q_{sw} + Q_{dw}^i - \sum_{r \in R} \sum_{m \in M} Y_{wrm} D_{ri} = 0 \qquad \forall i \in I, \forall w \in W \quad (3)$$

$$\sum_{s \in S} Q_{sd} \leq C_d X_d \tag{4}$$

$$\sum_{s \in S} Q_{sw} + \sum_{i \in I} Q^i_{dw} \leq C_w X_w \qquad \forall w \in W \tag{5}$$

$$\sum_{i \in I} \sum_{m \in M} Q^i_{drm} = \sum_{i \in I} D_{ri} \sum_{m \in M} Y_{drm} \qquad \forall r \in R \tag{6}$$

$$\sum_{w \in W} \sum_{i \in I} \sum_{m \in M} Q^i_{wrm} = \sum_{i \in I} D_{ri} \sum_{w \in W} \sum_{m \in M} Y_{wrm} \qquad \forall r \in R \tag{7}$$

$$\sum_{m \in M} Y_{drm} + \sum_{w \in W} \sum_{m \in M} Y_{wrm} = 1 \qquad \forall r \in R \tag{8}$$

$$\sum_{s \in A_i} Q_{sd} + \sum_{s \in A_i} \sum_{w \in W} Q_{sw} = S_i \qquad \forall i \in I \tag{9}$$

$$X_d, X_w, Y_{drm}, Y_{wrm} = \{0,1\} \tag{10}$$

$$Q_{sd}, Q_{sw}, Q^i_{dw}, Q^i_{drm}, Q^i_{wrm} \geq 0 \tag{11}$$

Objective function (1) of the problem formulation minimizes the total cost of the network. The total cost of the network consists of costs of operating distribution center and existing warehouses as well as the estimated opening costs and operating costs for the candidate warehouses and transportation costs. The term $f_d x_d + \sum_{w \in W} f_w X_w$ represents the fixed costs associated with opening and operating the facilities. The term $\sum_{s \in S} Q_{sd} t_{sd} + \sum_{s \in S} \sum_{w \in W} Q_{sw} t_{sw} + \sum_{w \in W} \sum_{i \in I} Q^i_{dw} t_{dw}$ represents the transportation costs from the suppliers to the distribution centers and warehouses, and from the distribution center to the warehouses. These costs are functions of the volume of transported spare parts. The term $\sum_{r \in R} \sum_{m \in M} Y_{drm} p_{drm} + \sum_{w \in W} \sum_{r \in R} \sum_{m \in M} Y_{wrm} p_{wrm}$ represents the transportation cost of deliveries from distribution centers and warehouses to the repair vendors; this is not a function of the amount of the deliveries to the vendors.

Constraint (2) is the inbound-outbound balance equations for the distribution center that ensures the conservation of flow of each spare part. Constraint (3) ensures the conservation of flow for each warehouse and spare part.

Constraint (4) consists of the upper bound constraints honoring inbound handling capacity of the distribution center; total received quantity cannot exceed the capacity for inbound handling. The same inbound handling constraint for warehouses is given by the constraint (5). These constraints link the facility opening decision variable and flow variables. If the facility is open, it has an upper bound for the capacity of inbound handling activities.

Constraint (6) ensures that the demand of a repair vendor is satisfied by distribution center, if the repair vendor is assigned to the distribution center; and the total delivered quantity to the repair vendor should be equal to the total demand of repair vendor. Furthermore, constraint (7) ensures the same if the demand of repair vendor is met from a warehouse. Constraint (8) is the single sourcing constraint ensuring that a repair vendor's demand can be fulfilled by either a warehouse or a distribution center and only by a single transportation mode type.

Supply capacity is represented with constraint (9) where for each item total procurement equals available supply. Constraint (10) and constraint (11) are the domain constraints for the decision variables.

Formulation (1)-(11) provide a basic model which can be extended and/or slightly modified to represent various settings and design issues for the post sale network of the company.

Note that determination of inventory levels of the spare parts are beyond the scope of our study. The company fulfills 80% of the demands within seven days. Therefore inventory level of the spare parts is not a decision that needs to be taken for high fulfillment rate. Because of the part aggregation, it is also not plausable to make inventory decisions of the parts in aggregated level.

In this study, we consider a set of scenarios and find an optimal solution for each scenario under consideration using this mathematical programming formulation. We first find an optimal solution for the existing setting with the same number of facilities and the assignments of repair vendors to the warehouses and the distribution center as

they are in the existing setting. Only one transportation mode is used with pre-determined routes as in the existing practice. This solution is the benchmark scenario. The aim of studying other scenarios is to find the optimum number of facilities and their locations, the assignment of repair vendors to the warehouses and the distribution center, and assignment of the suppliers to the facilities.

The second scenario optimizes the post sale network with transportation to the repair vendors by fixed routes as in the existing setting. However, we consider a less centralized distribution network and allow internal suppliers to send spare parts to the warehouses. The third scenario considers a single transportation mode by truck to the repair vendors and furthermore relaxes the pre-determined routes setting by allowing direct shipment. The last scenario uses two transportation mode for delivery to the repair vendors. These options are direct shipment with truck and freight deliveries.

Chapter 4

4. Model Results for Different Scenarios

In this part, we present 4 different scenarios which are solved using the proposed mathematical formulation and analyze their results. First, we provide the results of each scenario and evaluate the total cost as well as detailed cost items associated with facilities and transportation costs. Then, we compare and contrast all scenario results. Furthermore, we examine the applicability of optimal decisions in real life.

For all scenarios, we compare the optimum number of warehouses, transportation cost, facility operating cost and warehouse opening cost. Moreover, we present the following results in detail for each scenario:

- assignment of suppliers to warehouses and distribution center,
- assignment of repair vendors to the distribution center and warehouses,
- mode of transportation for each repair vendor,
- the used warehouses.

The mathematical model is coded on MATLAB R2012b and solved by GUROBI 5.6.3. on an Intel Core i3 processor with 2.40 GHz speed and 4 GB RAM, and 64-bit Windows 7 operating system. Different scenarios solved by the model are depicted in Table 4.1.

Table 4.1 Computational Results of Scenarios

Scenario	# of suppliers	# of facilitiies	# of repair vendors	# of transportation mode	CPU Run Time (sec)	Iteration count
1	83	9	73	1	0.7790	278
2	83	24	73	1	79.2515	59,087
3	83	24	532	1	202.8416	70,277
4	83	24	532	2	240.4288	80,311

4.1. Scenario 1: Existing system

In this scenario; the existing system settings are imposed with estimated parameters of the distribution network. Constraints are modified to reflect the existing system settings. The post sale network structure of the existing setting is demonstrated in Figure 4.1.

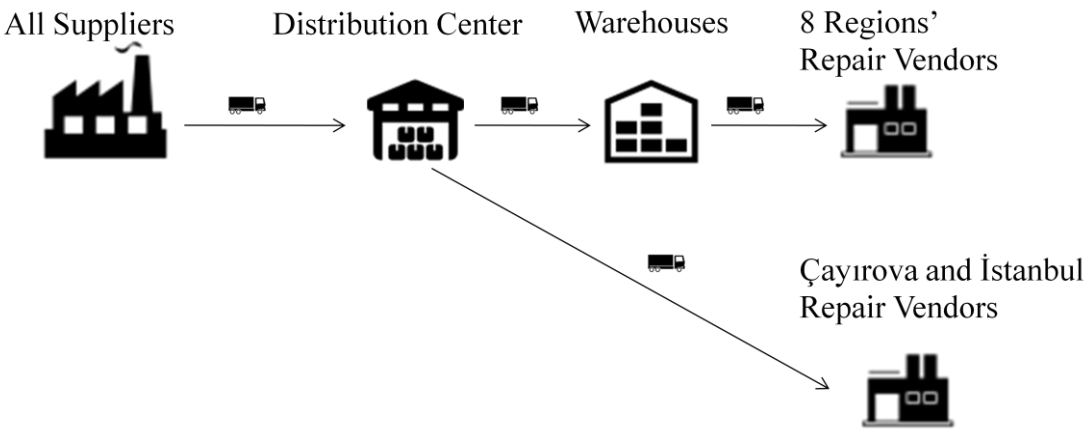

Figure 4.1 Existing Setting of the Distribution Network

Characteristics of the existing system are summarized as follows:

- All suppliers including the import location have to deliver the spare parts to the distribution center (not to any other facility). Hence, a highly centralized network.
- Distribution center is responsible for meeting demand of the repair vendors in Çayırova and Istanbul regions' as well as all existing warehouses. The distribution center also fulfills export location's demand.
- There are no candidate warehouses.
- Warehouses serve only the repair vendors which are assigned to them.

- Transportation mode is by truck only.
- Pre-determined routes are used to deliver the spare parts to the repair vendors. Each repair vendor is included in a single route.
- A warehouse cannot deliver/receive parts to/from another warehouse.
- Each repair vendor is served by only one facility, (the associated demand cannot be divided). Hence, we have single sourcing.

Solving the mathematical model presented in section 3.5 using the existing system characteristics, the results presented in Table 4.2 are obtained. Figure 4.2 represents existing facility locations and distribution of repair vendors. Detailed assignments of facilities to the repair vendors are presented in Appendix F.

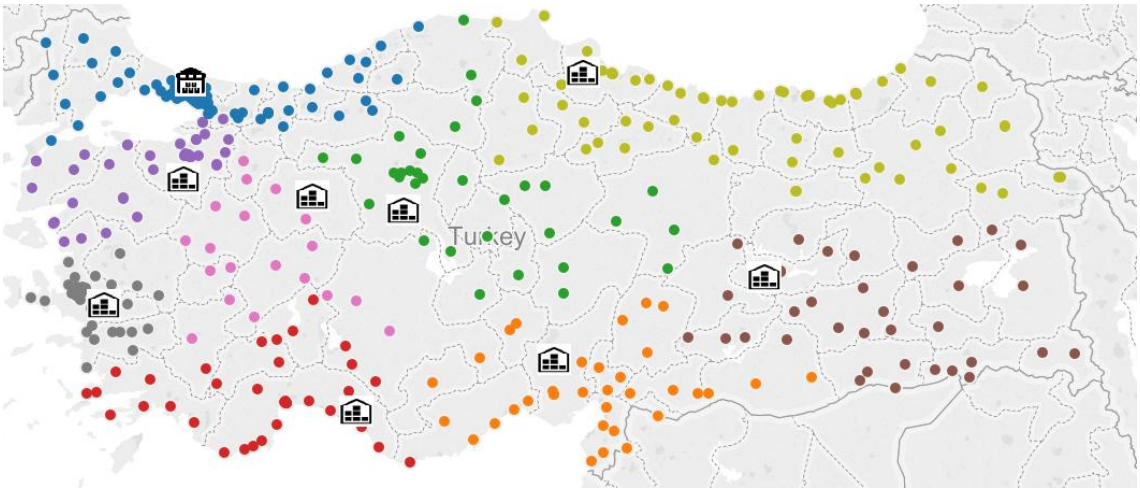

Figure 4.2 Scenario 1 Locations of the Network

Table 4.2 shows that 83% of total cost is due to facility operating costs that include also rental costs. Moreover, it is easily observed that almost 82% of facility operating cost is associated with the distribution center.

In the existing system, 68% of the total transportation cost is due to transportation costs to the repair vendors. Hence, there is an improvement opportunity on transportation costs by creating new transportation options for the deliveries to the repair vendor.

Table 4.2 Results of Scenario 1

Total costs		287,191			
Total transportation costs of network		47,947	**17%**		
Total transportation costs to the repair vendors		32,507			
Total facility costs		239,243	**83%**		
Used facilities (DC and region's warehouses)	**Operating costs**	**Warehouse opening cost**	**Is any supplier serving this facility?**	**# of assigned repair vendors to facility**	**Transportation costs to the repair vendors**
Distribution Center	194,654	-	✓	135	5,916
Adana	5,198	-	✘	59	3,039
Ankara	4,490	-	✘	55	3,673
Antalya	9,158	-	✘	37	3,075
Bursa	9,356	-	✘	40	1,713
Elazığ	4,500	-	✘	59	5,625
Eskişehir	2,730	-	✘	27	1,700
İzmir	5,364	-	✘	47	1,545
Samsun	3,792	-	✘	72	6,222

4.2. Optimization Scenarios

We propose 3 different optimization scenarios. The first optimization scenario utilizes the current routes to serve the repair vendors but allows the design of a less centralized spare parts network. The second one, furthermore, allows direct shipments to repair vendors. The third optimization scenario besides allowing direct shipments to repair vendors, presents two alternative modes of transportation (i.e. freight services are also included).

4.2.1. Scenario 2: Network Optimization with Existing Delivery Routes

This scenario focuses on keeping the current set of pre-determined delivery routes to the repair vendors as they are. The mathematical model is used to optimize the network

according to the delivery scheme in a less centralized spare part network with new warehouse candidates.

Scenario 2 can be summarized as follows:

- External suppliers and import location can deliver parts only to the distribution center.
- Internal suppliers may deliver spare parts either to the distribution center or to any warehouse.
- Demand of the repair vendors can be met either by the distribution center or any warehouse.
- There are 15 candidate warehouses.
- A warehouse cannot deliver/receive parts to/from another warehouse.
- Warehouses serve only the repair vendors which are assigned to them according to optimization results.
- A repair vendor's demand must be fulfilled by one facility only.
- Transportation mode is by truck only
- Pre-determined and established routes are used for deliveries to the repair vendors. Each repair vendor is included in a single route.

A schematic illustration of this scenario is presented in Figure 4.3.

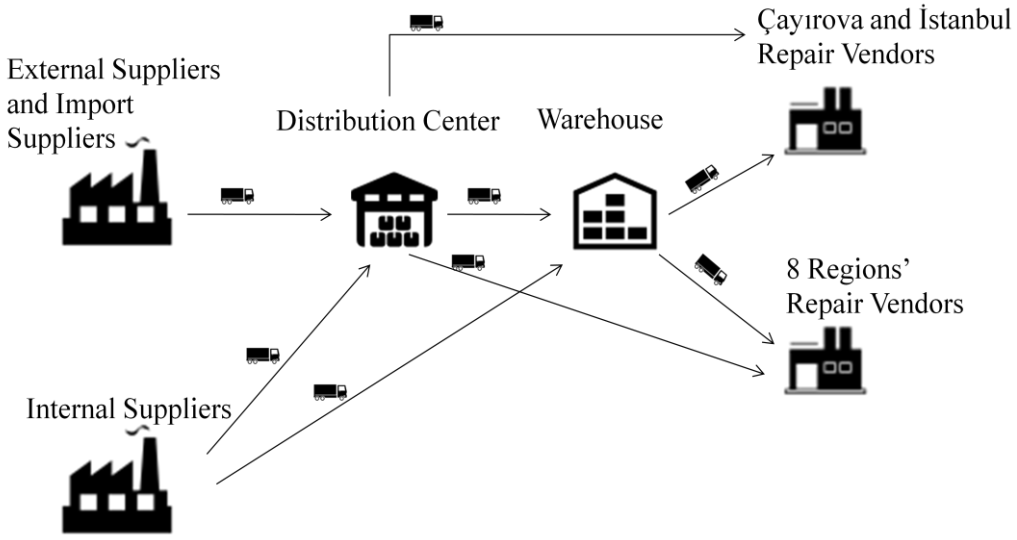

Figure 4.3 Schematic Illustration of Scenario: 2

An optimal solution with this scenario keeps the distribution center and three of the exiting warehouses open while the remaining five are closed. In Figure 4.4 we depict the facilities and the distribution of the repair vendors according to their assignments to facilities. Blue nodes are the repair vendors served directly by the distribution center, green nodes represent repair vendors served by warehouse in İzmir, repair vendors denoted by red nodes are served by warehouse in Samsun and finally, the orange colored repair vendors are served by warehouse in Adana.

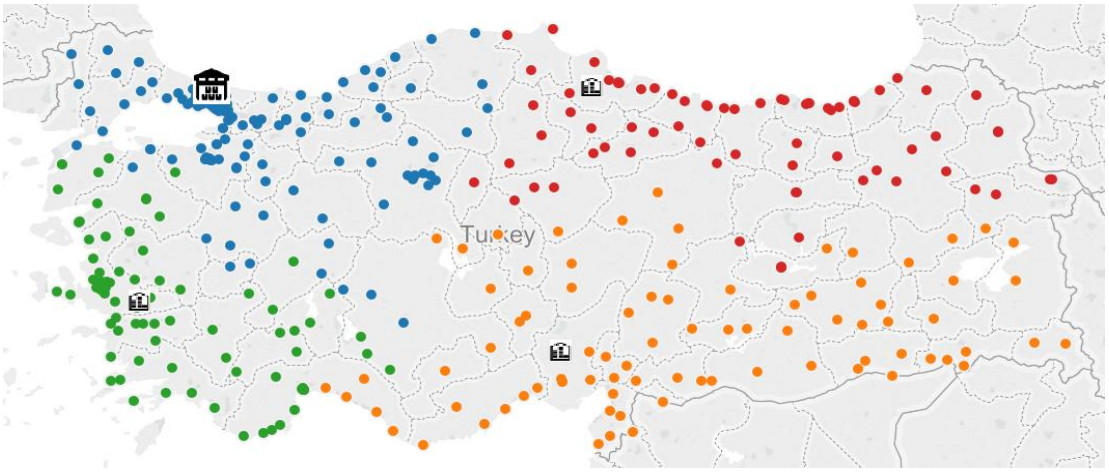

Figure 4.4 Facility Location Results of the Scenario 2

The results are summarized in Table 4.3. In contrast to the existing system where none of the suppliers may deliver parts to warehouses other than the distribution center, internal suppliers deliver to all facilities in an optimal solution. Assignments of suppliers to facilities and facilities to the repair vendors are detailed in Appendix G.

93.13% of the total facility cost is due to the distribution center operating cost. The distribution center is not closed due to the constraint which blocks the external suppliers to directly meet the demand of warehouses.

Transportation to the repair vendors using the pre-determined routes constitutes 91% of the total transportation costs. Therefore, it will be critical to observe how the cost pattern changes in the other scenarios where delivery to the repair vendors uses alternative transportation schemes or modes.

Table 4.3 Results of Scenario 2

Total costs		256,640			
Total transportation costs of network		47,632	**19%**		
Total transportation costs to the repair vendors		43,511			
Total facility costs		209,009	**81%**		
Used facilities (DC and region's warehouses)	**Operating costs**	**Warehouse opening cost**	**Is any supplier serving this facility?**	**# of assigned routes to facility**	**Transportation costs to the repair vendors**
Distribution Center	194,654	-	✓	21	13,131
Adana	5,198	-	✓	22	13,432
İzmir	5,364	-	✓	17	8,571
Samsun	3,792	-	✓	13	8,378

4.2.2. Scenario 3: Network Optimization

Direct shipment strategy is a viable option for deliveries to the repair vendors. We aim to show the cost difference between delivery by pre-determined routes and direct shipment policy. The original mathematical model is modified accordingly with added transportation links (i.e. delivery via pre-determined routes or direct shipment) for deliveries directly to the repair vendors.

In the optimal solution, the distribution center and 8 warehouses serve the repair vendors. Two of the existing warehouses (Bursa and Elazığ) are closed and two new warehouses are opened (Diyarbakır and Erzurum). The resulting network solution and assignment of repair vendors to the facilities are illustrated in Figure 4.5.

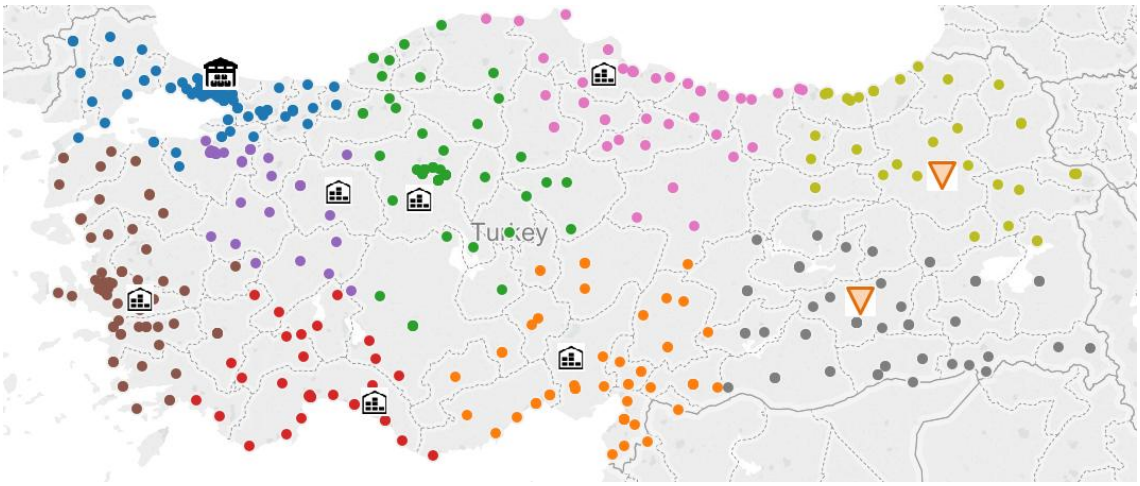

Figure 4.5 Facility Location Results of Scenario 3

Detailed assignments of suppliers to facilities and facilities to the repair vendors are presented in Appendix H.

Table 4.4 presents the detailed results for this scenario. In this scenario, internal suppliers may deliver not only the distribution center but also the warehouses.

Total cost includes, transportation costs, facility operating costs and opening costs for new facilities. Total transportation cost is 29% of total network cost. Furthermore, transportation costs to the repair vendors are higher than other transportation costs in the network. Because each facility has to serve repair vendors by individual truck trips the marginal transportation cost to serve a repair vendor is unavoidably higher than the marginal transportation costs subject to routing trips by trucks. In an optimal solution tradeoff between facility operating costs and the cost of transportation to the repair vendors might have been balanced out. However it was not the case for this data set.

Table 4.4 Results of Scenario 3

Total costs		339,352			
Total transportation costs of network		97,278	**29%**		
Total transportation costs to the repair vendors		97,034			
Total facility costs		242,073	**71%**		
Used facilities (DC and region's warehouses)	**Operating costs**	**Warehouse opening cost**	**Is any supplier serving this facility?**	**# of assigned repair vendors to facility**	**Transportation costs to the repair vendors**
Distribution Center	194,654	-	✓	135	19,284
Adana	5,198	-	✓	60	11,896
Ankara	4,490	-	✓	59	9,820
Antalya	9,158	-	✓	32	5,105
Eskişehir	2,730	-	✓	32	7,526
İzmir	5,364	-	✓	74	11,103
Samsun	3,792	-	✓	44	9,080
Diyarbakır	7,343	1,000	✓	60	13,850
Erzurum	7,343	1,000	✓	36	9,371

4.2.3. Scenario 4: Network Optimization with Direct Shipment to the Repair Vendors and Third Party Freight Services

In addition to the direct shipment option in Scenario 3, we introduce the option of using third party freight services for delivery to the repair vendors. We still enforce the single-sourcing rule where a vendor can be served from only one facility and by a single transportation mode.

Figure 4.6 shows a schematic illustration of Scenario 4 with alternative transportation modes for delivery to the repair vendors.

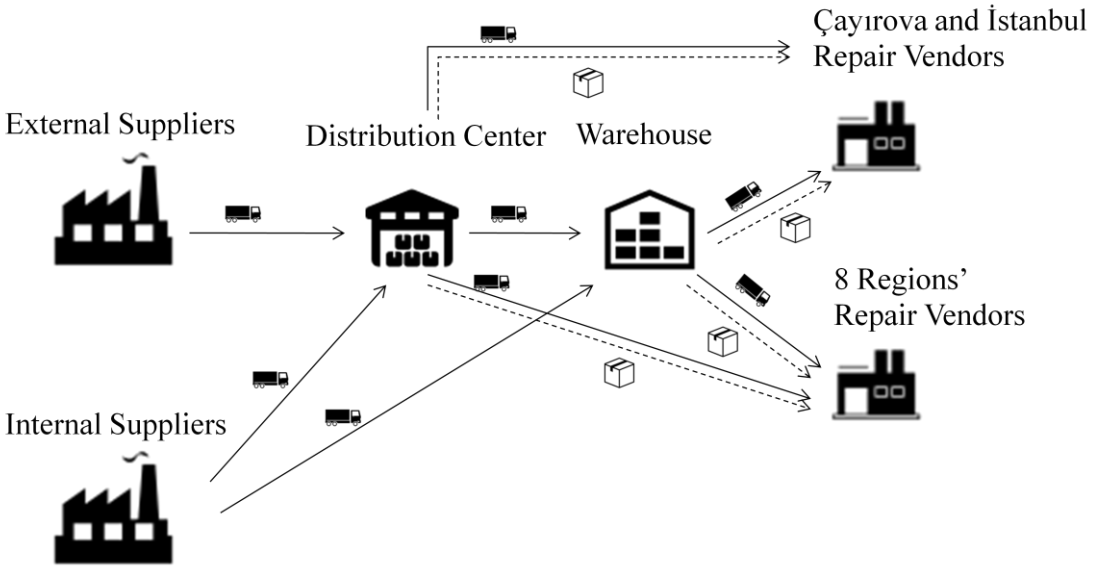

Figure 4.6 Schematic Illustration of Scenario 4

In the optimal solution, all of the existing warehouses are closed and none of the candidate warehouses is opened. In a completely centralized network the distribution center fulfills the orders from all repair vendors either by trucks or with third party freight services.

In Figure 4.7, the network solution is shown where alternative transportation modes are depicted in different colors on the nodes representing the vendors. The blue nodes represent the vendors served with trucks while orange nodes are those with third party freight service.

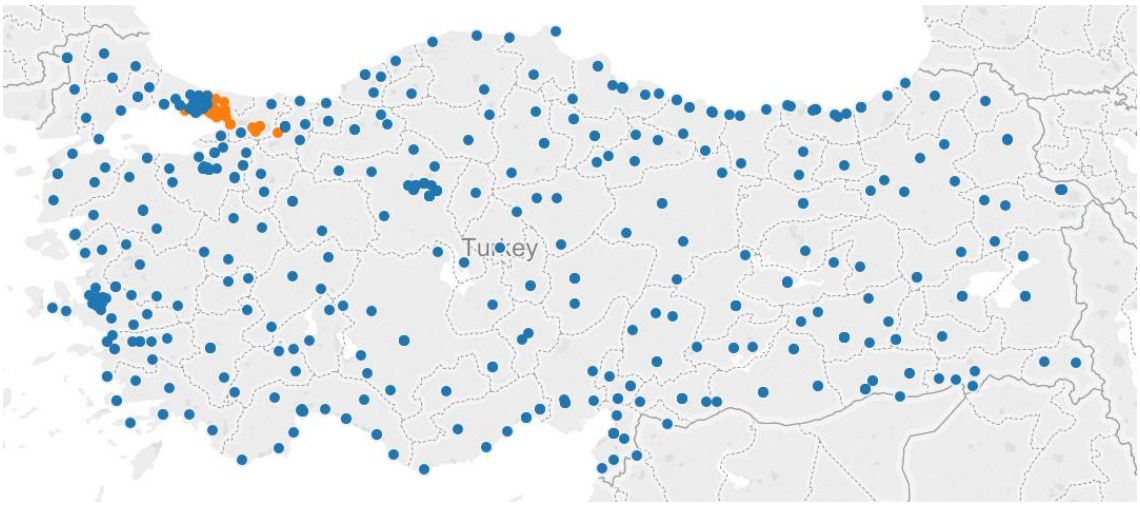

Figure 4.7 Facility Locations Result of the Scenario 4

Detailed assignments of transportation modes to the repair vendors are presented in Appendix I.

Table 4.5 Results of Scenario 4

Total costs	253,719	
Total transportation costs of network	59,064	**23%**
Total transportation costs to the repair vendors	58,673	
Transportation costs to the repair vendors by truck	7,166	**12%**
Transportation costs to the repair vendors by freight	51,507	**88%**
Total facility costs	194,654	**77%**

Used facilities (DC and region's warehouses)	**Operating Costs**	**Facility Setup Costs**	**Is any supplier serve this facility?**	**Number of vendors facility serves by road**	**Number of vendors facility serves by freight**	**Transportation costs to the repair vendors by road**	**Transportation costs to the repair vendors by freight**
Distribution Center	194,654	-	✓	61	471	7,166	51,507

Table 4.5 depicts that solution has only one facility operating, which is the distribution center. Although it is an extremely centralized network, total network cost is lower than other scenarios. Therefore, facility operating cost is remarkably lower than other scenarios. However, high percentage of the total cost is due to facility operating costs.

Total transportation cost, which is 23% of the total cost, includes transportation costs to the repair vendors and transportation costs to the distribution center from suppliers. Most common transportation mode is freight for repair vendor deliveries. Therefore 88% of the transportation costs to the repair vendor is due to the freight transportation.

4.3. Comparison of Results

We investigate the results obtained from the mathematical model according to the four different scenarios by comparing the optimal cost and the distribution among cost items as shown in Table 4.6.

Table 4.6 Cost Comparison of Different Scenarios

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
Scenario description	**Existing network**	**Optimization scenario with existing routes**	**Optimization scenario with direct shipment to the repair vendors**	**Optimization scenario with direct shipment to the repair vendors by freight option**
Number of total facility	9	4	9	1
Total costs	287,190.56	256,640.30	339,351.75	253,718.85
Total facility costs	239,243.10	209,008.66	242,073.44	194,654.44
Total transportation costs of network	47,947.46	47,631.64	97,278.30	59,064.41
Total transportation costs to the repair vendors	32,506.55	43,511.42	97,034.49	58,672.56
Transportation cost from suppliers to the facilities and from the distribution center to the warehouses	15,440.91	4,120.22	243.81	391.85

Total cost includes, facility costs and total transportation costs. We also decompose the transportation cost into two: delivery to the repair vendors and transportation from suppliers to the facilities together with the transportation cost from the distribution center to the warehouses if applicable.

Total cost of Scenario 2 is 11% better than total cost of Scenario 1. This is mainly due to a decrease in the number of facilities. Total facility operating cost of Scenario 2 is 13% lower than total facility operating cost of Scenario 1.

In Scenario 2 all internal suppliers deliver parts directly to the warehouses and the distribution center is not a transport location between suppliers and warehouses. Therefore, transportation cost from suppliers to the facilities is lower than first scenario. Because of the decrease in number of facilities, transportation costs to the repair vendors is higher than Scenario 1 while total cost does not change significantly.

Scenario 3 has the highest total cost. There is little difference between Scenario 1 and Scenario 3 with respect to facility costs. Total transportation cost to the repair vendors is 104% higher than Scenario 2 because of the direct shipment strategy. Since internal suppliers deliver parts to warehouses without using the distribution center, transportation cost between suppliers and facilities and the distribution center and warehouses is extremely low.

Total cost of Scenario 4 is 12% lower than Scenario 1. Although total transportation cost is not the lowest, Scenario 4 has the lowest total cost. Only the distribution center sends parts to the repair vendors either by trucks or with third party freight services. Therefore, total facility cost is lower than others.

Rather than total cost of the network, the company focuses on the applicability of the network configurations. For Scenario 2, they take into account facility opening and closing decisions. However, they have concerns about operational challenges of transportation between internal suppliers and warehouses. The company wants to use third party freight service transportation mode for repair vendor deliveries. For future decisions they want to investigate applicability of deliveries from internal suppliers to the repair vendors by freight.

CHAPTER 5

5. Conclusion and Future Research

In this study, we present a generic mathematical model of a post sale services network design problem of the spare parts distribution system for a household appliances manufacturer. This mathematical model is depicted as a single objective mixed integer linear formulation for a static multi-commodity, multi-echelon network design problem. Objective function of the problem is total cost minimization. We work with 2013 data of the company which is a large scale data. A series of aggregation and consolidation techniques are employed to transform this very-large scale data into a smaller-scale without sacrificing accuracy. Various estimation methods are used in order to decrease complexity of post sale distribution network. Since major motivation of this study is to simplify the data as much as possible and to decrease the complexity of the problem, we prefer to focus on the network design decisions and reflect decisions on the transportation scheme by using a scenario-based approach.

We used scenario-based approach in order to evaluate different network configurations. In the scope of scenario-based approach, four different scenarios are created in order to evaluate alternative configurations and transportation scheme along with the mode choice. In order to obtain solutions, we slightly modify decision variables, constraints and parameters of the basic formulation according to these scenarios. We aim to compare and contrast different scenarios varying in terms of delivery strategy such as by routes, direct shipment and transportation modes such as road and freight service.

In the first scenario, the existing system settings are imposed with estimated parameters of the distribution network. Constraints of the formulation are modified to reflect the existing system settings. The second scenario has extended set of constraints which allows a less centralized post sale network (by allowing internal suppliers ship parts to warehouses) and incorporates new 15 warehouse candidates. In this scenario, deliveries via pre-determined routes are maintained. The third scenario has a totally different transportation strategy which is allowing direct shipments. Fourth scenario allows direct shipment strategy by truck or using third party freight service.

According to the results, we see that the direct shipment strategy (Scenario 3) is not viable due to the extremely high total cost. The solution obtained from Scenario 2 is reasonable for implementation. However, all deliveries are made by pre-determined routes.

Even better results could be obtained once the routes are pre-determined again according new facility locations. Scenario 4 has the minimum total cost due to significantly lower facility operating cost in comparison to other scenarios. When transportation mode selection is allowed, majority of the repair vendors are served via freight service and only a few repair vendors are served by road distribution under direct shipment. A mixture of direct shipment and delivery by routes could also be integrated for further decrease in overall transportation costs.

In addition to the facility location decisions of the network design problem, our problem is concerned with transportation operations and delivery decisions. Hence our problem is a variation of the location-routing problem with alternative modes of transportation. Future research might be involved with simultaneous consideration of location and transportation-distribution decisions. The location-routing problem involves finding the optimal number and locations of facilities while allocating customers to these facilities and determining vehicle routes. The post sale network design problem is not necessarily a particular application area of location-routing problems. However, the company uses pre-determined routes instead of direct shipment option for delivery of spare parts to the repair vendors. Therefore, one may need to solve a problem which deals with both the facility location and routing decisions simultaneously.

REFERENCES

Accounting Study Guide, Retrieved 2014, from http://accountinginfo.com/study/dep/depreciation-01.htm

Andel, T. (1997). Reverse logistics: a second chance to profit, *Transportation and Distribution* 38(7): 61–3.

Bacchetti, A., Plabani, F., Saccani, N., and Syntetos, A. (2011). Spare parts classification and inventory management: a case study. (Working paper, No. 408/12). Manchester: Salford Business School, 37.

Brandeau, M., Chiu, S. (1989). An Overview of Representative Problems in Location Research, *Management Science* 35(6): 645-674.

Du, F., Evans, G., (2008). A bi-objective reverse logistics network analysis for post-sale service, *Computers & Operations Research* 35(8): 2617 – 2634.

Eskandarpour, M., Nikbakhsh, E. (2014), Zegordi H. Variable neighborhood search for the bi-objective post-sales network design problem: A fitness landscape analysis approach, *Computers & Operations Research* 52: 300-314.

Eskandarpour, M., Zegordi H., Nikbakhsh, E. (2013). A parallel variable neighborhood search for the multi-objective sustainable post-sales network design problem, *International Journal of Production Economics* 145(1): 117–131.

Euromonitor International. (2014). *Consumer Appliances Market Size*. Retrieved from Euromonitor Passport GMID database.

Ghiani, G., Laporte, G., Musmanno, R., (2004) *Introduction to Logistics Systems Planning and Control (Wiley Interscience Series in Systems and Optimization)*, John Wiley & Sons.

Gooijer, J., Franses, P. (1997). Forecasting and Seasonality, *International Journal of Forecasting* 13(3): 303-305.

Household Appliance Manufacturing Report Summary, Retrieved 2014, from http://www.hoovers.com/industry-facts.household-appliance-manufacturing.1168.html

Kalchschmidt, M., Zotteri, G., Verganti, R. (2003). Inventory management in a multi-echelon spare parts supply chain, *Int. J. Production Economics* 81–82: 397–413.

Howell, D. C. (2012). Treatment of missing data: Part 1. *Dave Howell's Statistical Home Page*

Landrieux, B., Vandaele, N. (2012). A spare parts network design model for a digital cinema projector manufacturer, *International Working Seminar on Production Economics* Edition: 17

Lele, M., (1997). After-sales service necessary evil or strategic opportunity?, *Managing Service Quality* 7(3): 141-145.

Murty, D., Solem, O., Roren, T. (2004). Product warranty logistics: Issues and challenges, *European Journal of Operational Research* 156(1): 110–126.

Owen, S., Daskin, M. (1998). Strategic facility location: A review, *European Journal of Operational Research* 111(3): 423–447.

Piplani, R., Saraswat, A. (2012). Robust optimisation approach to the design of service networks for reverse logistics, *International Journal of Production Research* 50(5): 1424–1437.

Rogers, D., Plante, R., Wong, R., Evans, J. (1991). Aggregation and disaggregation techniques and methodology in optimization, *Operations Research* 39(4): 553-582.

Tsiakis, P., Shah, N., Pantelides, C. (2001). Design of multi-echelon supply chain networks under demand uncertainty, *Industrial & Engineering Chemistry Research* 40(16): 3585-3604.

Weber, Alfred [translated by Carl J. Friedrich from Weber's 1909 book]. (1929). *Theory of the Location of Industries*, Chicago: The University of Chicago Press.

World Major Household Appliances - Industry Market Research, Market Share, Market Size, Sales, Demand Forecast, Market Leaders, Company Profiles, Industry Trends, Retrieved 2014, from http://www.freedoniagroup.com/World-Major-Household-Appliances.html

Zegordi, S., Eskandarpour, M., Nikbakhsh, E. (2011). A novel bi-objective multi-product post-sales reverse logistics network design model, *Proceedings of the World Congress on Engineering* (WCE) *2011* (London, U.K.).

Appendix A: Expected half-week volumetric demands of different items for each demand point

Repair Vendor	BI	BMI	BTVI	ÇMI	KMI-ESI-TMI	MDI	PCİ
1	165.50	20.74	10.67	156.11	6.65	19.11	20.67
2	329.48	33.20	15.05	130.03	8.48	16.02	39.47
3	260.34	22.43	14.13	112.44	11.16	16.35	31.53
4	421.68	52.98	40.85	233.14	13.20	22.65	53.30
5	1,067.03	89.81	51.11	670.76	29.31	33.21	128.57
6	404.90	49.36	57.58	246.56	14.54	32.69	47.84
7	96.29	7.24	0.53	32.74	2.41	6.58	9.68
8	189.33	11.84	6.70	73.96	3.79	12.59	15.05
9	171.89	11.70	6.57	52.35	2.51	7.01	16.97
10	256.07	24.29	13.35	106.77	4.88	15.18	50.95
11	339.45	26.66	30.32	124.61	11.68	24.25	39.96
12	273.12	36.55	17.43	95.41	10.14	20.39	28.18
13	168.94	18.60	10.54	48.81	3.01	13.84	9.75
14	106.13	20.72	13.79	59.54	4.33	14.73	13.36
15	41.33	7.05	8.60	57.27	3.76	7.01	5.11
16	84.51	17.02	7.40	79.29	4.80	15.19	6.07
17	167.23	18.25	11.25	157.81	6.46	16.03	15.15
18	292.75	44.95	23.17	344.81	16.80	32.27	21.17
19	140.14	23.29	5.90	343.73	11.47	11.75	10.50
20	112.19	15.47	23.67	94.71	6.94	4.22	5.93
21	170.53	17.56	13.75	288.14	13.46	21.13	21.93
22	45.42	5.71	5.27	147.54	9.51	4.40	5.75
23	44.26	7.57	3.45	38.99	2.96	4.73	4.40
24	56.38	7.36	6.43	52.18	2.69	3.97	5.41
25	42.58	6.18	2.48	51.43	7.61	6.41	1.61
26	67.55	9.08	6.94	71.38	2.06	11.48	7.13
27	137.46	49.21	16.16	96.22	9.93	28.59	14.88
28	88.52	17.53	6.07	55.02	5.18	15.36	7.52
29	128.64	35.26	33.13	112.07	8.23	33.32	14.80
30	60.51	8.57	5.21	25.66	2.39	8.30	4.80
31	138.05	26.01	18.58	91.97	9.85	13.90	11.54
32	122.49	12.81	6.92	51.25	4.11	11.88	14.90
33	80.38	8.91	5.62	84.97	3.28	15.69	10.56
34	78.56	4.75	0.98	39.22	3.15	6.67	8.64
35	105.73	8.62	6.19	162.31	3.41	7.82	4.32
36	183.25	13.16	12.51	61.66	3.52	16.72	15.45
37	148.61	31.20	6.46	74.42	4.52	13.09	22.71
38	135.47	20.82	5.49	77.89	4.65	8.88	23.00
39	82.23	5.78	3.22	76.62	3.41	6.85	4.13

40	151.69	37.69	13.93	111.54	3.63	12.75	27.28
41	90.68	14.49	1.79	48.99	2.94	9.07	14.09
42	154.75	25.95	27.29	140.34	9.81	21.37	34.97
43	70.36	4.48	6.82	51.94	3.15	24.19	4.22
44	180.69	19.78	15.99	74.78	3.17	18.86	11.92
45	346.48	39.23	33.47	85.82	6.72	34.03	33.05
46	162.02	14.60	9.08	42.00	3.55	9.40	13.93
47	182.93	15.85	13.43	108.13	5.72	7.75	16.95
48	150.98	30.47	8.79	161.54	10.81	37.22	19.09
49	146.59	27.93	12.12	177.70	13.20	27.87	10.88
50	24.52	4.65	4.66	33.67	1.83	6.35	4.72
51	15.27	5.99	4.73	27.13	1.32	3.08	2.43
52	50.78	10.73	6.71	23.20	2.92	9.76	6.27
53	76.45	21.12	9.35	65.14	6.64	19.62	15.02
54	35.59	8.18	7.46	30.38	2.98	8.14	6.90
55	40.93	8.55	6.91	18.93	1.90	6.35	6.64
56	103.53	8.61	6.38	90.89	5.61	9.77	8.59
57	110.47	14.26	9.68	63.10	3.84	9.55	11.67
58	54.94	13.90	7.58	33.81	4.25	13.21	9.81
59	70.03	14.77	6.93	33.90	2.34	21.73	9.00
60	21.03	3.39	1.64	22.39	0.66	5.08	3.00
61	69.48	26.31	9.15	145.83	10.54	35.15	24.70
62	25.86	5.06	3.87	26.13	1.55	5.29	5.82
63	91.97	14.94	9.97	47.30	5.65	20.26	9.63
64	38.42	6.63	7.62	18.16	3.12	10.76	2.78
65	27.83	10.95	2.93	25.30	1.31	6.05	1.37
66	14.71	3.62	2.79	21.87	1.52	5.64	1.67
67	75.66	18.41	11.01	55.40	7.92	27.49	6.13
68	44.95	9.46	6.16	29.86	2.27	17.67	4.39
69	155.94	44.70	63.95	63.58	13.61	66.76	34.30
70	178.16	35.23	16.96	86.18	5.96	34.68	31.03
71	113.60	24.74	7.14	61.32	7.04	23.57	20.91
72	55.36	15.12	6.30	48.41	3.33	12.25	8.50
73	303.35	66.26	23.79	147.94	15.24	55.99	29.36
74	70.06	14.83	9.43	76.32	6.07	17.80	6.49
75	125.76	30.08	7.04	94.03	12.16	28.48	20.28
76	98.96	17.06	3.06	85.84	7.07	17.73	13.51
77	118.87	29.54	4.52	58.75	7.38	24.61	16.61
78	131.83	41.94	4.43	71.66	20.06	32.79	17.96
79	152.46	37.51	9.96	111.00	11.80	49.16	17.03
80	204.96	38.17	14.52	65.83	8.57	52.25	36.16
81	147.85	24.44	15.40	97.61	8.40	39.39	19.37
82	242.50	60.16	8.34	158.02	16.30	49.89	25.11
83	157.83	29.02	2.74	69.81	13.12	39.82	13.27
84	452.79	97.08	35.44	298.68	27.10	85.86	52.76

85	166.79	41.67	16.76	82.84	9.58	31.30	16.10
86	55.99	19.00	4.90	57.19	3.00	14.08	7.85
87	69.83	14.56	9.43	46.98	5.20	12.24	6.65
88	53.83	8.47	5.03	45.38	2.09	13.41	6.90
89	140.76	66.27	22.35	68.40	8.39	25.12	11.81
90	4.32	0.92	0.74	4.63	0.22	0.53	0.74
91	139.00	21.68	12.02	71.77	7.67	26.62	19.88
92	84.60	17.14	11.37	65.88	5.21	26.41	15.40
93	14.20	1.89	0.88	13.98	1.38	1.39	0.81
94	16.06	3.60	2.24	11.09	1.25	2.74	2.50
95	43.93	10.39	8.15	38.80	3.53	17.79	8.40
96	61.85	23.33	9.68	44.83	4.47	29.61	10.10
97	36.69	13.08	12.33	32.48	2.89	17.35	6.66
98	77.10	14.89	10.41	58.38	5.68	51.08	11.98
99	29.63	4.04	6.86	25.06	1.80	17.50	4.47
100	17.53	15.92	3.20	30.04	1.48	16.30	1.77
101	140.51	9.85	11.80	360.77	15.55	12.57	6.80
102	93.49	21.25	7.30	57.90	5.01	17.22	9.63
103	173.43	39.26	14.64	127.55	14.07	33.77	15.49
104	162.33	37.47	8.70	94.08	11.41	30.31	13.66
105	93.45	23.56	6.56	70.39	9.07	24.22	8.58
106	56.24	12.97	1.32	38.14	6.33	12.08	6.93
107	131.53	28.29	5.02	88.37	15.74	31.01	14.61
108	161.80	49.68	10.91	101.68	21.64	35.14	25.63
109	154.08	32.14	13.64	78.92	27.06	46.15	23.69
110	24.48	9.10	0.06	14.61	1.66	8.21	4.91
111	81.99	21.26	5.70	38.47	7.19	34.31	13.16
112	113.58	30.88	20.84	64.49	8.36	37.77	15.57
113	2.15	0.84	0.00	2.25	0.08	2.18	0.19
114	90.25	24.82	18.61	69.11	5.18	15.22	16.86
115	28.31	3.39	5.48	44.77	4.13	6.03	4.25
116	29.16	5.18	3.78	33.90	1.89	6.36	3.65
117	36.56	5.01	6.77	27.88	2.80	8.08	4.47
118	15.82	4.15	3.42	12.11	0.60	5.70	3.76
119	15.21	2.19	1.03	19.19	0.68	1.39	1.72
120	176.75	20.42	14.41	83.10	3.88	25.01	31.13
121	286.83	27.51	36.49	153.50	10.72	35.36	53.71
122	126.21	5.35	8.71	62.69	1.72	9.81	10.20
123	89.58	11.39	9.31	49.52	2.14	11.78	10.33
124	34.02	3.32	9.32	26.27	4.33	4.40	3.32
125	114.06	6.09	35.01	38.56	4.51	19.23	8.01
126	47.94	6.26	10.73	22.53	2.07	12.24	7.04
127	145.28	16.34	15.01	129.55	8.28	24.92	14.92
128	88.22	14.29	7.35	56.81	5.90	13.21	13.22
129	51.32	5.95	2.61	27.41	1.38	5.05	4.15

130	153.13	48.32	19.53	147.38	12.68	23.49	15.68
131	38.35	4.78	10.57	37.70	2.11	8.13	3.86
132	23.03	1.74	1.98	45.22	1.15	7.71	3.00
133	49.35	5.79	12.82	78.72	5.63	11.75	7.71
134	66.29	15.15	13.00	103.77	5.23	16.79	10.03
135	40.84	3.30	7.96	29.00	2.36	9.92	3.36
136	190.33	16.06	21.95	132.82	11.35	22.28	31.54
137	68.37	6.57	29.44	45.59	5.67	8.76	7.52
138	6.10	0.94	2.52	3.03	0.44	1.58	0.62
139	122.80	9.11	52.18	63.41	5.76	22.52	9.12
140	81.12	6.80	20.14	53.99	3.29	21.36	12.12
141	44.68	7.04	6.16	42.58	4.70	10.13	6.14
142	77.61	10.38	16.36	68.09	5.98	15.11	10.84
143	23.01	2.90	5.81	17.18	1.37	6.16	3.28
144	76.35	14.41	12.97	74.47	5.42	19.35	11.24
145	197.35	33.39	27.38	126.28	7.38	38.78	28.86
146	82.53	13.37	7.80	39.08	2.84	14.33	10.05
147	689.30	101.57	86.75	424.30	18.48	71.04	98.65
148	98.62	7.21	3.11	53.91	4.67	14.51	6.85
149	54.97	7.66	4.06	23.66	4.46	9.10	4.79
150	258.62	43.53	19.91	118.52	11.57	33.87	28.58
151	246.28	40.09	15.24	141.53	12.90	47.06	34.75
152	47.17	10.28	4.86	61.68	4.22	9.32	8.15
153	35.95	5.55	3.54	25.02	1.88	4.86	4.79
154	40.72	13.05	4.45	40.28	3.32	6.51	4.37
155	41.29	11.99	3.73	49.51	4.24	12.15	6.27
156	61.04	7.05	8.24	40.23	2.32	7.47	3.95
157	61.96	9.96	3.39	42.20	3.51	8.33	10.61
158	30.94	7.07	1.82	30.25	1.84	5.23	4.90
159	68.29	9.62	7.71	45.01	6.69	13.94	8.66
160	114.35	19.62	8.47	93.00	7.69	13.42	18.05
161	38.55	8.35	12.17	25.87	4.03	13.69	6.21
162	140.55	10.28	5.55	41.34	4.54	6.00	8.14
163	73.57	13.25	9.51	60.59	2.41	10.75	6.78
164	64.12	19.37	7.95	91.06	5.47	9.64	11.15
165	175.69	27.78	19.47	126.62	9.28	28.88	28.06
166	55.83	12.00	7.79	36.71	2.50	7.16	7.99
167	78.70	11.47	7.57	58.57	4.27	11.23	8.83
168	43.34	10.04	5.13	37.21	3.43	5.54	4.89
169	103.41	13.98	11.22	68.62	6.78	15.86	14.45
170	122.81	15.40	8.93	64.77	9.56	14.58	21.01
171	107.72	11.91	7.23	49.93	4.73	14.84	8.52
172	76.29	23.26	7.25	38.84	6.93	17.09	6.81
173	38.90	4.21	4.99	20.07	2.13	5.98	7.78
174	97.61	23.77	11.27	105.72	7.85	17.80	26.23

175	440.76	38.84	31.75	204.24	8.44	33.82	73.25
176	208.17	30.29	12.84	56.12	5.16	24.03	31.70
177	16.02	5.92	4.07	48.75	2.12	2.71	3.76
178	25.17	2.97	4.56	30.84	2.24	2.15	2.25
179	76.68	15.75	10.57	66.71	7.97	11.10	16.39
180	78.21	10.94	9.40	53.78	8.50	23.65	15.40
181	24.62	2.40	3.58	31.26	1.16	4.68	2.12
182	62.64	11.25	6.39	39.46	3.66	7.10	6.74
183	105.48	22.62	6.55	72.53	7.83	19.72	12.50
184	229.99	47.64	14.24	210.23	16.31	28.13	25.57
185	73.14	15.27	4.58	40.78	8.27	13.23	9.56
186	94.47	18.79	10.81	46.00	7.37	13.62	16.47
187	133.82	42.95	5.02	126.79	12.17	36.27	25.97
188	174.72	44.72	17.13	135.20	18.25	31.13	32.71
189	132.90	26.02	7.15	77.76	10.60	18.76	21.43
190	134.38	28.39	10.27	63.34	6.87	16.22	15.00
191	168.76	38.70	18.97	103.71	10.84	33.10	23.83
192	163.17	36.30	15.12	110.20	9.39	19.46	18.87
193	119.96	19.20	2.65	69.94	8.21	10.75	26.70
194	115.37	18.60	4.59	104.66	9.62	22.23	24.54
195	55.38	7.09	6.04	19.58	2.42	4.64	8.42
196	86.51	15.13	9.47	58.11	6.49	10.97	16.87
197	158.29	18.89	9.42	111.96	6.32	19.90	26.21
198	122.94	11.18	10.81	72.08	5.14	15.47	14.71
199	93.94	17.97	6.12	110.32	5.43	13.72	17.48
200	124.55	14.83	3.47	54.78	3.21	19.89	15.50
201	100.83	11.78	9.79	62.68	5.81	19.53	15.27
202	140.46	30.87	10.92	113.56	7.44	35.12	29.01
203	64.34	13.74	3.19	62.87	2.81	8.54	11.24
204	40.16	9.17	7.82	35.28	4.28	11.09	5.51
205	53.30	15.36	12.61	31.54	1.89	10.70	6.65
206	194.95	18.05	7.62	178.73	6.01	11.50	17.92
207	222.80	23.77	5.84	124.34	5.04	14.19	31.53
208	141.74	20.23	9.33	105.93	6.39	12.74	14.05
209	57.53	7.95	7.10	45.06	2.63	7.71	5.16
210	7.76	3.34	3.32	7.48	0.94	1.94	4.00
211	175.34	26.57	16.98	145.69	6.48	23.78	20.71
212	33.93	3.52	4.57	21.34	1.69	6.65	4.24
213	113.44	21.42	11.64	94.49	5.08	22.76	13.62
214	17.28	2.81	2.93	15.44	0.83	3.51	2.16
215	236.27	40.41	27.12	168.28	8.86	20.61	28.46
216	184.72	27.87	11.27	90.93	6.90	16.42	22.81
217	206.27	34.53	16.34	151.93	10.02	39.42	32.64
218	162.61	33.40	11.49	121.58	6.95	20.35	24.84
219	118.94	16.58	16.13	78.68	6.28	14.14	19.66

220	124.35	9.43	6.15	50.66	3.96	13.78	13.56
221	218.83	54.94	27.61	156.58	14.25	30.81	48.91
222	155.44	40.38	10.27	183.52	9.20	12.78	25.17
223	145.30	31.40	6.78	103.70	8.57	9.16	21.95
224	89.92	16.82	4.73	51.20	6.53	6.97	8.81
225	213.88	35.34	14.20	105.64	20.86	38.96	32.63
226	266.93	68.58	5.08	238.72	21.01	18.64	26.82
227	157.06	33.41	8.69	142.26	23.46	23.38	29.66
228	58.84	12.48	10.55	33.15	10.08	14.29	7.49
229	161.79	35.88	8.41	107.77	8.93	25.33	28.35
230	117.55	25.28	13.91	95.85	13.36	11.41	16.29
231	217.32	52.15	11.69	161.10	10.43	32.15	26.48
232	183.49	52.11	7.49	108.70	20.05	45.42	20.42
233	117.01	22.08	10.88	74.54	9.91	31.26	14.29
234	160.07	36.67	9.28	130.05	16.12	29.36	26.59
235	139.82	39.42	3.52	141.12	4.91	17.37	13.37
236	89.76	16.29	10.69	61.53	4.44	7.38	9.90
237	285.49	82.09	16.11	229.01	26.05	52.82	30.92
238	29.57	8.77	1.16	18.55	4.83	7.83	4.39
239	228.03	42.44	25.23	107.15	16.97	41.48	32.01
240	186.95	29.64	27.01	120.05	11.21	20.44	13.86
241	57.94	16.25	2.34	44.41	5.98	11.43	12.91
242	198.03	48.32	10.50	122.37	10.27	13.52	31.78
243	133.21	26.00	10.15	106.72	7.50	20.44	15.31
244	477.27	64.42	23.92	291.14	17.83	29.26	39.32
245	305.69	64.58	14.67	299.32	31.21	41.05	65.37
246	187.86	39.39	7.28	153.63	14.11	24.13	27.43
247	290.05	38.09	12.78	173.04	18.37	21.99	30.07
248	300.65	92.21	10.56	350.94	23.94	62.49	29.12
249	172.39	46.22	4.73	94.14	18.68	18.27	18.33
250	307.15	81.70	25.37	214.52	26.62	39.48	53.35
251	58.09	12.50	2.98	40.42	10.74	9.10	6.14
252	160.24	23.84	13.71	84.95	12.02	18.95	14.17
253	172.41	38.73	14.78	107.99	18.58	27.07	13.68
254	130.37	21.74	11.90	100.22	9.61	11.71	18.99
255	102.05	11.37	2.78	63.74	7.02	18.11	15.04
256	66.20	9.18	3.39	45.26	2.50	10.29	8.95
257	95.23	13.04	10.47	74.80	6.17	24.88	13.40
258	116.12	20.19	14.86	56.98	9.05	18.95	11.83
259	84.23	6.81	4.54	98.55	2.94	13.35	3.60
260	129.50	13.54	2.80	117.79	7.78	17.96	12.44
261	132.77	22.81	7.26	187.91	5.22	23.08	7.04
262	70.12	4.86	3.87	52.55	2.72	7.01	7.18
263	116.55	12.45	7.72	354.98	22.65	20.94	16.74
264	85.29	7.93	3.98	253.13	10.44	6.06	13.38

265	35.47	1.82	2.59	62.39	3.76	4.41	2.41
266	77.79	5.96	4.94	109.14	5.92	10.88	11.18
267	29.13	2.74	0.33	65.27	2.77	2.81	2.44
268	122.31	14.26	6.59	281.49	8.67	14.28	27.06
269	168.31	18.07	7.91	324.27	6.97	45.36	45.50
270	309.35	37.47	10.77	212.82	8.00	49.19	43.15
271	213.46	29.21	10.55	275.81	12.84	19.13	39.66
272	201.44	14.07	30.73	300.12	11.19	21.72	20.08
273	82.70	2.58	4.55	147.58	5.32	9.97	6.36
274	201.35	22.98	10.77	569.79	17.66	33.91	28.28
275	168.10	27.56	5.14	331.99	9.89	15.13	34.34
276	91.53	29.49	3.02	110.63	5.25	13.06	14.43
277	168.84	24.41	6.41	166.16	6.16	36.38	30.53
278	135.88	29.65	9.01	254.78	12.00	20.08	26.39
279	164.72	19.59	6.78	708.23	11.72	74.90	37.43
280	184.46	27.44	23.27	276.67	11.59	18.54	27.55
281	133.73	18.69	8.89	182.18	6.29	18.63	21.34
282	68.03	11.56	3.05	84.15	4.10	6.57	8.70
283	89.46	9.44	5.39	183.72	7.06	31.92	16.56
284	121.83	12.53	5.07	292.61	7.95	17.13	26.35
285	16.56	1.82	1.53	20.09	0.99	5.71	1.99
286	109.67	7.36	3.67	175.68	3.31	21.50	13.61
287	66.29	2.62	3.90	206.88	5.43	3.15	17.79
288	159.85	12.66	7.35	223.35	9.08	13.39	26.35
289	56.74	6.91	6.30	210.63	3.91	3.54	9.97
290	28.69	6.77	2.02	110.48	3.44	5.35	4.65
291	44.12	9.58	5.62	59.81	2.38	3.50	4.97
292	95.28	12.62	14.48	324.58	7.42	14.50	14.38
293	41.38	2.35	2.00	101.87	4.29	2.50	5.19
294	11.87	2.70	3.28	82.34	6.06	2.20	1.71
295	21.32	1.66	1.33	39.94	2.43	5.52	3.56
296	98.36	12.99	15.40	147.68	7.25	13.07	13.83
297	47.55	4.88	6.25	128.00	4.33	10.79	9.27
298	61.65	6.55	4.22	110.64	3.73	1.86	7.71
299	64.87	2.34	4.24	138.56	5.55	4.78	3.62
300	27.36	2.12	3.73	96.56	4.42	4.32	5.43
301	30.18	2.22	8.22	205.83	5.40	2.55	2.90
302	16.99	1.58	1.96	116.56	3.80	1.36	2.02
303	56.70	2.29	4.29	170.44	6.43	18.89	5.69
304	48.65	2.37	2.78	152.26	3.60	13.33	6.11
305	65.62	5.08	1.79	157.63	5.46	18.36	16.49
306	41.77	0.86	1.57	84.32	2.08	3.80	5.87
307	82.34	8.34	4.27	120.11	3.65	15.42	21.50
308	76.44	9.64	2.97	165.45	4.89	26.99	16.09
309	114.38	16.25	9.41	59.60	4.28	20.82	19.47

310	77.27	7.50	8.06	83.20	6.65	15.58	8.23
311	104.26	24.58	6.35	71.54	2.74	31.68	21.86
312	38.83	7.63	5.13	23.90	2.22	13.02	6.39
313	29.14	1.43	1.81	54.04	5.15	2.58	1.39
314	0.34	0.25	0.12	0.93	0.20	0.22	0.25
315	79.67	10.02	10.11	59.25	8.39	7.18	13.83
316	141.92	33.32	14.64	85.06	7.43	42.32	23.08
317	140.50	49.25	17.24	147.07	9.58	19.72	15.98
318	124.30	21.43	28.14	82.89	8.85	30.84	24.65
319	121.92	22.30	22.41	68.41	5.30	48.40	19.07
320	317.00	82.36	38.97	202.11	15.48	67.26	55.25
321	88.50	25.76	15.19	78.13	3.89	21.03	14.98
322	91.84	23.67	30.39	53.37	3.55	17.52	20.46
323	34.90	5.55	6.65	26.97	2.14	3.40	4.97
324	50.45	9.45	4.99	38.92	2.71	9.98	7.25
325	48.15	6.70	6.97	36.25	2.65	10.80	6.19
326	44.41	14.27	3.91	33.13	4.43	7.80	3.25
327	20.69	4.72	4.29	30.12	3.07	4.95	3.06
328	108.80	17.04	8.65	81.57	6.45	14.63	16.41
329	90.34	24.17	7.20	47.74	4.13	10.76	8.64
330	154.73	30.36	13.50	82.84	6.33	19.30	21.93
331	103.44	23.62	18.21	57.78	6.15	18.16	11.76
332	31.10	8.40	4.26	26.36	3.03	7.71	4.95
333	35.11	10.40	4.43	30.83	2.49	12.24	4.10
334	118.56	26.51	17.80	77.08	10.04	34.48	17.86
335	24.45	4.14	3.24	38.08	1.93	3.51	2.44
336	104.51	25.52	13.67	76.35	7.61	33.01	14.87
337	36.16	3.91	4.99	18.13	0.86	8.96	8.57
338	33.83	5.89	3.79	23.53	0.99	6.33	3.95
339	52.49	12.41	7.20	39.75	2.27	10.87	8.03
340	112.93	45.24	8.96	126.86	13.57	23.75	27.99
341	62.73	8.19	6.32	47.51	5.51	7.42	4.60
342	88.34	17.75	4.35	66.71	10.58	8.22	11.89
343	95.28	17.93	1.37	96.68	7.87	10.08	10.91
344	128.36	34.75	12.68	100.09	10.68	25.58	22.04
345	53.00	6.58	4.48	74.39	4.06	6.57	15.74
346	35.77	9.80	2.01	41.31	12.62	7.56	3.90
347	54.48	7.06	1.94	47.62	4.25	8.13	11.19
348	94.72	19.08	6.64	72.80	8.38	17.61	18.79
349	117.16	16.88	13.91	84.73	16.79	21.48	21.07
350	58.41	11.59	3.53	42.92	9.57	7.34	11.99
351	34.33	8.48	3.26	29.60	4.32	6.67	5.47
352	106.16	15.64	15.94	100.34	8.99	19.25	15.66
353	67.00	9.25	14.62	55.66	6.05	12.76	10.80
354	72.68	10.05	7.04	55.40	7.13	10.38	11.72

355	51.87	7.32	12.15	38.95	3.88	13.89	8.31
356	112.23	14.65	9.27	151.34	12.15	11.65	9.87
357	42.19	7.49	8.29	35.98	4.87	7.30	4.72
358	149.35	32.00	7.60	124.52	14.26	20.87	20.67
359	133.82	26.65	6.40	110.54	16.59	18.06	18.11
360	119.20	28.38	3.23	97.48	10.29	14.17	12.91
361	105.38	25.42	3.44	126.91	16.54	12.55	16.94
362	65.36	10.24	12.07	55.63	4.40	35.23	8.19
363	53.96	21.43	1.84	69.78	8.23	9.32	12.33
364	92.89	14.13	4.28	53.97	11.17	12.01	11.17
365	95.74	13.49	12.33	84.48	10.59	12.88	11.14
366	597.20	89.30	21.37	407.53	41.81	85.59	82.93
367	76.80	18.41	8.68	52.82	6.54	19.18	14.59
368	95.30	18.35	3.18	75.42	8.03	10.35	17.29
369	38.09	5.63	9.74	14.49	4.31	9.85	3.97
370	41.55	6.37	1.01	25.49	6.46	13.36	3.49
371	83.65	11.14	2.31	57.08	5.68	10.01	11.60
372	424.22	76.02	5.11	286.44	15.87	34.88	57.00
373	129.19	26.99	9.72	131.85	11.30	19.19	22.81
374	49.73	8.98	3.51	45.45	1.48	7.95	4.40
375	91.18	15.43	4.66	42.47	13.94	15.08	8.42
376	79.04	19.63	8.31	58.46	11.50	13.73	13.18
377	250.08	57.40	2.97	191.55	23.37	24.83	51.69
378	382.43	77.30	22.58	273.15	19.54	38.92	49.41
379	255.22	55.59	10.08	315.75	16.36	39.15	33.34
380	105.99	23.30	12.23	107.05	17.40	16.04	14.61
381	213.82	36.48	3.16	150.19	20.80	24.13	22.53
382	81.23	16.23	1.84	83.35	19.09	15.63	10.94
383	114.14	15.72	0.09	72.63	8.38	17.61	14.40
384	232.13	33.86	3.33	84.23	10.04	19.47	25.38
385	199.20	29.97	2.59	149.77	11.24	27.29	30.59
386	98.98	23.31	0.83	95.08	8.90	10.14	14.68
387	67.16	15.31	2.27	62.74	13.62	19.88	7.79
388	38.17	8.60	7.61	39.38	5.87	10.87	5.24
389	284.72	57.54	16.74	214.82	20.34	42.65	42.41
390	280.59	69.80	5.52	153.83	15.53	35.73	19.76
391	117.85	18.11	5.81	77.11	8.76	23.80	15.25
392	202.49	22.95	6.75	123.67	12.91	21.44	17.21
393	69.39	8.83	1.16	58.39	9.10	7.02	5.38
394	104.73	20.65	4.40	82.42	13.28	10.56	9.56
395	98.80	21.80	0.93	65.51	8.09	14.16	12.02
396	106.47	18.15	5.91	157.28	13.04	27.28	16.01
397	274.13	38.61	7.17	161.75	8.16	17.65	26.47
398	57.39	3.83	8.66	66.28	3.62	10.51	6.46
399	95.42	35.25	17.60	88.28	14.66	15.71	11.57

400	186.79	48.06	4.83	160.14	20.22	15.98	20.86
401	229.71	71.24	7.91	303.71	20.78	34.88	46.74
402	150.78	39.87	7.93	125.80	7.13	29.97	22.00
403	395.94	103.91	24.89	352.54	49.00	51.76	73.49
404	97.99	20.76	1.50	103.36	4.46	8.16	16.74
405	187.64	29.16	7.78	125.65	10.70	31.33	21.23
406	182.33	33.00	6.49	86.59	14.87	23.47	16.99
407	171.19	28.53	6.28	129.42	16.24	25.44	16.12
408	224.53	49.40	13.70	160.67	19.15	36.06	41.25
409	237.16	60.30	6.21	160.87	45.10	28.65	31.14
410	147.73	36.25	4.22	116.08	10.77	31.82	25.58
411	161.72	29.01	8.75	85.67	12.11	24.31	33.04
412	252.99	41.08	11.31	171.53	10.73	30.92	29.84
413	60.86	8.61	8.66	47.51	5.65	14.49	8.00
414	83.68	16.79	10.57	55.28	6.11	12.25	10.60
415	80.89	13.83	22.18	60.39	4.06	16.66	8.86
416	71.27	13.29	12.78	42.83	5.42	16.94	11.00
417	127.75	17.88	17.92	111.31	9.75	28.94	14.48
418	40.27	5.78	5.78	29.58	1.68	8.46	2.57
419	220.25	20.29	19.04	110.40	9.79	24.41	22.28
420	125.95	32.07	13.96	117.84	8.68	11.62	11.73
421	70.38	17.23	9.48	65.36	11.93	13.35	9.84
422	40.42	3.18	3.03	58.69	2.85	7.61	5.37
423	84.51	8.71	2.31	53.98	3.66	6.97	9.00
424	73.60	10.01	4.92	40.29	2.52	14.11	7.82
425	35.29	12.11	8.55	19.60	1.50	8.45	4.85
426	58.66	9.09	2.90	60.67	4.92	9.46	4.46
427	63.35	11.17	5.89	44.21	2.76	11.65	5.79
428	21.86	3.96	4.20	33.73	1.57	2.73	1.24
429	32.02	13.87	5.17	28.11	1.64	4.83	6.77
430	87.33	64.68	7.66	103.42	5.19	16.46	16.86
431	26.15	13.80	6.99	29.11	1.95	3.03	3.69
432	64.37	9.03	10.54	50.71	2.04	7.52	8.22
433	52.34	12.23	4.31	31.07	1.59	8.13	7.01
434	63.87	25.26	4.33	93.77	4.05	15.37	7.03
435	25.50	12.54	2.31	15.63	2.56	7.44	4.24
436	167.64	22.41	20.73	133.70	5.46	19.77	17.61
437	52.76	6.36	4.92	35.82	3.06	12.07	5.34
438	64.41	7.43	8.93	32.61	4.02	10.72	6.57
439	159.17	29.27	24.12	108.71	6.61	35.31	18.42
440	126.79	29.76	13.62	105.64	6.20	12.24	16.63
441	111.70	16.44	23.56	107.87	17.69	15.23	20.04
442	52.19	10.90	4.42	41.38	5.54	13.65	11.75
443	59.43	15.27	6.07	23.76	5.38	11.49	7.22
444	66.72	12.95	5.77	39.29	5.03	24.34	7.84

445	104.44	33.13	12.33	81.74	10.88	20.20	13.36
446	123.28	27.79	8.55	108.23	9.69	14.23	11.85
447	291.79	50.60	26.49	158.64	10.99	36.27	24.32
448	115.46	32.10	8.65	102.36	6.83	21.44	15.89
449	151.32	22.50	17.03	114.77	4.08	22.95	21.08
450	112.48	22.70	9.31	65.88	4.96	11.32	12.57
451	127.49	21.42	9.75	125.85	5.60	24.95	13.47
452	167.33	29.16	44.88	110.69	6.13	28.30	18.16
453	59.38	13.83	21.67	38.62	5.35	11.64	9.29
454	46.31	13.66	3.68	30.88	4.83	6.39	7.10
455	48.47	10.04	3.74	50.79	2.32	6.23	3.51
456	108.48	29.56	18.00	96.48	6.63	21.25	21.19
457	158.17	25.04	37.82	82.55	8.00	28.60	18.68
458	264.37	45.93	21.65	166.36	13.68	38.08	48.44
459	288.64	47.74	46.16	161.59	9.45	31.36	32.29
460	200.97	18.67	13.33	105.49	7.75	19.23	17.95
461	146.46	9.66	6.01	66.73	2.32	13.42	12.48
462	73.30	9.30	3.50	51.31	2.51	8.88	13.12
463	102.41	13.53	13.15	45.97	3.33	11.25	13.37
464	107.39	7.37	8.56	37.36	1.68	8.91	7.02
465	161.66	12.92	8.38	42.75	2.27	16.69	14.90
466	59.84	4.51	1.58	18.80	2.17	3.15	2.80
467	66.33	7.22	7.24	83.00	5.65	13.04	5.97
468	48.98	9.97	4.57	25.22	1.38	11.55	6.66
469	58.33	10.14	7.48	30.03	1.78	12.46	10.79
470	122.14	16.05	13.93	57.31	3.16	11.14	12.07
471	105.73	10.19	10.80	43.34	1.35	12.47	15.33
472	135.99	15.44	8.04	80.42	4.64	14.54	16.57
473	36.79	11.83	1.65	25.77	2.07	15.91	6.82
474	59.42	10.74	9.12	21.62	1.46	9.26	7.04
475	48.22	13.60	4.05	27.55	2.66	12.65	4.40
476	165.95	31.66	12.52	120.04	7.66	49.69	27.52
477	53.34	9.90	3.20	29.15	1.82	15.40	7.04
478	44.82	8.83	3.45	90.67	3.22	11.92	6.69
479	51.54	14.18	6.86	76.65	3.46	18.74	11.17
480	28.79	5.76	0.61	13.00	0.78	4.44	3.82
481	42.37	8.54	3.90	26.91	1.65	7.26	4.64
482	53.76	9.15	6.88	36.31	1.93	8.76	6.52
483	97.53	25.23	7.96	87.66	3.10	19.34	19.00
484	65.40	8.07	7.67	62.77	3.19	4.88	4.19
485	44.05	4.52	5.96	23.21	1.14	8.43	3.57
486	54.25	3.36	4.40	39.11	2.96	3.07	2.39
487	19.19	2.42	1.39	13.76	0.69	2.08	1.96
488	10.94	1.90	1.71	9.69	0.72	2.99	1.77
489	17.06	2.74	0.76	62.57	2.96	2.45	0.72

490	6.97	0.66	0.99	22.42	1.78	1.59	0.92
491	68.02	5.57	6.31	189.75	8.72	12.09	8.90
492	52.50	5.27	8.27	130.84	4.07	11.35	6.55
493	47.30	5.09	2.78	93.12	2.68	9.42	5.06
494	20.20	1.89	6.57	42.01	1.61	5.03	2.31
495	47.78	10.51	4.36	106.73	5.90	16.46	10.45
496	21.43	5.57	3.53	42.27	3.42	4.78	3.55
497	39.73	5.36	4.83	106.40	5.91	8.14	4.38
498	10.62	5.81	3.36	29.50	1.26	5.81	2.92
499	220.27	26.72	15.46	129.04	8.98	30.82	27.61
500	178.31	20.44	13.49	84.41	5.88	33.89	16.58
501	104.76	12.32	6.80	33.99	1.25	7.09	14.21
502	165.80	15.85	14.81	107.80	5.76	21.21	35.85
503	110.68	13.25	13.79	47.22	3.80	9.61	17.78
504	109.56	13.13	9.19	37.85	3.33	8.64	12.57
505	93.19	10.13	3.24	78.47	4.38	8.90	17.44
506	107.14	17.61	4.66	87.59	4.45	13.22	33.56
507	63.06	10.63	4.16	60.60	3.48	7.02	16.64
508	171.72	20.00	9.63	76.46	7.64	22.37	49.18
509	75.78	10.85	5.19	99.57	3.05	14.34	23.88
510	92.06	9.21	4.34	51.78	2.53	7.50	23.32
511	27.92	2.39	1.41	12.38	0.97	4.36	6.93
512	46.56	8.19	2.44	31.24	2.60	14.04	7.64
513	86.59	9.18	2.29	42.11	3.18	4.34	26.06
514	28.57	4.99	2.79	16.54	0.44	5.59	7.72
515	161.06	15.50	8.74	84.60	4.66	25.75	37.88
516	59.75	4.06	2.02	19.66	1.07	5.44	9.21
517	70.04	9.94	6.95	74.19	1.42	7.64	19.69
518	60.38	8.62	8.47	63.41	8.79	8.36	8.59
519	28.71	4.60	3.08	28.98	1.50	7.06	6.00
520	23.21	5.09	4.32	75.66	4.68	9.51	7.68
521	10.98	2.44	0.92	23.46	0.79	2.83	2.43
522	87.70	16.46	5.44	91.98	5.17	21.76	13.57
523	50.58	15.28	4.04	54.29	2.79	13.24	10.45
524	90.43	20.24	6.81	173.31	10.00	14.50	18.05
525	45.60	8.55	3.43	26.65	4.38	10.65	8.22
526	26.76	5.34	4.64	22.36	1.65	5.88	7.20
527	15.98	4.59	1.08	35.07	1.12	7.19	2.50
528	133.54	25.08	3.43	135.17	7.12	34.70	14.18
529	130.67	17.24	3.70	48.08	4.42	13.25	14.00
530	224.55	25.11	13.74	87.29	5.56	33.36	24.60
531	172.47	28.67	26.46	79.63	5.16	18.14	22.14
532	6,273.27	2,295.15	422.56	9,561.83	1,815.75	452.27	2,095.13

Repair Vendor	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5	Supplier 6	Supplier 7	Supplier 8	Fictive Supplier
1	3.88	17.57	18.67	176.08	12.21	51.01	12.18	-	28.31
2	24.29	71.95	9.22	191.30	6.69	53.72	13.61	-	26.16
3	23.91	45.34	4.02	147.10	6.78	33.33	9.88	20.03	25.51
4	26.00	136.76	3.83	209.28	4.52	80.65	13.40	56.11	34.03
5	10.71	75.40	8.17	499.57	5.47	422.03	67.55	-	100.67
6	12.66	29.14	11.99	155.03	12.88	97.49	12.37	-	37.68
7	8.72	1.96	3.20	55.09	2.65	7.83	3.73	-	8.73
8	-	8.71	6.50	84.81	6.07	12.89	7.61	-	14.09
9	6.86	2.90	1.42	87.09	1.82	10.40	5.39	4.01	11.22
10	-	9.39	2.25	140.34	5.17	28.15	12.03	-	25.27
11	43.43	2.97	7.58	187.89	5.87	42.44	13.25	-	27.76
12	7.44	2.66	6.84	138.10	8.05	64.05	14.10	-	35.89
13	13.37	75.39	7.20	204.44	5.28	77.85	12.93	-	21.54
14	21.92	200.13	9.02	154.87	12.02	47.47	20.24	119.19	36.06
15	6.42	1.28	10.02	48.17	6.72	12.27	3.37	10.02	16.16
16	8.24	4.14	6.87	48.66	5.71	6.37	0.77	12.02	10.21
17	8.85	4.46	9.09	191.50	10.23	178.41	3.15	2.00	39.99
18	4.90	44.64	11.24	261.79	15.94	82.49	6.22	-	167.34
19	27.28	4.15	6.42	77.77	4.46	91.38	4.47	18.03	27.80
20	14.33	2.21	2.88	93.25	1.51	14.57	2.71	-	16.05
21	45.38	8.27	8.73	249.76	15.24	189.10	7.09	6.01	43.93
22	12.34	0.83	0.77	88.31	3.52	112.01	1.51	2.00	20.08
23	3.08	-	5.02	20.82	1.98	4.02	0.82	-	4.65
24	1.12	2.25	0.09	23.83	3.07	12.35	1.02	2.00	3.90
25	0.22	0.83	0.70	22.05	2.84	4.77	0.73	-	2.80
26	8.92	8.97	1.25	62.42	3.87	15.92	2.25	-	9.49
27	12.12	6.91	5.38	91.14	7.61	14.34	4.75	-	24.54
28	1.70	27.97	3.69	64.37	4.86	9.90	2.82	-	12.30
29	25.06	10.32	9.82	97.53	11.42	14.54	4.65	-	25.14
30	-	4.18	0.90	59.32	2.17	15.13	1.94	2.00	9.44
31	3.98	7.64	0.28	45.42	5.02	11.40	2.64	6.01	9.63
32	-	13.74	0.33	65.05	3.77	20.05	4.17	2.00	10.88
33	3.49	2.70	3.96	67.67	4.01	29.98	1.33	-	12.87
34	2.88	0.56	2.36	36.97	2.06	3.95	2.29	-	9.56
35	9.30	65.79	3.08	9.91	3.88	16.87	3.06	38.06	13.07
36	-	1.74	10.70	97.06	6.50	12.99	5.05	-	13.86
37	9.34	15.45	15.36	79.59	6.13	21.05	4.47	-	16.21
38	7.12	0.69	4.24	128.76	4.08	24.69	6.28	-	12.24
39	5.00	1.89	3.46	28.69	1.73	7.02	0.87	-	8.77
40	12.93	7.09	2.74	71.22	2.83	27.79	4.31	-	17.29
41	7.44	1.40	4.01	25.17	2.58	4.72	1.69	6.01	14.10
42	8.21	-	5.05	45.58	5.78	20.33	2.76	18.03	19.11
43	-	1.83	13.69	52.40	7.26	11.93	2.19	-	7.61

44	6.22	5.76	16.45	56.84	7.66	15.18	1.99	22.04	19.94
45	29.07	53.20	16.71	136.46	9.79	39.22	8.06	-	34.44
46	-	1.38	2.73	84.70	3.29	19.62	6.62	-	17.90
47	29.13	20.40	0.08	166.97	3.69	18.77	7.55	-	24.04
48	11.03	10.53	7.97	55.96	20.11	67.01	3.27	-	19.71
49	11.22	2.11	7.83	75.30	8.20	16.23	4.71	38.06	26.52
50	0.61	2.71	1.85	3.90	3.63	17.51	-	2.00	5.57
51	0.93	25.15	3.44	1.97	5.12	1.28	0.43	-	3.37
52	3.88	16.20	5.85	9.28	7.67	56.72	0.57	8.01	6.75
53	4.20	11.34	8.54	10.58	12.52	2.18	0.70	-	13.81
54	1.38	-	1.58	6.74	2.74	1.18	0.20	-	6.07
55	2.28	0.98	7.38	16.91	6.28	1.37	0.72	12.02	6.06
56	2.48	17.68	13.20	3.09	5.43	12.21	0.80	-	8.19
57	2.37	3.26	3.91	17.87	4.11	3.37	0.56	8.01	7.24
58	3.43	9.22	5.40	50.83	6.63	7.77	0.95	-	7.96
59	2.21	0.28	6.88	21.86	5.34	14.61	0.29	4.01	4.31
60	0.77	3.63	5.32	3.60	5.97	0.87	0.42	2.00	2.92
61	4.90	30.54	11.00	0.21	14.81	37.32	0.40	-	20.85
62	1.96	2.59	6.78	11.00	2.97	1.67	0.77	2.00	4.64
63	1.06	-	12.84	9.35	8.72	0.95	0.36	4.01	7.77
64	0.87	8.05	7.58	5.78	5.34	3.75	0.66	14.02	7.44
65	1.12	2.67	0.51	9.35	4.62	3.84	0.51	-	3.38
66	0.48	0.26	4.09	5.32	2.31	2.20	0.19	2.00	3.20
67	1.44	0.68	18.25	12.04	11.84	12.44	1.23	2.00	8.88
68	0.61	0.14	6.29	1.89	6.98	0.32	0.20	-	4.87
69	10.51	26.27	4.41	29.76	25.47	50.28	2.25	-	21.09
70	5.22	1.92	8.99	27.45	13.14	7.19	1.43	-	26.11
71	4.20	0.65	4.82	22.78	10.57	3.18	1.63	-	11.23
72	0.06	-	2.68	0.74	3.33	0.76	0.06	-	3.68
73	6.25	32.51	5.93	55.41	20.95	20.35	4.84	2.00	17.02
74	0.38	1.02	8.73	0.32	8.12	0.79	0.02	-	3.64
75	2.12	9.41	17.18	15.94	10.81	13.41	1.28	-	11.13
76	1.60	7.00	4.03	5.17	7.49	3.31	0.36	2.00	3.96
77	3.27	9.11	1.84	15.12	8.33	6.33	0.77	-	8.31
78	2.72	18.46	25.00	-	18.15	32.72	0.51	10.02	24.50
79	6.58	17.85	3.67	5.26	11.35	29.86	1.48	8.01	24.05
80	7.89	26.72	3.87	41.90	20.14	16.03	1.94	28.04	24.62
81	12.25	33.13	5.73	65.48	8.92	11.38	3.57	-	17.58
82	10.26	9.37	10.56	42.83	18.42	17.72	2.97	-	33.04
83	-	-	12.65	-	19.38	0.00	-	-	9.15
84	7.28	13.29	1.88	26.29	42.01	28.96	0.66	-	40.28
85	2.53	22.09	3.44	0.93	9.93	23.37	0.82	4.01	6.86
86	0.77	1.54	5.15	3.20	3.79	1.61	0.68	-	7.08
87	0.77	6.04	3.96	0.12	6.46	1.08	0.17	-	6.08
88	0.35	0.62	2.14	1.82	6.81	0.49	0.12	-	4.85

89	7.71	28.59	17.38	36.94	15.74	15.58	3.46	-	21.85
90	-	-	0.57	-	0.35	-	-	-	0.26
91	2.18	12.89	28.46	-	14.70	5.06	0.26	-	14.98
92	0.77	2.41	13.07	2.86	9.97	0.53	0.13	-	10.48
93	0.19	0.39	1.11	0.09	1.10	0.48	-	-	1.64
94	-	0.55	3.86	0.05	4.68	0.37	0.06	-	4.89
95	2.98	6.40	3.81	13.04	4.17	5.60	0.86	6.01	5.45
96	5.17	35.91	5.14	1.23	12.39	42.82	0.73	34.64	12.28
97	0.80	3.29	8.91	4.25	10.68	0.22	0.25	-	9.58
98	3.49	4.58	46.22	16.06	23.01	2.74	1.63	6.01	10.33
99	1.48	12.77	6.74	4.92	7.07	1.56	0.66	2.00	5.83
100	0.13	1.38	4.18	2.64	4.22	0.45	0.23	-	3.22
101	22.56	4.74	8.86	139.48	10.02	88.29	3.41	4.01	29.69
102	1.12	0.26	4.22	4.42	7.65	1.84	0.20	-	3.87
103	5.01	8.78	3.40	18.29	10.37	13.33	1.53	10.02	14.23
104	0.67	1.15	27.39	6.95	13.62	1.65	0.20	-	9.25
105	2.82	1.64	4.29	17.99	11.52	2.30	0.72	2.00	18.43
106	10.27	54.85	4.91	35.60	5.85	33.31	3.72	-	20.28
107	4.62	8.26	9.21	24.78	22.40	4.91	1.30	-	16.36
108	15.62	86.34	41.73	18.82	21.19	14.70	2.56	-	36.74
109	40.71	124.40	18.77	200.68	20.97	44.65	8.85	-	34.66
110	-	0.14	1.70	0.72	5.71	2.32	-	-	3.86
111	8.56	26.26	6.80	23.45	12.69	1.79	2.04	-	12.57
112	2.63	5.29	17.48	10.76	15.55	2.75	0.90	-	18.02
113	6.67	65.74	0.28	3.65	0.75	22.52	0.87	-	36.15
114	3.81	-	5.14	19.53	4.80	11.91	0.91	-	19.66
115	1.47	-	4.83	7.13	2.50	11.17	0.46	-	4.11
116	0.67	3.02	1.31	5.57	2.16	2.66	0.26	4.01	2.21
117	0.35	0.51	9.58	3.17	6.03	0.83	0.20	2.00	4.13
118	0.26	0.30	3.00	2.45	2.93	1.44	0.12	-	2.46
119	0.22	0.31	3.88	1.49	1.15	0.48	0.05	-	0.97
120	7.72	87.27	5.00	75.97	12.64	85.07	15.18	10.02	21.97
121	9.95	474.96	12.93	153.06	12.66	353.98	42.50	36.06	54.06
122	5.14	7.47	10.56	33.19	3.29	7.23	2.31	12.02	12.61
123	6.77	8.91	9.21	60.29	6.71	11.15	5.06	16.03	11.28
124	16.63	46.54	3.87	48.09	1.51	61.07	8.84	48.08	5.88
125	18.85	21.93	18.87	97.98	9.42	22.23	6.91	-	18.70
126	23.22	44.59	9.62	89.96	5.09	58.83	9.64	36.06	13.57
127	20.40	23.85	14.99	125.24	8.30	85.74	14.63	74.12	23.02
128	14.11	-	21.42	80.97	7.09	21.35	4.65	2.00	18.51
129	2.92	13.30	4.04	6.94	2.38	16.88	0.38	2.00	3.53
130	50.72	172.31	20.26	232.10	5.72	79.20	11.91	258.41	116.26
131	1.57	-	10.94	8.57	5.49	35.02	0.61	8.01	5.81
132	0.58	2.76	10.18	1.50	2.11	2.54	0.10	2.00	5.60
133	1.73	4.33	29.38	10.47	10.16	5.77	0.83	10.02	9.81

134	5.74	3.69	13.12	31.26	5.77	10.52	1.63	20.03	14.05
135	3.66	10.23	5.32	27.56	3.18	3.12	1.99	-	7.86
136	7.16	43.37	21.24	62.22	14.26	228.85	18.44	36.14	30.82
137	14.44	139.46	4.92	84.70	4.03	74.07	12.31	30.05	25.63
138	0.03	-	1.90	2.68	0.48	0.67	0.19	2.00	1.54
139	7.71	25.93	13.40	122.65	10.80	54.49	10.46	24.04	27.29
140	18.58	38.79	16.82	73.94	8.41	51.43	8.38	46.07	28.19
141	13.83	87.19	16.21	1.94	4.03	51.59	4.52	68.11	16.71
142	42.92	186.70	37.48	99.52	7.46	69.58	11.34	96.15	82.18
143	8.09	47.28	9.22	35.57	2.66	18.14	4.89	62.10	11.07
144	8.76	2.46	12.51	66.22	10.05	26.30	3.87	30.05	22.88
145	3.12	3.67	23.38	184.08	21.16	147.03	20.45	10.06	41.63
146	7.00	3.24	7.14	58.99	8.42	13.93	5.01	14.02	12.34
147	25.59	105.14	13.46	672.96	22.20	255.28	60.95	16.07	97.91
148	14.28	4.06	4.27	83.13	6.02	36.11	8.48	14.02	11.66
149	14.60	15.20	6.14	82.29	4.75	16.21	7.02	10.02	10.97
150	40.72	270.02	8.05	195.85	9.90	115.98	28.92	188.56	53.98
151	18.39	117.09	22.22	87.94	17.18	131.19	12.87	20.03	52.79
152	6.36	0.93	14.10	50.82	4.16	14.85	3.56	28.04	14.26
153	4.62	6.67	3.46	16.47	2.30	25.58	1.72	10.02	8.05
154	6.54	0.99	2.79	32.89	2.13	5.55	1.74	2.00	9.16
155	2.02	1.18	4.78	14.92	2.62	8.40	0.63	4.01	7.29
156	5.23	3.24	2.25	33.33	2.70	7.29	2.86	-	7.51
157	4.62	4.83	9.71	25.48	4.86	7.07	1.47	-	6.81
158	0.80	-	8.96	4.20	1.96	0.95	0.34	2.00	3.09
159	1.67	14.53	3.12	48.72	6.74	19.51	3.68	12.02	20.95
160	10.45	32.85	3.71	23.80	6.41	87.90	6.31	-	18.59
161	8.30	18.42	9.56	16.86	7.16	17.21	5.06	2.00	13.31
162	7.50	2.49	8.69	37.02	6.00	15.33	1.88	-	12.53
163	8.92	25.98	6.57	42.68	5.29	13.53	1.86	14.02	11.37
164	3.72	1.11	13.17	18.92	7.49	15.66	0.87	-	12.04
165	7.03	0.77	49.02	73.25	21.66	21.41	4.88	-	30.91
166	10.83	14.33	6.19	61.04	2.98	5.84	3.50	-	7.77
167	6.73	4.14	6.21	28.41	7.88	10.68	1.53	-	8.71
168	5.32	9.09	3.51	17.22	3.38	13.99	1.59	6.01	7.50
169	5.74	4.21	27.53	49.71	7.30	5.59	3.61	8.01	17.61
170	5.71	7.44	7.67	51.12	6.96	31.72	4.05	28.04	18.59
171	5.13	12.31	12.55	17.46	4.19	13.76	1.32	-	12.33
172	6.76	12.79	5.27	35.00	5.90	14.81	2.34	18.03	18.28
173	2.50	1.72	2.40	17.45	3.44	6.76	1.02	-	4.34
174	6.67	11.60	7.23	35.45	7.53	22.09	1.47	-	21.98
175	0.87	4.89	9.31	238.35	11.89	61.36	18.82	-	47.91
176	3.62	2.07	3.21	166.45	7.99	51.12	13.79	-	25.42
177	2.63	0.85	3.01	13.31	2.43	1.60	0.95	8.01	6.40
178	1.38	-	1.50	14.39	1.41	1.81	0.51	-	2.78

179	7.63	9.32	6.09	50.88	6.17	9.67	3.83	-	14.23
180	4.08	14.41	21.68	54.75	14.32	11.50	3.86	12.02	20.79
181	0.90	12.57	0.10	2.14	1.09	1.46	0.87	-	2.19
182	4.07	2.09	4.51	17.93	3.89	11.79	2.01	6.01	12.22
183	8.21	5.44	6.87	42.89	8.25	8.15	3.41	8.01	12.20
184	5.13	50.34	8.64	51.12	12.22	20.41	5.00	4.01	36.18
185	12.92	17.74	4.69	42.76	4.47	72.26	3.59	2.00	14.16
186	4.71	13.84	11.63	5.17	6.85	18.04	2.00	-	14.68
187	8.99	67.07	17.02	43.11	16.63	61.91	4.12	28.04	25.55
188	2.53	103.96	5.24	48.62	13.23	77.86	5.39	-	32.13
189	15.71	64.73	4.66	85.34	6.13	14.63	6.26	-	47.29
190	12.74	27.40	1.71	72.40	2.26	50.24	6.42	12.02	21.63
191	12.55	123.13	11.12	10.00	10.77	95.33	4.99	-	25.90
192	3.50	14.19	4.75	30.57	5.39	5.78	3.66	22.04	19.62
193	5.45	0.70	13.09	29.78	10.89	5.91	1.74	-	14.00
194	8.56	4.16	9.85	45.64	17.29	43.14	2.49	16.03	14.45
195	4.10	1.98	2.77	26.94	2.60	27.57	1.58	-	5.14
196	3.30	1.23	3.28	24.93	5.88	6.22	1.17	-	8.98
197	3.21	0.28	6.64	16.76	9.63	4.66	1.02	-	11.81
198	4.20	3.37	15.36	12.60	9.70	3.85	0.82	8.01	12.92
199	6.28	6.00	0.70	36.58	4.91	20.36	2.83	-	13.11
200	2.79	0.51	11.59	23.51	11.15	4.89	1.15	4.01	6.66
201	2.31	2.46	1.93	16.95	8.67	5.13	0.84	4.01	9.71
202	0.67	13.61	36.57	11.85	25.86	6.92	1.28	-	16.07
203	3.53	4.59	5.74	16.97	5.19	5.63	0.88	-	8.70
204	2.76	19.06	15.01	12.45	7.22	8.28	1.31	-	19.05
205	0.96	2.19	11.07	10.25	3.26	2.31	0.38	2.00	13.99
206	3.97	2.05	12.15	18.52	6.84	4.76	1.16	16.03	21.19
207	1.44	4.08	2.52	8.21	3.95	6.21	0.54	10.02	18.67
208	1.22	6.50	2.80	5.70	5.17	4.76	0.56	-	9.06
209	1.80	4.41	5.34	9.90	3.23	22.40	0.46	6.01	6.36
210	0.61	1.28	0.88	1.87	1.52	15.91	0.11	-	3.16
211	10.07	16.30	19.19	22.87	13.02	13.59	1.31	16.03	21.29
212	0.42	-	0.70	5.95	3.58	1.51	0.23	2.00	4.58
213	6.93	15.23	18.79	48.02	9.30	9.17	2.09	-	16.16
214	0.06	0.31	0.30	0.83	2.06	0.12	0.07	-	1.39
215	9.74	4.51	5.67	56.81	12.08	15.01	3.38	-	21.07
216	9.53	10.89	7.25	80.13	6.27	13.55	5.41	8.01	23.56
217	7.40	2.72	23.63	47.95	20.08	13.23	2.50	-	29.57
218	15.17	27.86	6.13	86.65	4.84	68.96	5.98	32.05	28.95
219	7.08	8.19	16.47	35.83	9.01	25.63	1.78	2.00	12.30
220	2.54	-	0.47	23.44	5.13	9.83	1.43	8.01	8.57
221	33.27	45.00	13.65	126.17	20.73	63.71	7.85	-	34.49
222	3.65	1.18	2.47	23.29	5.24	3.33	1.53	-	13.26
223	2.18	2.12	4.34	11.85	2.93	3.31	0.87	-	7.36

224	1.41	10.99	3.79	33.81	3.39	9.74	1.84	-	10.06
225	17.24	19.95	3.25	61.30	15.60	11.93	3.63	-	36.13
226	1.41	2.32	1.01	16.90	6.34	22.37	1.56	-	12.43
227	6.00	3.05	2.68	27.57	6.42	15.32	2.28	-	13.95
228	9.46	18.86	14.99	34.98	6.81	9.59	2.98	-	20.78
229	10.64	13.01	9.07	61.12	13.72	17.96	2.36	-	18.97
230	4.07	-	4.77	35.83	4.67	17.72	1.28	-	9.28
231	9.27	19.09	6.10	68.19	10.51	14.33	4.60	-	17.28
232	27.60	79.79	0.98	85.28	21.42	125.16	8.53	20.03	69.20
233	14.16	173.50	14.72	3.63	13.66	35.46	8.15	-	44.04
234	19.87	29.24	17.02	59.73	14.29	35.12	6.49	-	35.86
235	6.48	13.31	1.79	6.82	4.31	8.99	2.08	-	11.83
236	3.34	2.33	2.64	34.54	3.41	6.05	2.01	-	10.05
237	20.13	75.61	20.99	69.36	14.55	23.11	6.76	-	36.96
238	6.61	12.78	6.20	29.40	4.59	23.47	1.45	14.02	8.43
239	6.76	2.62	10.60	30.14	14.11	6.97	2.45	-	21.56
240	3.33	1.88	22.85	59.23	9.53	10.57	4.65	-	18.61
241	0.83	-	13.05	14.16	4.65	0.96	0.80	-	5.09
242	41.17	92.25	3.50	51.29	5.38	98.78	4.04	300.48	28.87
243	2.41	0.31	12.00	24.13	12.30	3.55	1.41	-	16.21
244	7.09	24.37	9.63	27.91	13.53	21.76	1.62	-	16.71
245	14.14	77.51	11.54	34.01	15.00	46.54	3.33	-	30.10
246	1.09	6.29	14.65	43.71	9.27	12.56	2.11	6.01	16.03
247	5.29	8.67	12.11	36.22	9.78	19.92	2.39	2.00	24.67
248	17.79	39.44	5.99	45.42	7.07	26.07	4.44	10.02	20.60
249	9.88	13.34	4.42	58.83	7.70	54.34	3.76	-	30.28
250	20.22	41.35	13.70	114.86	12.72	88.72	6.28	72.12	49.85
251	6.10	7.49	2.20	35.54	3.27	10.01	2.30	12.02	13.63
252	19.39	40.42	5.57	74.67	5.85	11.58	5.52	-	26.40
253	15.67	23.88	8.99	70.03	12.35	24.79	5.82	2.00	31.22
254	3.27	4.26	3.20	19.75	4.30	3.08	1.30	-	9.17
255	5.39	7.82	18.70	33.61	11.97	7.92	2.19	-	15.08
256	5.96	0.91	10.05	25.97	8.73	6.29	1.53	-	10.15
257	-	2.63	14.98	43.77	16.34	10.86	2.61	10.02	19.21
258	11.89	9.95	9.29	50.61	5.47	3.59	2.59	4.01	13.84
259	2.18	-	1.20	16.70	3.14	2.78	1.00	-	4.93
260	10.77	0.97	1.97	77.16	5.16	12.75	3.67	-	20.04
261	11.22	1.52	8.72	83.42	12.37	18.55	4.02	-	17.98
262	7.56	1.91	4.39	35.29	5.86	11.81	2.20	-	8.35
263	16.81	3.04	9.19	101.65	13.11	76.68	3.15	-	32.17
264	16.60	0.69	2.84	53.36	2.70	53.24	1.02	-	28.23
265	7.69	-	2.24	36.37	2.57	31.51	0.92	-	12.24
266	20.27	3.14	8.24	272.63	6.48	22.67	7.68	-	45.33
267	11.31	0.14	0.09	68.14	0.14	24.91	1.43	-	15.19
268	19.09	1.38	1.69	122.03	10.12	33.67	5.10	-	30.67

269	25.91	3.46	5.58	121.60	18.05	57.90	3.87	16.03	33.25
270	19.91	7.99	2.91	161.74	17.63	82.92	5.35	-	42.65
271	35.71	-	3.20	214.77	5.68	47.27	7.03	-	52.48
272	11.09	2.97	4.33	139.52	14.43	33.59	5.80	-	28.05
273	23.56	7.02	4.02	133.91	2.39	38.50	2.90	-	30.82
274	26.19	2.23	9.03	150.75	8.63	72.82	5.29	-	88.65
275	33.27	0.51	3.64	194.70	4.08	57.64	5.33	-	51.14
276	23.75	13.52	5.47	111.94	4.00	27.23	2.45	-	26.00
277	23.75	4.05	8.62	123.82	23.32	37.16	4.27	-	34.16
278	24.59	7.88	6.40	206.27	4.02	60.36	6.56	-	43.24
279	39.01	5.00	0.27	188.07	12.74	100.29	6.29	-	32.63
280	0.01	4.74	1.28	225.50	3.59	46.35	7.89	4.01	38.89
281	0.16	6.88	1.92	102.93	10.64	54.95	3.46	-	27.32
282	4.68	7.87	8.06	75.33	3.43	16.94	2.59	-	14.95
283	16.73	1.32	7.38	89.47	12.00	80.99	2.45	-	24.21
284	10.71	1.97	9.47	80.65	6.46	100.51	1.32	-	31.80
285	8.08	1.25	0.66	47.04	2.03	16.49	1.63	-	7.47
286	-	-	6.49	80.24	9.28	95.96	0.46	-	16.88
287	0.10	1.10	0.96	0.79	7.71	6.09	0.03	-	7.77
288	2.28	5.77	0.52	15.55	15.26	29.39	0.46	-	17.32
289	0.35	-	0.26	1.24	4.05	2.57	-	-	8.08
290	3.62	12.72	2.73	13.55	3.57	11.77	0.20	-	7.11
291	0.61	4.87	1.29	3.01	1.79	3.96	0.15	-	5.38
292	2.34	12.70	7.27	13.10	6.85	202.71	0.26	8.01	18.72
293	1.48	0.56	5.16	18.16	2.29	1.99	1.05	-	7.60
294	0.74	0.41	0.51	6.43	1.63	4.50	0.42	-	3.89
295	1.51	0.14	2.49	6.51	1.44	0.27	0.29	-	3.51
296	2.79	1.11	12.67	22.55	12.90	3.54	0.87	-	18.39
297	0.58	17.02	0.50	0.09	10.99	2.59	0.33	-	10.31
298	-	12.66	0.09	4.06	2.12	2.98	0.33	-	2.97
299	-	0.15	0.12	1.99	2.99	13.40	0.06	-	9.23
300	0.06	1.24	0.12	0.48	0.94	9.35	0.06	-	3.60
301	0.29	2.30	0.28	-	4.15	0.61	0.07	-	6.83
302	0.26	0.58	1.14	1.72	1.62	2.20	0.02	-	2.07
303	25.38	5.68	2.12	144.19	4.38	75.54	7.70	-	21.60
304	15.10	2.86	6.06	85.74	3.18	23.85	3.51	-	19.60
305	17.60	13.18	9.50	124.14	10.58	70.04	4.48	-	34.48
306	10.46	3.67	0.54	75.92	2.01	23.66	5.41	-	13.55
307	11.12	-	2.10	83.35	7.14	21.09	4.94	-	12.80
308	5.10	0.69	1.90	88.95	10.05	36.59	3.47	38.06	14.86
309	11.54	43.33	21.41	38.19	9.95	5.29	2.20	-	10.38
310	3.31	0.28	14.08	15.53	8.36	46.25	1.74	-	10.30
311	7.82	5.80	27.23	31.66	10.28	7.67	2.16	-	15.16
312	5.04	2.47	3.15	30.62	3.24	3.15	0.92	-	5.67
313	1.99	0.92	8.28	12.14	1.52	6.02	1.23	-	5.83

314	0.58	1.42	0.31	0.88	0.10	0.03	-	-	5.74
315	5.26	6.71	9.29	8.50	7.27	2.85	0.36	-	21.99
316	7.38	34.74	21.68	7.84	19.94	27.76	0.99	18.03	37.59
317	13.04	107.04	14.64	-	5.86	69.41	2.92	64.10	43.94
318	6.38	26.20	13.82	63.13	11.66	13.96	2.36	16.05	22.81
319	7.19	11.51	19.96	28.39	33.84	6.36	2.34	4.01	18.80
320	4.59	17.32	18.95	105.45	25.69	54.76	6.05	-	40.71
321	2.31	8.49	24.95	32.58	14.14	8.11	1.87	8.01	11.18
322	7.05	3.10	3.23	29.39	3.58	2.81	1.53	-	12.97
323	1.41	5.14	1.96	4.38	4.25	1.66	0.49	4.01	3.09
324	0.83	1.79	4.30	8.05	5.86	3.47	0.39	2.00	6.18
325	2.05	1.54	3.70	13.37	5.30	4.03	0.41	6.01	4.53
326	0.96	14.56	4.30	0.49	3.57	20.51	0.36	-	5.52
327	1.44	0.56	1.41	17.70	1.39	1.01	1.19	-	4.48
328	15.80	41.19	10.01	70.69	6.84	7.53	10.83	-	20.33
329	5.07	9.14	3.19	44.18	3.70	19.04	3.55	24.04	8.96
330	14.95	27.60	11.71	90.60	9.45	35.23	6.11	18.03	29.27
331	11.28	6.90	7.67	51.58	11.72	15.11	3.37	24.04	13.21
332	1.28	0.82	7.63	10.04	2.44	0.98	0.73	4.01	6.29
333	0.22	2.21	3.97	10.40	2.81	2.34	0.58	-	4.35
334	-	70.11	3.74	29.30	15.09	11.64	1.89	-	24.80
335	0.64	2.36	0.27	1.25	0.82	2.55	0.15	6.01	1.66
336	7.15	45.60	13.79	32.72	13.88	17.10	1.83	46.07	17.83
337	2.24	13.63	5.61	0.24	2.37	2.20	0.77	-	3.90
338	1.76	1.05	3.04	7.50	3.66	0.28	0.38	-	4.45
339	1.60	15.29	4.58	-	1.79	17.89	0.43	4.01	9.49
340	4.81	16.02	6.74	22.82	6.58	9.91	1.00	-	11.07
341	2.56	0.54	5.60	16.20	3.34	3.72	0.89	-	11.09
342	6.12	6.11	17.27	23.90	4.30	5.91	1.17	-	10.55
343	7.72	7.96	4.44	32.71	4.04	8.24	1.82	-	12.63
344	13.79	18.87	48.56	61.83	14.00	21.49	4.50	-	39.51
345	1.22	0.77	4.40	9.38	4.30	6.15	0.92	2.00	10.37
346	0.32	1.04	4.34	13.21	3.07	4.72	0.66	-	5.82
347	2.05	3.44	6.11	19.96	2.15	25.73	0.77	4.01	8.96
348	-	53.01	10.82	12.53	6.65	16.69	0.89	-	16.92
349	5.14	29.42	20.38	0.70	10.28	55.89	4.04	26.04	17.03
350	9.78	33.10	8.33	1.17	4.00	67.13	2.91	28.04	16.32
351	1.63	10.39	3.77	-	3.20	1.78	0.67	2.00	10.42
352	8.59	9.56	21.67	43.17	9.08	15.78	2.08	42.07	22.76
353	4.71	11.46	23.51	12.06	4.50	37.95	1.61	12.02	13.86
354	4.62	10.86	14.80	47.14	7.94	14.69	3.53	10.02	16.68
355	5.51	2.60	22.49	28.39	6.48	12.72	1.74	14.02	15.79
356	5.71	11.47	6.90	31.10	5.33	21.32	2.25	-	17.48
357	3.34	3.08	8.83	23.47	3.01	16.61	1.39	10.02	5.40
358	12.41	30.15	6.84	64.47	11.45	7.41	4.75	32.05	31.63

359	5.71	10.26	15.38	17.90	9.00	14.12	1.58	6.01	12.66
360	9.76	22.58	3.78	33.46	4.10	13.01	4.06	52.08	18.45
361	2.31	10.67	1.65	21.56	2.14	4.31	1.72	-	12.17
362	4.46	6.02	15.47	14.39	17.51	2.97	0.61	-	7.20
363	9.91	39.27	3.35	32.43	4.15	19.34	3.58	-	18.11
364	7.05	3.07	3.41	44.19	5.56	23.60	2.80	-	15.26
365	6.55	3.27	4.89	51.81	4.25	6.51	4.32	-	14.93
366	28.90	60.82	14.26	124.88	24.78	41.30	10.01	-	78.56
367	4.11	6.20	2.96	17.93	5.54	18.64	1.56	6.01	10.55
368	2.73	3.18	5.10	11.92	2.86	4.41	1.74	8.01	12.72
369	3.81	1.25	6.27	30.37	6.44	1.71	1.63	-	10.64
370	2.95	26.71	6.95	7.66	12.79	16.15	0.77	34.99	8.67
371	6.16	8.59	9.95	30.92	4.63	5.18	2.38	-	8.17
372	9.11	0.97	4.92	59.57	11.02	39.81	4.19	-	20.17
373	6.45	10.11	1.09	26.31	2.28	8.47	2.15	-	9.55
374	0.99	29.06	10.79	32.71	4.49	12.62	2.79	34.05	7.68
375	10.87	58.58	3.08	116.56	3.66	17.36	7.50	-	27.54
376	13.35	38.54	2.36	70.84	5.54	23.76	5.26	12.02	23.52
377	40.71	45.41	3.99	107.88	6.77	88.31	7.52	-	30.66
378	15.77	1.66	8.82	109.96	13.05	31.94	9.81	-	50.60
379	1.19	62.56	14.67	67.05	14.92	10.72	5.21	-	25.92
380	6.38	2.34	6.11	46.62	7.05	2.82	3.36	2.00	11.19
381	14.73	34.14	8.82	91.07	8.01	30.13	4.81	-	36.45
382	4.65	21.87	5.84	47.53	6.43	21.73	2.76	-	27.18
383	5.42	13.00	5.83	25.22	5.49	23.01	2.23	8.01	12.58
384	4.43	5.19	1.39	27.69	6.46	19.74	2.33	-	12.22
385	14.65	24.71	8.34	68.86	6.95	11.16	3.64	-	33.02
386	1.99	1.74	3.54	13.95	4.82	7.53	0.97	-	5.07
387	8.49	3.17	10.73	47.34	11.99	17.58	2.80	4.01	17.45
388	4.23	0.30	8.76	31.99	4.75	5.62	1.69	-	10.16
389	27.02	82.99	14.48	145.53	13.95	21.33	11.24	-	55.48
390	-	2.70	21.35	72.05	21.41	35.58	5.08	-	23.31
391	1.79	1.54	16.41	9.21	11.59	4.66	0.77	-	9.40
392	2.89	8.04	2.33	32.95	9.30	14.00	2.04	2.00	12.47
393	7.53	6.94	0.82	6.07	2.02	39.85	2.46	-	8.35
394	10.13	1.71	4.62	45.29	5.19	31.64	2.96	-	20.34
395	16.44	13.72	6.63	53.07	5.22	68.89	3.46	-	20.94
396	14.39	14.28	15.22	28.38	9.39	27.88	2.55	-	22.14
397	5.71	2.44	3.40	36.71	5.42	33.74	1.28	-	24.52
398	2.24	11.53	6.91	8.37	4.79	5.55	1.19	10.02	24.72
399	4.81	3.91	11.51	24.53	6.21	9.93	1.97	-	34.84
400	17.08	260.42	3.92	58.86	6.05	25.46	3.88	-	18.05
401	8.50	7.72	11.60	48.25	9.16	8.26	3.06	2.00	24.10
402	5.36	7.65	11.07	41.10	10.78	19.11	2.08	-	13.85
403	64.65	251.08	8.03	94.05	12.77	28.34	9.87	-	51.65

404	0.19	-	1.08	14.63	3.42	6.56	0.81	-	2.92
405	8.59	3.64	14.23	51.51	14.61	15.45	3.44	4.01	26.43
406	11.19	41.11	3.44	28.10	8.71	25.84	2.85	8.01	13.15
407	24.01	88.11	4.61	12.40	7.68	51.65	7.10	-	41.31
408	5.77	8.99	6.10	66.27	9.39	21.54	4.44	-	23.57
409	59.81	57.08	4.75	136.78	8.65	23.55	22.51	-	48.70
410	3.01	17.26	13.07	15.29	10.62	24.28	0.92	2.00	12.14
411	8.17	7.32	4.12	39.23	7.56	33.94	2.81	-	12.55
412	5.81	9.68	4.23	19.78	8.18	17.82	3.27	2.00	12.35
413	11.81	7.58	7.60	50.69	5.10	12.51	3.83	-	11.35
414	10.07	2.37	2.29	60.11	4.95	16.14	4.50	-	12.10
415	22.15	4.89	4.78	95.06	4.86	17.41	7.61	-	21.34
416	8.82	11.73	5.63	55.44	6.22	22.70	3.68	16.03	11.86
417	14.20	1.63	1.69	65.55	9.28	12.32	4.90	-	31.49
418	2.95	-	2.64	21.98	2.69	27.77	2.09	-	4.30
419	11.73	4.85	3.19	54.46	9.99	27.67	4.34	-	23.19
420	8.30	30.40	2.86	31.28	5.32	39.66	3.84	-	31.25
421	0.77	5.64	1.86	47.19	4.58	27.92	4.50	-	28.73
422	4.68	10.39	4.05	16.57	1.39	6.17	1.48	14.02	14.02
423	6.03	2.69	2.81	32.01	4.34	7.76	1.58	-	17.06
424	7.95	4.75	21.67	37.99	9.60	20.70	1.79	16.03	15.86
425	6.83	5.58	2.95	29.00	1.65	10.65	1.74	-	8.91
426	6.03	3.95	4.30	41.64	3.60	17.26	2.28	12.02	7.96
427	4.39	6.10	3.29	31.29	4.16	20.69	2.09	16.03	12.64
428	4.07	14.51	1.77	14.99	2.80	24.12	1.69	24.04	6.05
429	2.76	2.19	2.71	19.19	3.08	7.30	1.28	14.02	9.74
430	33.14	143.67	15.59	34.54	4.18	46.51	4.75	4.01	32.64
431	7.85	-	1.62	39.12	1.62	10.92	2.96	-	18.58
432	3.91	2.11	4.65	32.83	2.45	7.57	1.66	14.02	12.36
433	0.19	0.39	3.80	1.11	1.62	5.06	0.05	4.01	6.90
434	24.55	71.53	9.53	83.28	4.82	148.87	8.48	10.02	77.20
435	4.05	0.74	2.26	21.71	1.69	86.64	4.70	-	7.89
436	19.47	17.77	5.36	84.12	6.96	74.34	5.67	66.11	34.75
437	8.46	3.57	4.12	51.53	3.76	8.62	3.42	14.02	9.13
438	4.82	2.70	19.29	40.48	5.63	12.35	3.22	40.06	10.91
439	22.45	11.37	13.43	120.71	8.62	22.46	5.62	-	27.88
440	8.28	17.76	1.69	48.76	3.48	46.17	2.66	-	15.64
441	27.27	3.84	1.70	72.78	4.72	114.62	7.97	-	29.86
442	12.25	16.97	5.56	59.09	2.88	19.43	4.34	10.02	21.05
443	8.08	2.37	17.85	50.95	8.69	18.55	2.82	-	19.13
444	5.90	0.14	4.88	45.98	7.48	13.66	3.12	-	14.57
445	9.05	3.25	5.44	61.60	7.72	12.73	3.73	34.05	15.05
446	2.76	2.54	1.86	20.06	5.33	15.04	0.92	6.01	14.03
447	17.80	12.41	10.30	112.37	9.99	17.73	6.69	34.05	31.68
448	14.47	6.31	7.59	72.02	7.07	29.59	3.91	-	17.62

449	8.31	4.41	4.32	55.58	6.28	14.12	4.04	10.02	19.24
450	1.19	1.28	3.69	42.65	2.95	17.10	1.79	-	13.35
451	15.36	4.43	1.69	83.37	4.77	53.53	4.55	-	19.88
452	10.78	1.28	18.07	63.87	9.51	21.42	3.42	32.05	33.94
453	20.09	43.92	1.61	56.85	3.15	66.01	3.68	130.21	23.32
454	7.09	4.45	2.45	42.90	2.06	10.15	1.79	24.04	17.40
455	11.00	1.30	4.88	55.94	1.82	8.12	3.47	-	10.56
456	19.95	32.22	3.73	74.48	8.02	42.64	8.07	-	28.47
457	11.52	6.33	18.84	93.05	12.12	37.29	5.02	54.09	30.44
458	18.40	56.36	20.02	41.70	13.41	49.69	6.33	42.07	43.80
459	24.22	10.74	5.03	142.50	9.17	29.38	8.22	-	52.79
460	3.91	3.56	7.79	21.08	9.22	32.71	0.99	12.02	12.02
461	0.55	5.81	3.88	5.16	4.83	52.28	0.41	10.02	11.26
462	2.37	1.12	9.07	12.85	7.87	22.32	0.44	-	7.46
463	1.54	1.93	5.83	12.34	4.43	1.42	0.49	-	17.40
464	1.47	4.44	2.37	4.85	2.97	29.61	0.05	-	6.55
465	1.86	5.27	6.06	13.43	6.03	3.93	0.44	-	14.02
466	0.26	0.31	2.72	0.09	2.30	0.22	-	-	2.17
467	1.06	0.97	7.07	9.08	4.94	29.57	0.61	10.02	7.17
468	2.15	1.01	10.31	9.50	4.56	9.90	0.58	4.01	8.94
469	1.83	1.49	4.42	10.11	4.93	20.26	0.35	2.00	6.00
470	5.45	9.18	13.69	16.42	5.70	7.46	1.23	-	15.16
471	1.67	0.62	7.89	10.24	4.86	21.68	0.31	-	14.49
472	3.49	5.98	7.25	8.39	6.89	15.03	0.29	-	16.20
473	0.67	0.91	4.48	3.57	3.66	0.24	0.17	-	6.93
474	1.19	1.53	4.64	11.96	4.17	0.98	1.16	-	8.80
475	2.69	0.14	8.15	17.05	4.82	3.61	0.74	4.01	8.74
476	1.25	1.25	25.10	8.39	16.48	31.16	0.52	2.00	18.55
477	0.77	1.01	6.46	8.28	5.94	9.90	0.43	-	5.44
478	0.58	-	5.58	1.95	7.13	1.52	0.10	-	4.36
479	4.71	9.64	6.51	18.16	10.12	9.99	0.79	2.00	5.72
480	0.64	0.15	1.87	6.83	1.60	2.32	0.32	-	2.77
481	0.99	0.65	1.74	4.16	3.97	1.39	0.20	-	4.07
482	5.42	0.51	1.80	7.31	4.46	1.45	0.32	-	13.10
483	2.60	0.45	1.12	15.98	10.08	12.40	0.75	-	12.91
484	1.41	0.14	5.56	6.37	3.67	3.31	0.36	-	5.49
485	0.64	0.98	4.89	4.61	3.66	2.50	0.21	-	6.20
486	-	0.74	2.08	0.82	2.96	0.55	0.03	-	3.66
487	0.03	-	1.40	0.19	2.37	0.02	0.04	-	2.20
488	0.35	0.70	1.70	1.89	1.55	0.15	0.01	-	2.30
489	-	-	1.03	-	1.52	0.00	-	-	3.34
490	-	-	0.79	0.09	1.39	0.97	0.01	-	1.51
491	0.03	0.65	0.67	1.21	8.45	1.32	0.03	-	11.91
492	0.48	2.76	5.65	13.71	9.40	17.39	0.46	-	14.27
493	1.22	-	5.70	7.67	8.73	2.12	0.35	-	8.75

494	1.03	1.16	0.62	10.96	2.66	1.01	0.69	-	4.89
495	0.22	1.21	2.32	1.07	12.02	0.84	0.03	2.00	9.05
496	0.06	0.31	0.63	1.14	1.47	9.80	0.02	2.00	3.16
497	-	0.31	4.16	0.48	3.19	1.37	0.02	-	3.87
498	0.13	-	6.84	1.80	1.87	0.36	0.05	-	3.77
499	6.48	8.09	5.87	29.51	16.14	11.69	1.32	-	26.91
500	4.14	17.38	10.49	20.64	11.27	6.21	0.73	18.03	21.95
501	0.93	5.41	2.21	8.31	3.42	0.83	0.64	-	8.86
502	3.62	9.51	8.62	18.42	9.18	7.00	0.84	14.02	24.51
503	2.89	2.63	20.12	21.39	4.60	6.69	0.77	-	10.88
504	0.29	2.91	9.58	6.38	7.64	3.03	0.32	2.00	6.87
505	0.67	0.28	12.24	2.84	10.97	11.78	0.14	-	7.57
506	2.98	0.69	5.07	22.45	6.27	9.26	1.48	10.02	16.27
507	2.05	3.30	7.94	9.39	5.97	2.99	0.68	-	8.00
508	11.35	71.50	0.25	27.11	12.60	10.81	1.74	-	23.13
509	6.73	37.79	5.36	15.20	7.59	11.21	1.35	12.02	18.38
510	0.96	0.56	3.99	5.31	8.84	1.17	0.31	-	10.98
511	0.29	0.69	3.73	2.08	3.58	0.94	0.10	-	3.69
512	1.89	1.18	7.94	10.87	4.25	1.31	0.52	-	8.23
513	3.94	3.67	1.64	14.50	4.11	3.90	0.66	2.00	7.25
514	0.06	-	2.67	2.07	3.58	1.49	0.10	-	2.34
515	4.01	4.89	17.45	12.27	18.74	29.06	0.51	-	10.23
516	2.82	9.33	0.33	10.38	6.03	0.73	0.72	-	8.27
517	3.05	4.90	8.31	21.30	4.14	22.22	0.96	4.01	11.42
518	2.12	1.54	18.47	22.44	10.58	13.43	0.97	4.01	11.85
519	-	-	2.53	2.88	5.03	0.31	0.07	-	2.52
520	0.35	-	4.90	1.77	13.47	0.48	0.05	-	8.14
521	0.19	0.97	1.03	1.33	1.75	6.24	0.07	-	2.51
522	0.64	0.28	6.65	3.02	19.92	20.18	0.08	-	10.94
523	0.93	4.75	4.22	0.83	5.69	1.00	0.02	-	6.68
524	0.74	8.90	2.80	6.41	5.82	2.15	0.11	-	11.16
525	3.62	31.13	4.72	-	4.35	30.61	0.46	2.00	6.26
526	1.54	6.78	4.18	3.73	7.66	19.26	0.44	10.02	7.48
527	0.19	0.31	1.15	1.20	1.92	0.24	0.07	2.00	3.08
528	3.79	11.37	19.22	8.60	14.39	9.05	0.81	18.03	44.80
529	-	3.18	10.48	23.72	5.45	2.75	1.28	-	12.20
530	9.30	61.80	9.71	11.36	17.24	17.54	2.46	6.01	20.47
531	4.39	6.29	5.86	22.41	9.11	3.90	1.33	-	15.72
532	-	-	3.78	16.58	61.57	231.98	0.01	-	269.34

Appendix B: Delivery routes to the repair vendors

Repair Vendor	Region	Route Number
1	ADANA	Route 1
2	ADANA	Route 1
3	ADANA	Route 1
4	ADANA	Route 1
5	ADANA	Route 1
6	ADANA	Route 1
7	ADANA	Route 2
8	ADANA	Route 2
9	ADANA	Route 2
10	ADANA	Route 2
11	ADANA	Route 2
12	ADANA	Route 2
13	ADANA	Route 3
14	ADANA	Route 3
15	ADANA	Route 3
16	ADANA	Route 4
17	ADANA	Route 4
18	ADANA	Route 4
19	ADANA	Route 4
20	ADANA	Route 4
21	ADANA	Route 4
22	ADANA	Route 4
23	ADANA	Route 5
24	ADANA	Route 5
25	ADANA	Route 5
26	ADANA	Route 5
27	ADANA	Route 5
28	ADANA	Route 5
29	ADANA	Route 5
30	ADANA	Route 5
31	ADANA	Route 5
32	ADANA	Route 6
33	ADANA	Route 6
34	ADANA	Route 6
35	ADANA	Route 6
36	ADANA	Route 7
37	ADANA	Route 7
38	ADANA	Route 7
39	ADANA	Route 7
40	ADANA	Route 7
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315	ESKİŞEHİR	Route 48
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412	İSTANBUL	Route 54
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414	İZMİR	Route 55
415	İZMİR	Route 55
416	İZMİR	Route 55
417	İZMİR	Route 55
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419	İZMİR	Route 55
420	İZMİR	Route 56
421	İZMİR	Route 56
422	İZMİR	Route 57
423	İZMİR	Route 57
424	İZMİR	Route 57
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430	İZMİR	Route 58
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457	İZMİR	Route 61
458	İZMİR	Route 61
459	İZMİR	Route 61
460	SAMSUN	Route 62
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526	SAMSUN	Route 71
527	SAMSUN	Route 71
528	SAMSUN	Route 72
529	SAMSUN	Route 72
530	SAMSUN	Route 72
531	SAMSUN	Route 72
532	İSTANBUL	Route 73

Appendix C: The calculated distances

	Route 27	Route 32	Route 34	Route 40	Route 54	Route 61
Distribution Center	1,234	203	422	251	1,105	1,569
Adana	1,093	844	1,588	6,056	11,975	2,733
Ankara	928	408	782	2,731	5,785	1,797
Antalya	39	579	1,058	4,411	8,920	1,417
Bursa	1,036	100	52	1,443	3,406	1,053
Elazığ	2,059	1,165	2,232	7,736	15,093	3,858
Eskişehir	808	224	350	1,772	4,017	1,308
İzmir	874	413	658	3,592	6,285	132
Samsun	1,748	764	1,548	4,992	9,999	3,078
Aydın	680	533	842	4,236	7,611	385
Çanakkale	1,342	365	564	2,414	2,437	982
Denizli	444	470	814	3,767	7,722	762
Diyarbakır	2,123	1,296	2,494	8,758	16,993	4,242
Erzurum	2,459	1,247	2,514	8,373	16,278	4,404
Gaziantep	1,511	1,049	1,998	7,337	14,339	3,357
Kayseri	1,209	7,331	1,364	4,992	9,997	2,559
Konya	603	537	976	3,970	8,101	1,731
Malatya	1,845	1,063	2,028	7,162	14,027	3,543
Manisa	844	380	592	3,361	5,895	207
Ordu	2,015	899	1,818	5,937	11,754	3,483
Sakarya	1,132	174	370	855	2,301	1,524
Şanlıurfa	1,787	1,180	2,260	8,135	15,821	3,771
Trabzon	2,365	1,074	2,168	7,162	14,027	4,011
Van	2,787	1,509	3,040	10,214	19,682	5,127

Appendix D: Calculated operating and opening costs of the facilities

Facility	Operating Costs (TL)	Opening Cost (TL)
Distribution Center	19,4654.44	0
Adana	5,198.05	0
Ankara	4,489.61	0
Antalya	9,158.46	0
Bursa	9,356.48	0
Elazığ	4,499.72	0
Eskişehir	2,730.17	0
İzmir	5,364.27	0
Samsun	3,791.90	0
Aydın	7,343.27	1,000
Çanakkale	7,343.27	1,000
Denizli	7,343.27	1,000
Diyarbakır	7,343.27	1,000
Erzurum	7,343.27	1,000
Gaziantep	7,343.27	1,000
Kayseri	7,343.27	1,000
Konya	7,343.27	1,000
Malatya	7,343.27	1,000
Manisa	7,343.27	1,000
Ordu	7,343.27	1,000
Sakarya	7,343.27	1,000
Şanlıurfa	7,343.27	1,000
Trabzon	7,343.27	1,000
Van	7,343.27	1,000

Appendix E: Freight service costs which is provided by the company

Volumetric Unit	0-200 km	200 - 600 km	600 - 1.000 km	1.000 km ++
1	2.26	2.57	2.65	2.79
2	2.42	2.65	2.81	2.96
3	2.65	2.96	3.11	3.27
4	2.88	3.27	3.43	3.59
5	3.11	3.59	3.74	3.89
6	3.36	3.82	3.97	4.13
7	3.59	4.13	4.29	4.44
8	3.82	4.37	4.6	4.75
9	4.05	4.68	4.83	4.98
10	4.29	4.91	5.06	5.23
11	4.44	4.98	5.14	5.3
12	4.6	5.06	5.23	5.38
13	4.75	5.14	5.3	5.46
14	4.91	5.23	5.38	5.53
15	5.06	5.3	5.46	5.61
16	5.23	5.38	5.53	5.69
17	5.38	5.53	5.61	5.76
18	5.53	5.69	5.76	5.84
19	5.69	5.76	5.84	5.92
20	5.84	5.92	6	6.07
21	6.07	6.15	6.24	6.31
22	6.31	6.39	6.47	6.55
23	6.55	6.62	6.7	6.78
24	6.78	6.85	6.93	7.01
25	7.01	7.08	7.17	7.25
26	7.25	7.33	7.38	7.44
27	7.48	7.56	7.63	7.71
28	7.71	7.79	7.87	7.94
29	7.94	8.02	8.11	8.18
30	8.18	8.26	8.34	8.42
31	8.42	8.49	8.57	8.65
32	8.65	8.72	8.8	8.88
33	8.88	8.95	9.04	9.12
34	9.12	9.2	9.27	9.35
35	9.35	9.43	9.5	9.58
36	9.58	9.66	9.74	9.81
37	9.81	9.89	9.98	10.05
38	10.05	10.13	10.21	10.29
39	10.29	10.36	10.45	10.53
40	10.52	10.59	10.67	10.75
41	10.75	10.82	10.9	10.99

42	10.9	10.99	11.07	11.14
43	11.14	11.22	11.3	11.37
44	11.37	11.45	11.53	11.61
45	11.61	11.68	11.76	11.84
46	11.84	11.92	12	12.08
47	12.08	12.16	12.23	12.31
48	12.31	12.39	12.46	12.54
49	12.54	12.62	12.69	12.77
50	12.77	12.86	12.94	13.01
51	13.01	13.09	13.17	13.24
52	13.24	13.32	13.4	13.48
53	13.48	13.55	13.63	13.71
54	13.71	13.79	13.87	13.95
55	13.95	14.03	14.1	14.18
56	14.18	14.26	14.33	14.41
57	14.41	14.49	14.56	14.64
58	14.64	14.73	14.81	14.88
59	14.88	14.96	15.04	15.11
60	15.11	15.19	15.27	15.35
61	15.35	15.42	15.5	15.58
62	15.58	15.66	15.74	15.82
63	15.82	15.9	15.97	16.05
64	16.05	16.13	16.2	16.28
65	16.28	16.36	16.43	16.51
66	16.51	16.59	16.68	16.75
67	16.75	16.83	16.91	16.98
68	16.98	17.06	17.14	17.22
69	17.22	17.29	17.37	17.45
70	17.45	17.52	17.61	17.69
71	17.69	17.77	17.84	17.92
72	17.92	18	18.07	18.15
73	18.15	18.23	18.3	18.38
74	18.38	18.46	18.55	18.62
75	18.62	18.7	18.78	18.85
76	18.85	18.93	19.01	19.09
77	19.09	19.16	19.24	19.32
78	19.32	19.39	19.48	19.56
79	19.56	19.64	19.71	19.79
80	19.79	19.87	19.94	20.02
81	20.02	20.1	20.17	20.25
82	20.25	20.33	20.42	20.49
83	20.49	20.57	20.65	20.72
84	20.72	20.8	20.88	20.96
85	20.96	21.03	21.11	21.19
86	21.19	21.26	21.34	21.43

87	21.43	21.51	21.58	21.66
88	21.66	21.74	21.81	21.89
89	21.89	21.97	22.04	22.12
90	22.12	22.2	22.28	22.36
91	22.36	22.44	22.52	22.59
92	22.59	22.67	22.75	22.83
93	22.83	22.9	22.98	23.06
94	23.06	23.13	23.21	23.3
95	23.3	23.38	23.45	23.53
96	23.53	23.61	23.68	23.76
97	23.76	23.84	23.91	23.99
98	23.99	24.07	24.15	24.23
99	24.23	24.31	24.39	24.46
100	24.46	24.54	24.62	24.77
100+ additional	0.23	0.24	0.25	0.26

Appendix F: Scenario 1: Detailed assignments of facilities to the repair vendors

Origin	Origin Description	Destination Route Number
82	Adana	1
82	Adana	2
82	Adana	3
82	Adana	4
82	Adana	5
82	Adana	6
82	Adana	7
82	Adana	8
82	Adana	9
82	Adana	10
83	Ankara	11
83	Ankara	12
83	Ankara	13
83	Ankara	14
83	Ankara	15
83	Ankara	16
83	Ankara	17
83	Ankara	18
83	Ankara	19
84	Antalya	20
84	Antalya	21
84	Antalya	22
84	Antalya	23
84	Antalya	24
84	Antalya	25
84	Antalya	26
84	Antalya	27
85	Bursa	28
85	Bursa	29
85	Bursa	30
85	Bursa	31
85	Bursa	32
85	Bursa	33
85	Bursa	34
81	Distribution Center	35
81	Distribution Center	36
81	Distribution Center	37
81	Distribution Center	38
81	Distribution Center	39
81	Distribution Center	40
86	Elazığ	41
86	Elazığ	42
86	Elazığ	43
86	Elazığ	44
86	Elazığ	45
86	Elazığ	46
86	Elazığ	47
87	Eskişehir	48
87	Eskişehir	49
87	Eskişehir	50
87	Eskişehir	51
81	Distribution Center	52
81	Distribution Center	53
81	Distribution Center	54
88	İzmir	55
88	İzmir	56
88	İzmir	57
88	İzmir	58
88	İzmir	59
88	İzmir	60
88	İzmir	61
89	Samsun	62
89	Samsun	63
89	Samsun	64
89	Samsun	65
89	Samsun	66
89	Samsun	67
89	Samsun	68
89	Samsun	69
89	Samsun	70
89	Samsun	71
89	Samsun	72
81	Distribution Center	73

Appendix G: Scenario 2: Detailed assignments of facilities to the repair vendors

Origin	Origin Description	Destination Route Number
82	Adana	1
82	Adana	2
82	Adana	3
82	Adana	4
82	Adana	5
82	Adana	6
82	Adana	7
82	Adana	8
82	Adana	9
82	Adana	10
81	Distribution Center	11
81	Distribution Center	12
82	Adana	13
81	Distribution Center	14
89	Samsun	15
82	Adana	16
82	Adana	17
82	Adana	18
81	Distribution Center	19
88	İzmir	20
82	Adana	21
88	İzmir	22
88	İzmir	23
88	İzmir	24
82	Adana	25
88	İzmir	26
88	İzmir	27
88	İzmir	28
88	İzmir	29
81	Distribution Center	30
81	Distribution Center	31
81	Distribution Center	32
88	İzmir	33
81	Distribution Center	34
81	Distribution Center	35
81	Distribution Center	36
81	Distribution Center	37
81	Distribution Center	38
81	Distribution Center	39
81	Distribution Center	40
82	Adana	41
82	Adana	42
82	Adana	43
82	Adana	44
82	Adana	45
82	Adana	46
89	Samsun	47
81	Distribution Center	48
81	Distribution Center	49
88	İzmir	50
81	Distribution Center	51
81	Distribution Center	52
81	Distribution Center	53
81	Distribution Center	54
88	İzmir	55
88	İzmir	56
88	İzmir	57
88	İzmir	58
88	İzmir	59
88	İzmir	60
88	İzmir	61
89	Samsun	62
89	Samsun	63
89	Samsun	64
89	Samsun	65
89	Samsun	66
89	Samsun	67
89	Samsun	68
89	Samsun	69
89	Samsun	70
89	Samsun	71
89	Samsun	72
81	Distribution Center	73

Appendix H: Scenario 3: Detailed assignments of facilities to the repair vendors

Origin	Origin Description	Destination Repair Vendor Number
82	Adana	1
82	Adana	2
82	Adana	3
82	Adana	4
82	Adana	5
82	Adana	6
82	Adana	7
82	Adana	8
82	Adana	9
82	Adana	10
82	Adana	11
82	Adana	12
82	Adana	13
82	Adana	14
82	Adana	15
82	Adana	16
93	Diyarbakır	17
93	Diyarbakır	18
93	Diyarbakır	19
93	Diyarbakır	20
93	Diyarbakır	21
93	Diyarbakır	22
82	Adana	23
82	Adana	24
82	Adana	25
82	Adana	26
82	Adana	27
82	Adana	28
82	Adana	29
82	Adana	30
82	Adana	31
82	Adana	32
82	Adana	33
82	Adana	34
82	Adana	35
82	Adana	36
82	Adana	37
82	Adana	38
82	Adana	39
82	Adana	40
82	Adana	41
82	Adana	42
82	Adana	43
82	Adana	44
82	Adana	45
82	Adana	46
82	Adana	47
82	Adana	48
82	Adana	49
82	Adana	50
82	Adana	51
82	Adana	52
82	Adana	53
82	Adana	54
82	Adana	55
82	Adana	56
82	Adana	57
82	Adana	58
83	Ankara	59
83	Ankara	60
83	Ankara	61
89	Samsun	62
83	Ankara	63
83	Ankara	64
83	Ankara	65
87	Eskişehir	66
83	Ankara	67
82	Adana	68
82	Adana	69
82	Adana	70
82	Adana	71
83	Ankara	72
83	Ankara	73
83	Ankara	74
83	Ankara	75
83	Ankara	76
83	Ankara	77
83	Ankara	78
83	Ankara	79
83	Ankara	80
83	Ankara	81
83	Ankara	82
83	Ankara	83

83	Ankara	84
83	Ankara	85
83	Ankara	86
83	Ankara	87
83	Ankara	88
83	Ankara	89
89	Samsun	90
89	Samsun	91
89	Samsun	92
89	Samsun	93
82	Adana	94
83	Ankara	95
82	Adana	96
82	Adana	97
83	Ankara	98
83	Ankara	99
83	Ankara	100
83	Ankara	101
83	Ankara	102
83	Ankara	103
83	Ankara	104
83	Ankara	105
83	Ankara	106
83	Ankara	107
83	Ankara	108
83	Ankara	109
83	Ankara	110
83	Ankara	111
83	Ankara	112
83	Ankara	113
84	Antalya	114
84	Antalya	115
84	Antalya	116
84	Antalya	117
84	Antalya	118
84	Antalya	119
84	Antalya	120
84	Antalya	121
84	Antalya	122
84	Antalya	123
84	Antalya	124
84	Antalya	125
84	Antalya	126
84	Antalya	127
88	İzmir	128
88	İzmir	129
88	İzmir	130
84	Antalya	131
84	Antalya	132
84	Antalya	133
84	Antalya	134
84	Antalya	135
84	Antalya	136
84	Antalya	137
84	Antalya	138
84	Antalya	139
84	Antalya	140
88	İzmir	141
88	İzmir	142
88	İzmir	143
88	İzmir	144
84	Antalya	145
84	Antalya	146
84	Antalya	147
84	Antalya	148
84	Antalya	149
84	Antalya	150
88	İzmir	151
88	İzmir	152
88	İzmir	153
88	İzmir	154
88	İzmir	155
88	İzmir	156
88	İzmir	157
88	İzmir	158
88	İzmir	159
88	İzmir	160
88	İzmir	161
81	Distribution Center	162
81	Distribution Center	163
81	Distribution Center	164
81	Distribution Center	165
81	Distribution Center	166
81	Distribution Center	167
81	Distribution Center	168
81	Distribution Center	169
81	Distribution Center	170
88	İzmir	171
87	Eskişehir	172
87	Eskişehir	173

87	Eskişehir	174
87	Eskişehir	175
87	Eskişehir	176
87	Eskişehir	177
81	Distribution Center	178
88	İzmir	179
88	İzmir	180
88	İzmir	181
81	Distribution Center	182
87	Eskişehir	183
87	Eskişehir	184
87	Eskişehir	185
87	Eskişehir	186
87	Eskişehir	187
87	Eskişehir	188
87	Eskişehir	189
87	Eskişehir	190
87	Eskişehir	191
87	Eskişehir	192
81	Distribution Center	193
81	Distribution Center	194
81	Distribution Center	195
81	Distribution Center	196
81	Distribution Center	197
81	Distribution Center	198
81	Distribution Center	199
81	Distribution Center	200
81	Distribution Center	201
81	Distribution Center	202
81	Distribution Center	203
83	Ankara	204
83	Ankara	205
83	Ankara	206
83	Ankara	207
83	Ankara	208
83	Ankara	209
83	Ankara	210
83	Ankara	211
83	Ankara	212
83	Ankara	213
83	Ankara	214
81	Distribution Center	215
81	Distribution Center	216
81	Distribution Center	217
81	Distribution Center	218

81	Distribution Center	219
81	Distribution Center	220
81	Distribution Center	221
81	Distribution Center	222
81	Distribution Center	223
81	Distribution Center	224
81	Distribution Center	225
81	Distribution Center	226
81	Distribution Center	227
81	Distribution Center	228
81	Distribution Center	229
81	Distribution Center	230
81	Distribution Center	231
81	Distribution Center	232
81	Distribution Center	233
81	Distribution Center	234
81	Distribution Center	235
81	Distribution Center	236
81	Distribution Center	237
81	Distribution Center	238
81	Distribution Center	239
81	Distribution Center	240
81	Distribution Center	241
81	Distribution Center	242
81	Distribution Center	243
81	Distribution Center	244
81	Distribution Center	245
81	Distribution Center	246
81	Distribution Center	247
81	Distribution Center	248
81	Distribution Center	249
81	Distribution Center	250
81	Distribution Center	251
81	Distribution Center	252
81	Distribution Center	253
81	Distribution Center	254
93	Diyarbakır	255
93	Diyarbakır	256
93	Diyarbakır	257
93	Diyarbakır	258
82	Adana	259
93	Diyarbakır	260
93	Diyarbakır	261
93	Diyarbakır	262
93	Diyarbakır	263

93	Diyarbakır	264
93	Diyarbakır	265
93	Diyarbakır	266
93	Diyarbakır	267
93	Diyarbakır	268
93	Diyarbakır	269
93	Diyarbakır	270
93	Diyarbakır	271
93	Diyarbakır	272
93	Diyarbakır	273
93	Diyarbakır	274
93	Diyarbakır	275
93	Diyarbakır	276
93	Diyarbakır	277
93	Diyarbakır	278
93	Diyarbakır	279
93	Diyarbakır	280
93	Diyarbakır	281
93	Diyarbakır	282
93	Diyarbakır	283
93	Diyarbakır	284
93	Diyarbakır	285
93	Diyarbakır	286
93	Diyarbakır	287
93	Diyarbakır	288
93	Diyarbakır	289
93	Diyarbakır	290
93	Diyarbakır	291
93	Diyarbakır	292
93	Diyarbakır	293
93	Diyarbakır	294
93	Diyarbakır	295
93	Diyarbakır	296
93	Diyarbakır	297
93	Diyarbakır	298
94	Erzurum	299
94	Erzurum	300
94	Erzurum	301
94	Erzurum	302
93	Diyarbakır	303
93	Diyarbakır	304
93	Diyarbakır	305
93	Diyarbakır	306
93	Diyarbakır	307
93	Diyarbakır	308

93	Diyarbakır	309
93	Diyarbakır	310
93	Diyarbakır	311
93	Diyarbakır	312
93	Diyarbakır	313
87	Eskişehir	314
87	Eskişehir	315
87	Eskişehir	316
87	Eskişehir	317
87	Eskişehir	318
83	Ankara	319
83	Ankara	320
83	Ankara	321
83	Ankara	322
83	Ankara	323
87	Eskişehir	324
87	Eskişehir	325
87	Eskişehir	326
87	Eskişehir	327
88	İzmir	328
88	İzmir	329
88	İzmir	330
88	İzmir	331
84	Antalya	332
84	Antalya	333
87	Eskişehir	334
87	Eskişehir	335
88	İzmir	336
87	Eskişehir	337
87	Eskişehir	338
87	Eskişehir	339
87	Eskişehir	340
81	Distribution Center	341
81	Distribution Center	342
81	Distribution Center	343
81	Distribution Center	344
81	Distribution Center	345
81	Distribution Center	346
81	Distribution Center	347
81	Distribution Center	348
81	Distribution Center	349
81	Distribution Center	350
81	Distribution Center	351
81	Distribution Center	352
81	Distribution Center	353

81	Distribution Center	354
81	Distribution Center	355
81	Distribution Center	356
81	Distribution Center	357
81	Distribution Center	358
81	Distribution Center	359
81	Distribution Center	360
81	Distribution Center	361
81	Distribution Center	362
81	Distribution Center	363
81	Distribution Center	364
81	Distribution Center	365
81	Distribution Center	366
81	Distribution Center	367
81	Distribution Center	368
81	Distribution Center	369
81	Distribution Center	370
81	Distribution Center	371
81	Distribution Center	372
81	Distribution Center	373
81	Distribution Center	374
81	Distribution Center	375
81	Distribution Center	376
81	Distribution Center	377
81	Distribution Center	378
81	Distribution Center	379
81	Distribution Center	380
81	Distribution Center	381
81	Distribution Center	382
81	Distribution Center	383
81	Distribution Center	384
81	Distribution Center	385
81	Distribution Center	386
81	Distribution Center	387
81	Distribution Center	388
81	Distribution Center	389
81	Distribution Center	390
81	Distribution Center	391
81	Distribution Center	392
81	Distribution Center	393
81	Distribution Center	394
81	Distribution Center	395
81	Distribution Center	396
81	Distribution Center	397
81	Distribution Center	398
81	Distribution Center	399
81	Distribution Center	400
81	Distribution Center	401
81	Distribution Center	402
81	Distribution Center	403
81	Distribution Center	404
81	Distribution Center	405
81	Distribution Center	406
81	Distribution Center	407
81	Distribution Center	408
81	Distribution Center	409
81	Distribution Center	410
81	Distribution Center	411
81	Distribution Center	412
88	İzmir	413
88	İzmir	414
88	İzmir	415
88	İzmir	416
88	İzmir	417
88	İzmir	418
88	İzmir	419
88	İzmir	420
88	İzmir	421
88	İzmir	422
88	İzmir	423
88	İzmir	424
88	İzmir	425
88	İzmir	426
88	İzmir	427
88	İzmir	428
88	İzmir	429
88	İzmir	430
88	İzmir	431
88	İzmir	432
88	İzmir	433
88	İzmir	434
88	İzmir	435
88	İzmir	436
88	İzmir	437
88	İzmir	438
88	İzmir	439
88	İzmir	440
88	İzmir	441
88	İzmir	442
88	İzmir	443

88	İzmir	444
88	İzmir	445
88	İzmir	446
88	İzmir	447
88	İzmir	448
88	İzmir	449
88	İzmir	450
88	İzmir	451
88	İzmir	452
88	İzmir	453
88	İzmir	454
88	İzmir	455
88	İzmir	456
88	İzmir	457
88	İzmir	458
88	İzmir	459
89	Samsun	460
89	Samsun	461
89	Samsun	462
89	Samsun	463
89	Samsun	464
89	Samsun	465
89	Samsun	466
89	Samsun	467
89	Samsun	468
89	Samsun	469
89	Samsun	470
89	Samsun	471
89	Samsun	472
89	Samsun	473
89	Samsun	474
89	Samsun	475
89	Samsun	476
89	Samsun	477
83	Ankara	478
89	Samsun	479
89	Samsun	480
89	Samsun	481
89	Samsun	482
89	Samsun	483
89	Samsun	484
89	Samsun	485
89	Samsun	486
89	Samsun	487
89	Samsun	488
94	Erzurum	489
94	Erzurum	490
94	Erzurum	491
94	Erzurum	492
94	Erzurum	493
94	Erzurum	494
94	Erzurum	495
94	Erzurum	496
94	Erzurum	497
94	Erzurum	498
89	Samsun	499
89	Samsun	500
89	Samsun	501
89	Samsun	502
89	Samsun	503
89	Samsun	504
89	Samsun	505
94	Erzurum	506
94	Erzurum	507
94	Erzurum	508
94	Erzurum	509
94	Erzurum	510
94	Erzurum	511
94	Erzurum	512
94	Erzurum	513
94	Erzurum	514
94	Erzurum	515
94	Erzurum	516
94	Erzurum	517
94	Erzurum	518
94	Erzurum	519
94	Erzurum	520
94	Erzurum	521
94	Erzurum	522
94	Erzurum	523
94	Erzurum	524
94	Erzurum	525
94	Erzurum	526
94	Erzurum	527
89	Samsun	528
89	Samsun	529
89	Samsun	530
89	Samsun	531
81	Distribution Center	532

Appendix I: Scenario 4: Detailed assignments of transportation modes to the repair vendors

Repair Vendor	Transportation Mode
1	Freight
2	Freight
3	Freight
4	Freight
5	Freight
6	Freight
7	Freight
8	Freight
9	Freight
10	Freight
11	Freight
12	Freight
13	Freight
14	Freight
15	Freight
16	Freight
17	Freight
18	Freight
19	Freight
20	Freight
21	Freight
22	Freight
23	Freight
24	Freight
25	Freight
26	Freight
27	Freight
28	Freight
29	Freight
30	Freight
31	Freight
32	Freight
33	Freight
34	Freight
35	Freight
36	Freight
37	Freight
38	Freight
39	Freight
40	Freight
41	Freight
42	Freight
43	Freight
44	Freight
45	Freight
46	Freight
47	Freight
48	Freight
49	Freight
50	Freight
51	Freight
52	Freight
53	Freight
54	Freight
55	Freight
56	Freight
57	Freight
58	Freight
59	Freight
60	Freight
61	Freight
62	Freight
63	Freight
64	Freight
65	Freight
66	Freight
67	Freight
68	Freight
69	Freight
70	Freight
71	Freight
72	Freight
73	Freight
74	Freight
75	Freight
76	Freight
77	Freight
78	Freight
79	Freight
80	Freight

81	Freight
82	Freight
83	Freight
84	Freight
85	Freight
86	Freight
87	Freight
88	Freight
89	Freight
90	Freight
91	Freight
92	Freight
93	Freight
94	Freight
95	Freight
96	Freight
97	Freight
98	Freight
99	Freight
100	Freight
101	Freight
102	Freight
103	Freight
104	Freight
105	Freight
106	Freight
107	Freight
108	Freight
109	Freight
110	Freight
111	Freight
112	Freight
113	Freight
114	Freight
115	Freight
116	Freight
117	Freight
118	Freight
119	Freight
120	Freight
121	Freight
122	Freight
123	Freight
124	Freight
125	Freight

126	Freight
127	Freight
128	Freight
129	Freight
130	Freight
131	Freight
132	Freight
133	Freight
134	Freight
135	Freight
136	Freight
137	Freight
138	Freight
139	Freight
140	Freight
141	Freight
142	Freight
143	Freight
144	Freight
145	Freight
146	Freight
147	Freight
148	Freight
149	Freight
150	Freight
151	Freight
152	Freight
153	Freight
154	Freight
155	Freight
156	Freight
157	Freight
158	Freight
159	Freight
160	Freight
161	Freight
162	Freight
163	Freight
164	Freight
165	Road
166	Freight
167	Freight
168	Freight
169	Freight
170	Freight

171	Freight
172	Freight
173	Freight
174	Freight
175	Road
176	Freight
177	Freight
178	Freight
179	Freight
180	Freight
181	Freight
182	Freight
183	Freight
184	Freight
185	Freight
186	Freight
187	Freight
188	Freight
189	Freight
190	Freight
191	Freight
192	Freight
193	Freight
194	Road
195	Freight
196	Freight
197	Freight
198	Freight
199	Road
200	Freight
201	Freight
202	Freight
203	Freight
204	Freight
205	Freight
206	Freight
207	Freight
208	Freight
209	Freight
210	Freight
211	Freight
212	Freight
213	Freight
214	Freight
215	Road

216	Road
217	Road
218	Road
219	Road
220	Freight
221	Road
222	Road
223	Road
224	Freight
225	Road
226	Road
227	Road
228	Road
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