LOGISTICS MANAGEMENT FOR BLOOD COLLECTION AND BLOOD PRODUCTS DISTRIBUTION IN TURKISH RED CRESCENT

VAHDİ YOLCU

SEPTEMBER 2019

LOGISTICS MANAGEMENT FOR BLOOD COLLECTION AND BLOOD PRODUCTS DISTRIBUTION IN TURKISH RED CRESCENT

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES OF
ÇANKAYA UNIVERSITY

BY
VAHDİ YOLCU

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN
INDUSTRIAL ENGINEERING
DEPARTMENT

SEPTEMBER 2019

Title of the Thesis: **Logistics Management for Blood Collection and Blood Products Distribution in Turkish Red Crescent**

Submitted By Vahdi YOLCU

Approval of the Graduate School of Natural and Applied Sciences, Çankaya University.

Prof. Dr. Can ÇOĞUN
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Assoc. Prof. Ferda Can ÇETINKAYA
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assist. Prof. Dr. Benhür SATIR
Supervisor

Examination Date:

Examining Committee Members

Assoc. Prof. Dr. Sedef MERAL	METU
Assoc. Prof. Dr. Orhan KARASAKAL	Çankaya Univ.
Assist. Prof. Dr. Benhür SATIR	Çankaya Univ.

STATEMENT OF NON-PLAGIARISM PAGE

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name : Vahdi YOLCU
Signature :
Date : 13.09.2019

ABSTRACT

LOGISTICS MANAGEMENT FOR BLOOD COLLECTION AND BLOOD PRODUCTS DISTRIBUTION IN TURKISH RED CRESCENT

YOLCU, Vahdi
M.Sc., Department of Industrial Engineering
Supervisor: Assist. Prof. Dr. Benhür SATIR
September 2019, 160 pages

Turkish Red Crescent has opened blood centers for the regionalization of blood management system for blood collection and distribution of blood products. The aim of our study is to minimize the time and cost problems in the transportation of blood and blood products between the centers determined in the current system. For this purpose, models, in which the assignment criteria and logistics decisions are released in the logistics network between the centers, decisions can be made for assignments between units and transportation routes, and that take into account bag type, as a distinctive characteristic, and the diversity of products – especially, such as thrombocyte suspension - were developed. In this process, the total cost and total transport times were minimized, and the model was solved by using real data separately and together with multi-objective optimization methods.

Key Words: Multi-Objective Optimization, Logistics, Blood Bag Type, Blood Products

ÖZ

TÜRK KIZILAYINDA KAN TOPLAMA VE KAN ÜRÜNLERİ DAĞITIMI İÇİN LOJİSTİK YÖNETİMİ

YOLCU, Vahdi
Yüksek Lisans, Endüstri Mühendisliği Anabilim Dalı
Tez Yöneticisi: Dr. Öğr. Üyesi Benhür SATIR
Eylül 2019, 160 sayfa

Türk Kızılayı kan toplama ve kan ürünlerinin dağıtımı için kan yönetim sisteminin bölgeselleştirilmesi adına kan merkezleri açmıştır. Bu amaçla merkezler arasındaki lojistik ağında atama kriterlerinin ve lojistik kararlarının serbest bırakıldığı, birimler arası atamalar ve taşıma yolları kararlarını verecek ve bu süreçte ayırt edici özellik olan torba tipi ile üretilecek ürün çeşitliliğini -özellikle trombosit süspansiyon gibi dikkate alacak modeller geliştirilmiştir. Toplam maliyet ve toplam taşıma süreleri minimize edilerek ayrı ayrı ve birlikte çok amaçlı eniyileme yöntemleri ile model gerçek veriler kullanılarak çözülmüştür.

Anahtar kelime: Çok Amaçlı Eniyileme, Lojistik, Kan Torbası Tipi, Kan Ürünleri

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to **Assist. Prof. Dr. Benhür SATIR** for his supervision, special guidance, suggestions, and encouragement through the development of this thesis.

I would like to express my special thanks to **Turkish Red Crescent**, which has ranked first among the humanitarian organizations in the world, for giving me the opportunity to conduct my study and to the personnel of The General Directorate of Blood Services of Turkish Red Crescent who supported my study in every way. I especially thank to **Mr. Derviş ÜLGER**, Manager of the Blood Collection and Stock Management Unit, for accepting my meeting and interview requests and providing me the information and document requirements throughout the study.

I wish to also offer thanks to **Assoc. Prof. Dr. Sedef MERAL** and **Assoc. Prof. Dr. Orhan KARASAKAL** for accepting to be jury members in my defense and reviewing my thesis. I am grateful for their feedback and suggestions.

During my hard work, I would like to thank my wife **Elif Sinem YOLCU** for showing me patience and enduring me and my mother **Sade YOLCU** and my father **Osman YOLCU** for standing by me and my children **Ipek Vera** and **Ali Osman** who allowed me to work even when I stole from our playing hours and concentrated on my work and dear **Türker YOLCU** for providing me with a working environment, showing me all the necessary facilities and supporting me spiritually, and to all those who did not spare their great and small help during my work.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

RBC:	Regional Blood Centers
BDC:	Blood Donation Centers
BCU:	Blood Collection Units
MT:	Mobile Teams
TC:	Transfusion Centers
LAB:	Central Screening Laboratory
WB:	Whole Blood
ES:	Erythroside Suspension
AD:	Apheresis Donation
TS:	Thrombocyte Suspension
FFP:	Fresh Frozen Plasma
BC:	Buffy Coat
LP:	Liquid Plasma
BP:	Blood Products
BS:	Blood Samples
T&T:	Top and Top Bag Type
T&B:	Top and Bottom Bag Type
THY:	Turkish Air Ways
NE:	Not Exists
E:	Exist
DM:	Decision Maker
NGO:	Non-Governmental Organization

CHAPTER 1

INTRODUCTION

The Turkish Red Crescent (TRC) was founded in June 1868 under the name of "Ottoman Aid Society for Wounded and Ill Soldiers" to help the soldiers who were wounded or sick on the battlefield. The great Turkish leader, Mustafa Kemal ATATÜRK, lent the name "KIZILAY" (Red Crescent) to the institution.

The basic principles of Turkish Red Crescent are "Humanity, non-discrimination, impartiality, independence, charity, unity and universality". The Turkish Red Crescent is a non-profit, voluntary social service organization providing unrequited benefits and services.

Turkish Red Crescent provides humanitarian aid to every victim of war, whether Turkish or enemy, based on the principle of neutrality and immunity in the war. In addition to this, with its developing technologies, vehicle fleet, trained competent health personnel, youth and education services, and public awareness campaigns, it is an institution that has a place in the world in the field of humanitarian aid.

In recent years, TRC is the most powerful social service organization in the fields of following health technologies closely, bringing blood donation services to the feet of the citizen, conducting organ donation studies, aids, care, protection and awareness activities for the civilian population by providing the fastest, safest and best services to the Turkish people in any disaster, war or extraordinary situation.

In this thesis, we examine Logistics Network and Management for Blood Collection and Blood Products Distribution. The model will develop optimal solutions for the assignment of blood centers between each other within a strategic plan. In the journey of blood products from donors to people in need; variables which are like the assignment of blood centers to each other, time, distance, the method used during donation, cost, the type of blood product produced, the duration and amount of destruction are important in many respects. Optimal results for assignments will be determined by ensuring cost and time balance. In our study, mathematical modeling will be used as the theoretical approach, and multi-objective optimization methods will be used for the solution.

In the following chapter, the blood units in the TRC's blood supply chain system, their tasks and relations with each other are detailed. The different types of bags used during blood donation, which is a distinctive feature of our study, were explained and the effects of bag types on the production of blood products, cost and time were examined.

Within the scope of the thesis, the problem we are dealing with is introduced. The data used in the solution of the problem and the collection and analysis of these data are mentioned. The new coding system, which is designed for indexes of blood centers, is introduced and the calculation of distance and time between blood centers is explained.

In chapter 3; literature researches, studies on blood, blood products and their logistic network have been examined both in our country and internationally. Linear programming models were used in the studies. Blood center assignments, facility location, inventory, vehicle routing and their relationship with cost and production have been studied. The differences of these studies with the model we designed are also mentioned.

In chapter 4, the Cost Model and Time Model which are the basis of our study are introduced. These models are designed to determine the effects of blood centers' assignments and bag type on total cost and total transportation time of blood products. The results of models, assignments, usage of bag type, changes in production, etc. were examined comparatively. Total cost and total transport times were minimized by multi-objective optimization methods.

In chapter 5; our study was completed with a brief summary and information about the system.

CHAPTER 2

PROBLEM DEFINITION

2.1 Blood Supply Chain Structure in TRC

Turkish Red Crescent (TRC) has been working for 159 years to protect human dignity and to relieve its suffering. The safe and voluntary blood donation program and all the applications required by modern blood banking are meticulously actualized.

The goal of the TRC is to increase the blood services above international standards and, also it aims to improve blood donation consciousness in the society and to create a healthy donor database.

2.1.1 Blood Centers

There were only two blood centers when the TRC took the road for the safe blood supply in 1957. This number increased from two to 15 regional blood centers (RBC) at the end of 2012 and it was transformed into a fleet of 15 RBC and 62 blood donation centers (BDC). As of 2017, there are 17 RBC and they want to build and open more RBCs. Today, the need for blood and blood components in our country is met by TRC. The blood service units of the TRC may be summarized as follows:

a. Regional Blood Centers (RBC):

These are established in regions determined by the Ministry. They are the most comprehensive units, which can work in cooperation with the blood donation and transfusion centers in its own region. In addition, their capacity can meet the blood requirements of the respective region and can perform all the work and interventions related to blood banking.

These centers take all necessary security measures against the medical risks to protect the donor and receiver, giving and receiving the blood, blood components and products, respectively. They ensure that the blood, blood components and products are taken under the doctor's responsibility and control. They monitor and record complications related with the donor and report these to related authorized institutions.

The responsibilities of RBCs can be listed as follows:

- Separating blood into its components
- Storing blood products in appropriate conditions
- Ensuring that blood samples are shipped to laboratories and blood tests are performed
- Distributing blood products to transfusion centers

In this study, 17 RBCs are examined and listed in below Table 1:

Table 1: Regional Blood Center and Cities

REGINAL BLOOD CENTERS	CITY
Kuzey Marmara Regional Blood Center	ISTANBUL-ANATOLIA
Orta Akdeniz Regional Blood Center	ADANA
Orta Anadolu Regional Blood Center	ANKARA
Batı Akdeniz Regional Blood Center	ANTALYA
Guney Marmara Regional Blood Center	BURSA
Guney Anadolu Regional Blood Center	DIYARBAKIR
Doğu Anadolu Regional Blood Center	ERZURUM
Batı Anadolu Regional Blood Center	ESKIŞEHIR
Doğu Akdeniz Regional Blood Center	GAZIANTEP
Avrupa Regional Blood Center	ISTANBUL-EUROPE
Ege Regional Blood Center	IZMIR
Iç Anadolu Regional Blood Center	KAYSERI
Guney Batı Anadolu Regional Blood Center	MALATYA
Orta Karadeniz Regional Blood Center	SAMSUN
Doğu Karadeniz Regional Blood Center	TRABZON
Guney Doğu Regional Blood Center	VAN
Batı Karadeniz Regional Blood Center	DUZCE

b. Blood Donation Centers (BDC):

These are opened at locations that are considered necessary by RBC and they are also units which take place in voluntary, complimentary, and regular donor organizations that are organized by RBC. They basically collect blood donations and transfer them to RBCs. They temporarily store blood, but they don't store blood products on any account. BDCs can collect blood donations themselves or collect donations by using Blood Collection Units (BCU) or by organizing Mobile Teams (MT). In addition, BCU and MT can collect only whole blood, but BDCs can collect both whole blood and apheresis. These are listed in Table 2 below.

Table 2 : Blood Donation Centers

ITEM NO	BDC	ITEM NO	BDC	ITEM NO	BDC
1	ADANA	23	ÇAPA	45	MARMARIS
2	ISKENDERUN	24	ÇORLU	46	ÖDEMIŞ
3	MERSIN	25	EDIRNE	47	UŞAK
4	ÇORUM	26	LULEBURGAZ	48	KAYSERI
5	KIRIKKALE	27	ÇANAKKALE	49	KIRŞEHIR
6	KONYA	28	YALOVA	50	NEVŞEHIR
7	KASTAMONU	29	BATMAN	51	SIVAS
8	ANKARA	30	DIYARBAKIR	52	YOZGAT
9	ANTALYA	31	SIIRT	53	ELAZIĞ
10	BURDUR	32	DUZCE	54	MALATYA
11	ISPARTA	33	KARABUK	55	ADIYAMAN
12	BALIKESIR	34	SAKARYA	56	ORDU
13	BURSA	35	ZONGULDAK	57	SAMSUN
14	ESKIŞEHIR	36	KOCAELI	58	TOKAT
15	KUTAHYA	37	ERZINCAN	59	ARTVIN
16	K.MARAŞ	38	ERZURUM	60	GIRESUN
17	GAZIANTEP	39	AFYON	61	GUMUŞHANE
18	KILIS	40	BAŞAKŞEHIR	62	RIZE
19	ŞANLIURFA	41	AYDIN	63	TRABZON
20	KARTAL	42	DENIZLI	64	MUŞ
21	Z.KAMIL	43	IZMIR	65	VAN
22	ÇEKMEKÖY	44	MANISA		

c. Blood Collection Units (BCU):

BCUs are managed by the BDCs and they send the blood they collect to the relevant BDCs.

d. Mobile Teams (MT):

MTs are managed by assigned BDCs, such as BCUs. The blood they collect by themselves is sent to the relevant BDCs. The difference from BCU is that they are not fixed. They usually stay just one day at a point.

e. Transfusion Centers (TC):

They also depend on the RBCs and provide the blood from RBCs to make cross-comparison and other necessary tests for transfusion and prepare the blood for use of the patient. However, they don't have authority to take blood except in emergencies. 1,535 hospitals from 1,592 were given a transfusion center license in 2012. Today, the state hospitals, especially university hospitals contain transfusion center within themselves in our country. There are 1,105 transfusion centers connected to the region blood center. Related table is very long because of the number of TCs. Their related table is shown in Appendix-1.

f. Central Screening Laboratory (LAB):

Since 2009, the Turkish Red Crescent has closed down the Microbiological and immune hematological Test Laboratories in the Regional Blood Centers and switched to the central laboratory system.

In this direction, TRC established microbiological and immune hematological test laboratories in Kuzey Marmara (Istanbul), Orta Anadolu (Ankara), Ege (Izmir) and Doğu Anadolu (Erzurum) Regional Blood Centers.

In parallel with the increasing blood need, the Turkish Red Crescent increases the number of blood donations every year and continues its efforts to meet the whole blood need of the country. In this context, the central laboratory in Erzurum was closed and central microbiological and immune hematological test laboratory was established in Adana in order to ensure the effective use of local resources on site and started to give service to Orta Akdeniz RBC, Dogu Akdeniz RBC and Ic Anadolu RBC.

Central Screening Laboratories are directly connected to the RBCs and the bloods and blood products which come from the RBCs are tested in there. The Laboratories and assigned RBCs are shown below in Table 3 and Figure 1:

Table 3: The list of Regional Blood Center Laboratories

LAB INDEX (I)	LAB NAME	CITY
010101	Orta Akdeniz Regional Blood Center Laboratory	ADANA
060602	Orta Anadolu Regional Blood Center Laboratory	ANKARA
000003	Kuzey Marmara Regional Blood Center Laboratory	ISTANBUL-ANADOLU
353504	Ege Regional Blood Center Laboratory	IZMIR

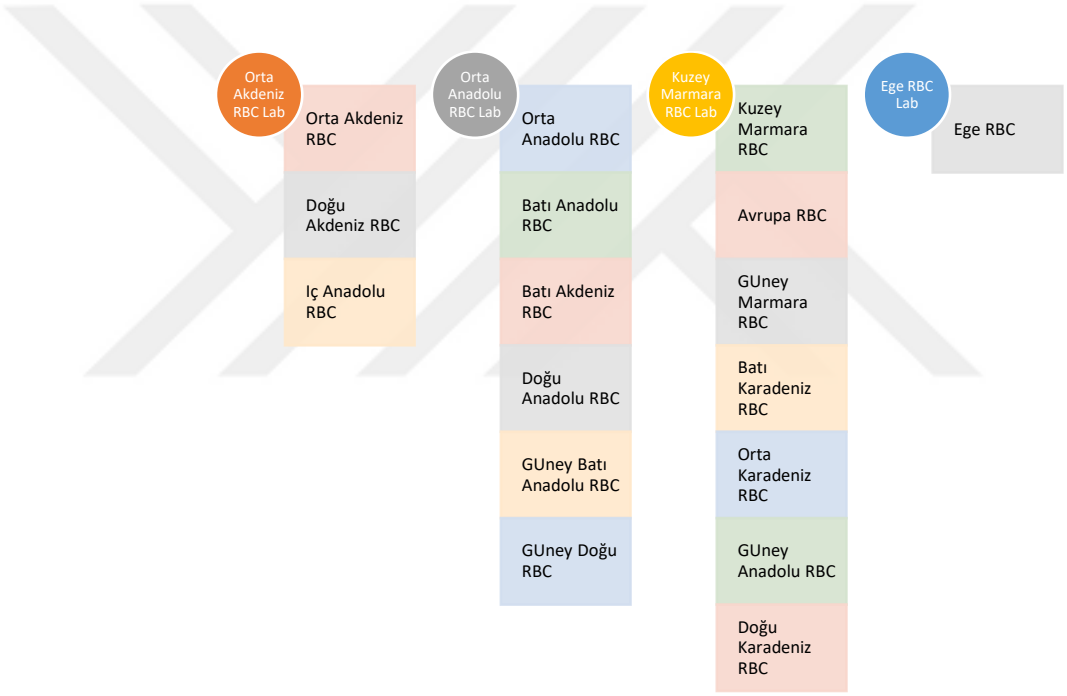


Figure 1: Regional Blood Centers which are assigned to related Laboratories

2.1.2 Bag Types

In line with the instruction of the Ministry of Health in Turkey and the decision of the Board of Directors of TRC, dated 09.09.2014 and numbered 17, 4-Bag (Top & Top / Top & Bottom) Blood Bag Systems and Platelet Pooling Bag System with In-line Filter have been started. In the new blood bag system, Pooled Platelet

Concentrate is required within 24 hours after the Top & Bottom blood bags are separated into their components.

Ministry of Health standardized reduction of leukocytes from all blood components and in parallel with the filtration for reduction of leukocytes to be done with in-line filter systems and use of thrombocyte suspensions as pooled.

In this context; the decision was made to switch to system of "Whole Blood Inline Leukocyte Filter SAG-M Four Quad Top & Top", "In-line Leukocyte Filter SAG-M Quatro Top & Bottom" and "In-line Leukocyte Filter Buffy Coat Pool Bag". The new bag system started to be used in 2016.

The relationship of blood centers with each other, the connection of bag types with the production of blood products, and the distribution chain of blood products are explained as follows in Figure-2.

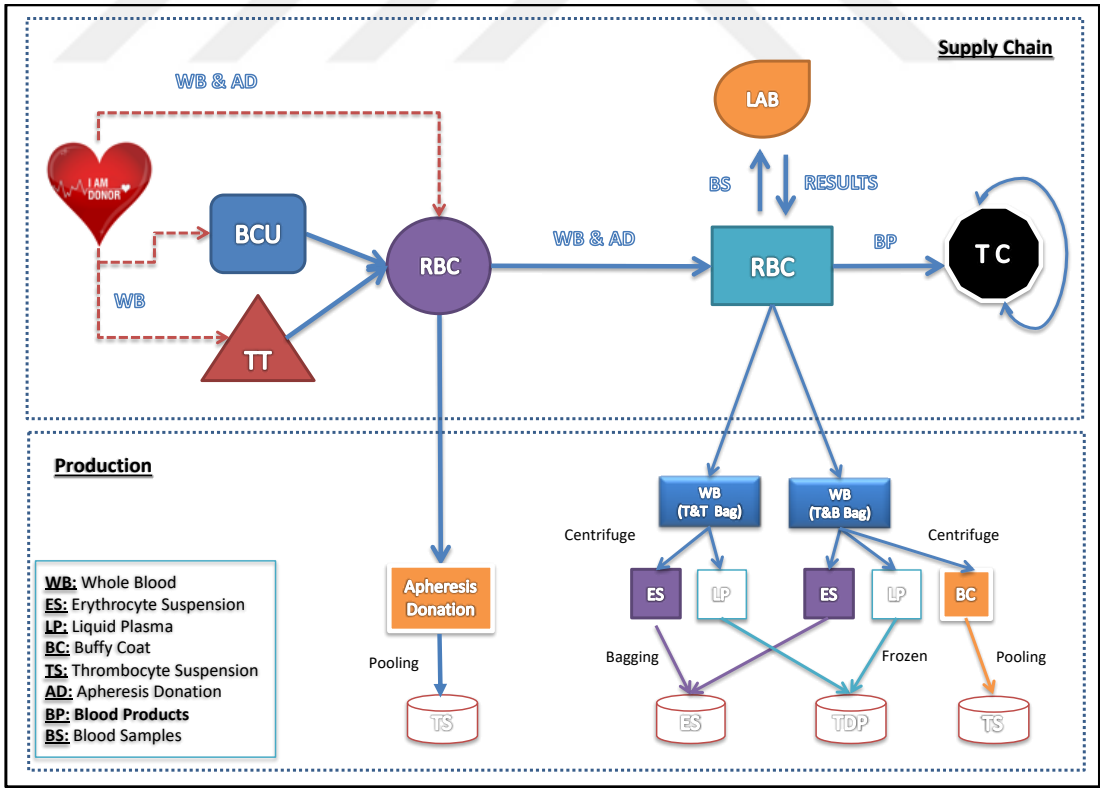


Figure 2: Blood Supply Chain Structure in TRC

A donor donates his/her blood into two ways which are as whole blood or apheresis. In the supply chain part of Figure-2, the whole blood is donated in BCUs, TTs and BDCs, however, apheresis is donated only in BDCs. Donations are collected by BDCs and all of them send to RBCs. Donations are transformed to blood products and witness samples taken during blood donation are sent to laboratories in RBCs. Produced blood products are sent to the relevant transfusion center that needs it for any patient.

In production part of Figure 2, the whole blood is taken from the donor with two different bag types which are named Top & Top and Top & Bottom. The products produced vary according to the bag types. If the whole blood is taken with T&T bag, ES and LP can be produced. On the other hand, when the whole blood is taken with T&B bag, ES, LP and BC can be produced. ES is produced after separation of plasma from the whole blood. Remaining liquid plasma is frozen to produce fresh frozen plasma. TS is produced into two ways. Firstly, with the help of BC and some operations, TS can be produced. Secondly, TS can be produced with the help of apheresis donations. In addition, each part of the production operation contains its own destruction because of expiration date, laboratories results, taking more or less blood and etc. While final blood products which are ES, TDP and TS are destructed, also mid-products which are LP and BC can be destructed.

In addition, another type of donation is apheresis donation. The platelet apheresis process is a blood exchange process between the blood donor and the apheresis device until the required blood component (platelet) is obtained for the patient. The device extracts the donor's blood in small amounts, separating the required platelets, and returns the blood outside the platelet to the donor. Thus, TS is produced.

2.2 Problem

BDC-RBC assignment decision, which is one of the basic decisions in the system, affects the system fundamentally. If the distance is too long, one of the other basic

decisions in the system which is the bag type decision to be used in BDCs and the connected BCU and GE will be eliminated and only T&T bag type is used. This affects the production decision which is another basic decision in the system, because usage of T&T bag type means that TS will not be produced. It is possible to think of the bag type decision as follows: a decision can be made for collection of the whole blood with "% a" of T&B bag (and the remaining (1-a)% T&B bag type) in a given period on a city basis, however, if the distance to connected RBC is far, %a must be equal to zero (%a=0). As an example, Konya BDC is connected to Orta Anadolu RBC in Ankara and the distance between the two is considered far away. Therefore, the products are transported by car, not plane, from Konya to Ankara and T&T bag is used. Based on the idea that the amount of TS will increase over time, it is aimed to increase the use of T&B bag type in the central units.

In this study, the real values for donations and demand will be used. In addition, inventory decisions will be excluded and the solution will be developed to cover one year. The focus will be on RBCs-BDCs assignments and the determination of the production decision by bag type decision. Total cost and total transport times will be minimized by multi-objective optimization methods

Mathematical modeling will be used for the design of the logistics network and management of blood collection and distribution of blood products. In terms of modeling, the relationship between blood bag type decisions, according to bag type, blood product production type and quantity relationships, early destruction of blood mid-products and cost reduction decisions will be taken into consideration by using assignments not previously considered.

2.3 Data

2.3.1 Developing a New Coding System

In this study, 17 RBCs, 65 BDCs, 1105 TCs and finally 4 Labs are examined and as mentioned before they have relationships between each other to understand the interdependent units and determine which cities the units are located in. Firstly, two digits are used for the RBCs. The two digits mean plate numbers. The plate numbers indicate the cities where RBCs are located. Secondly, five digits are determined for BDCs. The first two digits indicate the number which is assigned to the RBCs. The second two digits show city plate number of the assigned and last digit indicates how many BDCs there are. Finally, transfusion centers are shown with seven digits. As in BDCs, the first two digits indicate the RBC to which it is connected, the next two digits indicate the city plate and the last 3 digits indicate the number of TCs. For laboratories, six digits are used. The first two digits relate to connected RBCs, next two digits indicate plate number where labs are located and finally last two numbers show how many labs there are. All relations are also shown in Figure 3. All digits and blood centers and labs are shown in Appendix-1, 2, 3 and 4.

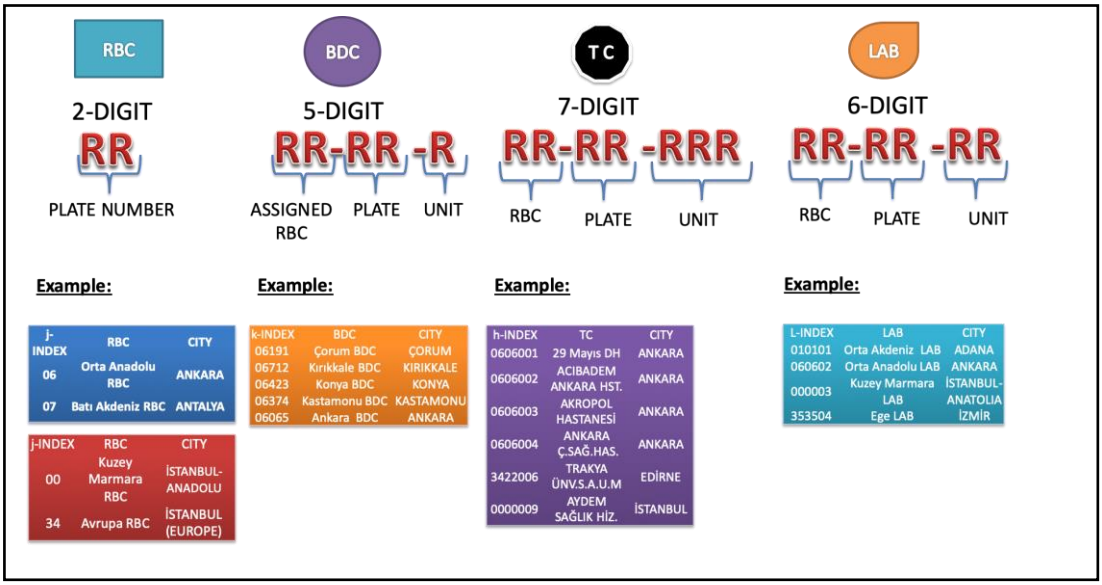


Figure 3: New coding systems for Indexes

2.3.2 Data Gathering and Analyzing Process

The most time was spent in this study on the data collection and analysis process. Because the reliability of the data also affects the reliability of the model and its results. All data related to the model were requested from the Turkish Red Crescent. Cross checks were performed for this data for 2017. During these analyzes, it was determined that there is a negative difference between BC and LP quantities of production and destruction. The mistakes in the BCs were caused by incorrect entry of the data by the TRC and they were informed about these mistakes and necessary corrections were made by them. LP can be destroyed due to more than one reason and each reason is entered to the system for a LP and a LP is destroyed more than one time. One of the most remarkable points when examining the data is that they gave BDCs name instead of RBCs name to make it easy for their processes. For example, the data is for Orta Akdeniz RBC but they entered the system as Adana RBCs. However, Adana is a BDC, not an RBC. Faults were removed during analyzing phase of the data. Crosscheck-comparisons are performed for other products. With this way, we try to provide both the correct data entering for TRC and the correctness of the parameters used in the solution of the model. A total of 8,173 data were examined and 294 errors were detected. Errors were corrected during the analysis of the data.

In addition, there have been several meetings about costs data in TRC, but the only information we obtained about the costs is the approximate cost of blood products in one year. This cost is in the range 500-600 million Turkish Liras. For this reason, if the result of our cost model is obtained in this range, it will also test the accuracy of our model. Although we have officially consulted to TRC regarding the cost data, we received a negative response. Then, as a result of the researches and investigations we have made, we generated the data that we could not obtain from the TRC. A constant value was taken with the assumption that the costs per km for a vehicle for transporting blood products do not vary according to city. Since TRC is a non-profit organization, the production and distribution costs actually correspond to the approximate sales costs of these products. Considering the destruction of products,

the sale price can be considered equal to the cost of destruction. The necessary infrastructure is provided for the data used in the model and they can be easily updated by everyone and solutions for current data can be obtained.

2.3.3 Logistics Management in TRC

This section is actually located in the supply chain section of TRC. The reason we mentioned here is explained under this title because of the studies carried out to obtain data on the distances between blood centers.

When the Safe Blood Supply Program entered into force in 2005, the General Directorate of Blood Services had a fleet of 104 old-fashioned vehicles operating in all areas without any sharing of duties. In 2013, the number of vehicles in the fleet was increased to 527. 144 of the vehicles used in the regional blood centers and blood donation centers belong to the Turkish Red Crescent Blood Services General Directorate, and 383 were supplied by central leasing. Since 2010, in line with the efforts to reduce costs, centralized leasing service has been acquired and effective use of the fleet has been ensured.

In line with their strategy, TRC increases the number of rental vehicles by decreasing the number of vehicles in its inventories. While TRC's own number of cars was 141 at the beginning of 2018, it was 563 for rental cars and it had a fleet of 704 vehicles in total. In the transports from RBCs to TCs, either their own vehicles or rental vehicles are used. In the distribution of blood products, 167 vehicles are used inn total. 7 vehicles of them are own cars, 160 of them are rental cars. In addition, each RBC and BDC has 7 types of vehicles. These vehicles are blood collection vehicle, blood collection bus, blood collection truck, blood donation vehicle, blood transportation vehicle, plasma transportation vehicle, organization and planning vehicle.

TRC, on the other hand, basically uses three methods to transport blood and blood products: its own or rental vehicles and airline transportation. Their own vehicles are used in order to meet the blood need within the city and nearby cities. Long-distance rental vehicles are used. In addition, transportation services are purchased from logistics companies if needed, but in our study this cost is negligible. Airline transportation is provided free of charge for certain needs in accordance with the agreement signed between TRC and Turkish Airlines (THY). In general, airline transportation is preferred for sample transport for blood testing and transfers of blood products between RBCs. Summer and winter tariffs of THY are used statically for planning and non-dynamic data such as delays or temporary changes are not used.

In the light of this information, we have identified two types of transport modes in this study. First, transportation is performed with rental vehicles. TRC's own vehicles were not taken into account because in total, 141 vehicles appear to be their own vehicles, but only 10 of them are used as blood transport vehicles, which is considerably lower than the number of rental vehicles. In this mode of transport, all blood products are shipped by ground transport. Second mode aims at transportation of the products with consideration of both ground transportation and airway transportation.

In our model, RBC-RBC, BDC-RBC, RBC-TC, RBC-LAB, RBC-airport and airport-airport matrices are formed according to transportation modes. For the calculations of km and time between these units, the coordinates of each center were determined and entered from Google map and the related data were obtained. In total, 22,035 km data and 22,035 time data were taken from Google map.

Air distances between airports were not added from km calculations when creating matrices. Because THY carries blood products free of charge. Therefore, it has no effect on costs. When considered as time, Turkey's most remote points in terms of time of flight between airports are approximately 1 hour 40 minutes. Highway

distances between airports are multiplied by 4.5 minutes per 100 km and 45 minutes are added for the departure and landing times. For example, km calculation of Sakirpasa Airport and Atatürk Airport is shown in below equation;

(894,10 km)(4.5 min) / (100 km+ 105 min) = 145.23 min.

The calculations of the matrices which are mentioned above are illustrated by the following explanations;

1- ***Calculation of km and time between RBC and RBC***

- ***For Mode-1-km/time:*** Blood products are transported between regional blood centers by road transportation

  Km Calculation:

  Orta Akdeniz RBC – Orta Anadolu RBC= 480.6 km

  Time Calculation:

  Orta Akdeniz RBC – Orta Anadolu RBC = 423 min

- ***For Mode-2 -km/time:*** Blood products were considered by taking into account the road and airline transportation of the regional blood centers. For example; products from Orta Akdeniz RBC will go to Sakirpasa Airport in Adana by road. From here it will reach Esenboga Airport by airway and then to Orta Anadolu RBC by road. This distance is multiplied by two since the vehicle will return from the blood center to the airport. The calculation is as follows.

  Km Calculation:

  Orta Akdeniz RBC - Sakirpasa Airport = 9.6 km

  Sakirpasa – Esenboga = 0 km (ignore)

Esenboga Airport – Orta Anadolu RBC = (29.6 km) (2)
Total Km = 68.8 km

Time Calculation:

Orta Akdeniz RBC - Sakirpasa Airport = 20 min
Sakirpasa – Esenboga = 127.88 min
Esenboga Airport – Orta Anadolu RBC = (35 km) (2)
Total min = 217.88 min

2- Calculation of km and time between BDC and RBC

- ***For Mode-1-km/time:*** Blood products are transported from BDCs to RBCs and then between RBCs by road. For example:

  Km Calculation:

  Adana BDC – Orta Akdeniz RBC = 5.7 km
  Orta Akdeniz RBC – Orta Anadolu RBC = 480.6 km
  Total km = 486.3 km

  Time Calculation:

  Adana BDC – Orta Akdeniz RBC = 12 min
  Orta Akdeniz RBC – Orta Anadolu RBC = 324 min
  Total min = 336 min

- ***For Mode-2-km:*** Blood products are first transported from BDCs to RBCs, then from RBCs to the airport, after inter-airport transportation is performed, products are transported from the airport to the RBCs. For example;

  Km Calculation:

Adana BDC– Orta Akdeniz RBC = 5.7 km
Orta Akdeniz RBC – Sakirpasa Airport = 9.6 km
Sakirpasa Airport – Esenboga Airport = 0 km (ignore)
Esenboga Airport – Orta Anadolu RBC = (29.6 km) (2)
Total km = 74.5 km

Time Calculation:

Adana BDC– Orta Akdeniz RBC = 12 min
Orta Akdeniz RBC – Sakirpasa Airport = 20 min
Sakirpasa Airport – Esenboga Airport = 127.88 min
Esenboga Airport – Orta Anadolu RBC = (35 km) (2)
Total min = 229.88 min

3- Calculation of km and time between BKM and RBC LAB

- ***For Mode-1-km/time:*** Blood products are transported between RBC and Labs by road. For example:

Km Calculation:

Orta Anadolu RBC– Orta Akdeniz RBC Lab = 481.6 km

Time Calculation:

Orta Anadolu RBC– Orta Akdeniz RBC Lab = 324 min

- ***For Mode-2-km/time:*** Blood products are transported from BDCs to airports and then from airports to central labs. For example;

Km Calculation:

Orta Anadolu RBC – Esenboga Airport = 29.6 km

Esenboga Airport – Sakirpasa Airport = 0 km
Sakirpasa Airport – Ora Akdeniz RBC Lab = (9.6 km) (2)
Total km = 48.8 km

Time Calculation:

Adana BDC – Orta Akdeniz RBC = 12 min
Orta Akdeniz RBC – Sakirpasa Airport = 20 min
Sakirpasa Airport – Esenboga Airport = 127.88 min
Esenboga Airport – Orta Anadolu RBC = (35 km) (2)
Total km = 229.88 min

4- Calculation of km and time between RBC and TC

- ***For Mode-1-km/time:*** Blood products are transported between from RBC to TC by only road. For example;

Km Calculation:

Orta Akdeniz RBC – Avrupa RBC = 943.1 km
Avrupa RBC – Edirne State Hospital = 227.5 km
Total km = 1,170. 60 km

Time Calculation:

Orta Akdeniz RBC – Avrupa RBC = 592 min
Avrupa RBC – Edirne State Hospital = 135 min
Total min = 727 min

- ***For Mode-2-km/time:*** Blood products are transported from RBC to airport and then from airports to TC by airline and road. For example,

Km Calculation:

Orta Akdeniz RBC – Sakirpasa Airport = 9.6 km
Sakirpasa Airport – Atatürk Airport = 0 km
Atatürk Airport – Avrupa RBC = (17.2 km) (2)
Avrupa RBC – Edirne State Hospital = 227.5 km
Total km = 271.5 km

Time Calculation:

Orta Akdeniz RBC – Sakirpasa Airport = 20 min
Sakirpasa Airport – Atatürk Airport = 147.64 min
Atatürk Airport – Avrupa RBC = (25 min) (2)
Avrupa RBC – Edirne State Hospital = 135 min
Total km = 352.64 min

CHAPTER 3

LITERATURE REVIEW

In this section, we discuss the relevant part of the literature on the application of Operations Research and Management Science methods to supply chain management problems of blood products. There are many studies on blood supply chain in the world including our country. These studies can range from one of the smallest parts of the supply chain to an approach that models the overall system.

Studies in the literature have been studied at four different levels: collection, production, inventory and distribution. In addition, integrated models were examined as fifth category. Strategic, tactical and operational levels were defined for all five categories, and possible decisions and studies were evaluated accordingly. Linear programming models are one of the basic tools used in supply chain modeling in literature. In some cases, non-linear models are also used.

Günpınar and Centeno (2015) have developed an integer programming model that minimizes lack of blood products cost and overstock and disposal cost of blood products for a hospital.

Zahiri et.al. (2015) modeled strategic and tactical decisions in the blood supply chain with mixed integer linear programming in multiple planning horizons, and rationality

in parameters with robust probabilistic programming and with robust probabilistic programming they also gave the randomness in parameters. Models have been tested with real data in Iran.

In our country, there are studies done with linear and nonlinear programming models. Göçmen (2014) analyzed TCs which gave services as distribution centers with a structural change in the area covered by the Central Mediterranean RBC in Adana. With this structural change, the solution of the late response to demands made by the Central Mediterranean RBC and costly operation execution inefficiencies and the solution of the removal of other transfusion centers in the region by servicing the newly opened distribution centers has been examined. He solves the layout-routing problem in a basic sense using linear programming.

Yegül (2016), in the blood supply chain, handled facility location, inventory and vehicle routing problems in an integrated system. Created the mixed integer nonlinear programming model works for small problems. Since this model does not work in medium and large size problems, various intuitive solution methods were suggested and their performance was evaluated on real problems.

Osorio et al. (2015) belongs to integrated models class and seems to be the most comprehensive study in the literature. In this study, possible improvements in the system have been tried to be measured with Regional Transfusion Centers which is a new layer that can be added to the system and planned to hold stock. In order to provide a wide scope in the study, quite simplifying assumptions such as “blood products are one kind” were made, however, in return, a powerful tool has been developed to make integrated decisions for facility location selection, inventory and vehicle routing. Non-linearity due to inventory cost made the solution difficult with the mathematical programming model and the created mixed integer nonlinear programming model worked only for small problems. These reasons suggested various heuristic solution methods and their performance were compared. The

problem was solved by developing a very good heuristic method (Simulated Annealing Heuristic) in terms of solution quality and duration.

Cetin and Sarul (2009) applied multi-objective optimization in blood bank location selection problem for three purposes consisting of blood bank location selection fixed cost, transportation costs and inequality index using nonlinear target programming method.

Nagurney et.al. (2012) modeled the blood supply system with multi-criteria system optimization. The objective function consists of the costs (operation, waste blood products and costs of incomplete supply quantities) and the risk of disruption in the procurement network (which can be caused by disasters).

Hsieh (2014) first solved a strategic model involving decisions such as location selection and assignment with a two-stage method, and then solved a tactical model involving inventory control decisions. Using the non-dominated sequencing genetic algorithm (NSGA), the Pareto cluster was found (approximately). The method was applied to the actual data obtained from Taiwan. Researchers who want to consider uncertainties and randomness in their models have chosen simulation or random programming methods. Therefore, simulation is another one of the basic tools used in blood supply chain modeling.

Rytilä and Spens (2006) have developed a simulation model that can be used to measure the performance of changes that the decision makers think about the blood supply system, especially including blood transfusion services.

Katsaliaki and Brailsford (2007) used simulations in the problem of managing blood inventory in a typical UK hospital supplying from a regional blood center. In this way, they have measured the performance of various order policies.

Mustafee et al. (2009) developed a cut-time simulation model to evaluate blood unit order policies in the Southampton region of the United Kingdom. They have overcome the elongation of the solution time due to the size of the model by the method of dispersing on many computers.

Blake and Hardy (2013) simulated the blood supply chain assessment in the eastern provinces of the Maritime region in Canada. The basic research question is to reduce the two existing production / distribution centers to one and to find the effects of using a satellite distribution facility on the blood supply chain. It was observed that there was no decrease in the level of patient service with the decision to collect and use satellite facilities in a single center.

Zahraee et al. (2015), provided improvements in the blood supply chain in Iran by using dynamic simulation and Taguchi method together. They proposed an inventory policy as a solution.

Where decision-makers often need to use models, studies that create decision support systems are also available in the literature. Ghandforoush and Sen (2010) designed a decision support system for the production and traveling unit scheduling of the shortest shelf life of TS for an RBC. A non-convex integer programming model has been translated into 0-1 linear problem and made to be solved by RBC manager through decision support system.

Şahin et.al. (2007) is possibly the closest study to our proposed study. They studied the effect of facility location decisions for Turkish Red Crescent on the performance of system elements. The main research questions are which of the existing blood donation centers (BDCs) should be the Regional Blood Center (RBC) and how to make the assignment decisions accordingly. They have solved three different integer linear models. The first model has been solved with reassigned BDCs and RBCs in two versions and in addition, the current blood donation centers (BDCs) and the demand points were taken into account. The alpha parameter used in this model

shows the connection level between assignments of BDCs to RBCs. The alpha value close to zero means that BDC can operate independently and can perform functions of the RBC; if the alpha value is close to one, it shows an opposite situation. In the current situation, in the TRC blood supply system structure, alpha is used as one in accordance with strategic decisions, in the other words, it can be said that BDCs do not perform RBCs functions. The second model is a cluster-coverage model that determines the location of support units to be added to the system. The third model provides a balanced distribution of mobile units to service areas. Linear programming models are also frequently used in multi-objective decision-making models.

Arvan et. al. (2015) aims to determine the locations of donation point and central blood banks within the network and to decide on the amount of product that is shipped among the facilities. In addition, the network consists of donation points, laboratory, central blood bank and demand points.

Şahinyazan et. al. (2015) aims to increase the level of blood collection in the mobile blood collection system. It organizes blood collection tours of vehicles called "*Blood mobile*" and brings them to a designated warehouse to prevent deterioration.

The comparisons of these three important studies and our study are shown in the Table 4 below.

Table 4: Relevant Studies in the Literature

	Our Study	Arvan et.al. (2015)	Şahin et.al. (2007)	Şahinyazan et. al.(2015)
General				
Time horizon	Year	NE	NE	One week (planning horizon of 7 days)
Problem type	Strategic	Strategic	Strategic	
Nonlinearity	E (linearized)	E (linearized)	NE	NE
Assumptions	Perishability of products are considered as operational problem and beyond the scope of our study	There is a fixed rate of perishability for whole blood	The number of RBCs is exogenously determined by the decision makers & Demand for blood and blood products is assumed to be shaped by the hospitals.	Each district of European side of Istanbul is blood potential and it is assumed to be equal to the district's population
Sets				
Donation Center	E	E	E	NE
Regional Blood Center	E	E	E	NE
Transfusion Centers	E	E	NE	NE
Laboratories	E	E	NE	NE
				Note: Only Bloodmobiles and Depot
Product Types	E (not as set but separate Parts & DVs)	E	NE	NE
Parameters				
Distances	All distances calculated exactly	NE	Btw RBCs & Blood Centers and Blood Center& Demand Point	For Ankara and Istanbul only
Supply	E	Infinite	Infinite	The blood potential of node
Demand	E	E	NE	NE
Apheresis	E	NE	NE	NE
Cost	E	E	NE	E
Time	E	E (travel, max)	Response time	NE
Production Rates	E (w.r.t. Bag type)	NE	NE	NE
Waste	E	Fixed rate	NE	NE

Continuation of the Table 4

DVs				
collection	E (w.r.t. Bag type)	NE	NE	NE
operate	E (assignment DVs)	E (open/close location and operate link DVs)	E(open/close location and operate link DVs)	E(bloodmobile travels/ the shuttle travels links DVs)
transportation	E (including lateral b/w transfusion centers)	E (including lateral b/w transfusion centers)	E	NE
discard	E	NE	NE	NE
production	E	E	NE	NE
Constraints				
production	E	Without production rates, max{products} is used	NE	NE
perishability	NE	(transportation + fixed + etc.) has an upper limit	NE	NE
Objective(s)				
Objective 1	Cost	Cost	Distance (Demand Weighted)	Cost
Objective 2	Time	Time (sum of times that blood products remain in the network)	Facility (sum of additional blood stations to be opened)	Maximizes the total amount of blood
Objective 3	NE	NE	Allocation (distribute existing mobile units to the service regions so as to maximize the total of regional population-weighted fleet sizes)	NE
Other objectives	NE	NE	NE	NE
Application				
Country	Turkey	Iran	Turkey	Turkey
System	Combination of National Blood Transfusion Service and independent hospital-based blood banks	Nationally and governmentally organized Blood Transfusion Service	Combination of National Blood Transfusion Service and independent hospital-based blood banks	Combination of National Blood Transfusion Service and independent hospital-based blood banks

Blood collection bag type, distances between blood centers, apheresis donations production and waste are the main issues that distinguish our study from other three studies. Finally, in our study, the design and management of the logistics network will be analyzed by using integer linear programming models in a multi-criteria decision-making setting. In particular, the effect of assignment decisions on the type of blood bag used and its effect on the production and quantity of blood products is an approach that is not included in the literature.

CHAPTER 4

MODELS & RESULTS

The purpose of the Turkish Red Crescent is to provide the blood or blood products to people in need and to save lives. Even though people consider their lives ahead of costs, the slightest improvement in costs means reaching more people. Considering the importance of time in saving human life, in this section we examine both the costs that may occur in the transportation of blood and blood products and the effect of time on blood and blood products and we try to minimize them in a multi-objective fashion.

In this section, we first describe our single objective models (cost and time models), their solutions and results with comparisons for current situation and the optimal. Then we explain multi-objective approach to the problem, the solutions and results obtained.

4.1 Cost Model

Assumptions:

1- RBC, BDC and TC locations and the cities where these are located are known. Firstly, these lists are obtained from TRC. The physical locations,

distance and times with respect to transportation modes are calculated with the help of google map.

2- Blood donation is made in BDCs, blood product demand is met in TCs.
3- Blood donation amounts blood products demands were taken on annual basis.
4- Each BDC and each TC can be assigned to only one RBC.
5- BDC and TC assignments are city based. Part of the city cannot be assigned to one RBC and the rest to another RBC. (Exceptionally, Istanbul will be considered as 2 cities.)
6- Solution is applied for one year.
7- The decision of the bag type should be given as “only T&T bag” for remote assignments. The type of bag to be used during blood donation is a decision that affects the system from the beginning. For example, in a blood collection study for a BDC on a given day, the total number of bags to be used is based on the expected number of blood donations and the type is based on a number of restrictions. If the BDC is remote from the RBC to which it is assigned, all blood bags are supplied in the T&T type bag and as a result only ES and TP blood products are available, TS cannot be obtained. If it is close, it is possible to use a certain number of T&T and T&B bag types under the expected blood donation amount considering the TS requirement.
8- According to the obtained data from TRC, BC destruction before TS production and LP destruction before FFP production is possible.
9- Lateral transshipment of blood product delivery is only possible between RBCs.
10- Perishability of products is considered as an operational problem and beyond the scope of our study.
11- Whole blood is collected in blood donation centers and produced here and sent to regional blood centers. Otherwise, the model is non-linear. Detailed descriptions are made in the Cost Model.
12- Total annual transportation cost is considered.
13- Product shipments are carried out in batches. Each product is not carried alone. Single bag of blood product can be transported in practice in case of urgency. However, it is assumed that an average batch size is applicable in

our model. During the meetings with the Turkish Red Crescent, we received information that the transport of blood or blood products was carried out in batches. However, the TRC did not provide any information about the size of the parties. In our model, we had to calculate lot size not to carry each product with a single vehicle. The assumptions and calculation of the Lot Size are described in Cost Model.

14- TRC meets almost all of the blood needs, in other words production capacity is infinite and only 1% bag of the donations are destroyed. Therefore, all demands are assumed to be met.

COST Model:

Sets:

$\boldsymbol{I} = \{i: i = 1,2, \dots, I\}$ (Cities in Turkey)

$\boldsymbol{J} = \{j: j = 1,2, \dots, J\}$ (Sets of RBCs)

$\boldsymbol{K} = \{k: k = 1,2, \dots, K\}$ (Sets of BDCs)

$\boldsymbol{H} = \{h: h = 1,2, \dots, H\}$ (Sets of TCs)

$\boldsymbol{L} = \{l: l = 1,2, \dots, L\}$ (Sets of Labs)

$\boldsymbol{T} = \{t: t = 1,2, \dots, T\}$ (Transportation mode sets)

Subsets:

$H_i =$ Subset of TCs whic are located in same i city

Parameters:

$B_k =$ average donation amount in each k RBC (on annual basis)

$A_k =$ average apheresis donation amount in each k RBC (on annual basis)

$MTA =$ average amount of blood with whole blood donation(lt/unit)

TTS_h = Average TS demand amount in h TM (in liters per year)

TES_h = Average ES demand amount in h TM (in liters per year)

$TTDP_h$ = Average FFP demand amount in h TM (in liters per year)

$$YK_{kj} = \begin{cases} 1, \text{if } k \text{ BDC is close to } j \text{ RBC} \\ 0 \text{ otherwise} \end{cases}$$

MK_{kjt} = Distance from k BDC to j RBC with t mode (in kilometers)

$MB_{jj't}$ = Distance from j RBC to j' RBC with t mode (in kilometers)

MT_{hjt} = Distance from h TC to j RBC with t mode (in kilometers)

ML_{ljt} = Distance from l RBC LAB to j RBC with t mode (in kilometers)

$UOES =$

Average amount of ES produced with one unit of T&T bag type (in liters)

$UOLP =$

Average amount of LP produced with one unit of T&T bag type (in liters)

$AOES =$

Average amount of ES produced with one unit of T&B bag type (in liters)

$AOLP =$

Average amount of LP produced with one unit of T&B bag type (in liters)

$AOBC =$

Average amount of ES produced with one unit of T&T bag type (in liters)

$ASTS$ = Average amount of TS produced with apheresis donation received with one apheresis set (in liters)

FBC = one unit ready for sale BC quantity (liters / bag)

FTS = one unit ready for sale TS quantity (liters / bag)

$FATS$ = one unit ready for sale ATS quantity (liters / bag)

FLP = one unit ready for sale LP quantity (liters / bag)

$FTDP$ = one unit ready for sale FFP quantity (liters / bag)

FES = one unit ready for sale ES quantity (liters / bag)

CK_{kjt} =

Unit cost of transport from k BDC to j RBC with t mode (in TL / lt * km)

$CB_{jj't}$ =

Unit cost of transport from j RBC to j' BKMs with t mode (in TL / lt * km)

CT_{hjt} =

Unit cost of transport from j RBC to h TC with t mode (in TL / lt * km)

CL_{ljt} =

Unit cost of transport from j RBC to l LAB with t mode (in TL / lt * km)

SK_{kjt} = Time of transport from k BDC to j RBC with t mode (in minutes)

$SB_{jj't}$ = Time of transport from j RBC to j' RBC with t mode (in minutes)

ST_{hjt} = Time of transport from j RBC to h TC with t mode (in minutes)

SL_{ljt} = Time of transport from j RBC to l LAB with t mode (in minutes)

Cost Parameters:

Blood Bag Costs:

CTT = T&T bag type cost (TL/ unit)

CTB = T&B bag type cost (TL/ unit)

CAS = Apheresis set cost (TL /unit)

Production Costs:

$CTKU$ = Whole Blood cost taken with one Unit T&T bag (TL/ pcs)

$CTKA$ = Whole Blood cost taken with one Unit T&B bag (TL/ pcs)

CES = ES production cost (TL / bag)

CLP = LP production cost (TL / bag)

CBC = BC production cost (TL / bag)

$CTDP$ = FFP production cost (TL / bag)

CTS = TS production cost (TL / bag)

Destruction Costs:

$ITKU$ = The cost of whole blood destruction taken with one unit T&T bag (TL / unit)

$ITKA$ = The cost of whole blood destruction taken with one unit T&B bag (TL / unit)

IAS = The cost of destruction of apheresis taken with one apheresis set (TL / unit)

$CIES$ = ES destruction cost (TL /unit)

$CILP$ = LP destruction cost (TL /unit)

$CIBC$ = BC destruction cost (TL /unit)

$CITDP$ = FFP destruction cost (TL /unit)

$CITS$ = TS destruction cost (TL /unit)

LS_j = The lot size used for the products in a vehicle dispatch from RBC to TCs (highyway mode considered)

Decision Variables:

X_k = The rate of collection of the average donation amount in k BDC with T&B bag

$$Y_{kjt} = \begin{cases} 1, \text{if } k \text{ BDC is assigned to } j \text{ RBC with the transport mode } t \\ 0, \quad \text{otherwise} \end{cases}$$

$$Z_{ijt} = \begin{cases} 1, \text{if TC in } i \text{ city is assigned to } j \text{ RBC with the transport mode } t \\ 0 \text{ , otherwise} \end{cases}$$

$$U_{jlt} = \begin{cases} 1, \text{if } j \text{ RBC is assigned to } l \text{ LAB with the transport mode } t \\ 0, \text{otherwise} \end{cases}$$

UBC_k = The amount of BC produced by the avg donation in k BDC (in liters/year)

IBC_k = The amount of BC produced and destroyed by the avg donation in k BDC (in liters/year)

$UBTS_k$ = The amount of TS produced with BC in k BDC (in liters/year)

UTS_k = The amount of TS produced with the avg donation in k BDC (in liters/year)

ITS_k = The amount of TS produced and destroyed by the avg donation in k BDC (in liters/year)

$UATS_k$ = The amount of TS produced with the avg apheresis donation in k BDC (in liters/year)

$IATS_k$ = The amount of TS produced and destroyed by the avg apheresis donation in k BDC (in liters/year)

ULP_k = The amount of LP produced by the avg donation in k BDC (in liters/year)

ILP_k = The amount of LP produced and destroyed by the avg donation in k BDC (in liters/year)

$UTDP_k$ =
The amount of FFP produced by the avg donation in k BDC (in liters/year)

$ITDP_k$ =
The amount of FFP produced and destroyed by the avg donation in k BDC (in liters/year)

UES_k = The amount of ES produced by the avg donation in k BDC (in liters/year)

IES_k = The amount of ES produced and destroyed by the avg donation in k BDC (in liters/year)

$STS_{jj't}$ = The amount of TS shipped from j BKM to j' BKM with mode t (in liters/year)

$SES_{jj't}$ = The amount of ES shipped from j BKM to j' BKM with mode t (in liters/year)

$STDP_{jj't}$ = The amount of FFP shipped from j BKM to j' BKM with mode t (in liters/year)

$UESD_{kjt}$ = the amount of ES produced with the avg donation in k KBM and sent to j BKM with mode t (and then carried to h TC) (in liters/year)

$UESN_{kjt}$ = the amount of ES produced with the avg donation in k KBM and sent to j BKM with mode t (but not to ship to h TC and destroyed in j RBC) (in liters/year)

$UTSD_{kjt}$ = the amount of TS produced with the avg donation in k KBM and sent to j BKM with mode t (and then carried to h TC)(in liters/year)

$UTSN_{kjt}$ = the amount of TS produced with the avg donation in k KBM and sent to j BKM with mode t (but not to ship to h TC and destroyed in j RBC) (in liters/year)

$UTDPD_{kjt}$ = the amount of FFP produced with the avg donation in k KBM and sent to j BKM with mode t (and then carried to h TC)(in liters/year)

$UTDPN_{kjt}$ =
the amount of FFP produced with the avg donation in k KBM and sent to j BKM with mode t (but not to ship to h TC and destroyed in j RBC) (in liters/year)

Objective Functions:

Bag Costs

Top & Top Bag Cost	$(CTT)(B_k)(1 - X_k)$	(TL basis)	(4. 1)
Top & Bottom Bag Cost	$(CTB)(B_k)(X_k)$	(TL basis)	(4. 2)

Apheresis Cost	$(\mathrm{CAS})(\mathrm{A_k})$	(TL basis)	(4. 3)

Whole Blood Costs

Whole Blood Cost Collected with T&T Bag	$(CTKU)(B_k)(1-X_k)$	(TL basis)	(4.4)
Whole Blood Cost Collected with T&B Bag	$(CTKA)(B_k)(X_k)$	(TL basis)	(4.5)

Production & Destruction Costs

Production Cost	$(\mathrm{UBC_k})\ (\mathrm{CBC})/\ \mathrm{FBC}\ +(\mathrm{UTS_k})(\mathrm{CTS})/\ \mathrm{FTS}+(\mathrm{UATS_k})(\mathrm{CTS})/\mathrm{FATS}+(\mathrm{ULP_k})(\mathrm{CLP})/\mathrm{FLP}+\ (\mathrm{UTDP_k})(\mathrm{CTDP})/\ \mathrm{FTDP}+\ (\mathrm{UES_k})\ (\mathrm{CES})/\mathrm{FES}$	(TL basis)	(4.6)
Whole Blood Destruction Cost	$[(\mathrm{B_k})(0{,}012)]\ [(\mathrm{X_k})(\mathrm{ITKA})+(1-\mathrm{X_k})(\ \mathrm{ITKU})]$	(TL basis)	(4.7)
Production Product Destruction Cost	$(\mathrm{IBC_k})(\mathrm{CIBC})/\ \mathrm{FBC}\ +\ (\mathrm{ITS_k})(\mathrm{CITS})/\ \mathrm{FTS}+(\mathrm{IATS_k})(\mathrm{CITS})/\mathrm{FATS}\ +\ (\mathrm{ILP_k})(\mathrm{CILP})\ /\mathrm{FLP}\ +\ (\mathrm{ITDP_k})(\mathrm{CITDP})/\ \mathrm{FTDP}+\ (\mathrm{IES_k})(\mathrm{CIES})/\mathrm{FES}$	(TL basis)	(4.8)
Cost of destruction not carried to TC	$(\mathrm{UESN_{kjt}})(\mathrm{CIES})+(\mathrm{UTSN_{kjt}})(\mathrm{CITS})+(\mathrm{UTDPN_{kjt}}\ )(\mathrm{CITDP})$	(TL basis)	(4.9)

Transportation Costs

Cost of Transportation b/w BDC-RBC	$(365)(Y_{kjt})(2)(MK_{kjt})(CK_{kjt})$	(TL basis)	(4.10)
Cost of Transportation b/w RBC-RBC	$\sum_{j'=1}^{J'}\sum_{j=1}^{J}\sum_{t=1}^{T}[(STS_{jj't}/FTS + SES_{jj't}/FES + STDP_{jj't}/FTDP)\,((2)\,(MB_{jj't})(CB_{jj't}))\,]$ $(j' \neq j)$	(TL basis)	(4.11)
Cost of Transportation b/w RBC-TC	$\sum_{j=1}^{J}[\sum_{h\in H_i}\sum_{i=1}^{I}\sum_{t=1}^{T}[((Z_{ijt})TES_h/LS_j)(2)(MT_{hjt})(CT_{hjt})] + \sum_{h\in H_i}\sum_{i=1}^{I}\sum_{t=1}^{T}[((Z_{ijt})TTS_h/LS_j)(2)(MT_{hjt})(CT_{hjt})] + \sum_{h\in H_i}\sum_{i=1}^{I}\sum_{t=1}^{T}[((Z_{ijt})TTDP_h/LS_j)(2)(MT_{hjt})(CT_{hjt})]]$	(TL basis)	(4.12)
Cost of Transportation b/w RBC-LAB	$(365)(U_{jlt})(2)(ML_{ljt})(CL_{ljt})$	(TL basis)	(4.13)

MIN COST = (4.1) + … + (4.13)

S.to

Constraints:

1) Assignments

$$\sum_{j=1}^{J}\sum_{t=1}^{T} Y_{kjt} = 1 \qquad \forall k \in \mathbf{K} \tag{4.14}$$

$$\sum_{j=1}^{J}\sum_{t=1}^{T} Z_{ijt} = 1 \qquad \forall i \in \mathbf{I} \tag{4.15}$$

$$\sum_{l=1}^{L}\sum_{t=1}^{T} U_{jlt} = 1 \qquad \forall j \in \mathbf{J} \tag{4.16}$$

2) Production Amounts

$$ULP_k + ILP_k = (AOLP)(B_k)(X_k) + (UOLP)(B_k)(1 - X_k) \quad \forall k \in K \qquad \text{(Liter basis)} \tag{4.17}$$

$$ULP_k = UTDP_k + ITDP_k \qquad \forall k \in K \qquad \text{(Liter basis)} \tag{4.18}$$

$$UES_k + IES_k = (AOES)(B_k)(X_k) + (UOES)(B_k)(1 - X_k) \quad \forall k \in K \qquad \text{(Liter basis)} \tag{4.19}$$

$$IBC_k + UBTS_k = (AOBC)(B_k)(X_k) \quad \forall k \in K \qquad \text{(Liter basis)} \tag{4.20}$$

$$UATS_k + IATS_k = (ASTS)(A_k) \qquad \forall k \in K \qquad \text{(Liter basis)} \tag{4.21}$$

$$UTS_k + ITS_k = UBTS_k + ATS_k \quad \forall k \in K \qquad \text{(Liter basis)} \tag{4.22}$$

3) Demand, Supply and Shipment b/w RBCs

$$UES_k = \sum_{j=1}^{J}\sum_{t=1}^{T} UESD_{kjt} + \sum_{j=1}^{J}\sum_{t=1}^{T} UESN_{kjt} \qquad \forall k \in K \tag{4.23}$$

$$UESD_{kjt} \leq M \times Y_{kjt} \qquad \forall j \in J, \forall k \in K \; ve \; \forall t \in T \tag{4.24}$$

$$UESN_{kjt} \leq M \times Y_{kjt} \qquad \forall j \in J, \forall k \in K \; ve \; \forall t \in T \tag{4.25}$$

$$\sum_{k=1}^{K}\sum_{t=1}^{T} UESD_{kjt} + \sum_{j\prime=1}^{Jm}\sum_{t=1}^{T} SES_{j\prime jt} = \sum_{h\in H_i}\sum_{i=1}^{I}\sum_{t=1}^{T} Z_{ijt} \; (TES_h) + \sum_{j'=1}^{Jm}\sum_{t=1}^{T} SES_{jj't} \quad \forall j, j' \in J \; ve \; j \neq j' \tag{4.26}$$

$$UTS_k = \sum_{j=1}^{J} UTSD_{kjt} + \sum_{j=1}^{J} UTSN_{kjt} \qquad \forall k \in K \tag{4.27}$$

$$UTSD_{kjt} \leq M \times Y_{kjt} \qquad \forall j \in J\,, \forall k \in K \; ve \; \forall t \in T \tag{4.28}$$

$$UTSN_{kjt} \leq M \times Y_{kjt} \qquad \forall j \in J\,, \forall k \in K \; ve \; \forall t \in T \tag{4.29}$$

$$\sum_{k=1}^{K}\sum_{t=1}^{T} UTSD_{kjt} + \sum_{j\prime=1}^{Jm}\sum_{t=1}^{T} STS_{j\prime jt} = \sum_{h\in H_i}\sum_{i=1}^{I}\sum_{t=1}^{T} Z_{ijt} \tag{4.30}$$
$$(TTS_h) + \sum_{j'=1}^{Jm}\sum_{t=1}^{T} STS_{jj't} \;\; \forall j, j' \in J \; ve \; j \neq j'$$

$$UTDP_k = \sum_{j=1}^{Jm} UTDPD_{kjt} + \sum_{j=1}^{Jm} UTDPN_{kjt} \qquad \forall k \in K \tag{4.31}$$

$$UTDPD_{kjt} \leq M \times Y_{kjt} \qquad \forall j \in J\,, \forall k \in K \; ve \; \forall t \in T \tag{4.32}$$

$$UTDPN_{kjt} \leq M \times Y_{kjt} \qquad \forall j \in J\,, \forall k \in K \; ve \; \forall t \in T \tag{4.33}$$

$$\sum_{k=1}^{K}\sum_{t=1}^{T} UTDPD_{kjt} + \sum_{j\prime=1}^{Jm}\sum_{t=1}^{T} STDP_{j\prime jt} = \sum_{h\in H_i}\sum_{i=1}^{I}\sum_{t=1}^{T} Z_{ijt} \tag{4.34}$$
$$(TTDP_h) + \sum_{j'=1}^{Jm}\sum_{t=1}^{T} STDP_{jj't} \qquad \forall j, j' \in J \; ve \; j \neq j'$$

4) Bag Type Usage Rate

$$X_k \leq (YK_{kj})(\sum_{t=1}^{T} Y_{kjt}) + \left(1 - \sum_{t=1}^{T} Y_{kjt}\right) \qquad \forall k \in K, j \in J \tag{4.35}$$

5) Others

$$X_k \geq 0 \qquad \forall k \in K \tag{4.36}$$

$$UTS_k, UATS_k, UBC_k, IBC_k, ULP_k, ILP_k, UTDP_k, UES_k, UBTS_k \geq 0 \;\; \forall k \in K \tag{4.37}$$

$$ITS_k, IATS_k\,, ITDP_k, IES_k \;\geq 0 \qquad \forall k \in K \tag{4.38}$$

$$UESD_{kjt}, UTSD_{kjt},, UTDPD_{kjt} \;\geq 0 \qquad \forall j \in J\,, \forall k \in K \; ve \; \forall t \in T \tag{4.39}$$

$$UESN_{kjt}, UTSN_{kjt}\,, UTDPN_{kjt} \geq 0 \qquad \forall j \in J\,, \forall k \in K \; ve \; \forall t \in T \tag{4.40}$$

$$STS_{jj\prime}, SES_{jj\prime}, STDP_{jj\prime} \;\geq 0 \qquad \forall j, j' \in J \tag{4.41}$$

$$Y_{kjt} = \{0,1\} \qquad \forall j \in J\,, \forall k \in K \; ve \; \forall t \in T \tag{4.42}$$

$$Z_{ijt} = \{0,1\} \qquad \forall j \in J\,, \forall k \in K \; ve \; \forall t \in T \tag{4.43}$$

$$U_{jmt} = \{0,1\} \qquad \forall j \in J\,, \forall k \in K \; ve \; \forall t \in T \tag{4.44}$$

In this model, the objective consists of many cost equations, so these equations are divided into some groups. These are bag cost, whole-blood collection costs, production blood products cost, destruction cost and transportation cost. Firstly, cost of bags contains (4.1) which is cost for Top & Top bag type, (4.2) is Top & Bottom bag type and finally (4.3) is cost of apheresis set for apheresis donation. Secondly, whole-blood collection costs consist of (4.4) and (4.5) which are cost of blood taken with the Top & Top and Top & Bottom bag type respectively. (4.6) is production cost of the produced blood products. In addition, the costs of annihilation consist of whole-blood destruction cost (4.7), the produced products destruction cost (4.8) and the costs of destruction of products which are not transported to the transfusion centers (4.9). Finally, the transportation costs are formed (4.10), (4.11), (4.12) and (4.13). The equation (4.10) is blood products transportation cost from BDCs to RBCs, (4.11) is from RBCs to RBCs, (4.12) is from RBCs to TC and (4.13) is from RBCs to laboratories.

Assumption-11 states that blood products are produced in BDC and sent to RBCs. In fact, donations collected at BDC are carried to RBCs and blood products are produced. As it can be seen from the Figure 4, the donations are actually collected in BDCs and they are carried to RBCs and blood products are produced in there. However, in the real situation, donations in BDCs are taken with bag types and produced in RBCs, in other words, the products are taken with k index and produced with j index in the real situation of Figure 5 and this situation causes nonlinearities. To solve this nonlinearity, it was assumed that the products were collected in BDCs, then blood products were produced and sent to RBCs. In assumed situation part of Figure 4 and 5, productions of blood products are performed in BDCs. This means that products are collected with k index and also produced with again k index. With this way, nonlinearity is solved.

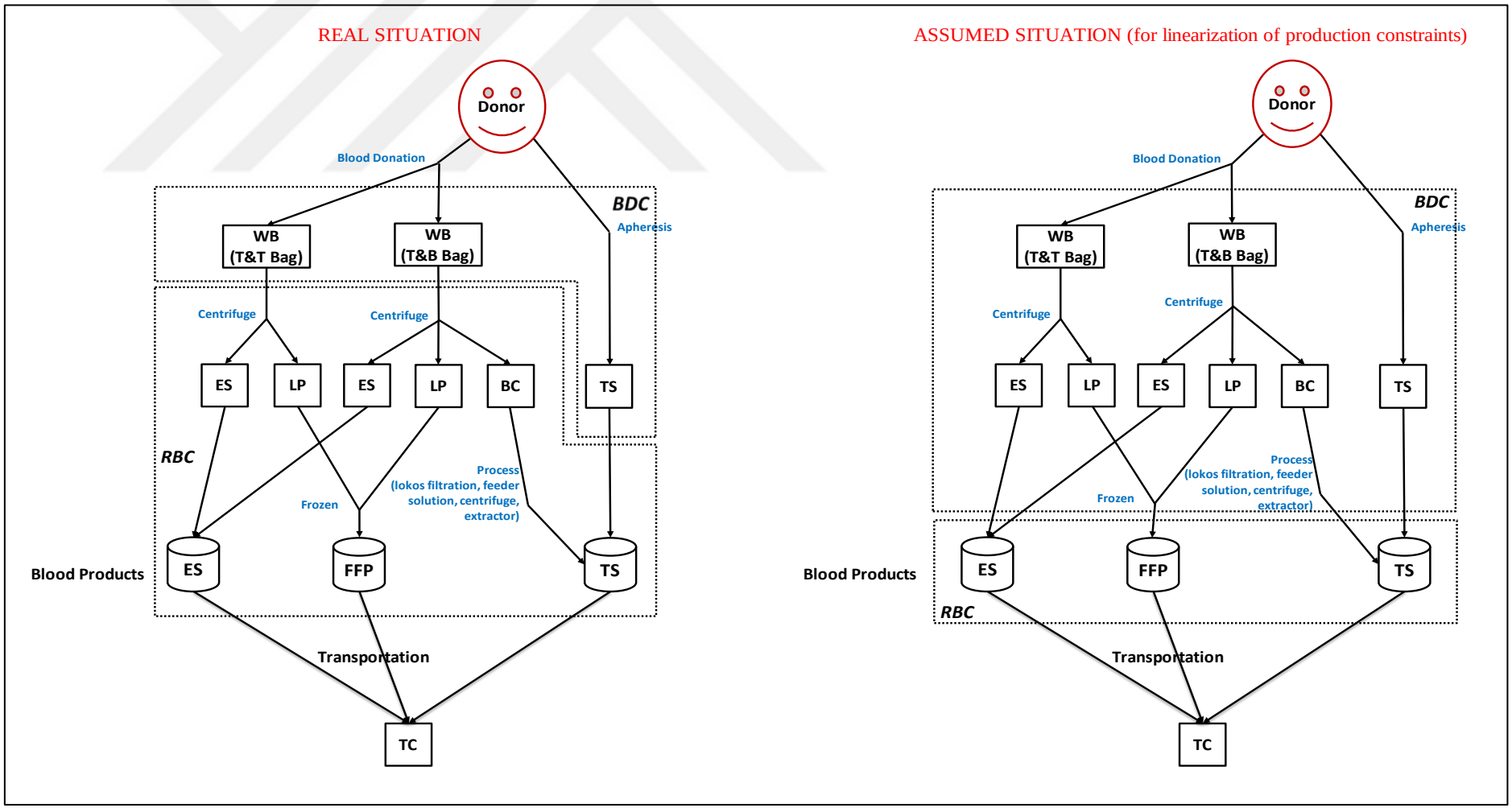


Figure 4: Blood Production Processes for Real and Assumed Situation

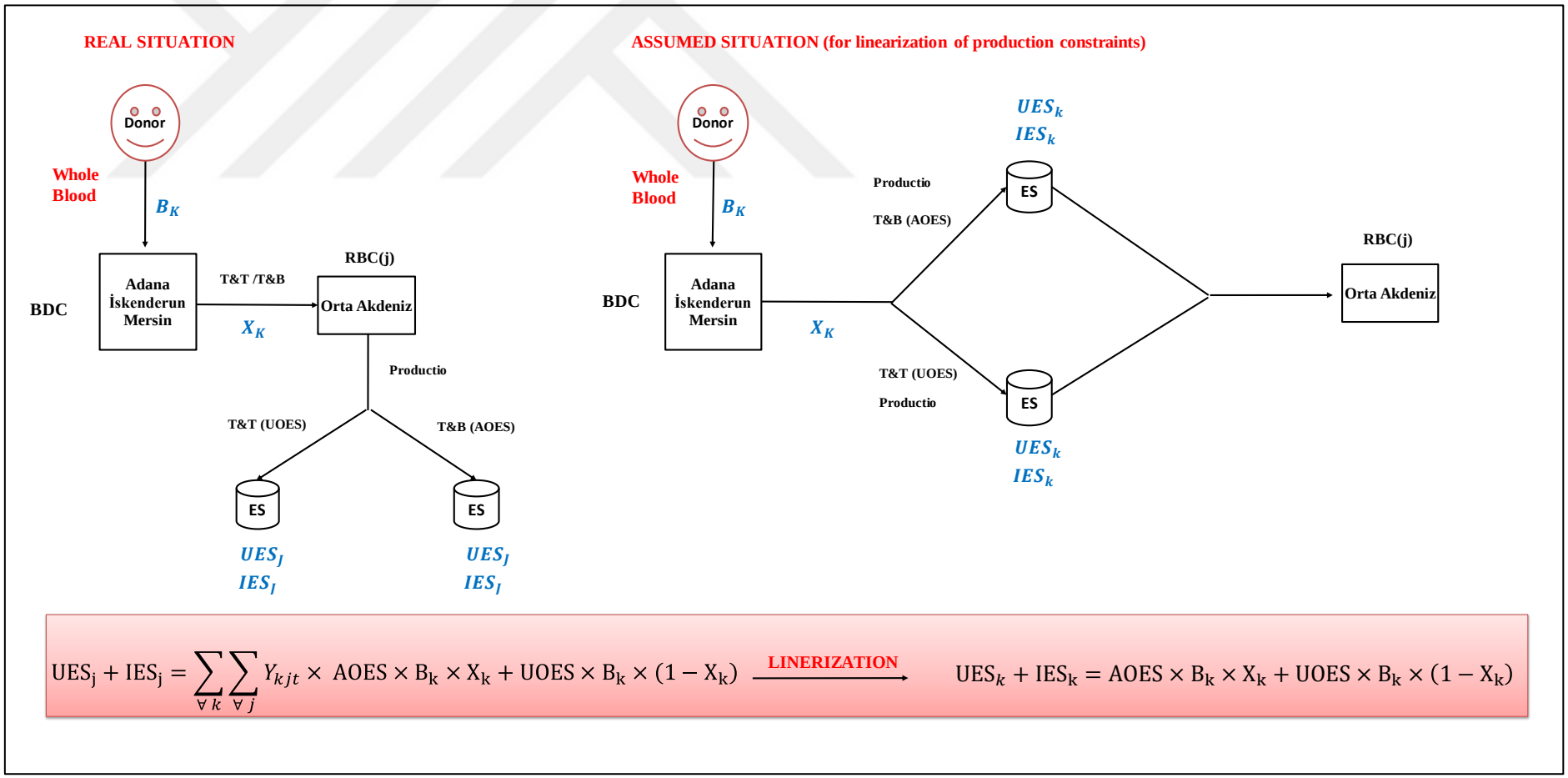


Figure 5 : Example for Linearization Process for Blood Product Supply Chain

Calculation of the Lot Size:

1- The donations are transferred from BDC to RBCs and supply is transferred from RBCs to TCs. The donations, demands and distances between the blood centers were determined in order to weight the distance traveled during the transportation of demands and donations. Direct shipment is used during distribution of the blood products.

2- Whole blood and blood samples transports are performed once daily between BDCs- RBCs and RBCs-Labs respectively. The distances between these centers are multiplied by 365 to calculate the annual total km.

3- In the interviews conducted with TRC, the average mileage information for a rental vehicle was determined as 125000 km. The total number of leased blood transport vehicles in the RBCs is multiplied with the total km for each vehicle per year to calculate total mileage.

4- For the calculation of the total km for the transportation to the TCs; the kilometers for all other transportation are subtracted from the km calculated for the total rental vehicles. The distance between RBC and TCs is multiplied by "2" since there is one round trip each day. Finally, demand-km weighting was calculated by multiplying km and demands with each other.

5- Demand-distance multiplication for TCs was divided by distributed km for TCs (4) and "***Lot Size***" was calculated.

Constraints are divided into five groups. First group is formed of assignment constraints. Constraints (4.14), (4.15) and (4.16) imply that each should be assigned to only one RBC. Second group is production / destruction quantities constraints. (4.17) shows the production and destruction amounts of liquid plasma. (4.18) shows the production of fresh frozen plasma produced and destroyed from liquid plasma. (4.19) production and destruction of erythrocyte suspensions (4.20), (4.21) and (4.22) show production and destruction of buffy coat and production thrombocyte suspensions from apheresis donation.

Third group is constraints of demand, supply and shipments between RBCs. Constraints from (4.23) to (4.34) refer to the demands of erythrocyte suspension, thrombocyte suspensions and fresh frozen plasma from transfusion centers and shipment between RBCs. The fourth group is a bag-type constraint and (4.35) is used to increase the use of the Top & Bottom bag type. Finally, the constraints between (4.36) and (4.44) indicate the domains and sign restrictions of the decision variables.

After finding the minimum amount of total cost, second model is solved to find the minimum time for shipping of the blood products. For time model, some parameters are added and some decision variables are different from the cost model. Therefore, we categorized the objective function according to shipping time between the BDCs, RBCs and TCs. The assumptions, changing parameters, decision variables, equations of the objective function are as follows:

4.2 Time Model

Assumptions:

1- Transports from RBC to LABs were neglected due to non-linearity and all blood samples were tested in laboratories. All blood and blood samples taken during blood donation are sent to the RBCs, then all samples are sent to laboratories for testing. Blood products are assumed to be produced in BDCs and transported to RBCs, as described in the Cost Model. For this reason, the model is designed to transport blood samples from BDCs to Labs. However, only blood samples are sent to the labs and whole blood is kept waiting and separated after test operation and results. In fact, TS is the product that is affected the most by the time spent in both transporting to the labs and test processes because it has the lowest shelf life. However, this period was not added to the Time Model due to the fact that it did not affect our model much in total. A parallel “Thesis

Study"[1] was conducted in our study on Lab processes and transportation time to labs brought nonlinearity to our model. Both transportation and testing time affect the shelf life of products, which are samples sent to the labs and the duration of the transport has no effect on the shelf life of blood products other than TS. Since all samples are strictly tested and the transportation time to the labs is a fixed procedure, the transportation time to labs has been neglected.

TIME Model:

Shelf Life Parameters:

$EDTS$ = Shelf Life for TS (minute basis)

$EDES$ = Shelf Life for ES (minute basis)

$EDTDP$ = Shelf Life for FFP (minute basis)

Decision Variables:

$tUTSD_{kjt}$ = The lost time for amount of TS transported from k BDC to j RBC with mode t (in liters $\times$ minutes)

$tUESD_{kjt}$ = The lost time for amount of ES transported from k BDC to j RBC with mode t (in liters $\times$ minutes)

$tUTDPD_{kjt}$ = The lost time for amount of FFP transported from k BDC to j RBC with mode t (in liters $\times$ minutes)

$tSTS_{j'jt}$ = The lost time for amount of TS transported from j RBC to j' RBC with mode t (in liters $\times$ minutes)

$tSES_{j'jt}$ = The lost time for amount of ES transported from j RBC to j' RBC with mode t (in liters $\times$ minutes)

[1] Dilaver, H. M. (2018). *A mathematical modeling approach for managing regional blood bank operations* (Doctoral dissertation, Bilkent University).

$tSTDP_{j'jt}$ = The lost time for amount of FFP transported from j RBC to j' RBC with mode t (in liters × minutes)

$tTES_h$ = The lost time for amount of ES transported from j RBC to h TC with mode t (in liters × minutes)

$tTTS_h$ = The lost time for amount of TS transported from j RBC to h TC with mode t (in liters × minutes)

$tTDP_h$ = The lost time for amount of FFP transported from j RBC to h TC with mode t (in liters × minutes)

$timeTS$ = Total Lost Time for amount of TS transfported (in liters × minutes)

$timeES$ = Total Lost Time for amount of ES transfported (in liters × minutes)

$timeTDP$ = Total Lost Time for amount of FFP transfported (in liters × minutes)

LTS_{TS} = Ratio of lost time of the amount of TS transported to TS shelf life (in liters/shelf life)

LTS_{ES} = Ratio of lost time of the amount of ES transported to ES shelf life (in liters/shelf life)

LTS_{TDP} = Ratio of lost time of the amount of FFP transported to FFP shelf life (in liters/shelf life)

Objective Functions:

Product Transportation Time

$$tTS_{kj} = \sum_{k=1}^{K}\sum_{j=1}^{J}\sum_{t=1}^{T} UTSD_{kjt}\,(SK_{kjt}) \quad \text{(in liter x minutes)} \quad (4.45)$$

$$tES_{kj} = \sum_{k=1}^{K}\sum_{j=1}^{J}\sum_{t=1}^{T} UESD_{kjt}\,(SK_{kjt}) \quad \text{(in liter x minutes)} \quad (4.46)$$

$$tTDP_{kj} = \sum_{k=1}^{K}\sum_{j=1}^{J}\sum_{t=1}^{T} UTDPD_{kjt}\,(SK_{kjt}) \quad \text{(in liter x minutes)} \quad (4.47)$$

$$tTS_{jj'} = \sum_{j'=1}^{Jm} \sum_{t=1}^{T} STS_{jj't} \ (SB_{jj't}) \quad \text{(in liter x minutes)} \quad (4.48)$$

$$tES_{jj'} = \sum_{j'=1}^{Jm} \sum_{t=1}^{T} SES_{jj't} \ (SB_{jj't}) \quad \text{(in liter x minutes)} \quad (4.49)$$

$$tTDP_{jj'} = \sum_{j'=1}^{Jm} \sum_{t=1}^{T} STDP_{jj't} \ (SB_{jj't}) \quad \text{(in liter x minutes)} \quad (4.50)$$

$$tES_{jh} = \sum_{h \in H_i} \sum_{i=1}^{I} \sum_{t=1}^{T} TES_h \ (ST_{hjt}) \quad \text{(in liter x minutes)} \quad (4.51)$$

$$tTS_{jh} = \sum_{h \in H_i} \sum_{i=1}^{I} \sum_{t=1}^{T} TTS_h \ (ST_{hjt}) \quad \text{(in liter x minutes)} \quad (4.52)$$

$$tTDP_{jh} = \sum_{h \in H_i} \sum_{j=1}^{J} \sum_{t=1}^{T} TTDP_h \ (ST_{hjt}) \quad \text{(in liter x minutes)} \quad (4.53)$$

$$timeTS = tTS_{kj} + tTS_{jj'} + tTS_{jh} \quad \text{(in liter x minutes)} \quad (4.54)$$

$$timeES = tES_{kj} + tES_{jj'} + tES_{jh} \quad \text{(in liter x minutes)} \quad (4.55)$$

$$timeTDP = tTDP_{kj} + tTDP_{jj'} + tTDP_{jh} \quad \text{(in liter x minutes)} \quad (4.56)$$

$$LTS_{TS} = timeTS/\{(EDBC)(1{,}440)\} \quad \text{(in liters / shelf life)} \quad (4.57)$$

$$LTS_{ES} = timeES/\{(EDES)(1{,}440)\} \quad \text{(in liters / shelf life)} \quad (4.58)$$

$$LTS_{TDP} = timeTDP/\{(EDTDP)(1{,}440)\} \quad \text{(in liters / shelf life)} \quad (4.59)$$

Objective Functions:

$$\textbf{min} \quad \mathbf{LTS_{TS} + LTS_{ES} + LTS_{TDP}} \quad (4.60)$$

S.to

constraints (4.14) to (4.44) of the Cost Model

$$\text{timeTS}, \text{timeES}, \text{timeTDP}, LT_{TS}, LT_{ES}, LT_{TDP} \geq 0 \quad (4.61)$$

$$LTS_{TS}, LTS_{ES}, LTS_{TDP}, LTSR_{TS}, LTSR_{ES}, LTSR_{TDP} \geq 0 \quad (4.62)$$

In this Time Model, (4.45), (4.46) and (4.47) show the transportation time ES, TS and FFP between the s to RBC. Equations (4.48), (5.49) and (4.50) imply shipping time of the products from RBC to another RBC and finally, equations (4.51), (4.52) and (4.53) calculate transportation time of the demand from RBCs to TCs. In addition, equation (4.54), (4.55) and (4.56) give the total transportation time of amount of ES, TS and FFP respectively.

Time is a fact that is impossible to return. Utilizing time in the most efficient way is one of the main goals of all of us, especially industrial engineers. When the time and duration of use of blood products are taken into consideration, the importance of time increases once again. In our solutions for Time Model, the total time of blood products transported directly to units such as minutes and hours is based on the calculation of the time taken from the shelf life of the products.

The objective function is calculated according to the ratio of shelf life of products to the time elapsed during transport of products. This value shows us how much product has reached the end of its shelf life in transport, and minimizing this time means more products reach people in need. Therefore, (4.57), (4.58) and (4.59) are the equations that constitute the objective function and are calculated by minimizing the amount of total transported ES, TS and FFP by dividing the shelf life.

To mention the constraints for the time model, all constraints are the same as the cost model. However, cost equations, parameters and decision variables are not used in time model. In addition, (4.61) and (4.62) are sign restrictions of the decision variables.

4.3 Solution of the Models

4.3.1 Current vs Optimal Solution of the Cost Models

TRC is a non-profit organization. To rescue more people, they try to apply “Total Cost = Total Income” approach. During the meeting with the authorities, it was learned that the “Actual Cost” in this approach was between 500-600 million. The current status assignments of RBCs, BDCs and TCs of the TRC were solved in the Cost Model. The cost obtained according to the current assignments is 574.055.164,09 TL. This cost is in the actual cost range. Then, the cost achieved in the solution without considering the current assignment is 554.924.777,22 TL. When both costs are compared, an improvement of 19.130.386,87 TL has been achieved with the optimal solution. The main difference between the two solutions is provided by the costs of transportation from RBCs to RBCs and from RBCs to TCs. The improvement in transportation costs is approximately 18 million TL. On the other hand, in bag types even if there is an increase in T&B bag type costs, this difference stems from the increase in the use of T&B bag type in our optimum solution. The use of T&B bags has increased by more than 53 thousand units (2 % of total bag used). In this way, the amount of TS produced by BC was increased. TS production increased by approximately 2,921.42 liters compared to the current solution and the optimum solution. All results are shown in Appendix-5 and Appendix-6.

When the assignment of BDCs to RBCs in current system and the Cost Model solutions is examined, the biggest change occurred in Guney Batı Anadolu RBC as shown in Table 5 below. While the number of connected BDCs in the current system was 3, only ground transport was used. After the optimal result, this number increases to 13 and in 8 of them, the products are sent to assigned RBCs by air transport. When Ege RBC is examined, the assignments decrease by 14% in total according to the current system. While there were 7 BDCs in the current system, this number decreased to 6 in the optimal solution. This is the one named, Izmir which is assigned to Guney Batı Anadolu RBC. On the other hand, when the Avrupa RBC is

examined, there is a 100% increase in the number of BDCs, which are 5 in the current system and use only ground transportation. In the Cost Model, this number increases to 10 and for 4 of them which are Yozgat, Giresun, Rize and Van RBCs, air transportation is used.

Table 5: Assignment and transportation mode comparison between Current and the Cost Model for BDC and RBC

RBC	MODEL	GROUND	AIR	CHANGES
GUNEY BATI ANADOLU	CURRENT	3	0	266.67%
	COST	5	8	
EGE	CURRENT	7	0	-14%
	COST	6	0	
AVRUPA	CURRENT	5	0	100%
	COST	6	4	

When the assignments of the TCs to RBCs are examined, the biggest change occurred in the Guney Batı Anadolu RBC where the total number of TC increased from 45 to 451 in total and 423 TCs are transported by air. Related data is shown in the Table 6 below. In Cost Model, 40% air transportation mode is used, in which 38% of this rate consists of Guney Batı Anadolu RBC.

Table 6: Assignment and Transportation Mode Comparison between Current and Cost Model for RBC and TC

	MODEL	GROUND	AIR	CHANGES
GUNEY BATI ANADOLU	CURRENT	45	0	902%
	COST	28	423	

When the assignment of RBCs to laboratories is examined, it can be seen from the Table 7 below that the number of RBCs in the Orta Akdeniz Lab increased from 3 to 12 (33%). In Marmara Lab, current system has 7 RBCs and 4 of them are transported by ground and the other 3 are transported by air. Dogu Karadeniz, Guney Anadolu

and Orta Karadeniz RBCs, of which all 3 are transported by air, have been assigned to the Orta Akdeniz Lab. When we look at the Orta Anadolu Lab, the number of RBCs decreased from 6 to 2. Batı Akdeniz, Dogu Anadolu, Guney Batı Anadolu and Guney Dogu RBCs are also assigned to the Orta Akdeniz Lab. Finally, in Ege RBC there was no change.

Table 7 : Assignment and Transportation Mode Comparison between Current and Cost Model for RBC and LAB

LAB	MODEL	GROUND	AIR	CHANGES
ORTA AKDENIZ LAB	CURRENT	3	0	300%
	COST	1	11	
KUZEY MARMARA LAB	CURRENT	4	3	-71%
	COST	2	0	
ORTA ANADOLU LAB	CURRENT	2	4	-67%
	COST	2	0	

In addition, assignments which were determined according to current status and which minimize the cost model were compared using Turkish map with the use of power bi ArcGIS. All changes in the assignments are shown in Appendix 7, 8 and 9 and also ArcGIS comparison maps are also shown in Appendix 10, 11 and 12.

FOOTNOTE:

Although TRC chooses the blood bag type, they accept that if RBCs are close to each other, the distance between them is at most 270 km. In accordance with this information, the constraint (5.38) which affects the bag type allows to increase the usage of T&B bag type.

In order to observe how "*YK-closeness parameters*" affect the Cost Model, all YK_{kj} is fixed to 1 to eliminate the closeness constraint to allow any type of bag usage. In other words, the closeness between RBCs is *RELAXED* and this option is called

"*RELAXED SYSTEM*". In the model, related changes were performed and solved in the model again. According to result in Appendix 5, the number of bag types used is the same. Therefore, there was no change in bag type and blood collection costs. Although there was no change in production amounts, TS destruction numbers increased by approximately 445 liters (1,8 %). The result can be seen in Appendix 13. In transportation costs, there is an increase in transportation between BDC-RBC and a decrease in transportation costs between RBC-RBC and RBC-TC. Considering the total costs, a decrease of 110 thousand TL can be seen, but solutions have been continued without considering this situation. Therefore, it is aimed to increase the use of T&B bag type in order to reduce TS destruction.

When the Cost Model and Relaxed System were examined, as shown in the Table 8 below, there was no change in numbers in Guney Batı Anadolu RBC's assignments. According to the cost model in Ege RBC, there are 6 BDCs and all transportations are made by ground. However, this number has decreased to 5 in the Relaxed System and one of them is transported by air. When the Avrupa RBC was examined, there were 10 BDCs while this number decreased to 5 in the relaxed system. In addition, the all related changes in assignments and transportation modes are shown in Appendix 7, 8 and 9 and ArcGIS comparison maps are also shown in Appendix 14, 15 and 16.

Table 8: Assignment and Transportation Mode Comparison b/w Cost Mode and Relaxed for BDC and RBC

RBC	MODEL	GROUND	AIR	CHANGES
GUNEY BATI ANADOLU	COST	5	8	0%
	RELAXED	5	8	
EGE	COST	6	0	-17%
	RELAXED	4	1	
AVRUPA	COST	6	4	-50%
	RELAXED	3	2	

4.3.2 Current vs. Optimal Solution of the Time Models

One of the most important parameters in blood and blood products is time. Time is directly proportionate to human health and the availability of products. When designing the model, it is not only considered as a "***TIME***" improvement like minute or hour for the results to have a meaning in this proportion. In order to make the future results more meaningful, we aimed to see how the time spent during the transportation of blood and blood products has an effect on the life of the blood products. Each improvement will prolong the life of the blood product and increase the fulfillment of the patient's requirement as time and quantity. As previously mentioned, the time model calculated the total amount of product reaching the end of the total life. As in the Cost Model, ***Time Model*** is solved for RBCs, BDCs, and TCs with current status and relaxed assignments. When the results were examined, according to current assignment, total products which reached the end of the shelf life are 1,361.12 liters. On the other side, according to relaxed assignments, total products which reached the end of the shelf life are 1,283.07 liters. Therefore, when both solutions are compared, optimal solution is better than the current status and our optimal solution provided an improvement of ***78.05 liters / shelf life (5,73%)*** from the total product shelf life. When the time spent transporting from BDCs to RBCs is examined, the time spent in transporting ES seems to be high in optimal solutions, improvements are provided in product transport time from RBCs to RBCs and from RBCs to TCs. When the ES transportation time is examined, approximately 5,5 million min x liter improvement was provided in total ES transportation time. This improvement has been achieved especially by air transport from RBCs to TCs and lateral transportation between RBCs. In this context, considering the shelf life of ES, approximately 64 liters of ES shelf life has been improved. As a result, the amount of blood products at the end of shelf life during transportation is 378.72 liters in TS, 891.91 in ES, 12.43 liters in FFP and 1,283.07 liters in total. Related results are shown in Appendix 17.

When the assignments for the Current System and the Time Model are examined, it can be seen in the Table 9 below that when the Orta Anadolu RBC is examined in

BDC and RBC assignments, while the number of BDCs that use ground transportation mode is 5 the in current system, this number is increased to 7 in Time Model. Two of these, which are Sivas and Yozgat in Orta Anadolu RBC, are assigned to Orta Anadolu RBC and the products are transported by airway. In the Avrupa RBC, there are 5 BDCs and only the ground transportation mode is used in the current system. However, this number is increased to 6 in the Time Model. This increase was realized with the assignment of Odemis BDC, which was previously assigned to Ege RBC, and air transportation is used in there. Finally, there was no change in number of BDCs and transport modes when the Guney Bati RBC was examined.

Table 9: Assignment and Transportation Mode Comparison b/w Current and Time Model for BDC and RBC

RBC	MODEL	GROUND	AIR	CHANGES
ORTA ANADOLU	CURRENT	5	0	40%
	TIME	5	2	
AVRUPA	CURRENT	5	0	20%
	TIME	5	1	
GUNEY BATI ANADOLU	CURRENT	3	0	0%
	TIME	3	0	

When the assignments of RBC and TC are examined, while all transportations are carried out by ground in the current system, 1.36% airline transportation mode is used in Time Model. As can be seen in the Table 10 below, this ratio occurred in Guney Dogu RBC. 15 RBCS connected to the Avrupa RBC are assigned to the Guney Dogu RBC. Finally, when the Labs assignments are examined, all RBCs are directly assigned to the Orta Akdeniz Lab. All assignments and transportation mode changes according to current status that minimize the Time Model were compared using Turkish map with the use of POWER BI ArcGIS. The changes in the assignment are shown in the Appendix 18, 19 and 20 and ArcGIS comparison maps are also shown in Appendix 21, 22 and 23.

Table 10: Assignment and Transportation Mode Comparison b/w Current and Time Model for RBC and TC

RBC	MODEL	GROUND	AIR	CHANGES
GUNEY DOĞU	CURRENT	28	0	54%
	TIME	28	15	

In order to determine how the closeness of RBCs and BDCs affect the transports, the Time Model was solved for relaxed system and the results were compared with the optimal model. Relaxed system solution is 2.80 liters higher than the optimal solution. Although the total amount of ES which are at the end of the shelf life for relaxed model has been improved, significant improvements have been found in the optimal model for the transports from RBC to RBC. The results are shown in Appendix-17. The changes in assignment and transportation mode of BDCs, RBCs and TCs are shown in comparison tables in Appendix 18, 19 and 20 and maps for assignments are in Appendix 24, 25 and 26.

4.4 Multi-Objective Model

In this section, we combined our cost and time models. We tried to determine the limits of our model in terms of cost and time. The mathematical model, results, and the solutions between objectives according to the Cost and Time Model will be mentioned.

BI-OBJECTIVE Model:

In this model objective function changed as follows:

Objective-1:

$$min \quad MINTIME = TIME + (\epsilon)(COST)$$

Objective-2:

$$min \quad MINCOST = COST + (\epsilon)(TIME)$$

s.t.

constraints (4.14) to (4.44) of Cost and Time Model

where " ϵ " is a small number

In the MINTIME objective function, the cost of function is added to the time function with a small number, ϵ, which does not affect the optimal solution of minimizing time alone. By this approach, we aim to reach minimum time value while having the smallest cost value among alternative solutions. In the MINCOST objective function, we do the same with changing time and cost functions. Our approach to obtain two extreme solutions is similar to the augmented ε-constraint method. For generating non-dominated solutions, we use ε-constraint method in the following parts of the study. The results are shown in the following Table 11 and other results of the model solution are shown in the table in Appendix 27.

Table 11: Objective function results of the Bi-Objective Model

	OBJECTIVE FUNCTION	
MODEL	MINTIME	MINCOST
TIME	1,278.74 (Optimal)	4064,39
COST	644,661,380	554,924,777 (Optimal)

Two extreme solutions can be seen in Table 11, while the end of shelf life for MINTIME objective function is 1,278.74 liters and the cost is above 644 million TL. For MINCOST objective function, the end of shelf life is 4.064,39 liters and the cost is above 554 million TL.

The changes in assignments as a result of solutions obtained according to objective functions were examined. For BDC and RBC assignments according to the current status and MINCOST objective function, as can be seen in Table 12 below, while the number of BDCs in Guney Batı Anadolu RBC is 3 and transportation is performed by ground in Current System, the number of BDCs has increased to 14 totally and for 9 of them products are transported by air in MINCOST objective function. The number of BDCs in Orta Anadolu RBC are 5 and ground transportation mode is used in the Current System; this number decreased to 4, but air transport increased to 2. Finally in Ege RBC, the number of BDCs decreased from 7 to 6 and this decrease occurred by assignment of Izmir to Guney Batı Anadolu RBC.

Table 12: Assignment and transportation mode comparison b/w Current and MINCOST Obj. Function for BDC and RBC

RBC	MODEL	GROUND	AIR	CHANGES
GUNEY BATI ANADOLU	CURRENT	3	0	316,7%
	COST	5	9	
ORTA ANADOLU	CURRENT	5	0	20%
	COST	4	2	
EGE	CURRENT	7	0	-14%
	COST	6	0	

In addition, when the Current System is compared to MINTIME obj. function in the Table 13, the number of BDCs in Ege RBC decreased from 7 to 6 because Marmaris was assigned to Dogu Akdeniz RBC. In Orta Anadolu RBC, the number of BDCs remained unchanged for road transportation, however, the number of BDCs increased from zero to 1 for air transportation. In the Avrupa RBC, the total number of BDCs remained unchanged.

Table 13: Assignment and Transportation Mode Comparison b/w Current, Time Model and MINTIME Obj. Function for BDC and RBC

RBC	MODEL	GROUND	AIR	CHANGES
EGE	CURRENT	7	0	-14%
	TIME	6	0	
ORTA ANADOLU	CURRENT	5	0	20%
	TIME	5	1	
AVRUPA	CURRENT	5	0	0%
	TIME	5	0	

When current and MINCOST objective function solutions are examined in RBC and TC assignments, the increase in air transport is 45.7%. The largest increase occurred in Guney Batı Anadolu RBC and according to Table 14, the number of total increased about 91%. On the other hand, in Current system and MINTIME objective function assignments, air transportation is increased about 2.9% according to the Current System. This change, as in the Time Model, occurred in Guney Dogu RBC.

Table 14: Assignment and Transportation Mode Comparison b/w Current and MINCOST Obj. Function for RBC and TC

RBC	MODEL	GROUND	AIR	CHANGES
GUNEY BATI ANADOLU	CURRENT	45	0	91%
	COST	28	496	

When the Lab and RBC assignments are examined, the Current System-MINCOST objective function comparisons are the same. On the other hand, in the current System and MINTIME objective function assignments, all RBCs were assigned to the Orta Akdeniz Lab with ground transportation. The assignment according to the Current System, MINCOST and MINTIME objective function for all BDC-RBC, TC (city based)-RBC and Lab-RBC are in Appendix 28, 29 and 30.

As a summary, there are increases about 27.69% and 9.23% in total in air transportation according to the Current System-Cost Model comparisons and the Current System and the Time Model, respectively. On the other hand, there are decreases from 27.69% to 23.08% and from 9.23% to 6.15% according to Cost Model-MINCOST Objective Function and Time Model-MINTIME objective functions, respectively. In addition, comparisons maps of all blood centers are shown in between Appendix 31 and Appendix 36 according to current status, between MINCOST and MINTIME objective functions results.

4.5 Cost Given Time Model

Some updates have been made to the "***Bi-Objective Model***" to provide a balance of time and cost and to calculate how variations were between the boundaries of the model. The time limits set in the bi-objective model are divided into equal parts. Afterwards, some changes were made in the bi-objective model, and ***Cost Given Time Model*** was obtained. Solutions have been taken for each *Given Time*.

We divide the time value into equal amounts in Table 11 and obtain R many time values, where $\boldsymbol{R} = \{r: r = 1,2, \dots, R\}$. The smallest time is $TIMElimit_1$ and the largest time is $TIMElimit_P$. For each r value, we solve the Cost Given Time Model. The changes in the Bi Objective Model are shown below.

Cost Given Time Model:

Objective:

$min \quad COST$

s.t.

constraints (4.14) to (4.44) of Cost and Time Model

$TIME \leq TIMElimit_p$

We iterate on r and solve Cost Given Time Model for all $TIMElimit_p$ values. For each iteration, we set $COST_r$ as the obtained minimum TIME value.

Pseudocode for Bi-Objective Solution Procedure

$For\ r = 1\ to\ R$

Solve Cost Given Time Model

Set $COST_r = COST$

end

Consider two solutions X_1 and X_2. If both cost and time objectives for X_1 are at least as good as for X_2, i.e., $COST(X_1) \leq COST(X_2)$ and $TIME(X_1) \leq TIME(X_2)$, and at least one objective is strictly better for X_1, i.e., either $COST(X_1) < COST(X_2)$ or $TIME(X_1) < TIME(X_2)$, than X_1 dominates X_2. In this situation, X_2 is called the dominated or inefficient solution. A solution not dominated by any other solution is called a non-dominated or an efficient solution. Efficient solutions form efficient frontier for the decision maker, where hopefully she/he chooses one of those solutions for implementation. As you can see in Table 15 and Figure 6 below, $r_1$value is lower than r_2. On the other hand, when the cost values are examined, $COST_{2\ to\ P}$ values are increasing. In other words, r values are less than the other ($r_1 < \cdots < r_P$). When COST values are examined, the values decrease according to given time value ($COST_1 > \cdots > COST_P$). Therefore, all points are non-dominated by each other.

Table 15: Result of Cost according to Given Time

COST GIVEN TIME MODEL RESULTS			
r	GIVEN TIME (LT/SHELF LIFE)	$COST_R$	COST SOLVED (TL)
1	1.278,74	$COST_1$	644.661.379,75
2	1.557,30	$COST_2$	560.735.998,98
3	1.835,87	$COST_3$	560.138.985,88
4	2.114,44	$COST_4$	559.910.408,68
5	2.393,00	$COST_5$	559.708.843,74
6	2.671,57	$COST_6$	558.764.977,38
7	2.950,13	$COST_7$	558.330.469,88
8	3.228,70	$COST_8$	557.269.222,21
9	3.507,27	$COST_9$	557.193.891,51
10	3.785,83	$COST_{10}$	555.961.846,43
11	4.064,40	$COST_{11}$	554.924.777,22

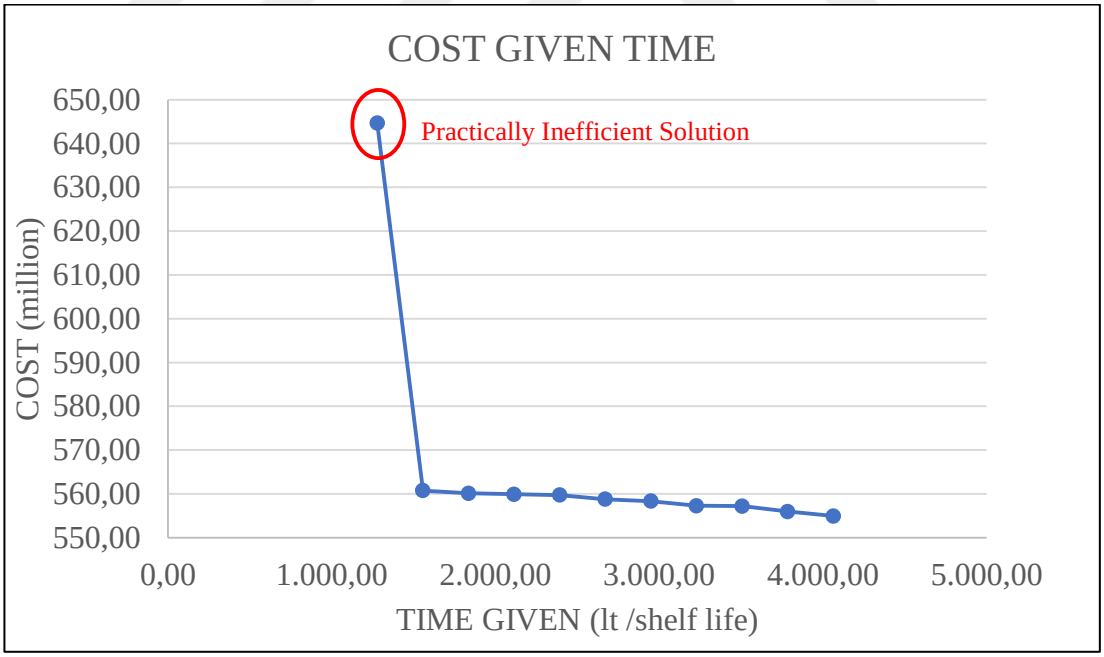


Figure 6: Costs according to amount of products which are at end of the shelf life according to given time values

In this model, $COST_{upper}$ does not make sense for the DM, so it can be called as "***Practically Inefficient Solution***". When this practically inefficient point is removed from Figure 6, the remaining r values reflect the results of our model and study. Here, the optimum result can be selected according to the DM. The corresponding Figure 7 for the remaining r values as follows.

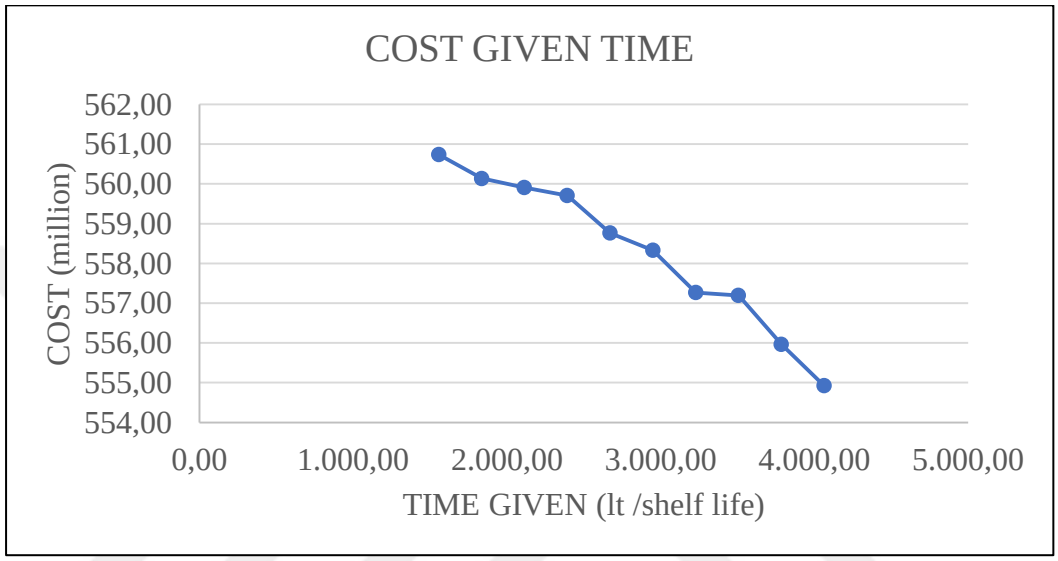


Figure 7: Non Dominated Cost Values

4.6 Time Given Cost Model

In this section, the processes, which are applied in the Cost Given Time Model, are performed. In this new model, the amount of products, which reached the end of the shelf life, are calculated by given or determined cost. We divide the time value into equal amounts in Table 11 and obtain P many cost values, where $\boldsymbol{P} = \{p: p = 1,2, \dots, P\}$. The smallest cost is $COSTlimit_1$ and the largest cost is $COSTlimit_P$. For each p value, we solve the ***Time Given Cost Model***. The changes in the Bi-Objective Model are shown below.

Time Given Cost Model:

Objective:

$min \quad TIME$

s.t.

constraints (4.14) to (4.65) of Cost and Time Model

$COST \leq COSTlimit_p$

We iterate on p and solve Time Given Cost model for all $COSTlimit_p$ values. For each iteration we set $TIME_p$ as the obtained minimum TIME value.

Pseudocode for Bi-Objective Solution Procedure

$For\ p = 1\ to\ P$

Solve Time Given Cost Model

Set $TIME_p = TIME$

end

In the multi-objective model, the difference between the costs determined by both objective functions is over 89 million. This difference was divided into equal parts and the cost ranges were calculated. For each determined cost value, solutions were taken in the Time Given Cost Model. However, as you can see in Table 16 and Figure 8 below, $p_1$value is higher than p_2. On the other hand, when the time values are examined, $TIME_{2\ to\ P}$ values are almost equal. Therefore $TIME_2$ dominates other $TIME_p$ values.

Table 16: Result of Time according to Given Cost

TIME GIVEN COST MODEL RESULTS			
p	COST LIMIT (TL)	$TIME_P$	MIN. TIME (LT/SHELF LIFE)
1	554.924.777,22	$TIME_1$	4064,40
2	563.898.437,48	$TIME_2$	1284,55
3	572.872.097,73	$TIME_3$	1278,84
4	581.845.757,98	$TIME_4$	1278,86
5	590.819.418,23	$TIME_5$	1279,15
6	599.793.078,49	$TIME_6$	1278,83
7	608.766.738,74	$TIME_7$	1278,89
8	617.740.398,99	$TIME_8$	1278,76
9	626.714.059,24	$TIME_9$	1278,84
10	635.687.719,50	$TIME_{10}$	1278,92
11	644.661.379,75	$TIME_{11}$	1278,74

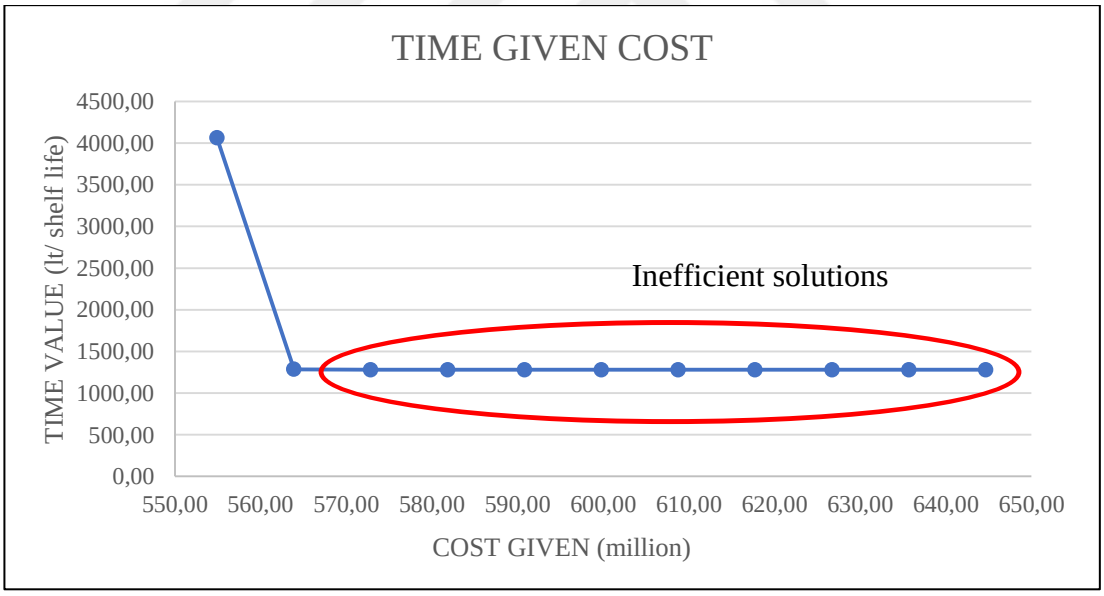


Figure 8 : Costs according to amount of products which are at the end of the shelf life according to first solution results

On the other hand, we found that the actual decrease was between 554 million TL and 563 million TL costs. The difference between these two cost values is approximately 8,9 million TL. This difference divided into equal parts and for each

cost p value, the Time Given Cost model was solved and we found that the distribution of the products at the end of their shelf life decreased linearly. Related model results as shown in Table 17 and Figure 9 below, p_{upper} value do not make sense for the DM, so it can be called as "***Practically Inefficient***". Then other cost p values are bigger than the others ($p_1 > \cdots > p_P$). On the other hand, when TIME values are examined, the values decrease according to given cost value ($TIME_1 > \cdots > TIME_P$). Therefore, all points are non-dominated by each other.

Table 17 : Result of Time according to Given Cost

TIME GIVEN COST MODEL RESULTS			
p	**GIVEN COST (TL)**	***TIME*$_P$**	**TIME SOLVED (LT/SHELF LIFE)**
1	**554.924.777,22**	*TIME* $_{upper}$	4.064,40
2	**555.822.143,25**	$TIME_1$	1.518,23
3	**556.719.509,27**	$TIME_2$	1.419,26
4	**557.616.875,30**	$TIME_3$	1.340,95
5	**558.514.241,32**	$TIME_4$	1.335,11
6	**559.411.607,35**	$TIME_5$	1.329,18
7	**560.308.973,37**	$TIME_6$	1.328,35
8	**561.206.339,40**	$TIME_7$	1.309,58
9	**562.103.705,42**	$TIME_8$	1.300,34
10	**563.001.071,45**	$TIME_9$	1.299,13
11	**563.898.437,48**	*TIME* $_{lower}$	1.284,55

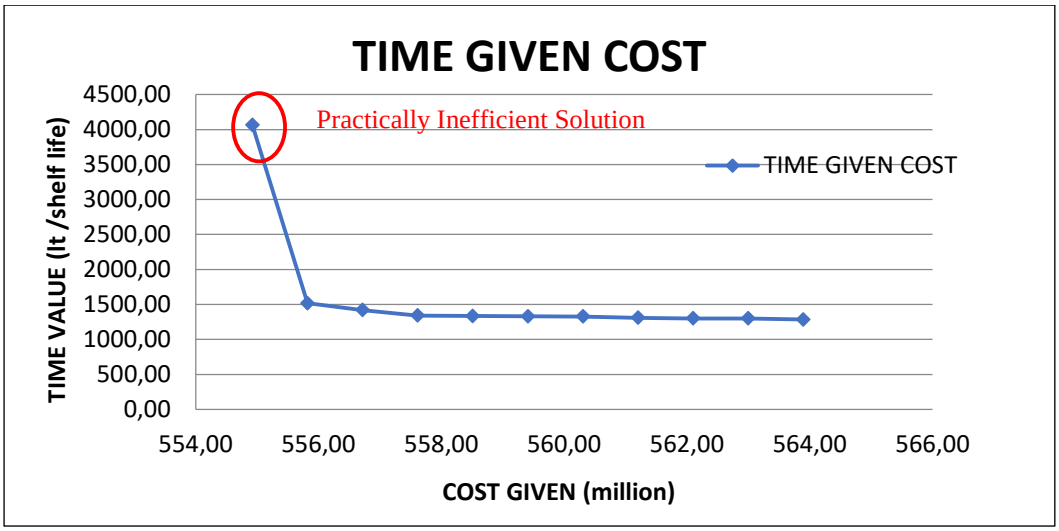


Figure 9 : Costs according to amount of products which are at end of the shelf life according to given cost values

As a result, when "***Practically Inefficient Solutiont***" is removed from Figure 9, the remaining p values reflect the results of our model and study. Here, the optimum result can be selected according to the DM. The corresponding Figure 10 for the remaining p values is as follows.

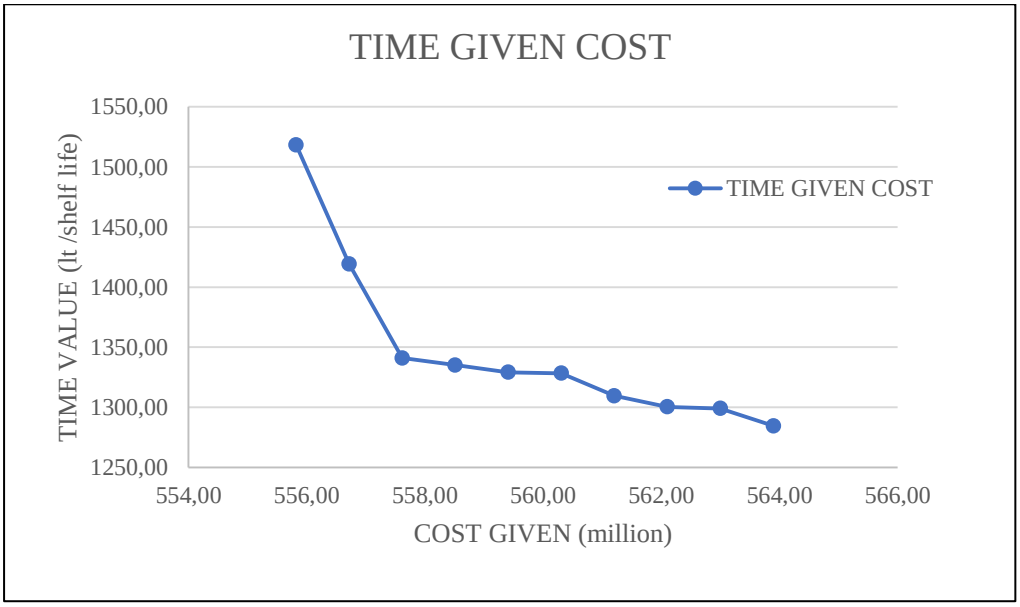


Figure 10 : Non Dominated Time Values

As a result, in the Time Given Cost Model, according to Table 17 and Figure 9, the highest decrease was between 554 million TL and 555 million TL and it means that approximately 2,546 liters of products reached the end of the shelf life. If TRC waives only about 1 million TL, 2,546 liters products which are at the end of the shelf life can be saved and there will be a possibility of sending these products to people in need. 2,546 lt is approximately 8,375 bags of ES, 10,184 bags of TS, 11,417 bags of FFP and approximately 5,360 bags of whole blood. On the other hand, it means preventing the donation of 5,360 people from the end of the shelf life.

Cost Given Time and Time Given Cost Models are combined in Figure 11 below. Figure 11 is nothing but composition of Figures 7 and 10 together. Apparently, the Time Given Cost Model solution works better than Cost Given Time Model. For example, when the two models are compared at the almost same cost value which is 560 million TL in Figure 11, 1,328.35 lt / shelf life product corresponds to 1,557.30 lt / shelf life product. This means that approximately 228.95 lt of blood products will be prevented from reaching the end of shelf life under the same cost but with a different solution.

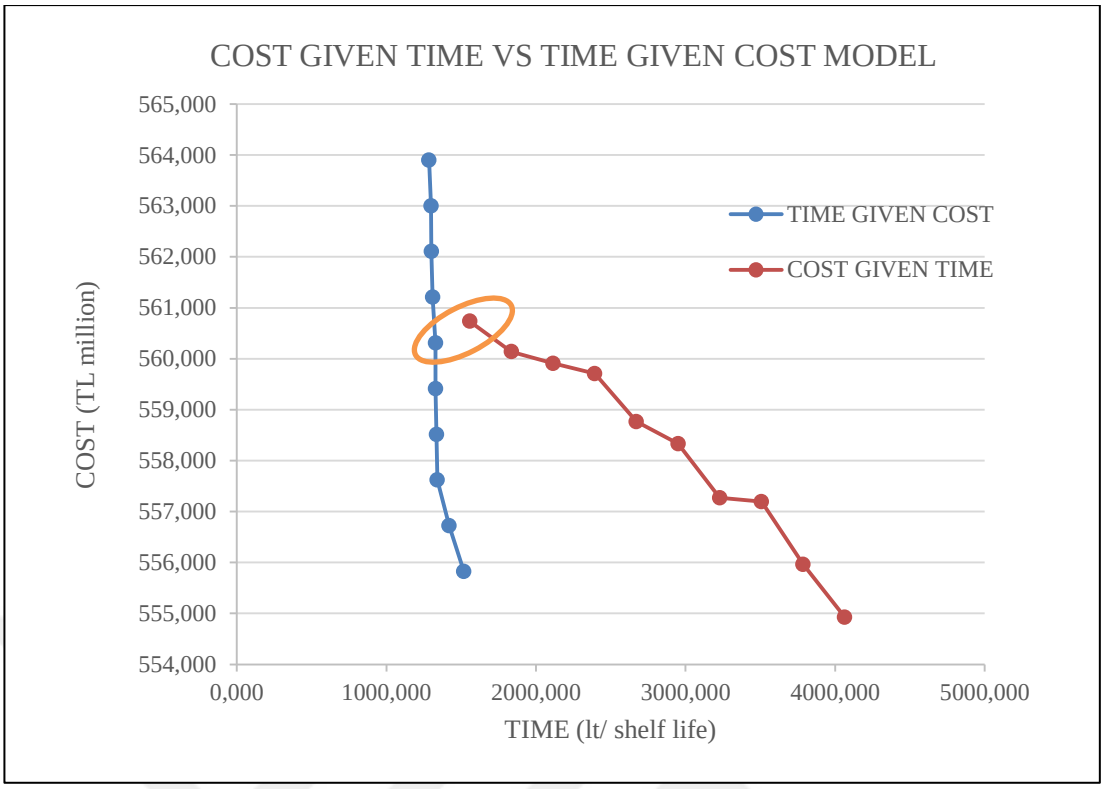


Figure 11: Comparison of Cost Given Time and Time Given Cost Model Results

After this comparison, it is clear that Time Given Cost Model produces better solutions. We suggest Decision maker to use Figure 10 solutions for a conclusion.

4.7 Decision Support System

In the cost and time model solutions, a decision support system has been established in the Figure 12 in order to improve and accelerate the decision-making process and to encourage the research and discovery capabilities of the decision maker. The mathematical models developed in this system are solved by GAMS with the data obtained from the database. The obtained results and the changes in the blood centers assignments are presented to the decision maker with the help of Power Bi ArcGIS. In this way, the decision maker will be able to make analyzes on the data stacks and support the decision-making process by classifying the data.

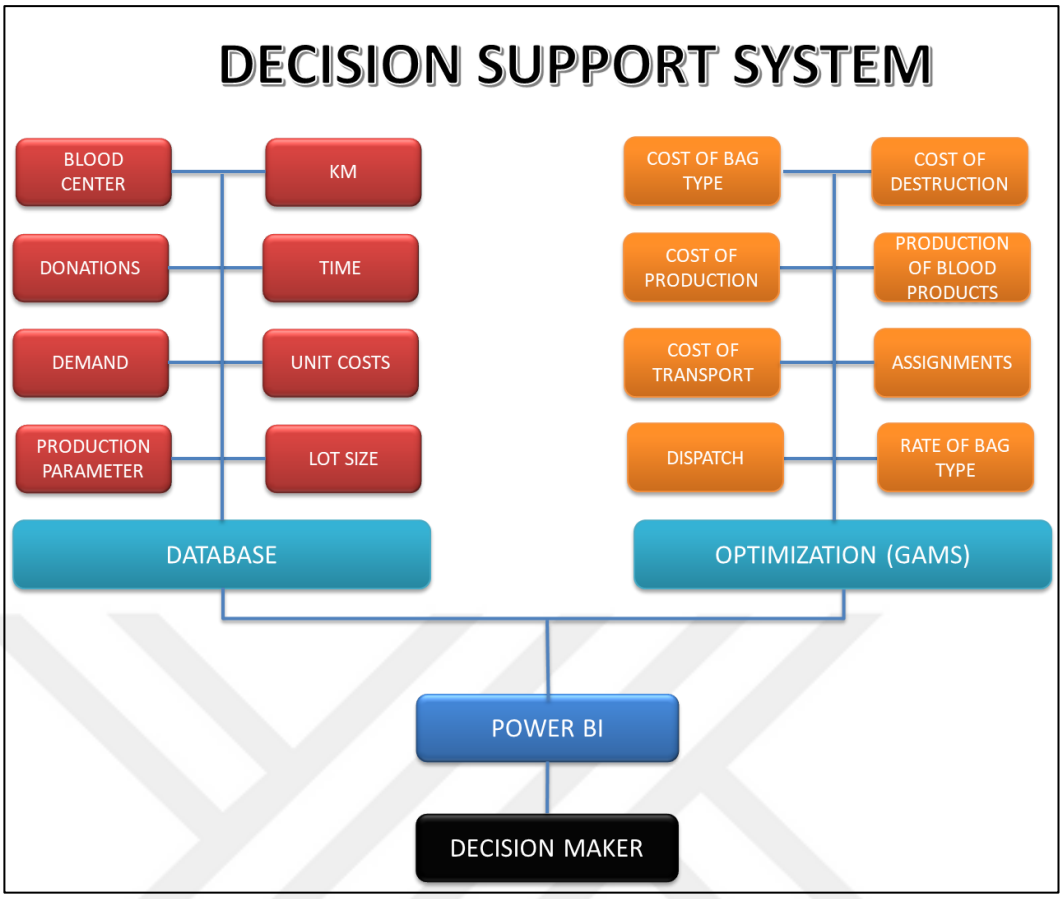


Figure 12 : Design Decision Support System for TRC

In addition, donation and demand data are added to the system on the basis of completed years. Therefore, the efficiency of blood centers can be examined easily. However, for following years, sustainable models can be realized by developing forecast models for donations and demands.

CHAPTER 5

CONCLUSIONS

Blood is the only drug of which the source is the human. When the need for blood occurs, the human is at the fine line between death and life. Delivery supply on time is essential at this point. Therefore, it is of utmost importance to meet the blood needs of people on time and quality.

Considering this situation, TRC conducted a regionalization of blood management system. Our study was conducted to minimize the cost, time and logistics problems between RBCs, BDCs and TCs in this regionalization study.

Firstly, the current system was analyzed. The blood supply chain of TRC has been examined. The new coding system developed for the indexes determined for blood centers, km, time calculations, analysis of the data used in the model are explained. The problem definitions introduced in our study are explained in detail. In the next chapter, literature studies for blood products in TRC and other organizations in the world are examined and their differences with our study are mentioned.

In the fourth chapter where our mathematical model is introduced, the Cost and Time Models between blood centers, transport network and transport decisions determined by TRC are solved. In addition, these decisions were released and solutions were

taken for our models, and the process was tried to be optimized by evaluating the effects of time and transportation cost according to current and our designed systems. The aim of the models is to meet demand quickly and efficiently and to minimize the problems arising from the variable parameters. It has been noticed that logistic management decisions determined in blood transport network can extend the demand meeting process. Because of these reasons, the distance between blood centers is calculated individually in terms of km / hour. The different variables affecting the system such as the product need, product variety and bag type usage are considered and a system that uses real data and multi objective optimization methods to provide the fastest and cheapest way of transportation is established.

With this system, the result will be given a positive acceleration in terms of quality and quantity in the process of saving human life and minimizing the risks and difficulties that may arise in this process. In addition, the results of our study will enable the TRC logistics network to be used more effectively. By reducing the most important variables such as cost and time, it will provide the possibility for a non-governmental organization (NGO) to reach more people.

The works have been completed for a sustainable structure where the best solution can be found easily in any parameter change and to enable users to analyze different decisions and scenarios.

REFERENCES

1. Gunpinar, S., & Centeno, G. (2015). Stochastic integer programming models for reducing wastages and shortages of blood products at hospitals. Computers & Operations Research, 54, 129-141.

2. Mousazadeh, M., Torabi, S. A., & Zahiri, B. (2015). A robust possibilistic programming approach for pharmaceutical supply chain network design. Computers & Chemical Engineering, 82, 115-128.

3. Göçmen, E. (2014) Solution approaches for blood banks location and routing problem. MSc Thesis. Çukurova University Industrial Engineering Department, Adana, TURKEY

4. Yegul, M. (2016). Blood Supply Network Design (Doctoral dissertation, PhD thesis, Middle East Technical University. Ankara, Turkey).

5. Osorio, A. F., Brailsford, S. C., & Smith, H. K. (2015). A structured review of quantitative models in the blood supply chain: a taxonomic framework for decision-making. International Journal of Production Research, 53(24), 7191-7212.

6. Cetin, E., & Sarul, L. S. (2009). A blood bank location model: A multiobjective approach. European Journal of Pure and Applied Mathematics, 2(1), 112-124.

7. Nagurney, A., Masoumi, A. H., & Yu, M. (2012). Supply chain network operations management of a blood banking system with cost and risk minimization. Computational Management Science, 9(2), 205-231.

8. Hsieh, C. L. (2014, June). An evolutionary-based optimization for a multi-objective blood banking supply chain model. In International Conference on

Industrial, Engineering and Other Applications of Applied Intelligent Systems (pp. 511-520). Springer, Cham.

9. Rytilä, J. S., & Spens, K. M. (2006). Using simulation to increase efficiency in blood supply chains. Management Research News, 29(12), 801-819.

10. Katsaliaki, K., & Brailsford, S. C. (2007). Using simulation to improve the blood supply chain. Journal of the Operational Research Society, 58(2), 219-227.

11. Mustafee, N., Taylor, S. J., Katsaliaki, K., & Brailsford, S. (2009). Facilitating the analysis of a UK national blood service supply chain using distributed simulation. Simulation, 85(2), 113-128.

12. Mustafee, N., Katsaliaki, K., Gunasekaran, A., Williams, M. D., Blake, J., & Hardy, M. (2013). Using simulation to evaluate a blood supply network in the Canadian maritime provinces. Journal of Enterprise Information Management.

13. Zahraee, S. M., Rohani, J. M., Firouzi, A., & Shahpanah, A. (2015). Efficiency improvement of blood supply chain system using Taguchi method and dynamic simulation. Procedia Manufacturing, 2, 1-5.

14. Ghandforoush, P., & Sen, T. K. (2010). A DSS to manage platelet production supply chain for regional blood centers. Decision Support Systems, 50(1), 32-42.

15. Şahin, G., Sural, H., & Meral, S. (2007). Locational analysis for regionalization of Turkish Red Crescent blood services. Computers & Operations Research, 34(3), 692-704.

16. Arvan, M., Tavakkoli-Moghaddam, R., & Abdollahi, M. (2015). Designing a bi-objective and multi-product supply chain network for the supply of blood. Uncertain Supply Cain Management, 3(1), 57-68.

17. Şahin, G., SUral, H., & Meral, S. (2007). Locational analysis for regionalization of Turkish Red Crescent blood services. Computers & Operations Research, 34(3), 692-704.

18. KHGM, \Turk Kızılayı Kan Hizmetleri Genel Mudurlugu Faaliyet Kitabı/2016," 2017.

19. KHGM, \Turk Kızılayı Kan Hizmetleri Genel Mudurlugu Faaliyet Kitabı/2015," 2016.

20. KHGM, \Turk Kızılayı Kan Hizmetleri Genel Mudurlugu Faaliyet Kitabı/2014," 2015.

21. KHGM, \Turk Kızılayı Kan Hizmetleri Genel Mudurlugu Faaliyet Kitabi/2013," 2014.

22. KHGM, \Turk Kızılayı Kan Hizmetleri Genel Mudurlugu Faaliyet Kitabi/2012," 2013.

23. Mavrotas, G. (2009). Effective implementation of the ε-constraint method in multi-objective mathematical programming problems. Applied mathematics and computation, 213(2), 455-465.

APPENDIX

APPENDIX-1: Regional Blood Centers and Indexes

RBC (j-INDEX)	RBC NAME	CITY
00	Kuzey Marmara	ISTANBUL-ANATOLIA
01	Orta Akdeniz	ADANA
06	Orta Anadolu	ANKARA
07	Batı Akdeniz	ANTALYA
16	Guney Marmara	BURSA
21	Guney Anadolu	DIYARBAKIR
25	Doğu Anadolu	ERZURUM
26	Batı Anadolu	ESKIŞEHIR
27	Doğu Akdeniz	GAZIANTEP
34	Avrupa	ISTANBUL-EUROPE
35	Ege	IZMIR
38	Iç Anadolu	KAYSERI
44	Guney Batı Anadolu	MALATYA
55	Orta Karadeniz	SAMSUN
61	Doğu Karadeniz	TRABZON
65	Guney Doğu	VAN
81	Batı Karadeniz	DUZCE

APPENDIX-2: Blood Donation Centers and Indexes

BDC(k-INDEX)	DBDC NAME	CITY	BDC(k-INDEX)	BDC NAME	CITY	BDC(k-INDEX)	DBDC NAME	CITY	BDC(k-INDEX)	DBDC NAME	CITY
01011	ADANA	ADANA	21563	SIIRT	SIIRT	00003	ÇEKMEKÖY	ISTANBUL	38665	YOZGAT	YOZGAT
01312	ISKENDERUN	HATAY	81811	DUZCE	DUZCE	34341	ÇAPA	ISTANBUL	44231	ELAZIĞ	ELAZIĞ
01333	MERSIN	MERSIN	81782	KARABUK	KARABUK	34592	ÇORLU	TEKIRDAĞ	44442	MALATYA	MALATYA
06191	ÇORUM	ÇORUM	81543	SAKARYA	SAKARYA	34223	EDIRNE	EDIRNE	44023	ADIYAMAN	ADIYAMAN
06712	KIRIKKALE	KIRIKKALE	81674	ZONGULDAK	ZONGULDAK	34394	LULEBURGAZ	KIRKLARELI	55521	ORDU	ORDU
06423	KONYA	KONYA	81415	KOCAELI	KOCAELI	34345	BAŞAKŞEHIR	ISTANBUL	55552	SAMSUN	SAMSUN
06374	KASTAMONU	KASTAMONU	25241	ERZINCAN	ERZINCAN	35091	AYDIN	AYDIN	55603	TOKAT	TOKAT
06065	ANKARA	ANKARA	25252	ERZURUM	ERZURUM	35202	DENIZLI	DENIZLI	61081	ARTVIN	ARTVIN
07071	ANTALYA	ANTALYA	26031	AFYON	AFYON	35353	IZMIR	IZMIR	61282	GIRESUN	GIRESUN
07152	BURDUR	BURDUR	26262	ESKIŞEHIR	ESKIŞEHIR	35454	MANISA	MANISA	61293	GUMUŞHANE	GUMUŞHANE
07323	ISPARTA	ISPARTA	26433	KUTAHYA	KUTAHYA	35455	MARMARIS	MUĞLA	61534	RIZE	RIZE
16101	BALIKESIR	BALIKESIR	27461	K.MARAŞ	K.MARAŞ	35356	ÖDEMIŞ	IZMIR	61615	TRABZON	TRABZON
16162	BURSA	BURSA	27272	GAZIANTEP	GAZIANTEP	35647	UŞAK	UŞAK	65491	MUŞ	MUŞ
16173	ÇANAKKALE	ÇANAKKALE	27793	KILIS	KILIS	38381	KAYSERI	KAYSERI	65652	VAN	VAN
16774	YALOVA	YALOVA	27634	ŞANLIURFA	ŞANLIURFA	38402	KIRŞEHIR	KIRŞEHIR			
21721	BATMAN	BATMAN	00001	KARTAL	ISTANBUL	38503	NEVŞEHIR	NEVŞEHIR			
21212	DIYARBAKIR	DIYARBAKIR	00002	Z.KAMIL	ISTANBUL	38584	SIVAS	SIVAS			

APPENDIX-3: Central Screening Laboratories and Indexes

LAB(l-INDEX)	LAB NAME	CITY
010101	Orta Akdeniz Lab	ADANA
060602	Orta Anadolu Lab	ANKARA
000003	Kuzey Marmara Lab	ISTANBUL-ANATOLIA
353504	Ege Bölge Lab	IZMIR

APPENDIX-4: Transfusion Centers and Indexes which are connected to Region Blood Center

TC (INDEX)	TC	TC CITY	TC (INDEX)	TC	TC CITY	TC (INDEX)	TC	TC CITY
3422001	EDIRNE DEVLET HST.	EDIRNE	2763013	SURUÇ DEVLET HST.	ŞANLIURFA	3840001	AHI EVRAN UNV. E.A.H	KIRŞEHIR
3422002	EKOL HASTANESI	EDIRNE	2763014	ŞANLIURFA EĞITIM HAS	ŞANLIURFA	3840002	AŞIKPAŞA HST.	KIRŞEHIR
3422003	KEŞAN D.H.	EDIRNE	2763015	VIRANŞEHIR DEV. HST.	ŞANLIURFA	3840003	KAMAN D.H.	KIRŞEHIR
3422004	ÖZEL TRAKYA HST.	EDIRNE	2763016	ŞANLIURFA Ç.H.HST.	ŞANLIURFA	3850001	DR.I.ŞEVKI ATASAGUN	NEVŞEHIR
3422005	SAROS SAĞ. HIZ.	EDIRNE	2575001	ARDAHAN DEV. HST.	ARDAHAN	3850002	KAPADOKYA HST.	NEVŞEHIR
3422006	TRAKYA UNV.S.A.U.M	EDIRNE	2569001	BAYBURT D.H.	BAYBURT	3850003	VERSA HASTANESI	NEVŞEHIR
3422007	UZUNKÖPRU DEV. HST.	EDIRNE	2524001	ERZINCAN M.GAZI HST	ERZINCAN	3851001	BOR DEVLET HASTANESI	NIĞDE
3434001	ACIBADEM ATAKENT H	ISTANBUL	2524002	NEON HST.	ERZINCAN	3851002	NIĞDE D.H.	NIĞDE
3434002	ACIBADEM BAKIRKÖY H.	ISTANBUL	2525001	AŞKALE ILÇE HST.	ERZURUM	3851003	ÖMER HALISDEMIR UNIV	NIĞDE
3434003	ACIBADEM FULYA HST.	ISTANBUL	2525002	ATATURK UNI.S.A.U.M	ERZURUM	3851004	ÖZEL NIĞDE HAYAT HST	NIĞDE
3434004	AKABE SAĞ. TESISLERI	ISTANBUL	2525003	ERZURUM B.E.VE A.H.	ERZURUM	3858001	CUMHURIYET UNV.T.F.	SIVAS
3434005	AMERIKAN HST.	ISTANBUL	2525004	HINIS DEVLET HST	ERZURUM	3858002	DIVRIĞI SADIK ÖZGUR	SIVAS
3434006	ARNAVUTKÖY D.H.	ISTANBUL	2525005	HORASAN DEVLET HST.	ERZURUM	3858003	NUMUNE HST.	SIVAS
3434007	AVICENNA HST.GULTEPE	ISTANBUL	2525006	IBRAHIM HAKKI D.H.	ERZURUM	3858004	ÖZEL MEDICANA SIVAS	SIVAS
3434008	AVRASYA HASTANESI	ISTANBUL	2525007	ISPIR DEVLET HST.	ERZURUM	3858005	SUŞEHRI DEVLET HST.	SIVAS
3434009	AVRUPA ŞAFAK HST.	ISTANBUL	2525008	M.ÇAKMAK DEVLET HST	ERZURUM	3858006	ŞARKIŞLA D.H.	SIVAS
3434010	AVUSTURYA SEN JORJ	ISTANBUL	2525009	NENEHATUN KADIN D.H.	ERZURUM	3858007	YILDIZELI D.H.	SIVAS
3434011	BAĞCILAR E.A.H.	ISTANBUL	2525010	OLTU DEVLET HST.	ERZURUM	3858008	ZARA D.H.	SIVAS
3434012	BAĞCILAR MEDILFE HAS	ISTANBUL	2525011	ÖZEL BUHARA HST.	ERZURUM	3866001	AKDAĞMADENI D.H.	YOZGAT
3434013	BAHÇELIEVLER DEVLET HST	ISTANBUL	2525012	PALANDÖKEN D.H.	ERZURUM	3866002	BOĞAZLIYAN D.H.	YOZGAT
3434014	BAHÇELIEVLER SAĞ.HIZ	ISTANBUL	2536001	KAFKAS UNV. TIP FAK.	KARS	3866003	BOZOK UNV. A.U.H.	YOZGAT
3434015	BALAT OR-AHAYIM	ISTANBUL	2536002	KAĞIZMAN DEVLET H.	KARS	3866004	ÇEKEREK DEVLET HST	YOZGAT
3434016	BALIKLI RUM HST.	ISTANBUL	2536003	KARS DEVLET HST.	KARS	3866005	SORGUN D.H.	YOZGAT
3434017	BALKAN SAĞ. HIZ.	ISTANBUL	2536004	SARIKAMIŞ ILÇE D.H.	KARS	3866006	SORGUN ÖZEL GUVEN HS	YOZGAT

Continuation of Appendix 4

3434018	BAŞAKŞEHIR ILÇE D.H.	ISTANBUL	2562001	TUNCELI DEVLET HASTANESI	TUNCELI	3866007	YERKÖY DEVLET HST.	YOZGAT
3434019	BAŞAKŞEHIR SAĞ.HIZ.	ISTANBUL	6108001	ARTVIN ARHAVI D.HST.	ARTVIN	3866008	YOZGAT D.H.	YOZGAT
3434020	BATI BAHAT HST.	ISTANBUL	6108002	ARTVIN D.H.	ARTVIN	3866009	YOZGAT ŞEHIR HST	YOZGAT
3434021	BAYRAMPAŞA DEV. HST.	ISTANBUL	6108003	ARTVIN HOPA D.H.	ARTVIN	0000001	ACADEMIC HOSPITAL	ISTANBUL
3434022	BAYRAMPAŞA KOLAN	ISTANBUL	6108004	BORÇKA D.H.	ARTVIN	0000002	ACIBADEM ALTUNIZADE	ISTANBUL
3434023	BEYLIKDUZU DEVLET HS	ISTANBUL	6108005	ŞAVŞAT DEV. HST.	ARTVIN	0000003	ACIBADEM KADIKÖY HST	ISTANBUL
3434024	BEYLIKDUZU KOLAN HST	ISTANBUL	6128001	BULANCAK D.H.	GIRESUN	0000004	ACIBADEM KOZYATAĞI	ISTANBUL
3434025	BEYLIKDUZU MEDILIFE HST	ISTANBUL	6128002	ESPIYE D.H.	GIRESUN	0000005	AFIYET HASTANESI	ISTANBUL
3434026	BEZMIALEM VAKIF UNI	ISTANBUL	6128003	GIRESUN K.D.VE Ç.H.H	GIRESUN	0000006	ATAŞEHIR MEMORIAL H.	ISTANBUL
3434027	BIRUNI UNIVERSITESI	ISTANBUL	6128004	GIRESUN KENT HST.	GIRESUN	0000007	ATLAS HASTANESI	ISTANBUL
3434028	BUYUKÇEKMECE KOLAN H	ISTANBUL	6128005	GÖRELE D.H.	GIRESUN	0000008	AVICENNA HST.	ISTANBUL
3434029	CERRAHI NIŞANTAŞI HST	ISTANBUL	6128006	PROF.DR.A.ILHAN D.H.	GIRESUN	0000009	AYDEM SAĞLIK HIZ.	ISTANBUL
3434030	ÇAPA HST.	ISTANBUL	6128007	ŞEBINKARAHISAR	GIRESUN	0000010	BAYINDIR H.IÇERENKÖY	ISTANBUL
3434031	ÇAPA MEDILIFE HST.	ISTANBUL	6128008	TIREBOLU D.H.	GIRESUN	0000011	BAY-MED SAĞ.HIZ.	ISTANBUL
3434032	DOĞAN HST.	ISTANBUL	6128009	TOPLUM SAĞ. HIZ.	GIRESUN	0000012	BEZMIALEM DRAGOS HST	ISTANBUL
3434033	DORA HOSPITAL	ISTANBUL	6129001	GUMUŞHANE D.H.	GUMUŞHANE	0000013	ÇAMLICA ERDEM HST.	ISTANBUL
3434034	DR. SADIK AHMET HST.	ISTANBUL	6129002	KELKIT D.H.	GUMUŞHANE	0000014	ÇAMLICA MEDICANA H.	ISTANBUL
3434035	DR.SADI KONUK EAH	ISTANBUL	6129003	ŞIRAN DEVLET HST.	GUMUŞHANE	0000015	DELTA HOSPITAL	ISTANBUL
3434036	DUYGU HST.	ISTANBUL	6153001	ISHAKOĞLU ÇAYELI D.H	RIZE	0000016	DIYABET HASTANESI	ISTANBUL
3434037	ECHOMAR ATAKÖY HST.	ISTANBUL	6153002	KAÇKAR DEVLET HST.	RIZE	0000017	DR.LUTFI KIRDAR EAH	ISTANBUL
3434038	ESENLER AVICENNA HST	ISTANBUL	6153003	RIZE DEVLET HST.	RIZE	0000018	DR.SIYAMI ERSEK	ISTANBUL
3434039	ESENLER ENSAR HST.	ISTANBUL	6153004	RIZE UNV. E.A.H.	RIZE	0000019	ECHOMAR GÖZTEPE HST.	ISTANBUL
3434040	ESENLER KADIN DOĞUM	ISTANBUL	6153005	ŞAR HOSPITAL	RIZE	0000020	EMSEY HOSPITAL	ISTANBUL
3434041	ESENYURT D.H.	ISTANBUL	6161001	AHI EVREN E.VE A.H.	TRABZON	0000021	ERDEM HASTANESI	ISTANBUL
3434042	ESLIFE HOSPITAL HST	ISTANBUL	6161002	AKÇAABAT D.H.	TRABZON	0000022	ERSOY HASTANESI	ISTANBUL
3434043	ESTEWORLD SAĞLIK H.	ISTANBUL	6161003	ARAKLI BAYRAM HALIL	TRABZON	0000023	FAT.SUL.MEHMET E.A.H	ISTANBUL

Continuation of Appendix 4

3434044	ETHICA INCIRLI HST.	ISTANBUL	6161004	IMPERIAL HST.	TRABZON	0000024	GISBIR SAĞLIK MERK.	ISTANBUL
3434045	EYUP DEVLET HAST.	ISTANBUL	6161005	K.T.U. FARABI HST.	TRABZON	0000025	GÖZTEPE E.A.H.	ISTANBUL
3434046	EYUP HALIÇ HOSPITAL	ISTANBUL	6161006	KANUNI E.A.H.	TRABZON	0000026	GÖZTEPE MEDICALPARK	ISTANBUL
3434047	FLORENCE NIGHTINGALE	ISTANBUL	6161007	MEDICALPARK TRABZON	TRABZON	0000027	HAYAT SAĞLIK	ISTANBUL
3434048	GAZI SAĞLIK	ISTANBUL	6161008	MLP TRABZON	TRABZON	0000028	HAYDARPAŞA E.A.Hasta	ISTANBUL
3434049	GAZIOSMANPAŞA AVRSYA	ISTANBUL	6161009	OF DEVLET HST.	TRABZON	0000029	HAYDARPAŞA NUMUNE	ISTANBUL
3434050	GAZIOSMANPAŞA HST.	ISTANBUL	6161010	SURMENE D.H.	TRABZON	0000030	HISAR SAĞ. HIZ.	ISTANBUL
3434051	GUNEŞLI ERDEM	ISTANBUL	6161011	TRABZON FATIH D.H.	TRABZON	0000031	IST.SAĞLIK UGY.AR.H.	ISTANBUL
3434052	GUNEY HASTANESI	ISTANBUL	6161012	VAKFIKEBIR D.H.	TRABZON	0000032	ISTANBUL BEYKOZ D.H.	ISTANBUL
3434053	GUNGÖREN HST.	ISTANBUL	6161013	YAVUZ SELIM KEM.HST.	TRABZON	0000033	ISTANBUL BÖLGE HST.	ISTANBUL
3434054	HALKALI KENT HST.	ISTANBUL	3509001	ADNAN MENDERES UNV.	AYDIN	0000034	ISTANBUL ONKOLOJI HS	ISTANBUL
3434055	HASEKI E.A.H.	ISTANBUL	3509002	ATATURK D.H.	AYDIN	0000035	KADIKÖY FLORENCE N.H	ISTANBUL
3434056	HOSPITALIST	ISTANBUL	3509003	AYDIN DEVLET HST.	AYDIN	0000036	KADIKÖY ŞIFA HST.	ISTANBUL
3434057	INTERNATIONAL HOSP.	ISTANBUL	3509004	AYDIN DIDIM DEVLET H	AYDIN	0000037	KADIKÖYŞIFA ATAŞEHIR	ISTANBUL
3434058	ISTANBUL MEDIPOL UNI.	ISTANBUL	3509005	AYDIN K.D.VE Ç.H.HST	AYDIN	0000038	KARTAL KOŞUYOLU	ISTANBUL
3434059	I.U KARDIYOLOJI ENS.	ISTANBUL	3509006	AYDIN NAZILLI D.H.	AYDIN	0000039	KARTAL YAV.SELIM D.H	ISTANBUL
3434060	I.U.TIP FAKULTESI H	ISTANBUL	3509007	BSK AYDIN SAĞ.HIZ.	AYDIN	0000040	KOZYATAĞI CENTRAL	ISTANBUL
3434061	ILGI HST.VE DOĞUMEVI	ISTANBUL	3509008	ÇINE DEVLET HST.	AYDIN	0000041	KURTKÖY ERSOY HAST.	ISTANBUL
3434062	ILKE HASTANESI	ISTANBUL	3509009	EGEMED HASTANESI	AYDIN	0000042	M.UNV. NÖROLOJIK B.E	ISTANBUL
3434063	ILYAS ÇOKAY D.H.	ISTANBUL	3509010	KUŞADASI DEVLET HST.	AYDIN	0000043	MALTEPE BÖLGE HST.	ISTANBUL
3434064	ISMAIL AKGUN D.H.	ISTANBUL	3509011	KUŞADASI HST.	AYDIN	0000044	MALTEPE DEVLET HST.	ISTANBUL
3434065	IST.UNV.CERRAHPAŞA	ISTANBUL	3509012	ÖZEL NYSA DOĞUM HST.	AYDIN	0000045	MALTEPE UNV. TIP FAK	ISTANBUL
3434066	Istanbul Bilim Uni.	ISTANBUL	3509013	ÖZEL REFERANS HST.	AYDIN	0000046	MARMARA UNV. PENDIK	ISTANBUL
3434067	ISTANBUL CERRAHI HST	ISTANBUL	3509014	SÖKE DEVLET HST.	AYDIN	0000047	MEDIVIA HOSPITAL	ISTANBUL
3434068	ISTANBUL EĞT.AR.H.	ISTANBUL	3509015	ÖZEL GÖZDE KUŞADASI	AYDIN	0000048	MEDIPOL HST.	ISTANBUL
3434069	ISTANBUL ŞAFAK HST.	ISTANBUL	3520001	ACIPAYAM DEV. HST.	DENIZLI	0000049	MEDISTATE KAVACIK H.	ISTANBUL

Continuation of Appendix 4

3434070	ISTINYE DEVLET HST.	ISTANBUL	3520002	BULDAN GÖĞUS H.H.	DENIZLI	0000050	MEGAPOL HASTANESI	ISTANBUL
3434071	ISTINYE UNI. SUAM	ISTANBUL	3520003	DENCER DENIZLI CER.H	DENIZLI	0000051	NP ISTANBUL BEYIN HS	ISTANBUL
3434072	KADIOĞLU SAĞ. HIZ.	ISTANBUL	3520004	DENIZLI ÇIVRIL D.H.	DENIZLI	0000052	OKAN UNIV. SUAM HST.	ISTANBUL
3434073	KAĞITHANE D.H.	ISTANBUL	3520005	DENIZLI D.H.	DENIZLI	0000053	ÖZEL ÇAĞINER HST.	ISTANBUL
3434074	KANUNI S.S. E.A.H.	ISTANBUL	3520006	DENIZLI TEKDEN HST.	DENIZLI	0000054	ÖZEL EREN HASTANESI	ISTANBUL
3434075	KOÇ UNIVERSITESI EAM	ISTANBUL	3520007	DENIZLI TIP MERKEZI	DENIZLI	0000055	ÖZEL HEKIMLER TIP M.	ISTANBUL
3434076	LUTFIYE N.B.DEV.HST	ISTANBUL	3520008	ER-PA DENIZLI SAĞLIK	DENIZLI	0000056	ÖZEL MALTEPE ERSOY H	ISTANBUL
3434077	M.AKIF ERSOY E.A.H.	ISTANBUL	3520009	ÖZEL EGE HST.	DENIZLI	0000057	ÖZEL MEDITIME	ISTANBUL
3434078	MASLAK ACIBADEM HST.	ISTANBUL	3520010	ÖZEL MEDIKLINIK HST	DENIZLI	0000058	ÖZEL REMEDY HOSPITAL	ISTANBUL
3434079	MECDIYEKÖY ÇEVRE HST	ISTANBUL	3520011	PAMUKKALE UNV.	DENIZLI	0000059	ÖZEL ŞIFA HST	ISTANBUL
3434080	MEDICALPARK	ISTANBUL	3520012	SERVERGAZI D.H.	DENIZLI	0000060	ÖZEL VERA HST	ISTANBUL
3434081	MEDICALPARK GOP	ISTANBUL	3520013	TAVAS DEV. HST.	DENIZLI	0000061	ÖZEL YUZYIL HST.	ISTANBUL
3434082	MEDICANA HOSPITALS	ISTANBUL	3520014	ÖZEL FINAL SAĞLIK H.	DENIZLI	0000062	PENDIK BOLGE HST.	ISTANBUL
3434083	MEDICANA INTERNAT.	ISTANBUL	3535001	AKUT KALP DAMAR HST.	IZMIR	0000063	PENDIK D.H.	ISTANBUL
3434084	MEDICINE HOSPITAL	ISTANBUL	3535002	ALIAĞA D.H.	IZMIR	0000064	SULTANBEYLI D.H.	ISTANBUL
3434085	MEDIGOLD SULTAN HST.	ISTANBUL	3535003	ALPER ÇIZGENAKAT D.H	IZMIR	0000065	SUR HASTANESI	ISTANBUL
3434086	MEDIPOL ESENLER	ISTANBUL	3535004	ATAKALP KALP HST.	IZMIR	0000066	SUREYYAPAŞA GÖĞ.HAS.	ISTANBUL
3434087	MEDIPOL MEGA HST. KO	ISTANBUL	3535005	ATATURK E.A.H.	IZMIR	0000067	ŞILE DEVLET HST.	ISTANBUL
3434088	MELTEM HASTANESI	ISTANBUL	3535006	BAKI UZUN HST.	IZMIR	0000068	TUZLA DEVLET HAST.	ISTANBUL
3434089	MEMORIAL HIZ. HST.	ISTANBUL	3535007	BAYINDIR DEVLET HST.	IZMIR	0000069	TUZLA HASTANESI	ISTANBUL
3434090	MEMORIAL HST.	ISTANBUL	3535008	BERGAMA D.H.	IZMIR	0000070	UMUT HST.	ISTANBUL
3434091	METIN SABANCI E.A.H.	ISTANBUL	3535009	BUCA K.D. VE Ç.H.H.	IZMIR	0000071	UMRANIYE E.A.H.	ISTANBUL
3434092	MLP SAĞLIK HIZMETLER	ISTANBUL	3535010	CENTRAL HOSPITAL	IZMIR	0000072	USKUDAR ANADOLU H.	ISTANBUL
3434093	MURAT KÖLUK D.HST	ISTANBUL	3535011	Çiğli Bölge Eğitim H	IZMIR	0000073	USKUDAR D.H.	ISTANBUL
3434094	NECMI AYANOĞLU D.H.	ISTANBUL	3535012	DOKUZ EYLUL UNV.HST.	IZMIR	0000074	VIA HOSPITAL SANCAKTEPE	ISTANBUL
3434095	NISA HASTANESI	ISTANBUL	3535013	DR. BEHÇET UZ HST.	IZMIR	0000075	YAKACIK D.VE Ç.H.H.	ISTANBUL

Continuation of Appendix 4

3434096	OKMEYDANI E.A.H.	ISTANBUL	3535014	DR. SUAT SEREN E.A.H	IZMIR	0000076	YEDITEPE UNV. HST.	ISTANBUL
3434097	OKMEYDANI HASTANESI	ISTANBUL	3535015	EGE UNIVERSITESI	IZMIR	0000077	YUNUS EMRE	ISTANBUL
3434098	OTA JINEMED	ISTANBUL	3535016	EGEPOL HST.	IZMIR	0000078	ZEYNEP KAMIL	ISTANBUL
3434099	Ö. YENI HAYAT TIP M.	ISTANBUL	3535017	EKOL BAZ ÖZEL SAĞ.	IZMIR	0000079	IST. FSM EAH SANCAK.	ISTANBUL
3434100	ÖZEL ACIBADEM TAKSIM	ISTANBUL	3535018	EMOT HASTANESI	IZMIR	0101001	ACIBADEM HST.	ADANA
3434101	ÖZEL AILE HASTANESI	ISTANBUL	3535019	EŞREFPAŞA HST.	IZMIR	0101002	ADANA D.H.	ADANA
3434102	ÖZEL ALIBEY HOSPITAL	ISTANBUL	3535020	GAZI SAĞ.HIZ.	IZMIR	0101003	ADANA K.D. VE Ç.H.H.	ADANA
3434103	ÖZEL ASYA HASTANESI	ISTANBUL	3535021	IZMIR BOZYAKA E.A.H.	IZMIR	0101004	ADANA NUMUNE E.A.H.	ADANA
3434104	ÖZEL AVCILAR ANADOLU	ISTANBUL	3535022	IZMIR FOÇA DEV. HST.	IZMIR	0101005	ADANA UYG.AR.HS.	ADANA
3434105	ÖZEL AVRUPA HST	ISTANBUL	3535023	IZMIR HASTANESI	IZMIR	0101006	BALCALI SAĞLIK EAM	ADANA
3434106	ÖZEL BAĞCILAR TEKDEN	ISTANBUL	3535024	IZMIR TEPECIK E.A.H.	IZMIR	0101007	CEYHAN ÇINAR HST.	ADANA
3434107	ÖZEL BAHAT HOSPITAL	ISTANBUL	3535025	KEMALPAŞA D.H.	IZMIR	0101008	CEYHAN D.H.	ADANA
3434108	ÖZEL BAŞARI HST	ISTANBUL	3535026	KENT HASTANESI	IZMIR	0101009	DR.AŞKIM TUFEKÇI D.H	ADANA
3434109	ÖZEL BAYPARK HSP.	ISTANBUL	3535027	KIRAZ D.H.	IZMIR	0101010	GUNEY ADANA HST.	ADANA
3434110	ÖZEL BILGE HASTANESI	ISTANBUL	3535028	M.PARK HST SENTEZ	IZMIR	0101011	IMAMOĞLU ILÇE D.H.	ADANA
3434111	ÖZEL ÇAMLIK HST.	ISTANBUL	3535029	MENEMEN DEV. HST.	IZMIR	0101012	KARAISALI DEVLET HST	ADANA
3434112	ÖZEL DERINDERE HST.	ISTANBUL	3535030	NECAT HEPKON DEV.HST	IZMIR	0101013	KOZAN D.H.	ADANA
3434113	ÖZEL DOĞA HOSPITAL	ISTANBUL	3535031	NEVVAR SALIH IŞGÖREN	IZMIR	0101014	METROPOL SAĞ. HIZ.	ADANA
3434114	ÖZEL ESENCAN	ISTANBUL	3535032	ÖDEMIŞ DEVLET HST.	IZMIR	0101015	ORTADOĞU SAĞLIK HST.	ADANA
3434115	ÖZEL ETHICA LEVENT	ISTANBUL	3535033	ÖZEL ATA SAĞLIK HST.	IZMIR	0101016	ORTOPEDIA HST.	ADANA
3434116	ÖZEL FATIH HASTANESI	ISTANBUL	3535034	ÖZEL ÇINARLI HST.	IZMIR	0101017	OZEL KALEPARK HST	ADANA
3434117	ÖZEL LEVENT HST.	ISTANBUL	3535035	ÖZEL DENIZ HASTANESI	IZMIR	0101018	ÖZEL ADANA MEDLINE	ADANA
3434118	ÖZEL MEDIAN HASTANES	ISTANBUL	3535036	ÖZEL EGE ŞEHIR H.	IZMIR	0101019	ÖZEL ALGOMED HST.	ADANA
3434119	ÖZEL MEDIGOL TIP M.	ISTANBUL	3535037	ÖZEL HAYAT HASTANESI	IZMIR	0101020	ÖZEL ANADOLU HST.	ADANA
3434120	ÖZEL ORTOMEDICA	ISTANBUL	3535038	ÖZEL KARATAŞ HAST.	IZMIR	0101021	ÖZEL AVRUPA HOSPITAL	ADANA
3434121	ÖZEL OSMANOĞLU HST.	ISTANBUL	3535039	ÖZEL MEDIFEMA HST.	IZMIR	0101022	ÖZEL AVRUPA HST	ADANA

Continuation of Appendix 4

3434122	ÖZEL RUMELI HOSPITAL	ISTANBUL	3535040	ÖZEL SU HOSPITAL	IZMIR	0101023	ÖZEL EPC HASTANESI	ADANA
3434123	ÖZEL ŞIŞLI KOLAN	ISTANBUL	3535041	SAFA TEŞ.VE TED.	IZMIR	0101024	ÖZEL GUZELYALI HAS.	ADANA
3434124	ÖZEL VITAL HASTANE	ISTANBUL	3535042	SELÇUK DEV. HST.	IZMIR	0101025	SEZAR HOSP. HANZADE	ADANA
3434125	ÖZEL YAŞAR HST.	ISTANBUL	3535043	SEYFI DEMIRSOY	IZMIR	0101026	ZIYA PAŞA K.D.VE Ç.H	ADANA
3434126	PROF.DR.MAZHAR OSMAN	ISTANBUL	3535044	TINAZTEPE HST.	IZMIR	0131001	ALTINÖZU DEVLET HST	HATAY
3434127	REYAP ISTANBUL HAST	ISTANBUL	3535045	TIRE D.H.	IZMIR	0131002	ANTAKYA AKADEMI HST.	HATAY
3434128	SAFA HST.	ISTANBUL	3535046	TORBALI DEVLET HST.	IZMIR	0131003	ANTAKYA D.H.	HATAY
3434129	SANTE PLUS HST.	ISTANBUL	3535047	ULTRA EMAR SAĞLIK.	IZMIR	0131004	DEFNE HASTANESI	HATAY
3434130	SARAY SAĞ.HIZ.	ISTANBUL	3535048	URLA DEVLET HST.	IZMIR	0131005	DÖRTYOL DEVLET HST.	HATAY
3434131	SILIVRI KOLAN HST.	ISTANBUL	3535049	ZUBEYDE HANIM	IZMIR	0131006	GELIŞIM HST.	HATAY
3434132	SILIVRI MEDIKAPARK	ISTANBUL	3545001	AKHISAR HST.	MANISA	0131007	HASSA D.H.	HATAY
3434133	SULEYMANIYE HAST.	ISTANBUL	3545002	AKHISAR SAĞ. HIZ.	MANISA	0131008	HATAY DEVLET HAS.	HATAY
3434134	ŞENEL SAĞ. HIZ.	ISTANBUL	3545003	ALAŞEHIR DEVLET HST.	MANISA	0131009	HATAY HST.	HATAY
3434135	ŞIŞLI ETFAL E.A.H.	ISTANBUL	3545004	CAN ÖZEL SAĞLIK HST.	MANISA	0131010	HATAY K.D.Ç.H. HST.	HATAY
3434136	TAKSIM E.A.HST.	ISTANBUL	3545005	CELAL BAYAR UNV.	MANISA	0131011	ISKENDERUN D.H.	HATAY
3434137	TEM HOSPITAL HST.	ISTANBUL	3545006	DEMIRCI D.H.	MANISA	0131012	KIRIKHAN BILIM HST.	HATAY
3434138	TURKIYE GAZETESI H.	ISTANBUL	3545007	EGEUMUT HST.	MANISA	0131013	KIRIKHAN CAN HST.	HATAY
3434139	YEDIKULE E.A.H.	ISTANBUL	3545008	GEDIZ TIP MERKEZI	MANISA	0131014	KIRIKHAN DEV. HST.	HATAY
3434140	YEDIKULE SURP PIRGIÇ	ISTANBUL	3545009	GÖRDES DEV. HST.	MANISA	0131015	M.K.U SAĞ.UYG.ARŞ.HS	HATAY
3434141	YENI HUZUR TIP MRK	ISTANBUL	3545010	KIRKAĞAÇ D.H.	MANISA	0131016	MOZAIK HST.	HATAY
3434142	YENI IKLIM HASTANESI	ISTANBUL	3545011	MANISA AKHISAR D.H.	MANISA	0131017	ÖZEL DOĞU AKDENIZ H.	HATAY
3434143	YENI UFUK HST.	ISTANBUL	3545012	MANISA D.H.	MANISA	0131018	ÖZEL GUNEYPARK H.	HATAY
3434144	ISTANBUL AYDIN UNI.	ISTANBUL	3545013	MANISA KULA D.H.	MANISA	0131019	ÖZEL PALMIYE HST.	HATAY
3439001	BABAESKI DEV.HST.	KIRKLARELI	3545014	MERKEZEFENDI D.H.	MANISA	0131020	REYHANLI DEVLET HST.	HATAY
3439002	BIR NEFES HST.	KIRKLARELI	3545015	ÖZEL MEDIGUN HST.	MANISA	0131021	SAMAK SAĞLIK HIZ.AŞ.	HATAY
3439003	DERMAN SAĞ.HIZ.	KIRKLARELI	3545016	ÖZEL MEDIGUNEŞ HST.	MANISA	0131022	SAMANDAĞ D.H.	HATAY

Continuation of Appendix 4

3439004	KIRKLARELI DEVLET H.	KIRKLARELI	3545017	SALIHLI D.H.	MANISA	0133023	AKMED MERSIN ÖZL HST	IÇEL
3439005	LULEBURGAZ DEV. HST.	KIRKLARELI	3545018	SALIHLI SAĞ. HIZ.	MANISA	0133024	ANAMUR ANAMED HST.	IÇEL
3439006	MEDIKENT HST.	KIRKLARELI	3545019	SARIGÖL DEVLET HST.	MANISA	0133025	ANAMUR D.H.	IÇEL
3439007	ÖZEL BALKAN HST	KIRKLARELI	3545020	SARUHANLI D.H.	MANISA	0133026	BOZYAZI D.H.	IÇEL
3439008	VIZE DEVLET HST.	KIRKLARELI	3545021	SEKIZ EYLUL HST.	MANISA	0133027	ERDEMLI D.H.	IÇEL
3459001	ÇERKEZKÖY DEVLET HST	TEKIRDAĞ	3545022	SELENDI ILÇE D.H.	MANISA	0133028	GULNAR DEVLET HST.	IÇEL
3459002	ÇORLU DEVLET HST.	TEKIRDAĞ	3545023	SOMA DEVLET HST.	MANISA	0133029	IMC HASTANESI	IÇEL
3459003	ÇORLU VATAN HST.	TEKIRDAĞ	3545024	TURGUTLU D.H.	MANISA	0133030	M CITY HOSPITAL	IÇEL
3459004	HAYRABOLU DEV.HST.	TEKIRDAĞ	3545025	YENI MANISA	MANISA	0133031	MEDICALPARK HST.	IÇEL
3459005	IRMET HOSPITAL	TEKIRDAĞ	3548001	75.YIL MILAS DEVLET	MUĞLA	0133032	MERSIN D.H.	IÇEL
3459006	LIFEPORT HOSPITAL	TEKIRDAĞ	3548002	ACIBADEM BODRUM HST.	MUĞLA	0133033	MERSIN K.D.VE Ç.H.H.	IÇEL
3459007	MALKARA DEVLET HST.	TEKIRDAĞ	3548003	BODRUM DEVLET HST.	MUĞLA	0133034	MERSIN ORTADOĞU HST.	IÇEL
3459008	MURATLI DEVLET HST.	TEKIRDAĞ	3548004	DALAMAN DEV. HST.	MUĞLA	0133035	MERSIN ŞEHIR HASTNSI	IÇEL
3459009	NAMIK KEMAL UNV. HST	TEKIRDAĞ	3548005	FETHIYE D.H.	MUĞLA	0133036	MERSIN UNV. TIP FAK.	IÇEL
3459010	OPTIMED HASTANESI	TEKIRDAĞ	3548006	FETMED SAĞ.HIZ.	MUĞLA	0133037	MUT DEVLET HST.	IÇEL
3459011	ÖZEL VEGA HOSPITAL	TEKIRDAĞ	3548007	KÖYCEĞIZ D.H.	MUĞLA	0133038	ÖMER SAYAR HST.	IÇEL
3459012	REYAP HST.	TEKIRDAĞ	3548008	LOKMAN HEKIM ESNAF H	MUĞLA	0133039	ÖZEL OLBAMED HST.	IÇEL
3459013	SARAY DEVLET HST.	TEKIRDAĞ	3548009	MARMARIS YUCELEN	MUĞLA	0133040	SILIFKE D.H.	IÇEL
3459014	SIMETRIK SAĞ. HIZ.	TEKIRDAĞ	3548010	MARMARIS D.H.	MUĞLA	0133041	TANRIÖVER DOĞUŞ H.	IÇEL
3459015	ŞARKÖY DEVLET HST.	TEKIRDAĞ	3548011	MUĞLA UNV.E.A.H.	MUĞLA	0133042	TARSUS D.H.	IÇEL
3459016	TEKIRDAĞ DEVLET HST.	TEKIRDAĞ	3548012	ORTACA DEVLET HST.	MUĞLA	0133043	TARSUS K.H. VE D.HST	IÇEL
3459017	TEKIRDAĞ YAŞAM H.	TEKIRDAĞ	3548013	ORTACA YUCELEN HST.	MUĞLA	0133044	TOROS DEVLET HST.	IÇEL
0707001	AKDENIZ HASTANESI	ANTALYA	3548014	ÖZEL AHU HST.	MUĞLA	0133045	TOROS SELIME TIP HIZ	IÇEL
0707002	AKDENIZ SAĞ. VAKFI	ANTALYA	3548015	ÖZEL BODRUM HST.	MUĞLA	0133046	YENIŞEHIR HST.	IÇEL
0707003	AKDENIZ ŞIFA HST.	ANTALYA	3548016	ÖZEL IZAN SAĞLIK HST	MUĞLA	0180001	DEVA SAĞLIK HIZ.	OSMANIYE
0707004	AKDENIZ UNV. HST.	ANTALYA	3548017	ÖZEL MARMARIS HAST.	MUĞLA	0180002	DUZIÇI D.H.	OSMANIYE

Continuation of Appendix 4

0707005	ALANYA ANADOLU HST.	ANTALYA	3548018	YATAĞAN D.H.	MUĞLA	0180003	KADIRLI D.H.	OSMANIYE
0707006	ALANYA D.H.	ANTALYA	3548019	YUCELEN HASTANESI	MUĞLA	0180004	KADIRLI YEDI MART	OSMANIYE
0707007	ANTALYA ANADOLU HST.	ANTALYA	3564001	EŞME DEVLET HST.	UŞAK	0180005	OSMANIYE DEV. HST.	OSMANIYE
0707008	ANTALYA E. A. HST.	ANTALYA	3564002	ÖZTAN HASTANESI	UŞAK	0180006	OSMANIYE PARK HST.	OSMANIYE
0707009	ANTALYA KAŞ DEV. HST	ANTALYA	3564003	SIVASLI ILÇE D.H.	UŞAK	0180007	OSMANIYE SEVGI HST.	OSMANIYE
0707010	ANTALYA KEPEZ DEV.HS	ANTALYA	3564004	UŞAK BANAZ D.H.	UŞAK	0180008	ÖZEL FBM	OSMANIYE
0707011	ANTALYA YAŞAM HST.	ANTALYA	3564005	UŞAK MEDICALPARK HST	UŞAK	0180009	YENIHAYAT HST.	OSMANIYE
0707012	ASPENDOS ANADOLU HST	ANTALYA	3564006	UŞAK UNI. TIP FK EAH	UŞAK	0606001	29 Mayıs DH	ANKARA
0707013	ATATURK D.H.	ANTALYA	2172001	BATMAN BÖLGE D.H.	BATMAN	0606002	ACIBADEM ANKARA HST.	ANKARA
0707014	BAŞKENT UNV. ALANYA	ANTALYA	2172002	BATMAN DUNYA HST.	BATMAN	0606003	AKROPOL HASTANESI	ANKARA
0707015	ELMALI D.H.	ANTALYA	2172003	BATMAN ECEM SAĞ.	BATMAN	0606004	ANKARA Ç.SAĞ.HAS.	ANKARA
0707016	FINIKE D.H.	ANTALYA	2172004	BATMAN K.D.VE Ç.H.H.	BATMAN	0606005	ANKARA E.A.H.	ANKARA
0707017	GAZIPAŞA D.H.	ANTALYA	2172005	BATMAN YAŞAM HST.	BATMAN	0606006	ANKARA FIZIK TEDAVI	ANKARA
0707018	KEMER ANADOLU HST.	ANTALYA	2172006	KOZLUK DEVLET HST	BATMAN	0606007	ANKARA GUVEN HST.	ANKARA
0707019	KEMER ILÇE D.H.	ANTALYA	2172007	MEDICALPARK BATMAN H	BATMAN	0606008	ANKARA ONKOLOJI EAH.	ANKARA
0707020	KEMER YAŞAM HST	ANTALYA	2172008	ÖZEL ZILAN HASTANESI	BATMAN	0606009	ANKARA ULUS DEV.HST.	ANKARA
0707021	KORKUTELI D.H.	ANTALYA	2112001	BINGÖL DEVLET HST.	BINGÖL	0606010	ANKARA UMUT HST	ANKARA
0707022	KORKUTELI MEDIYAŞAM	ANTALYA	2112002	BINGÖL HASTANESI	BINGÖL	0606011	ANKARA UNV. TIP F.	ANKARA
0707023	KUMLUCA D.H.	ANTALYA	2112003	BINGÖL K.D.Ç.H.H	BINGÖL	0606012	ANKARA UNV.CEBECI HS	ANKARA
0707024	LARA ANADOLU HST	ANTALYA	2112004	BINGÖL SOLHAN D.H.	BINGÖL	0606013	ATATURK E.A.H.	ANKARA
0707025	MANAVGAT D.H.	ANTALYA	2121001	BISMIL D.H.	DIYARBAKIR	0606014	ATATURK GÖĞ. HAS.	ANKARA
0707026	MEDICALPARK HST.	ANTALYA	2121002	ÇERMIK DEVLET HST.	DIYARBAKIR	0606015	BAŞKENT UNV.ANK.HAS.	ANKARA
0707027	MEDSTAR ANTALYA HS.	ANTALYA	2121003	D.YUSUF AZIZOĞLU D.H	DIYARBAKIR	0606016	BATIKENT BILGI SAĞ.	ANKARA
0707028	MEDSTAR TOPÇULAR HST	ANTALYA	2121004	DICLE UNIVERSITESI	DIYARBAKIR	0606017	BAYINDIR HST.	ANKARA
0707029	MEMORIAL HST.	ANTALYA	2121005	DIYAR DUNYA DĞM. H.	DIYARBAKIR	0606018	BEYPAZARI D.H.	ANKARA
0707030	OFM ANTALYA HST.	ANTALYA	2121006	DIYARBAKIR Ç.H.H.	DIYARBAKIR	0606019	ÇANKAYA HASTANESI	ANKARA

Continuation of Appendix 4

0707031	OLIMPOS HST.	ANTALYA	2121007	DIYARBAKIR DEVLET HS	DIYARBAKIR	0606020	ÇANKAYA YAŞAM HASTANESI	ANKARA
0707032	OPERA YAŞAM HST	ANTALYA	2121008	DIYARBAKIR E.A.HST.	DIYARBAKIR	0606021	DR. BAYRAM ÖZTURK HS	ANKARA
0707033	ÖZEL ALANYA YAŞAM H.	ANTALYA	2121009	DIYARLIFE HST.	DIYARBAKIR	0606022	DR. NAFIZ KÖREZ D.H.	ANKARA
0707034	ÖZEL BILGI HST	ANTALYA	2121010	ERGANI DEVLET HST.	DIYARBAKIR	0606023	DR. SAMI ULUS E.A.H.	ANKARA
0707035	Özel Likya Antalya H	ANTALYA	2121011	GENESIS HOSPITAL HST	DIYARBAKIR	0606024	DUATEPE D.H.	ANKARA
0707036	ÖZEL MANAVGAT E.H.	ANTALYA	2121012	MEMORIAL HST.	DIYARBAKIR	0606025	ELMADAĞ ILÇE D.H.	ANKARA
0707037	ÖZEL MANAVGAT YAŞAM	ANTALYA	2121013	ÖZEL BAĞLAR H.	DIYARBAKIR	0606026	ETIMESGUT SAIT ERTRK	ANKARA
0707038	ÖZEL MEDISU HASTANES	ANTALYA	2121014	ÖZEL MEMORIAL D HST.	DIYARBAKIR	0606027	ETLIK ZUBEYDE HANIM	ANKARA
0707039	SERIK D.H.	ANTALYA	2121015	SULTAN HASTANESI	DIYARBAKIR	0606028	GAZI M. KEMAL D.H.	ANKARA
0707040	SIDE ANADOLU HST.	ANTALYA	2147001	KIZILTEPE D.H.	MARDIN	0606029	GAZI UNV.TIP FAK.H.	ANKARA
0707041	UNCALI MEYDAN HST.	ANTALYA	2147002	KIZILTEPE SAĞ.HIZ.	MARDIN	0606030	GÖLBAŞI HASVAK D.H.	ANKARA
0707042	VITALE HASTANESI	ANTALYA	2147003	MARDIN D.H.	MARDIN	0606031	GULHANE ASKERI T.A.	ANKARA
0715001	BUCAK D.H.	BURDUR	2147004	MARDIN DERIK D.H.	MARDIN	0606032	HACETTEPE UNV.T.F.	ANKARA
0715002	BURDUR D.H.	BURDUR	2147005	MARDINPARK HST.	MARDIN	0606033	HALIL ŞIVGIN D.H.	ANKARA
0715003	GÖLHISAR D.H.	BURDUR	2147006	MIDYAT DEVLET HST.	MARDIN	0606034	HAYMANA D.H.	ANKARA
0715004	LIDER HASTANESI	BURDUR	2147007	NUSAYBIN DEVLET HAST	MARDIN	0606035	HRS ANKARA KADIN H.	ANKARA
0732001	DAVRAZ YAŞAM H.	ISPARTA	2147008	ÖZEL CIHANPOL HAST.	MARDIN	0606036	KAZAN HAMDI ERIŞ D.H	ANKARA
0732002	EĞRIDIR KEM.EKLEM H.	ISPARTA	2156001	ASEMA HOSPITAL	SIIRT	0606037	KEÇIÖREN E.A.H.	ANKARA
0732003	ISPARTA DEV. HST.	ISPARTA	2156002	MEDLIFE BINSINA HST.	SIIRT	0606038	KEÇIÖREN HST.	ANKARA
0732004	ISPARTA HST.	ISPARTA	2156003	ÖZEL SIIRT HAYAT H.	SIIRT	0606039	KIZILCAHAMAM D.H.	ANKARA
0732005	ISPARTA K.D.VE Ç.H.H	ISPARTA	2156004	SIIRT DEVLET HST.	SIIRT	0606040	KORU HASTANESI	ANKARA
0732006	ISPARTA ŞEHIR HST.	ISPARTA	2156005	SIIRT KURTALAN D.H.	SIIRT	0606041	KORU SINCAN HST.	ANKARA
0732007	ÖZEL MEDDEM HASTANES	ISPARTA	2156006	ÖZEL SIIRT IBNI SINA	SIIRT	0606042	KUDRET INTRN.HOSP.	ANKARA
0732008	SDU ARŞ.VE UYG. H.	ISPARTA	2173001	CIZRE D.H.	ŞIRNAK	0606043	LIV HOSPITAL ANKARA	ANKARA
0732009	ŞARKIKARAAĞAÇ D.H.	ISPARTA	2173002	IDIL DEVLET HST	ŞIRNAK	0606044	LOKMAN HEKIM AKAY	ANKARA
0732010	YALVAÇ DEVLET HST.	ISPARTA	2173003	SILOPI D.H.	ŞIRNAK	0606045	LOKMAN HEKIM HST.	ANKARA

Continuation of Appendix 4

2603001	AFYON D.H.	AFYON	2173004	ŞIRNAK D.H.	ŞIRNAK	0606046	LOKMAN HKM SINCAN	ANKARA
2603002	AFYON KOCATEPE UNV.	AFYON	4402001	ADIYAMAN PARK H.	ADIYAMAN	0606047	LÖSANTE HST.	ANKARA
2603003	AFYON TIP FUAR HST.	AFYON	4402002	ADIYAMAN UNV.E.A.H.	ADIYAMAN	0606048	MEMORIAL ANKARA HST.	ANKARA
2603004	BOLVADIN D.H.	AFYON	4402003	BESNI ILÇE DEV. HST.	ADIYAMAN	0606049	MESLEK HASTALIKLARI	ANKARA
2603005	ÇAY DEVLET HASTANESI	AFYON	4402004	GÖLBAŞI ILÇE D.H.	ADIYAMAN	0606050	NALLIHAN D.H.	ANKARA
2603006	DINAR D.H.	AFYON	4402005	KAHTA DEV. HST.	ADIYAMAN	0606051	NUMUNE E.A.H.	ANKARA
2603007	EMIRDAĞ D.H.	AFYON	4402006	ÖZEL GÖZDE	ADIYAMAN	0606052	ORTADOĞU 19 MAYIS H.	ANKARA
2603008	KIRMIZI PARK HST.	AFYON	4423001	DOĞU ANADOLU HST.	ELAZIĞ	0606053	ÖZEL ALDAN HASTANESI	ANKARA
2603009	SANDIKLI D.H.	AFYON	4423002	ELAZIĞ EĞITIM VE A.H	ELAZIĞ	0606054	ÖZEL ANKARA MEDICALPARK HST	ANKARA
2603010	ŞUHUT DEVLET HAST.	AFYON	4423003	ELAZIĞ HAYAT	ELAZIĞ	0606055	ÖZEL ERYAMAN HAST.	ANKARA
2611001	BILECIK D.H.	BILECIK	4423004	FIRAT UNV. H.	ELAZIĞ	0606056	ÖZEL ETIMED HST	ANKARA
2611002	BOZUYUK D.H.	BILECIK	4423005	KARAKOÇAN DEV.HST.	ELAZIĞ	0606057	ÖZEL MEDICANA I.A.H.	ANKARA
2611003	SÖĞUT D.H.	BILECIK	4423006	KOVANCILAR D.H.	ELAZIĞ	0606058	ÖZEL NATOMED HST	ANKARA
2626001	ACIBADEM HST.	ESKIŞEHIR	4423007	ÖZEL MEDIKAL PARK EL	ELAZIĞ	0606059	ÖZEL ORTADOĞU HST.	ANKARA
2626002	ÇIFTELER DEVLET HST.	ESKIŞEHIR	4444001	AKÇADAĞ DEVLET HAST.	MALATYA	0606060	POLATLI CAN HST.	ANKARA
2626003	ESKIŞEHIR D.H.	ESKIŞEHIR	4444002	D.HULUSI EFENDI D.H.	MALATYA	0606061	ŞEREFLIKOÇHISAR D.H.	ANKARA
2626004	MEDLINE HST.	ESKIŞEHIR	4444003	DOĞANŞEHIR DEV. HST	MALATYA	0606062	TOBB ETU HST.	ANKARA
2626005	OSMANGAZI UNV.	ESKIŞEHIR	4444004	EGM HAYAT HST.	MALATYA	0606063	UFUK UNV. HST.	ANKARA
2626006	SIVRIHISAR DEVLET H.	ESKIŞEHIR	4444005	GÖZDE AKADEMI HST.	MALATYA	0606064	YENIMAHALLE D.H.	ANKARA
2626007	UMIT HST.VIŞNELIK ŞB	ESKIŞEHIR	4444006	HEKIMHAN DEVLET HST.	MALATYA	0606065	YILDIRIM BEYAZIT E.A	ANKARA
2626008	UMIT SAĞLIK MERKEZI	ESKIŞEHIR	4444007	INÖNU UNV.T.Ö.TIP M.	MALATYA	0606066	YUKSEK IHTISAS E.A.H	ANKARA
2626009	YUNUS EMRE D.H.	ESKIŞEHIR	4444008	MALATYA DEVLET HST.	MALATYA	0606067	ZEKAI TAHIR BURAK	ANKARA
2643001	DOÇ.DR.M.KALEMLI D.H	KUTAHYA	4444009	MALATYA GÖZDE HST.	MALATYA	0606068	ÖZEL ARTE CERRAHI HS	ANKARA
2643002	EVLIYA ÇELEBI E.A.H.	KUTAHYA	4444010	MALATYA PARK	MALATYA	0606069	YUZUNCU YIL HST.	ANKARA
2643003	GEDIZ DEV.HST.	KUTAHYA	4444011	MALATYA SEVGI HST.	MALATYA	0618001	ÇANKIRI D.H.	ÇANKIRI
2643004	KUTAHYA EMET D.H.	KUTAHYA	4444012	MELID PARK HST	MALATYA	0618002	ÖZEL KARATEKIN HST	ÇANKIRI

Continuation of Appendix 4

2643005	MEDLINE HST.	KUTAHYA	4444013	MUJDE HST.	MALATYA	0619001	ALACA DEVLET HST	ÇORUM
2643006	SIMAV DEVLET HST.	KUTAHYA	4444014	ÖZEL GÖZDE KIŞLA HST	MALATYA	0619002	ATIF HOCA D.H.	ÇORUM
8174001	BARTIN D.H.	BARTIN	4444015	YEŞILYURT DEVLET HST	MALATYA	0619003	BAYAT DEVLET H	ÇORUM
8114001	ÇAĞSU HST.	BOLU	6504001	AĞRI D.H.	AĞRI	0619004	ÇORUM DEVLET HST.	ÇORUM
8114002	FATMA HATUN HST.	BOLU	6504002	DOĞUBAYAZIT D.HST.	AĞRI	0619005	ÇORUM GÖĞUS H.H.	ÇORUM
8114003	GEREDE D.H.	BOLU	6504003	ÖZEL AĞRI YAŞAM	AĞRI	0619006	ELITPARK HASTANESI	ÇORUM
8114004	IZZET BAYSAL D.H.	BOLU	6504004	ÖZEL MEDIZA HST.	AĞRI	0619007	OSMANCIK D.H.	ÇORUM
8114005	IZZET BAYSAL DHS	BOLU	6504005	PATNOS ILÇE D.H.	AĞRI	0619008	ÖZEL ÇORUM HST	ÇORUM
8181001	AKÇAKOCA DEV. HST.	DUZCE	6513001	ADILCEVAZ ONKOLOJI H	BITLIS	0619009	SUNGURLU DEVLET HST.	ÇORUM
8181002	ATATURK D.H.	DUZCE	6513002	AHLAT DEV. HST.	BITLIS	0670001	ERMENEK ILÇE D.H.	KARAMAN
8181003	DUZCE UNV. HST.	DUZCE	6513003	BITLIS DEVLET HST.	BITLIS	0670002	KARAMAN DEV. HAST.	KARAMAN
8181004	HAYRI SIVRIKAYA HST.	DUZCE	6513004	BITLIS TATVAN D.H.	BITLIS	0670003	KARAMAN SELÇUKLU HST	KARAMAN
8178001	KARABUK DEVLET HST.	KARABUK	6513005	ÖZEL TATVAN CAN	BITLIS	0670004	MUMINE HATUN HST.	KARAMAN
8178002	MEDIKAR HST.	KARABUK	6530001	HAKKARI DEVLET HST.	HAKKARI	0637001	DR.MUNIF ISLAMOĞLU H	KASTAMONU
8178003	SAFRANBOLU D.H.	KARABUK	6530002	ŞEMDINLI DEVLET HST.	HAKKARI	0637002	INEBOLU DEVLET HAST.	KASTAMONU
8141001	ACIBADEM HST.	KOCAELI	6530003	YUKSEKOVA D.H.	HAKKARI	0637003	ISFENDIYAR ANADOLU H	KASTAMONU
8141002	ANADOLU SAĞ. MER.	KOCAELI	6576001	IĞDIR D.H.	IĞDIR	0637004	ÖZEL KASTAMONU O.A.H	KASTAMONU
8141003	CIHAN ÖZEL SAĞLIK	KOCAELI	6549001	BULANIK DEVLET HST.	MUŞ	0637005	TAŞKÖPRU DEVLET HST.	KASTAMONU
8141004	DARICA FARABI D.HST.	KOCAELI	6549002	MALAZGIRT DEVLET HST	MUŞ	0637006	TOSYA D.H.	KASTAMONU
8141005	GEBZE DOĞA HST.	KOCAELI	6549003	MUŞ DEVLET HASTANESI	MUŞ	0671001	KIRIKKALE HILAL HST.	KIRIKKALE
8141006	GEBZE FATIH DEV.HST.	KOCAELI	6549004	MUŞ ŞIFA HASTANESI	MUŞ	0671002	KIRIKKALE ÖZEL YAŞAM	KIRIKKALE
8141007	GEBZE KONAK HST	KOCAELI	6549005	VARTO DEVLET HST.	MUŞ	0671003	KIRIKKALE UNV. HST.	KIRIKKALE
8141008	HOSPITALPARK DARICA	KOCAELI	6565001	BAŞKALE D.H.	VAN	0671004	YUKSEK IHTISAS HST.	KIRIKKALE
8141009	IZMIT SEKA D.HST.	KOCAELI	6565002	ERCIŞ DEV. HST.	VAN	0642001	AKŞEHIR ILÇE D.H.	KONYA
8141010	KANDIRA DEVLET HST.	KOCAELI	6565003	LOKMAN HEKIM HAYAT H	VAN	0642002	AKŞEHIR ÖZEL PARK HS	KONYA
8141011	KARAMURSEL DEV. HST.	KOCAELI	6565004	LOKMAN HEKIM VAN	VAN	0642003	ANIT HST.	KONYA

Continuation of Appendix 4

8141012	KOCAELI AKADEMI H.	KOCAELI	6565005	MURADIYE DEV. HST.	VAN	0642004	BAŞKENT U.KONYA U.A.	KONYA
8141013	KOCAELI DERINCE E.A.	KOCAELI	6565006	VAN AKDAMAR HOSPITAL	VAN	0642005	BELEDIYE SAĞLIK HST.	KONYA
8141014	KOCAELI DEV. HST.	KOCAELI	6565007	VAN BÖLGE E.A.H.	VAN	0642006	BEYHEKIM D.H.	KONYA
8141015	KOCAELI GÖLCUK D.H.	KOCAELI	6565008	YUZUNCU YIL UNIV.	VAN	0642007	BEYŞEHIR DEVLET HST.	KONYA
8141016	KOCAELI UNV.A.U.H.	KOCAELI	6565009	ÖZALP DEVLET HAST.	VAN	0642008	BOZKIR ILÇE D.H.	KONYA
8141017	KONAK HST.	KOCAELI	1610001	ATATURK D.H.	BALIKESIR	0642009	CANKAT NEFES SAĞLIK	KONYA
8141018	KÖRFEZ DEVLET HST.	KOCAELI	1610002	AYVALIK D.H.	BALIKESIR	0642010	CIHANBEYLI DEVLET H.	KONYA
8141019	KÖRFEZ MARMARA HST.	KOCAELI	1610003	BALIKESIR D.H.	BALIKESIR	0642011	ÇUMRA DEVLET HST.	KONYA
8141020	MEDIPLAZA SAĞ.HIZ.	KOCAELI	1610004	BALIKESIR GÖĞUS H.H.	BALIKESIR	0642012	DR. FARUK SUKAN K.D.	KONYA
8141021	ÖZEL AILE KONAK HST	KOCAELI	1610005	BALIKESIR UNV.	BALIKESIR	0642013	DR.VEFA TANIR ILGIN	KONYA
8141022	VM MEDICALPARK	KOCAELI	1610006	BANDIRMA D.H.	BALIKESIR	0642014	EREĞLI D.H.	KONYA
8141023	YUZYIL HASTANESI	KOCAELI	1610007	BANDIRMA HST.	BALIKESIR	0642015	HUYUK D.H.	KONYA
8141024	ÖZEL IZMIT KADIN S.M	KOCAELI	1610008	BIGADIÇ D.H.	BALIKESIR	0642016	KADINHANI DEVLET HST	KONYA
8154001	ADA MERT SAĞLIK A.Ş	SAKARYA	1610009	BURHANIYE D.H.	BALIKESIR	0642017	KARAPINAR D.H.	KONYA
8154002	ADA-MED BILGE HST.	SAKARYA	1610010	DURSUNBEY D.H.	BALIKESIR	0642018	KONYA E.A.HST.	KONYA
8154003	AKYAZI D.H.	SAKARYA	1610011	EDREMIT D.H.	BALIKESIR	0642019	KONYA FARABI HST.	KONYA
8154004	BEYHEKIM HST.	SAKARYA	1610012	EDREMIT KÖRFEZ HST.	BALIKESIR	0642020	KONYA NUMUNE HST.	KONYA
8154005	GEYVE D.H.	SAKARYA	1610013	GÖNEN D.H.	BALIKESIR	0642021	KULU DEVLET HST.	KONYA
8154006	HENDEK D.H.	SAKARYA	1610014	HAVRAN ILÇE HST.	BALIKESIR	0642022	MEDICANA KONYA HST.	KONYA
8154007	KARASU D.H.	SAKARYA	1610015	IVRINDI D.H.	BALIKESIR	0642023	MEDLINE KONYA	KONYA
8154008	KONAK HAST. SAKARYA	SAKARYA	1610016	IZMIRYOLU SEVGI HST	BALIKESIR	0642024	MERTIP SAĞ. HIZ.	KONYA
8154009	SAKARYA E.A.H.	SAKARYA	1610017	NEYYIRE SITKI DEV. H	BALIKESIR	0642025	NECMETTIN ERBAKAN U.	KONYA
8154010	TOYOTASA A.Y.HST.	SAKARYA	1610018	SEVGI HST.	BALIKESIR	0642026	ÖZEL MEDOVA HST.	KONYA
8154011	VATAN HST.	SAKARYA	1610019	SINDIRGI DEVLET HST.	BALIKESIR	0642027	SARAYÖNU D.H.	KONYA
8154012	YENIKENT D.H.	SAKARYA	1610020	SUSURLUK D.H.	BALIKESIR	0642028	SELÇUKLU SAĞ. HIZ.	KONYA
8167001	ALAPLI DEV. HST.	ZONGULDAK	1616001	ACIBADEM SAĞ.HIZ.	BURSA	0642029	SELÇUKLU TIP FAK.	KONYA

Continuation of Appendix 4

8167002	ATATURK D.H.	ZONGULDAK	1616002	ALI OSMAN SÖNMEZ HAS	BURSA	0642030	SEYDIŞEHIR D.H.	KONYA
8167003	BULENT ECEVIT UAH	ZONGULDAK	1616003	ARITMI OSMANGAZI HST	BURSA	0642031	TICARET BORSASI HST.	KONYA
8167004	ÇAYCUMA D.H.	ZONGULDAK	1616004	ATEK ÖZEL SAĞLIK HZM	BURSA	0642032	YUNAK D.H	KONYA
8167005	DEVREK D.H.	ZONGULDAK	1616005	BURSA ANADOLU HST.	BURSA	0642033	ALI KEMAL BELVIRANLI	KONYA
8167006	EREĞLI ANADOLU HST.	ZONGULDAK	1616006	BURSA DEVLET HST.	BURSA	5505001	GUMUŞHACIKÖY D.H.	AMASYA
8167007	EREĞLI ECHOMAR	ZONGULDAK	1616007	BURSA INEGÖL DHS	BURSA	5505002	MERZIFON D.H.	AMASYA
8167008	KDZ. EREĞLI D.H.	ZONGULDAK	1616008	CEYLAN HOSPITAL	BURSA	5505003	S.ŞEREFEDDIN E.A.H.	AMASYA
8167009	LEVEL HOSPITAL	ZONGULDAK	1616009	ÇEKIRGE D.H.	BURSA	5505004	SULUOVA ILÇE D.H.	AMASYA
8167010	UZUNMEHMET G.M.H.HST	ZONGULDAK	1616010	ÇEKIRGE KALP VE A.H.	BURSA	5552001	AVRASYA SAĞ. HIZ.	ORDU
8167011	ZONGULDAK K.D.Ç.H.H.	ZONGULDAK	1616011	DORUK HST.	BURSA	5552002	AYBASTI D.H.	ORDU
2727001	25 ARALIK D.H.	GAZIANTEP	1616012	DORUK YILDIRIM HST.	BURSA	5552003	ÇAKIRTEPE HST.	ORDU
2727002	CEMKA MEDIKAL	GAZIANTEP	1616013	DÖRTÇELIK Ç.H.HST.	BURSA	5552004	FATSA DEVLET HST.	ORDU
2727003	CENGIZ GÖKÇEK KDÇH	GAZIANTEP	1616014	HAYAT HST.	BURSA	5552005	GÖLKÖY D.H.	ORDU
2727004	DEFA LIFE HOSPTL HST	GAZIANTEP	1616015	IZNIK DEVLET HST.	BURSA	5552006	ORDU DEVLET HST.	ORDU
2727005	DR. ERSIN ARSLAN EAH	GAZIANTEP	1616016	KARACABEY D.H.	BURSA	5552007	ORDU MEDIKAL	ORDU
2727006	DR.ERSIN ARSLAN D.H.	GAZIANTEP	1616017	MEDICABIL HST	BURSA	5552008	ORDU SEVGI K.D.Ç.H.	ORDU
2727007	DUZTEPE YAŞAM H.	GAZIANTEP	1616018	MEDICAL PARK HST.	BURSA	5552009	ORDU UMUT HST	ORDU
2727008	GAZIANTEP AKADEMI HS	GAZIANTEP	1616019	MUAMMER AĞIM D.H.	BURSA	5552010	ORDU UNV. E.A.H.	ORDU
2727009	GAZIANTEP UNV.	GAZIANTEP	1616020	MUDANYA ŞAZIYERUŞTU	BURSA	5552011	UNYE DEVLET HST.	ORDU
2727010	HATEM HST.	GAZIANTEP	1616021	MUSTAFAKEMALPAŞA D.H	BURSA	5555001	ATASAM HASTANESI	SAMSUN
2727011	ISLAHIYE DEVLET HST	GAZIANTEP	1616022	ORHANELI DEV. HST.	BURSA	5555002	BAFRA DEVLET HST.	SAMSUN
2727012	INAYET TOPÇUOĞLU H.	GAZIANTEP	1616023	ORHANGAZI D.H.	BURSA	5555003	ÇARŞAMBA D.H.	SAMSUN
2727013	MEDICALPARK HST.	GAZIANTEP	1616024	OZEL ZEYTIN TIP MERK	BURSA	5555004	HAVZA D.H.	SAMSUN
2727014	NIZIP D.H.	GAZIANTEP	1616025	ÖZEL ARITMI HST.	BURSA	5555005	HOSPITALPARK ÇIFTLIK	SAMSUN
2727015	ÖZEL ANKA HASTANESI	GAZIANTEP	1616026	ÖZEL CIHANGIR HST.	BURSA	5555006	HOSPITALPARK MEYDAN	SAMSUN
2727016	ÖZEL ARTEMIS TIP MER	GAZIANTEP	1616027	ÖZEL JIMER HST.	BURSA	5555007	MEDIBAFRA HST	SAMSUN

Continuation of Appendix 4

2727017	ÖZEL DEVA HASTANESI	GAZIANTEP	1616028	PEMBEMAVI KADIN HST.	BURSA	5555008	MEDICALPARK	SAMSUN
2727018	ÖZEL EMEK HASTANESI	GAZIANTEP	1616029	ULUDAĞ UNV. TIP FAK.	BURSA	5555009	MEDICANA SAMSUN S.H.	SAMSUN
2727019	ÖZEL GAZIANTEP SEVGI	GAZIANTEP	1616030	YENIŞEHIR D.H.	BURSA	5555010	ONDOKUZ MAYIS UNV.	SAMSUN
2727020	ÖZEL HAYAT HST.	GAZIANTEP	1616031	YUKSEK IHTISAS E.A.H	BURSA	5555011	ÖZEL LIMAN HASTANESI	SAMSUN
2727021	Özel Ncr Int. HST	GAZIANTEP	1617001	BAYRAMIÇ DEVLET HST.	ÇANAKKALE	5555012	SAMSUN E.A.H.	SAMSUN
2727022	ÖZEL SUZAN KADIN DĞM	GAZIANTEP	1617002	BIGA CAN SAĞ.HIZ.	ÇANAKKALE	5555013	SAMSUN GAZI D.H.	SAMSUN
2727023	SANI KONUKOĞLU HST.	GAZIANTEP	1617003	BIGA D.H.	ÇANAKKALE	5555014	SAMSUN GÖĞUS H.G.C.H	SAMSUN
2727024	SEV AMERIKAN HST.	GAZIANTEP	1617004	ÇAN D.H.	ÇANAKKALE	5555015	SAMSUN K.D.Ç.H. HST.	SAMSUN
2727025	SULTANA HOSPITAL	GAZIANTEP	1617005	ÇANAKKALE D.H.	ÇANAKKALE	5555016	TERME D.H.	SAMSUN
2727026	ŞEHIT KAMIL D.H	GAZIANTEP	1617006	EZINE D.H.	ÇANAKKALE	5555017	VEZIRKÖPRU D.H.	SAMSUN
2727027	TAMMED HST.	GAZIANTEP	1617007	GELIBOLU D.H.	ÇANAKKALE	5557001	ATATURK D.H.	SINOP
2746001	AFŞIN D.H.	K.MARAŞ	1617008	GOKCEADA DEVLET HST.	ÇANAKKALE	5557002	AYANCIK D.H.	SINOP
2746002	ANDIRIN DEVLET HST.	K.MARAŞ	1617009	ONSEKIZ MART UNV.	ÇANAKKALE	5557003	BOYABAT 75.YIL D.H.	SINOP
2746003	DR.S.A.GÖKSUN D.HST.	K.MARAŞ	1617010	ÖZEL ANADOLU HST	ÇANAKKALE	5560001	ERBAA D.H.	TOKAT
2746004	ELBISTAN D.H.	K.MARAŞ	1677001	ÖZEL ATAKENT HST.	YALOVA	5560002	GAZIOSMANPAŞA UNV.	TOKAT
2746005	ELBISTAN YAŞAM HST.	K.MARAŞ	1677002	YALOVA D.H.	YALOVA	5560003	NIKSAR D.H.	TOKAT
2746006	HAYAT HASTANESI	K.MARAŞ	1677003	YALOVA HST.	YALOVA	5560004	REŞADIYE D.H.	TOKAT
2746007	MEGAPARK HASTANESI	K.MARAŞ	3868001	AKSARAY D.H.	AKSARAY	5560005	TOKAT D.H.	TOKAT
2746008	NECIP FAZIL Ş.D.H.	K.MARAŞ	3868002	AKSARAY HST.	AKSARAY	5560006	TOKAT MEDICALPARK	TOKAT
2746009	ÖZEL DEVAKENT HST.	K.MARAŞ	3868003	MAYA KADIN DOĞ. HST.	AKSARAY	5560007	TURHAL DEV. HST.	TOKAT
2746010	ÖZEL MARASH LIFE	K.MARAŞ	3868004	ORTAKÖY DEVLET HST.	AKSARAY	5560008	ZILE D.H.	TOKAT
2746011	ÖZEL MARKASI H.	K.MARAŞ	3838001	ACIBADEM HST.	KAYSERI			
2746012	ÖZEL SULAR VATAN HST	K.MARAŞ	3838002	BUNYAN D.H.	KAYSERI			
2746013	PAZARCIK DEVLET HST.	K.MARAŞ	3838003	ÇINAR TEDAVI HIZ.	KAYSERI			
2746014	SUTÇU IMAM UNV.A.U.H	K.MARAŞ	3838004	ERCIYES UNIV TIP FAKULTESI	KAYSERI			
2779001	KILIS DEVLET HST	KILIS	3838005	DEVELI DEVLET HST.	KAYSERI			

Continuation of Appendix 4

2763001	AKÇAKALE DEV. HST.	ŞANLIURFA	3838006	ERCIYES KARTAL HST.	KAYSERI			
2763002	BALIKLIGÖL D.H.	ŞANLIURFA	3838007	GÖKKUŞAĞI IBNI SINA	KAYSERI			
2763003	BIRECIK DEVLET HST.	ŞANLIURFA	3838008	HUMA K.H. VE D. HST.	KAYSERI			
2763004	CEYLANPINAR ILÇE D.H	ŞANLIURFA	3838009	KAYSERI E.A.H.	KAYSERI			
2763005	HARRAN U.A. VE U.H.	ŞANLIURFA	3838010	KAYSERI SEVGI HST.	KAYSERI			
2763006	MEHMET AKIF INAN EAH	ŞANLIURFA	3838011	MEDICAL PALACE HST	KAYSERI			
2763007	MEYDAN SAĞLIK	ŞANLIURFA	3838012	MEMORIAL KAYSERI HST	KAYSERI			
2763008	Özel Metrolife Has.	ŞANLIURFA	3838013	MODERN DUNYA HST.	KAYSERI			
2763009	ÖZEL ŞANMED HST.	ŞANLIURFA	3838014	Ö.T.T.I.S.S. KIZILAY	KAYSERI			
2763010	ÖZEL URFA LOTUS HST.	ŞANLIURFA	3838015	ÖZEL MAGNET HST	KAYSERI			
2763011	RUHA ACADEMIA HST	ŞANLIURFA	3838016	TEKDEN HST.	KAYSERI			
2763012	SIVEREK DEV. HST.	ŞANLIURFA	3838017	YAHYALI DEV. HST.	KAYSERI			

APPENDIX-5: Comparison Table of the Solution Results of the Cost Models

SOLUTION RESULT					
	OPTIMAL	**CURRENT**	**RELAXED**	**DIFFRENCES OF CURRENT vs OPTIMAL MODEL**	**DIFFRENCES OF OPTIMAL vs RELAXED MODEL**
TOTAL COST (on the basis of TL)	554.924.777,22	574.055.164,09	554.814.635,09	19.130.386,87	110.142,13
BDC-RBC Blood Transportation Cost (on the basis of TL)	3.993.924,90	3.455.688,60	4.166.131,90	- 538.236,30	- 172.207,00
RBC-RBC Blood Transportation Cost (on the basis of TL)	311.404,72	13.489.257,47	72.141,56	13.177.852,75	239.263,16
RBC-TC Blood Transportation Cost (on the basis of TL)	5.548.918,75	10.326.027,35	5.452.561,19	4.777.108,60	96.357,57
RBC-LAB Blood Transportation Cost (on the basis of TL)	435.014,30	814.125,20	435.014,30	379.110,90	-
Total Units of T&B Bag used (on annual Basis)	1.361.965,36	1.308.848,73	1.361.965,36	- 53.116,64	- 0,00
Total Units of T&T Bag used (on annual Basis)	1.029.607,64	1.082.724,27	1.029.607,64	53.116,64	0,00
Total Cost of Collection with T&B Bag Type (on the basis of TL)	58.564.510,64	56.280.495,27	58.564.510,64	- 2.284.015,36	- 0,00
Total Cost of Collection with T&T Bag Type (on the basis of TL)	46.332.343,64	48.722.592,27	46.332.343,64	2.390.248,64	0,00

APPENDIX-6: Comparison table of the amount of TS produced with the average BC in BDC

The amount of TS produced with the average BC in BDC (in liters)				
BDC	**RBC DIGIT**	**CURRENT SYSTEM**	**OPTIMAL SOLUTION**	**RELAXED SOLUTION**
ADANA	01011	0	4596,99	0
ADIYAMAN	44023	883,41	883,41	40,225
AFYON	26031	1188,495	1015,3	1188,495
ANKARA	06065	7447,94	6354,56	2899,325
ANTALYA	07071	0	1443,225	0
ARTVIN	61081	0	234,63	234,63
AYDIN	35091	2316,215	2316,215	2316,215
BALIKESIR	16101	1932,48	1932,48	423,64
BAŞAKŞEHIR	34345	4311,945	4311,945	2709,285
BATMAN	21721	490,93	490,93	490,93
BURDUR	07152	0	0	0
BURSA	16162	4433,22	4056,12	0
ÇANAKKALE	16173	0	0	1162,7
ÇAPA	34341	2821,965	0	6319,05
ÇEKMEKÖY	00003	1651,485	1651,485	0
ÇORLU	34592	2081,695	2081,695	2081,695
ÇORUM	06191	0	865,205	865,205
DENIZLI	35202	2435,73	2435,73	170,17
DIYARBAKIR	21212	337,59	1874,62	1874,62
DUZCE	81811	0	1130,855	1130,855
EDIRNE	34223	0	1138,61	1138,61
ELAZIĞ	44231	916,135	916,135	0
ERZINCAN	25241	800,855	800,855	800,855
ERZURUM	25252	2,97	1434,43	416,45
ESKIŞEHIR	26262	2175,855	2175,855	2175,855
GAZIANTEP	27272	2699,125	4879,93	4879,93
GIRESUN	61282	0	0	456,32
GUMUŞHANE	61293	0	292,16	292,16
ISPARTA	07323	658,9	0	568,7
ISKENDERUN	01312	2512,38	0	2539,35
IZMIR	35353	6273,695	0	0
K.MARAŞ	27461	0	1608,365	1608,365
KARABUK	81782	122,115	0	836,66

Continuation of Appendix 6

KARTAL	00001	3122,24	0	3047,18
KASTAMONU	06374	613,195	613,195	613,195
KAYSERI	38381	305,415	0	0
KIRIKKALE	06712	219,01	219,01	219,01
KIRŞEHIR	38402	0	344,85	344,85
KILIS	27793	0	333,52	333,52
KOCAELI	81415	2496,56	1345,645	1305,48
KONYA	06423	0	0	2231,715
KUTAHYA	26433	1304,38	644,675	1304,38
LULEBURGAZ	34394	895,565	895,565	895,565
MALATYA	44442	1386,35	1633,17	0
MANISA	35454	3507,955	1006,795	3507,955
MARMARIS	35455	1821,38	1821,38	0
MERSIN	01333	0	0	3785,98
MUŞ	65491	470,085	0	470,085
NEVŞEHIR	38503	438,46	298,235	438,46
ORDU	55521	1330,58	1402,83	1402,83
ÖDEMIŞ	35356	944,845	944,845	0
RIZE	61534	0	0	713,845
SAKARYA	81543	0	0	1039,515
SAMSUN	55552	0	3149,19	1875,93
SIIRT	21563	295,68	295,68	295,68
SIVAS	38584	0	0	1200,87
ŞANLIURFA	27634	0	1789,71	1789,71
TOKAT	55603	670,285	670,285	670,285
TRABZON	61615	1290,025	1580,975	1020,055
UŞAK	35647	1167,045	1167,045	0
VAN	65652	4,015	0	1552,375
YALOVA	16774	626,175	626,175	626,175
YOZGAT	38665	0	0	285,05
Z.KAMIL	00002	582,305	3203,585	3203,585
ZONGULDAK	81674	0	0	1114,52
TOTAL		**71986,68**	**74908,09**	**74908,09**

APPENDIX-7: Assignment of BDC and RBC According to Transportation Mode

ASSIGMENT & TRANSPORTATION MODE						
BDC	**RBC (CURRENT)**	**TRANS. MODE**	**RBC (COST MIN. MODEL)**	**TRANS. MODE**	**RBC (RELAXED SYSTEM)**	**TRANS. MODE**
ADANA	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR
ADIYAMAN	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
AFYON	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	DOĞU ANADOLU	AIR
ANKARA	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR
ANTALYA	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR
ARTVIN	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	ORTA AKDENIZ	AIR
AYDIN	EGE	GROUND	EGE	GROUND	EGE	GROUND
BALIKESIR	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
BAŞAKŞEHIR	AVRUPA	GROUND	AVRUPA	GROUND	GUNEY ANADOLU	AIR
BATMAN	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
BURDUR	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	BATIAKDENIZ	GROUND
BURSA	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR
ÇANAKKALE	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
ÇAPA	AVRUPA	GROUND	GUNEY BATI ANADOLU	AIR	AVRUPA	GROUND
ÇEKMEKÖY	KUZEY MARMARA	GROUND	AVRUPA	GROUND	GUNEY BATI ANADOLU	AIR
ÇORLU	AVRUPA	GROUND	AVRUPA	GROUND	GUNEY ANADOLU	AIR
ÇORUM	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
DENIZLI	EGE	GROUND	EGE	GROUND	EGE	GROUND
DIYARBAKIR	GUNEY ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY ANADOLU	GROUND
DUZCE	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
EDIRNE	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
ELAZIĞ	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND

Continuation of Appendix 7

ERZINCAN	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND	DOĞU KARADENIZ	AIR
ERZURUM	BATIKARADENIZ	GROUND	DOĞUANADOLU	GROUND	DOĞU ANADOLU	GROUND
ESKIŞEHIR	BATI ANADOLU	GROUND	ORTA ANADOLU	AIR	ORTA KARADENIZ	AIR
GAZIANTEP	DOĞU AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
GIRESUN	DOĞU KARADENIZ	GROUND	AVRUPA	AIR	DOĞU KARADENIZ	GROUND
GUMUŞHANE	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
ISPARTA	BATI AKDENIZ	GROUND	IÇ ANADOLU	AIR	BATI AKDENIZ	GROUND
ISKENDERUN	ORTA AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	ORTA ANADOLU	AIR
IZMIR	EGE	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
K.MARAŞ	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
KARABUK	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
KARTAL	KUZEY MARMARA	GROUND	ORTA KARADENIZ	AIR	ORTA AKDENIZ	AIR
KASTAMONU	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
KAYSERI	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	EGE	AIR
KIRIKKALE	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
KIRŞEHIR	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
KILIS	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
KOCAELI	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
KONYA	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	ORTA ANADOLU	GROUND
KUTAHYA	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR
LULEBURGAZ	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
MALATYA	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
MANISA	EGE	GROUND	EGE	GROUND	AVRUPA	AIR
MARMARIS	EGE	GROUND	EGE	GROUND	EGE	GROUND

Continuation of Appendix 7

MERSIN	ORTA AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	AVRUPA	AIR
MUŞ	GUNEYDOĞU	GROUND	GUNEY ANADOLU	AIR	GUNEY ANADOLU	AIR
NEVŞEHIR	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
ORDU	ORTA KARADENIZ	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
ÖDEMIŞ	EGE	GROUND	EGE	GROUND	EGE	GROUND
RIZE	DOĞU KARADENIZ	GROUND	AVRUPA	AIR	GUNEY ANADOLU	AIR
SAKARYA	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
SAMSUN	ORTA KARADENIZ	GROUND	GUNEY BATI ANADOLU	GROUND	ORTA KARADENIZ	GROUND
SIIRT	GUNEY ANADOLU	GROUND	GUNEYANADOLU	GROUND	IÇANADOLU	AIR
SIVAS	IÇ ANADOLU	GROUND	GUNEY ANADOLU	AIR	GUNEY ANADOLU	AIR
ŞANLIURFA	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
TOKAT	ORTA KARADENIZ	GROUND	ORTAKARADENIZ	AIR	GUNEY BATI ANADOLU	GROUND
TRABZON	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	BATI AKDENIZ	AIR
UŞAK	EGE	GROUND	EGE	GROUND	BATI AKDENIZ	AIR
VAN	GUNEY DOĞU	GROUND	AVRUPA	AIR	ORTA AKDENIZ	AIR
YALOVA	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
YOZGAT	IÇ ANADOLU	GROUND	AVRUPA	AIR	IÇ ANADOLU	GROUND
Z.KAMIL	KUZEY MARMARA	GROUND	AVRUPA	GROUND	ORTA ANADOLU	AIR
ZONGULDAK	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND

APPENDIX-8: Assignment of RBC and LAB According to Transportation Mode

ASSIGMENT & TRANSPORTATION MODE						
RBC	**LAB (CURRENT)**	**TRANS. MODE**	**LAB (COST MIN. MODEL)**	**TRANS. MODE**	**LAB (RELAXED SYSTEM)**	**TRANS. MODE**
AVRUPA	KUZEY MARMARA	GROUND	ORTA AKDENIZ	AIR	ORTA AKDENIZ	AIR
BATI AKDENIZ	ORTA ANADOLU	AIR	ORTA AKDENIZ	AIR	ORTA AKDENIZ	AIR
BATI ANADOLU	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
BATI KARADENIZ	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND
DOĞU AKDENIZ	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	AIR	ORTA AKDENIZ	AIR
DOĞU ANADOLU	ORTA ANADOLU	AIR	ORTA AKDENIZ	AIR	ORTA AKDENIZ	AIR
DOĞU KARADENIZ	KUZEY MARMARA	AIR	ORTA AKDENIZ	AIR	ORTA AKDENIZ	AIR
EGE	EGE	GROUND	EGE	GROUND	EGE	GROUND
GUNEY MARMARA	KUZEY MARMARA	GROUND	ORTA AKDENIZ	AIR	ORTA AKDENIZ	AIR
GUNEY ANADOLU	KUZEY MARMARA	AIR	ORTA AKDENIZ	AIR	ORTA AKDENIZ	AIR
GUNEY BATI ANADOLU	ORTA ANADOLU	AIR	ORTA AKDENIZ	AIR	ORTA AKDENIZ	AIR
GUNEY DOĞU	ORTA ANADOLU	AIR	ORTA AKDENIZ	AIR	ORTA AKDENIZ	AIR
IÇ ANADOLU	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	AIR	ORTA AKDENIZ	AIR
KUZEY MARMARA	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND
ORTA AKDENIZ	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
ORTA ANADOLU	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
ORTA KARADENIZ	KUZEY MARMARA	AIR	ORTA AKDENIZ	AIR	ORTA AKDENIZ	AIR

APPENDIX-9: Assignment of TC (City Based) and RBC According to Transportation Model

ASSIGMENT & TRANSPORTATION MODE						
TC (CITY)	**RBC(CURRENT)**	**TRANS. MODE**	**RBC (COST MIN. MODEL)**	**TRANS. MODE**	**RBC (RELAXED SYSTEM)**	**TRANS. MODE**
ISTANBUL (ANAT.)	KUZEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY ANADOLU	AIR
ADANA	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
ADIYAMAN	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
AFYON	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
AĞRI	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
AMASYA	ORTA KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	ORTA KARADENIZ	GROUND
ANKARA	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
ANTALYA	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND
ARTVIN	DOĞU KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
AYDIN	EGE	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
BALIKESIR	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR
BILECIK	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR
BINGÖL	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR
BITLIS	GUNEY DOĞU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
BOLU	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
BURDUR	BATI AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
BURSA	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
ÇANAKKALE	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR
ÇANKIRI	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
ÇORUM	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR

Continuation of Appendix 9

DENIZLI	EGE	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
DIYARBAKIR	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
EDIRNE	AVRUPA	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
ELÂZIĞ	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
ERZINCAN	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
ERZURUM	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND
ESKIŞEHIR	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	DOĞU ANADOLU	GROUND
GAZIANTEP	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
GIRESUN	DOĞU KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
GUMUŞHANE	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR
HAKKÂRI	GUNEY DOĞU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
HATAY	ORTA AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
ISPARTA	BATI AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
MERSIN	ORTA AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
ISTANBUL (EUROPE)	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
IZMIR	EGE	GROUND	EGE	GROUND	EGE	GROUND
KARS	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
KASTAMONU	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
KAYSERI	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
KIRKLARELI	AVRUPA	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
KIRŞEHIR	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
KOCAELI	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
KONYA	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR

Continuation of Appendix 9

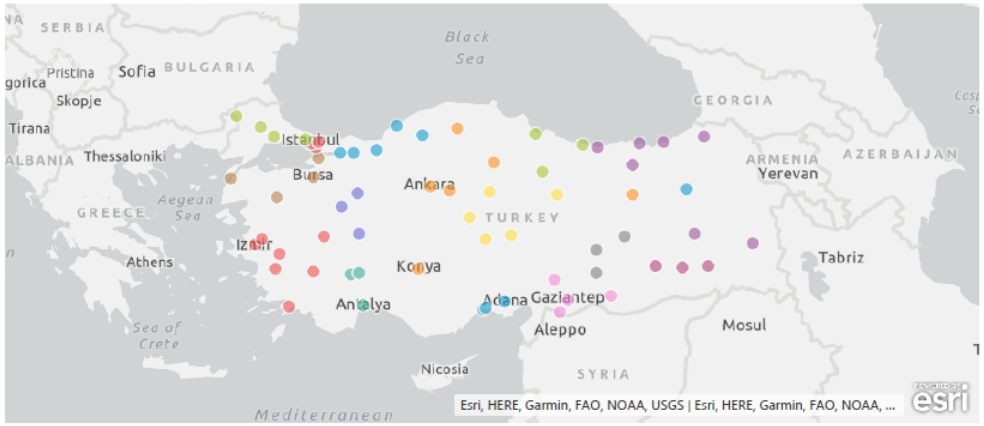
KUTAHYA	BATI ANADOLU	GROUND	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR
MALATYA	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
MANISA	EGE	GROUND	EGE	GROUND	EGE	GROUND
K.MARAŞ	DOĞU AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
MARDIN	GUNEY ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
MUĞLA	EGE	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
MUŞ	GUNEY DOĞU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
NEVŞEHIR	IÇ ANADOLU	GROUND	GUNEY MARMARA	AIR	GUNEY BATI ANADOLU	AIR
NIĞDE	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
ORDU	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
RIZE	DOĞU KARADENIZ	GROUND	IÇ ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
SAKARYA	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
SAMSUN	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
SIIRT	GUNEY ANADOLU	GROUND	GUNEY MARMARA	AIR	GUNEY BATI ANADOLU	AIR
SINOP	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
SIVAS	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
TEKIRDAĞ	AVRUPA	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
TOKAT	ORTA KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
TRABZON	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
TUNCELI	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
ŞANLIURFA	DOĞU AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
UŞAK	EGE	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
VAN	GUNEY DOĞU	GROUND	DOĞU ANADOLU	AIR	ORTA KARADENIZ	AIR

Continuation of Appendix 9

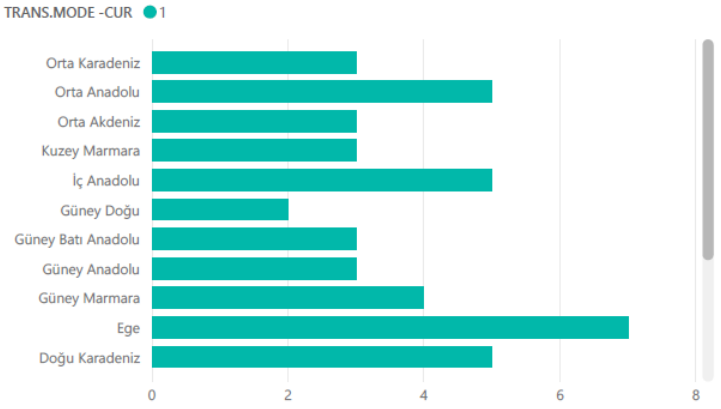
YOZGAT	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
ZONGULDAK	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR
AKSARAY	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
BAYBURT	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
KARAMAN	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
KIRIKKALE	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR
BATMAN	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
ŞIRNAK	GUNEY ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
BARTIN	BATI KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
ARDAHAN	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
IĞDIR	GUNEY DOĞU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
YALOVA	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR
KARABUK	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
KILIS	DOĞU AKDENIZ	GROUND	GUNEY ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
OSMANIYE	ORTA AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY BATI ANADOLU	AIR
DUZCE	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND

APPENDIX-10: Comparison maps of BDC-RBC assignment between Current System and Cost Min. Model

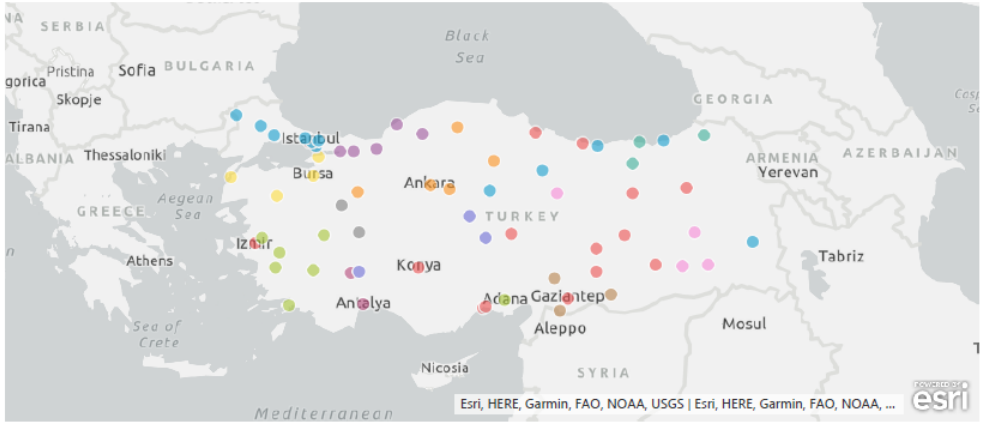
BDC-RBC ASSGN. IN CURRENT SYSTEM



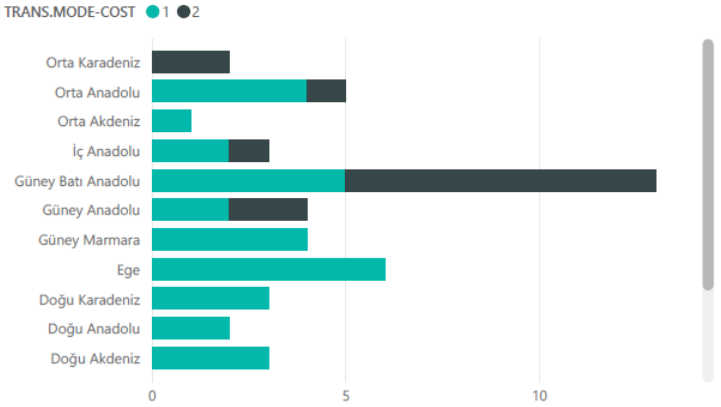
ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE



BDC-RBC ASSGN. IN COST MIN MODEL

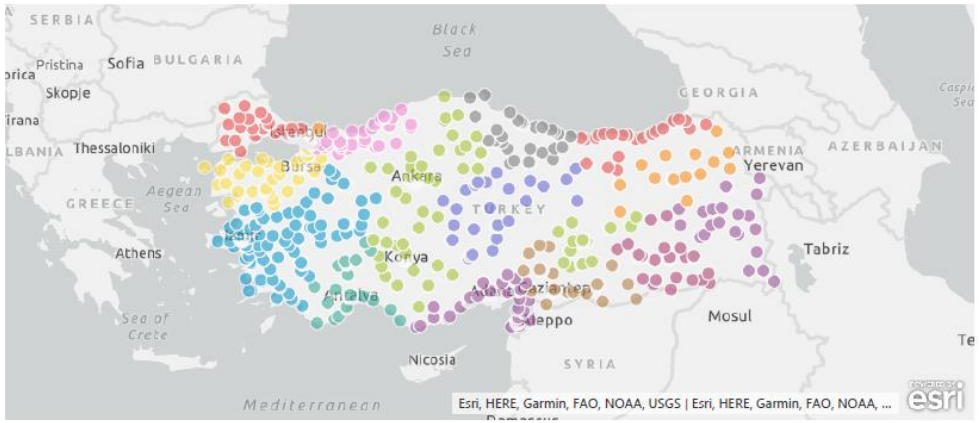


ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE

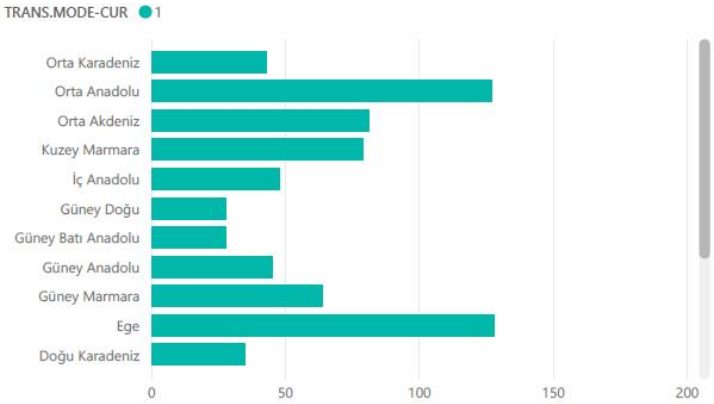


APPENDIX-11: Comparison maps of RBC-TC assignment between Current System and Cost Min. Model

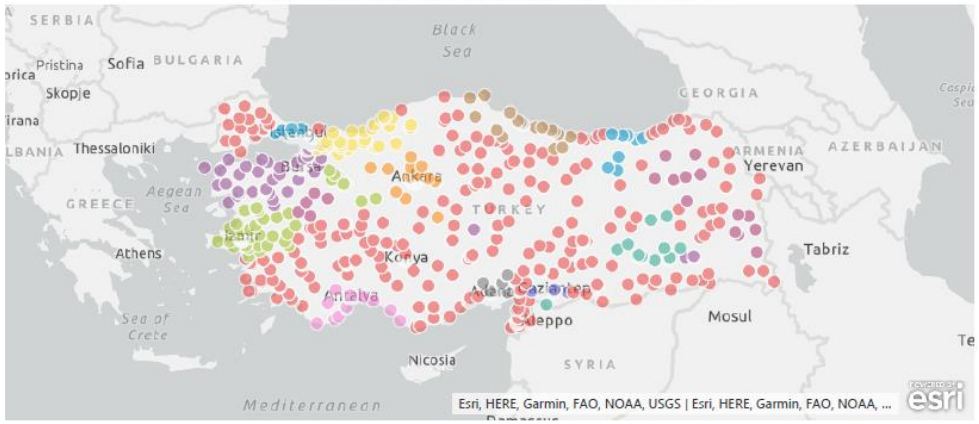
RBC-TC ASSGN. IN CURRENT SYSTEM



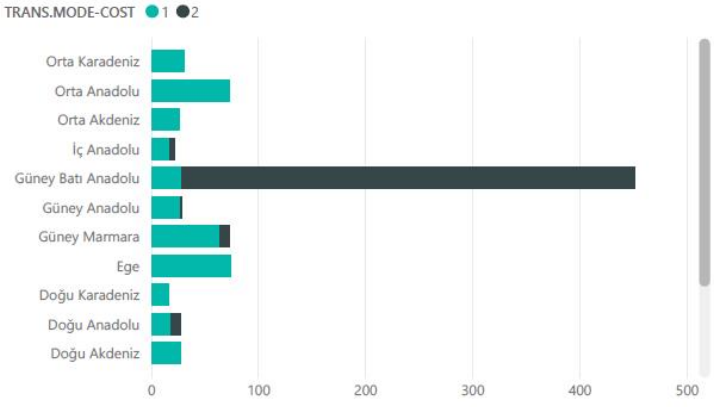
ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE



RBC-TC ASSGN. IN COST MIN MODEL

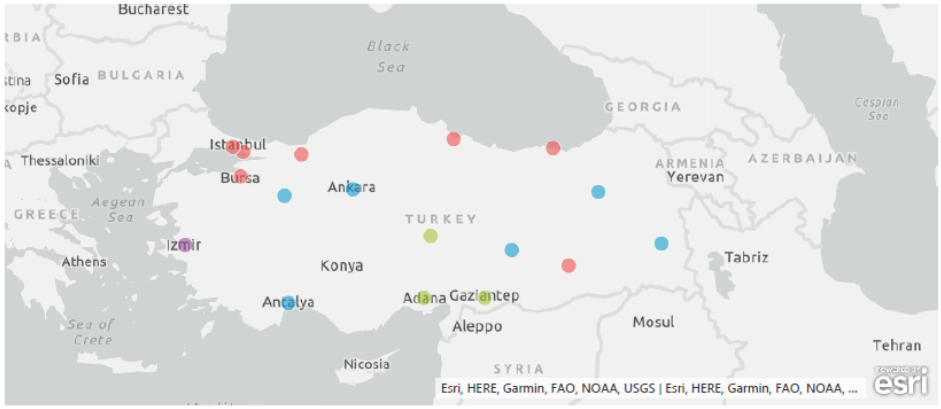


ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE

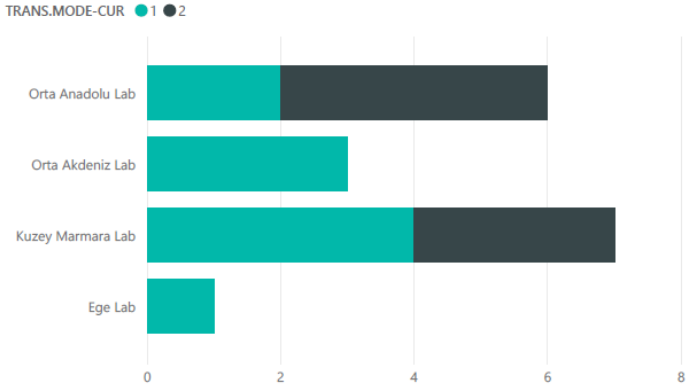


APPENDIX-12: Comparison maps of RBC-LAB assignment between Current System and Cost Min. Model

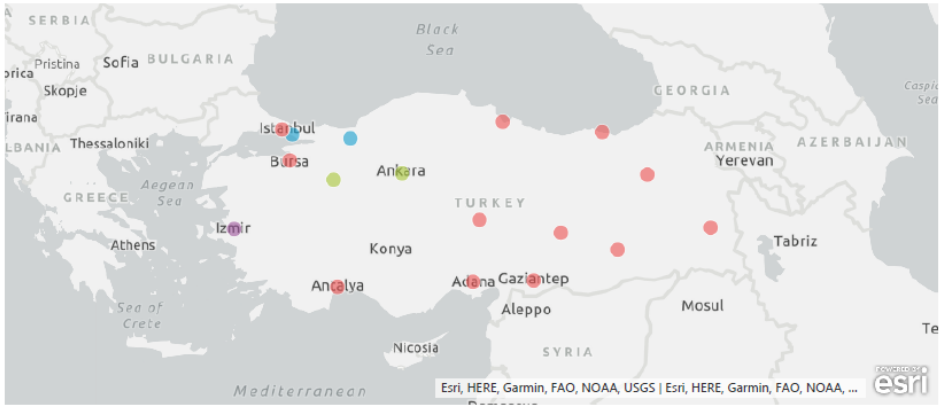
RBC- LAB ASSGN. IN CURRENT SYSTEM



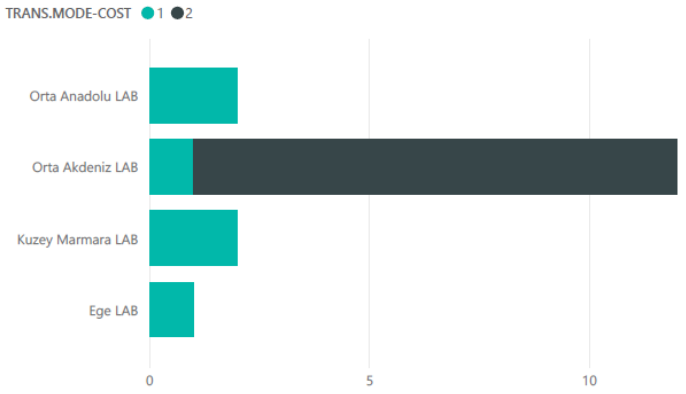
ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE



RBC- LAB ASSGN. IN COST MIN MODEL



ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE



APPENDIX-13: Comparison Table of The Amount of TS Destroyed with the Average Donation

RBC	RBC DIGIT	"TS" DESTROYED IN CURRENT SYSTEM	"TS" DESTROYED IN COST MODEL	"TS" DESTROYED IN RELAXED SYSTEM
ADANA	01011	0	3281,115	0
ADIYAMAN	44023	414,81	0	40,225
AFYON	26031	1188,495	0	0
ANKARA	06065	0	0	0
ANTALYA	07071	0	874,525	0
ARTVIN	61081	0	234,63	234,63
AYDIN	35091	2316,215	2316,215	0
BALIKESIR	16101	1932,48	1932,48	423,64
BAŞAKŞEHIR	34345	0	1495,835	2709,285
BATMAN	21721	0	0	0
BURDUR	07152	0	0	0
BURSA	16162	1487,695	935,97	0
ÇANAKKALE	16173	0	0	168,025
ÇAPA	34341	0	0	0
ÇEKMEKÖY	00003	0	0	0
ÇORLU	34592	0	0	0
ÇORUM	06191	0	670,695	0
DENIZLI	35202	2435,73	0	0
DIYARBAKIR	21212	0	43,835	39,545
DUZCE	81811	0	0	1130,855
EDIRNE	34223	0	0	0
ELAZIĞ	44231	916,135	0	0
ERZINCAN	25241	0	800,855	303,765
ERZURUM	25252	0	90,505	0
ESKIŞEHIR	26262	790,68	2175,855	2175,855
GAZIANTEP	27272	0	0	0
GIRESUN	61282	0	0	456,32
GUMUŞHANE	61293	0	292,16	0
ISPARTA	07323	0	0	0
ISKENDERUN	01312	0	0	0
IZMIR	35353	2615,92	0	0
K.MARAŞ	27461	0	1608,365	1608,365
KARABUK	81782	0	0	836,66
KARTAL	00001	0	0	1731,305

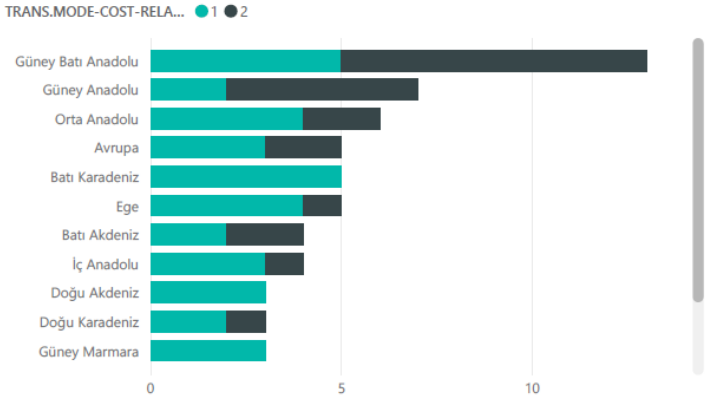
Continuation of Appendix 13

KASTAMONU	06374	0	0	0
KAYSERI	38381	0	0	0
KIRIKKALE	06712	0	0	0
KIRŞEHIR	38402	0	7,12	311,45
KILIS	27793	0	333,52	0
KOCAELI	81415	0	0	0
KONYA	06423	0	0	0
KUTAHYA	26433	1304,38	644,675	0
LULEBURGAZ	34394	0	0	352,155
MALATYA	44442	1386,35	0	0
MANISA	35454	3507,955	1006,795	3507,955
MARMARIS	35455	1821,38	1821,38	0
MERSIN	01333	0	0	0
MUŞ	65491	0	0	0
NEVŞEHIR	38503	0	0	438,46
ORDU	55521	861,815	0	0
ÖDEMIŞ	35356	944,845	944,845	0
RIZE	61534	0	0	0
SAKARYA	81543	0	0	1039,515
SAMSUN	55552	0	0	678,58
SIIRT	21563	0	0	295,68
SIVAS	38584	0	0	0
ŞANLIURFA	27634	0	521,96	855,48
TOKAT	55603	0	0	0
TRABZON	61615	0	765,325	1020,055
UŞAK	35647	1167,045	540,925	0
VAN	65652	0	0	1552,375
YALOVA	16774	626,175	626,175	0
YOZGAT	38665	0	0	0
Z.KAMIL	00002	0	0	2499,51
ZONGULDAK	81674	0	0	0
TOTAL		**25718,105**	**23965,76**	**24409,69**

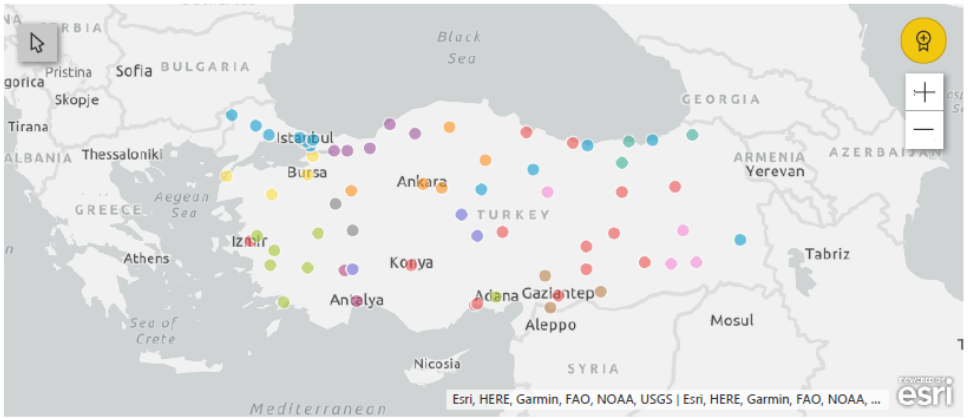
APPENDIX-14: Comparison maps of BDC-RBC assignment between Relaxed System and Cost Min. Model

BDC-RBC ASSGN. IN RELAXED SYSTEM

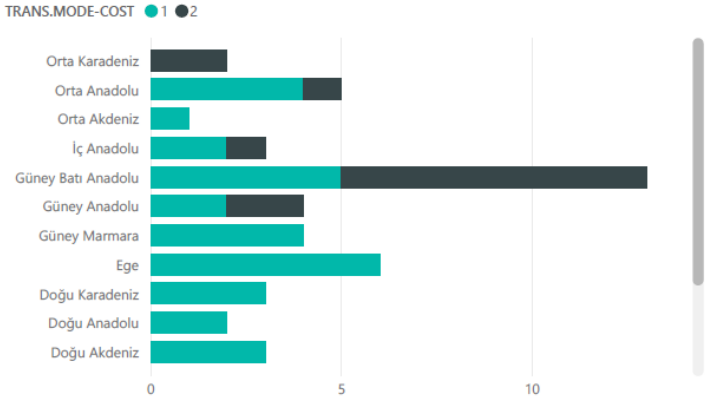
ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE



BDC-RBC ASSGN. IN COST MIN MODEL

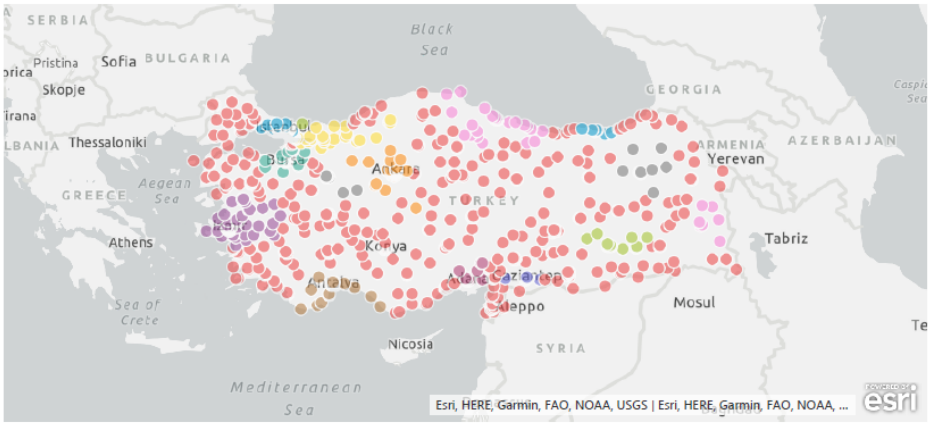


ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE

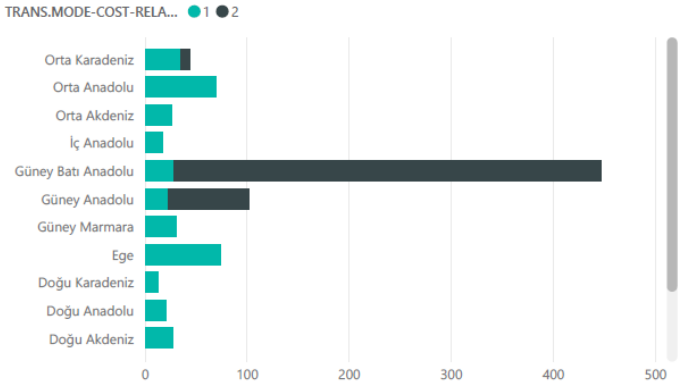


APPENDIX-15: Comparison maps of RBC-TC assignment between Relaxed System and Cost Min. Model

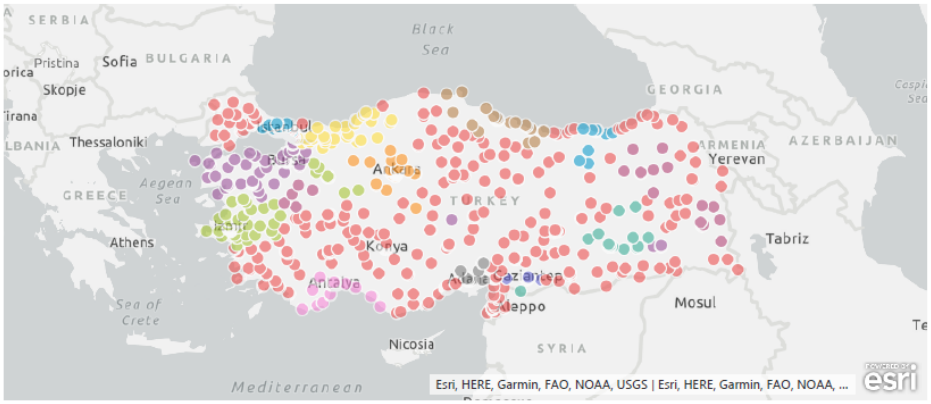
RBC-TC ASSGN. IN RELAXED SYSTEM



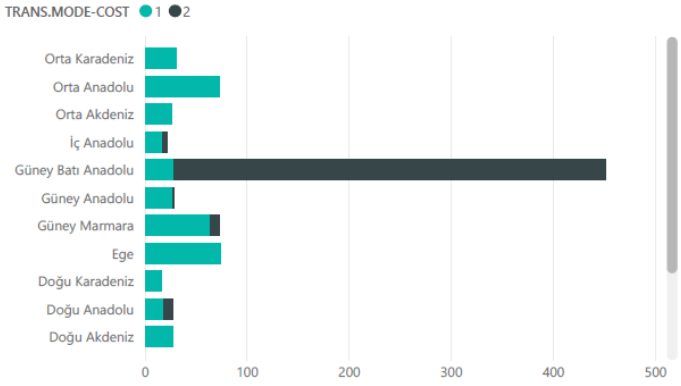
ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE



RBC-TC ASSGN. IN COST MIN MODEL

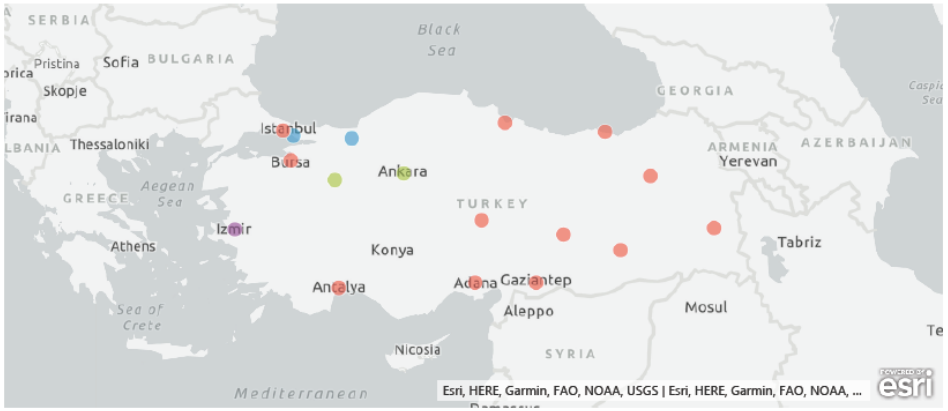


ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE

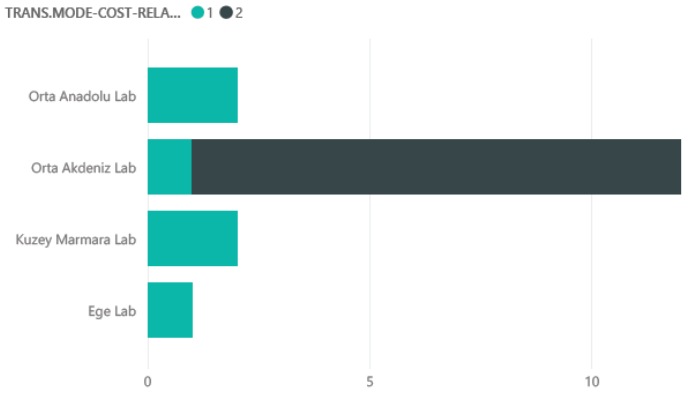


APPENDIX-16: Comparison maps of RBC-LAB assignment between Relaxed System and Cost Min. Model

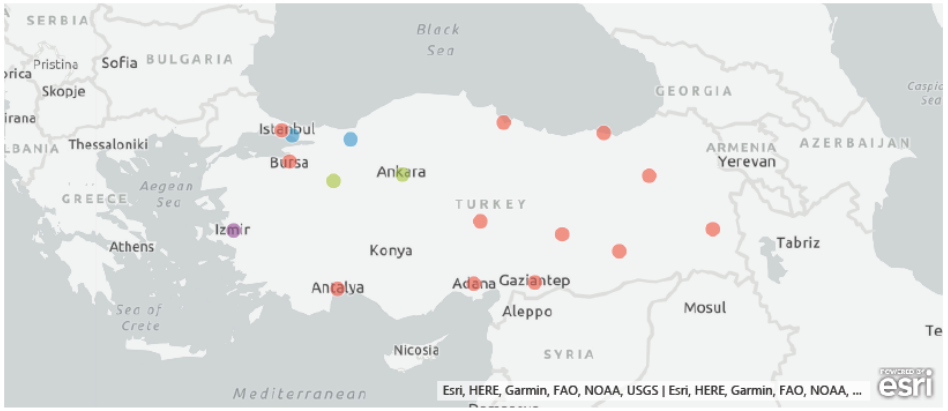
RBC- LAB ASSGN. IN RELAXED SYSTEM



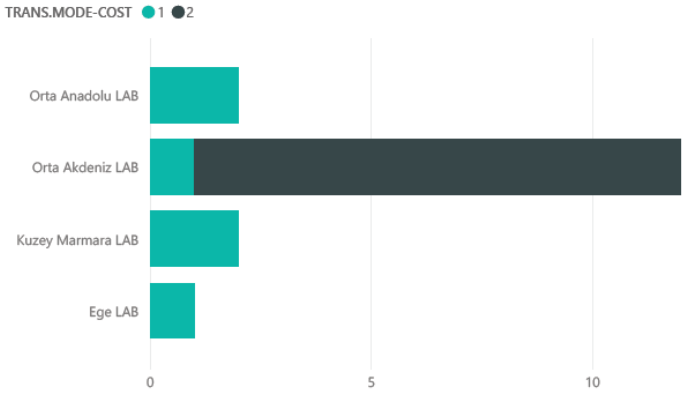
ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE



RBC- LAB ASSGN. IN COST MIN MODEL



ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE



APPENDIX-17: Comparison Table of the Solution Results of the Time Models

SOLUTION RESULT					
	TIME	**CURRENT**	**RELAXED**	**DIFFRENCES OF CURRENT vs TIME MIN. MODEL**	**DIFFRENCES OF TIME MIN. MODEL vs RELAXED MODEL**
TOTAL AMOUNT AT THE END OF THE SHELF LIFE (liter / shelf life)	**1283,07**	**1361,12**	**1285,87**	**78,05**	**2,80**
Total LOST TIME of TS transported amount from BDC to RBC (in liters x min)	**467.163,69**	**494.697,62**	**467.163,69**	**27.533,93**	**0,0000**
Total LOST TIME of ES transported amount from BDC to RBC (in liters x min)	**34.902.021,08**	**32.784.809,23**	**34.406.408,52**	**- 2.117.211,85**	**- 495.612,56**
Total LOST TIME of FFP transported amount from BDC to RBC (in liters x min)	**1.845.408,15**	**1.869.944,85**	**1.845.408,15**	**24.536,70**	**0,0000**
Total LOST TIME of TS transported amount from RBC to TC (in liters x min)	**2.259.686,83**	**2.331.443,95**	**2.259.686,83**	**71.757,12**	**0,0000**
Total LOST TIME of ES transported amount from RBC to TC (in liters x min)	**40.763.142,90**	**41.735.024,40**	**40.763.142,90**	**971.881,50**	**0,0000**
Total LOST TIME of FFP transported amount from RBC to TC (in liters x min)	**11.222.035,88**	**11.490.639,53**	**11.222.035,88**	**268.603,65**	**0,0000**
Total LOST TIME of TS transported amount from RBC to RBC (in liters x min)	**-**	**-**	**-**	**-**	**0,0000**

Continuation of Appendix 17

Total LOST TIME of ES transported amount from RBC to RBC (in liters x min)	**1.395.832,93**	**8.068.703,73**	**2.133.160,25**	**6.672.870,81**	**737.327,33**
Total LOST TIME of FFP transported amount from RBC to RBC (in liters x min)	-	-	-	-	**0,0000**
Total LOST TIME of TS transported amount (in liters x min)	**2.726.850,52**	**2.826.141,57**	**2.726.850,52**	**99.291,05**	**0,0000**
Total LOST TIME of ES transported amount (in liters x min)	**77.060.996,90**	**82.588.537,36**	**77.302.711,67**	**5.527.540,46**	**241.714,77**
Total LOST TIME of FFP transported amount (in liters x min)	**13.067.444,03**	**13.360.584,38**	**13.067.444,03**	**293.140,35**	**0,0000**
Ratio of LOST TIME of TS amount to TS shelf life (lt/ shelf life)	**378,7292**	**392,5197**	**378,7292**	**13,7904**	**0,0000**
Ratio of LOST TIME of ES amount to ES shelf life (lt/ shelf life)	**891,9097**	**955,8858**	**894,7073**	**63,9762**	**2,7976**
Ratio of LOST TIME of FFP amount to FFP shelf life (lt/ shelf life)	**12,4310**	**12,7098**	**12,4310**	**0,2789**	**0,0000**

APPENDIX-18: Assignments of BDC and RBC According to Transportation Mode

ASSIGMENT & TRANSPORTATION MODE						
BDC	**RBC (CURRENT)**	**TRANS. MODE**	**RBC (TIME MIN. MODEL)**	**TRANS. MODE**	**RBC (RELAXED SYSTEM)**	**TRANS. MODE**
ADANA	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
ADIYAMAN	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
AFYON	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND
ANKARA	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
ANTALYA	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND
ARTVIN	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	ORTA ANADOLU	AIR
AYDIN	EGE	GROUND	EGE	GROUND	EGE	GROUND
BALIKESIR	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
BAŞAKŞEHIR	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
BATMAN	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
BURDUR	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND
BURSA	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
ÇANAKKALE	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
ÇAPA	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
ÇEKMEKÖY	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND
ÇORLU	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
ÇORUM	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
DENIZLI	EGE	GROUND	EGE	GROUND	EGE	GROUND
DIYARBAKIR	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
DUZCE	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
EDIRNE	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
ELAZIĞ	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND

Continuation of Appendix 18

ERZINCAN	DOĞU ANADOLU	GROUND	GUNEY DOĞU	AIR	GUNEY DOĞU	AIR
ERZURUM	BATI KARADENIZ	GROUND	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND
ESKIŞEHIR	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND
GAZIANTEP	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
GIRESUN	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
GUMUŞHANE	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
ISPARTA	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND
ISKENDERUN	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
IZMIR	EGE	GROUND	EGE	GROUND	EGE	GROUND
K.MARAŞ	DOĞU AKDENIZ	GROUND	GUNEY DOĞU	AIR	GUNEY DOĞU	AIR
KARABUK	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
KARTAL	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND
KASTAMONU	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
KAYSERI	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
KIRIKKALE	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
KIRŞEHIR	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	GUNEY ANADOLU	AIR
KILIS	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
KOCAELI	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
KONYA	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
KUTAHYA	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND
LULEBURGAZ	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
MALATYA	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
MANISA	EGE	GROUND	EGE	GROUND	EGE	GROUND
MARMARIS	EGE	GROUND	DOĞU AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR
MERSIN	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND

Continuation of Appendix 18

MUŞ	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND
NEVŞEHIR	IÇ ANADOLU	GROUND	GUNEY ANADOLU	AIR	KUZEY MARMARA	AIR
ORDU	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
ÖDEMIŞ	EGE	GROUND	AVRUPA	AIR	EGE	GROUND
RIZE	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
SAKARYA	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
SAMSUN	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
SIIRT	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
SIVAS	IÇ ANADOLU	GROUND	ORTA ANADOLU	AIR	ORTA ANADOLU	AIR
ŞANLIURFA	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
TOKAT	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
TRABZON	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
UŞAK	EGE	GROUND	EGE	GROUND	EGE	GROUND
VAN	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND
YALOVA	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
YOZGAT	IÇ ANADOLU	GROUND	ORTA ANADOLU	AIR	IÇ ANADOLU	GROUND
Z.KAMIL	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND
ZONGULDAK	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND

APPENDIX-19: Assignment of LAB and RBC According to Transportation Mode

ASSIGMENT & TRANSPORTATION MODE						
RBC	**LAB (CURRENT)**	**TRANS. MODE**	**LAB (TIME MIN. MODEL)**	**TRANS. MODE**	**LAB (RELAXED SYSTEM)**	**TRANS. MODE**
AVRUPA	KUZEY MARMARA	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
BATI AKDENIZ	ORTA ANADOLU	AIR	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
BATI ANADOLU	ORTA ANADOLU	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
BATI KARADENIZ	KUZEY MARMARA	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
DOĞU AKDENIZ	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
DOĞU ANADOLU	ORTA ANADOLU	AIR	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
DOĞU KARADENIZ	KUZEY MARMARA	AIR	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
EGE	EGE	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
GUNEY MARMARA	KUZEY MARMARA	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
GUNEY ANADOLU	KUZEY MARMARA	AIR	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
GUNEY BATI ANADOLU	ORTA ANADOLU	AIR	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
GUNEY DOĞU	ORTA ANADOLU	AIR	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
IÇ ANADOLU	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
KUZEY MARMARA	KUZEY MARMARA	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
ORTA AKDENIZ	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
ORTA ANADOLU	ORTA ANADOLU	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
ORTA KARADENIZ	KUZEY MARMARA	AIR	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND

APPENDIX-20: Assignment of TC (City Based) and RBC According to Transportation Mode

ASSIGMENT & TRANSPORTATION MODE						
TC (CITY)	**RBC (CURRENT)**	**TRANS.MODE**	**RBC (TIME MIN. MODEL)**	**TRANS.MODE**	**RBC (RELAXED SYSTEM)**	**TRANS.MODE**
ISTANBUL(ANATOLIA)	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND	KUZEY MARMARA	GROUND
ADANA	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
ADIYAMAN	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
AFYON	ORTA ANADOLU	GROUND	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND
AĞRI	DOĞU ANADOLU	GROUND	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND
AMASYA	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
ANKARA	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
ANTALYA	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND
ARTVIN	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
AYDIN	EGE	GROUND	EGE	GROUND	EGE	GROUND
BALIKESIR	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
BILECIK	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND
BINGÖL	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
BITLIS	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND
BOLU	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	DOĞU ANADOLU	GROUND
BURDUR	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND
BURSA	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
ÇANAKKALE	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
ÇANKIRI	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
ÇORUM	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
DENIZLI	EGE	GROUND	EGE	GROUND	EGE	GROUND

Continuation of Appendix 20

DIYARBAKIR	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
EDIRNE	AVRUPA	GROUND	GUNEY DOĞU	AIR	GUNEY DOĞU	AIR
ELÂZIĞ	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
ERZINCAN	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND
ERZURUM	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND
ESKIŞEHIR	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND
GAZIANTEP	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
GIRESUN	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
GUMUŞHANE	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
HAKKÂRI	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND
HATAY	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
ISPARTA	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND
MERSIN	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
ISTANBUL(EUROPE)	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
IZMIR	EGE	GROUND	EGE	GROUND	EGE	GROUND
KARS	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND
KASTAMONU	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
KAYSERI	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
KIRKLARELI	AVRUPA	GROUND	GUNEY DOĞU	AIR	GUNEY DOĞU	AIR
KIRŞEHIR	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
KOCAELI	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	DOĞU ANADOLU	GROUND
KONYA	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
KUTAHYA	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND

Continuation of Appendix 20

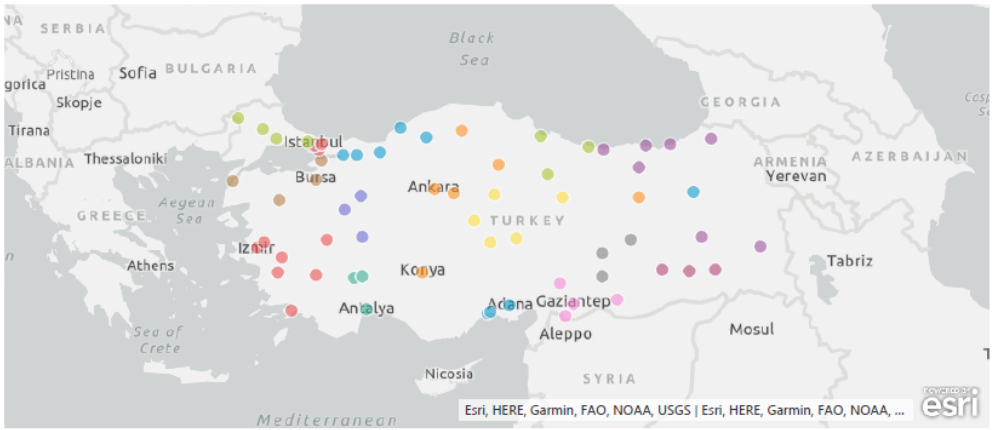
MALATYA	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
MANISA	EGE	GROUND	EGE	GROUND	EGE	GROUND
KAHRAMANMARAŞ	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
MARDIN	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
MUĞLA	EGE	GROUND	EGE	GROUND	EGE	GROUND
MUŞ	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND
NEVŞEHIR	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
NIĞDE	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
ORDU	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
RIZE	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
SAKARYA	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	DOĞU ANADOLU	GROUND
SAMSUN	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
SIIRT	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
SINOP	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
SIVAS	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
TEKIRDAĞ	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
TOKAT	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
TRABZON	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
TUNCELI	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND
ŞANLIURFA	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
UŞAK	EGE	GROUND	EGE	GROUND	EGE	GROUND
VAN	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND
YOZGAT	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
ZONGULDAK	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	DOĞU ANADOLU	GROUND

Continuation of Appendix 20

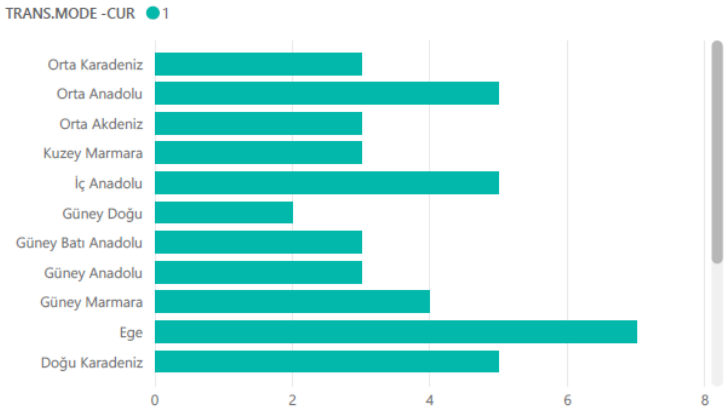
AKSARAY	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
BAYBURT	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND
KARAMAN	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
KIRIKKALE	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
BATMAN	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
ŞIRNAK	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
BARTIN	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	DOĞU ANADOLU	GROUND
ARDAHAN	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND
IĞDIR	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND	GUNEY DOĞU	GROUND
YALOVA	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
KARABUK	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	DOĞU ANADOLU	GROUND
KILIS	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
OSMANIYE	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
DUZCE	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	DOĞU ANADOLU	GROUND

APPENDIX-21: Comparison maps of BDC-RBC assignment between Current System and Time Min. Model

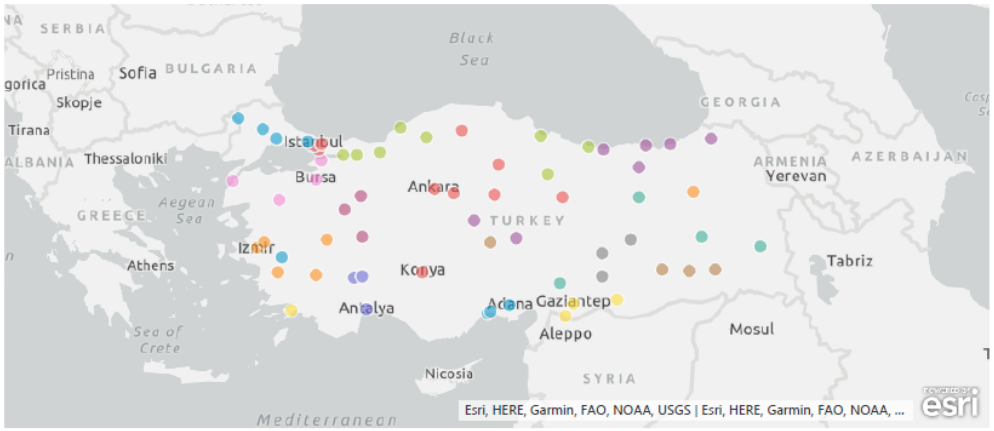
BDC-RBC ASSGN. IN CURRENT SYSTEM



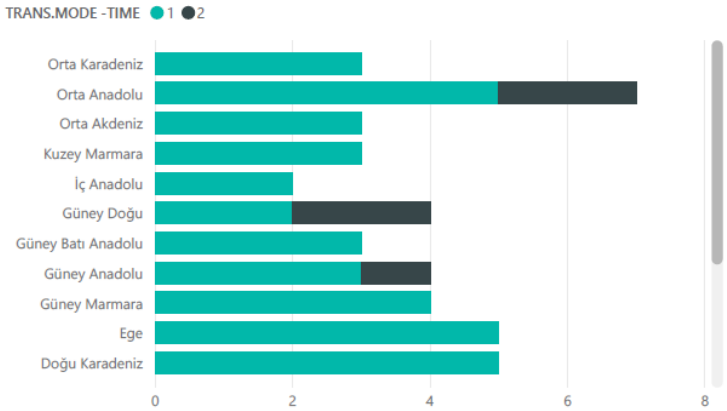
ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE



BDC-RBC ASSGN. IN TIME MIN MODEL

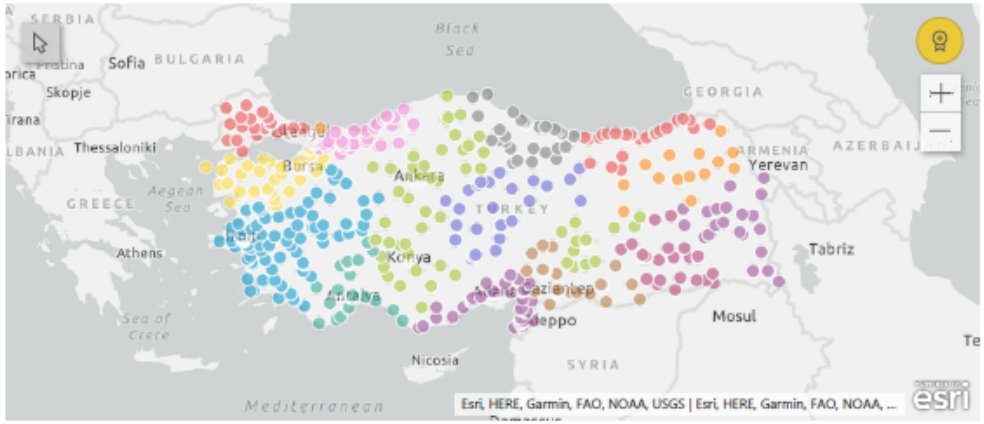


ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE

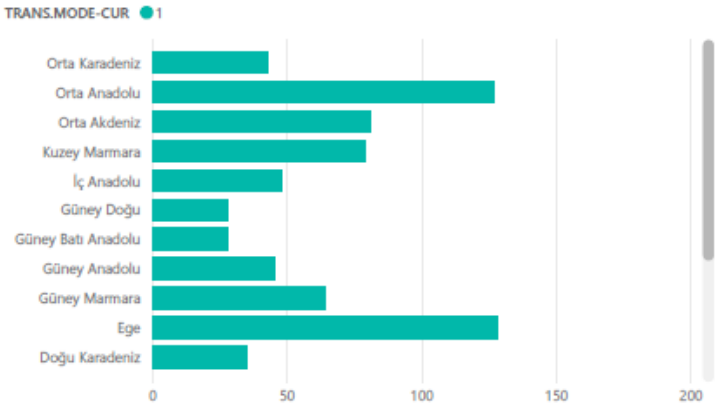


APPENDIX-22: Comparison maps of RBC-TC assignment between Current System and Time Min. Model

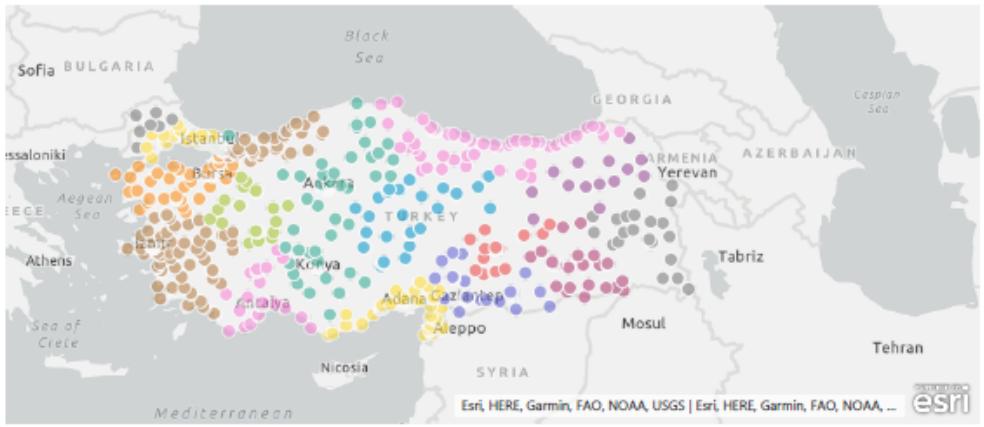
RBC-TC ASSGN. IN CURRENT SYSTEM



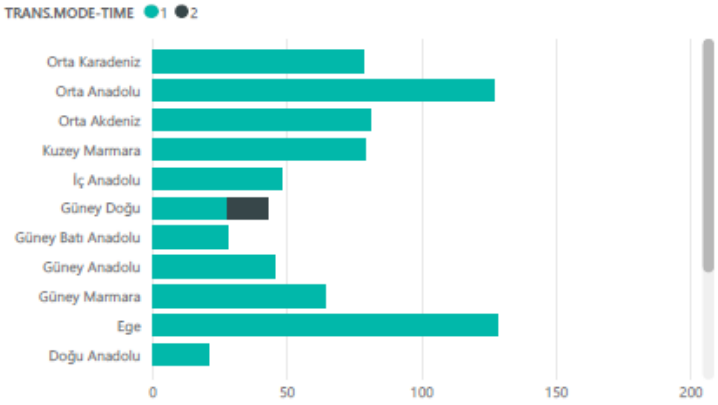
ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE



RBC-TC ASSGN. IN TIME MIN MODEL

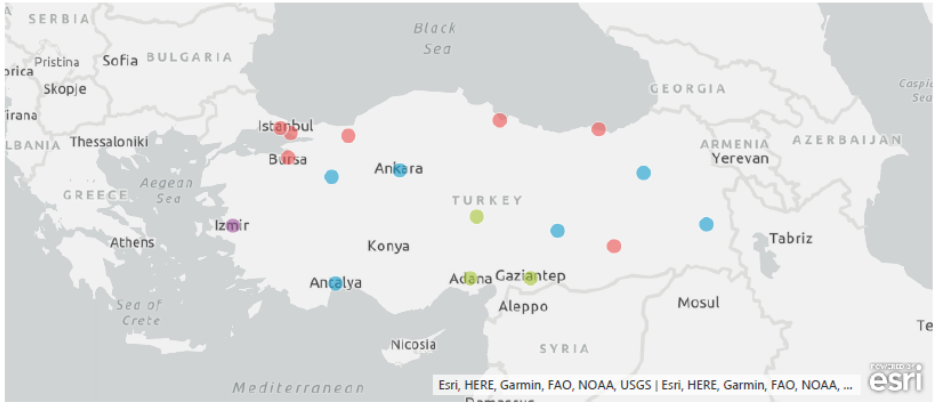


ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE

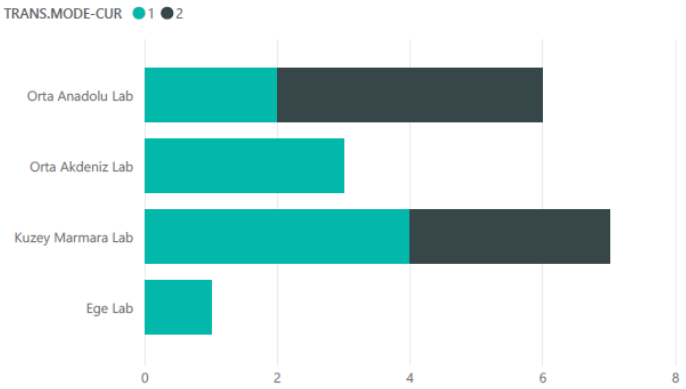


APPENDIX-23: Comparison maps of RBC-LAB assignment between Current System and Time Min. Model

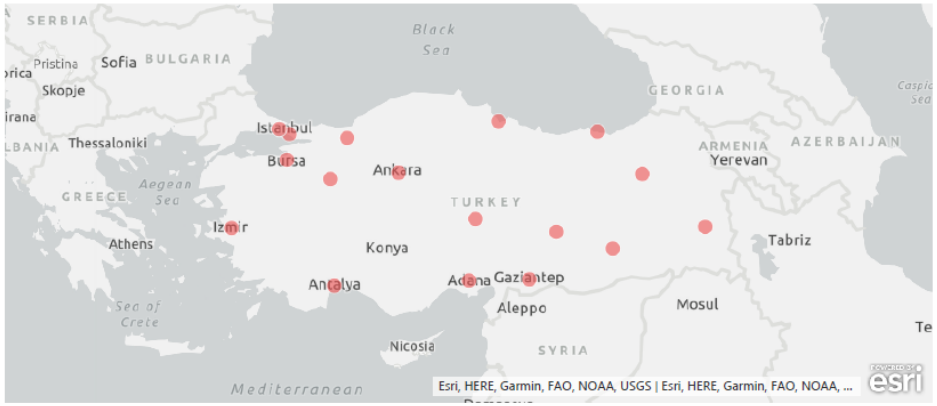
RBC- LAB ASSGN. IN CURRENT SYSTEM



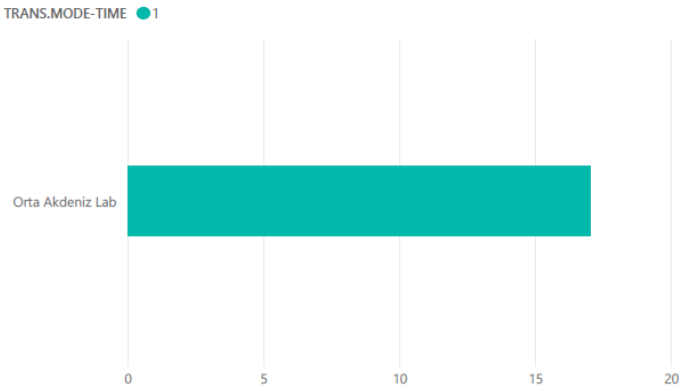
ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE



RBC- LAB ASSGN. IN TIME MIN MODEL

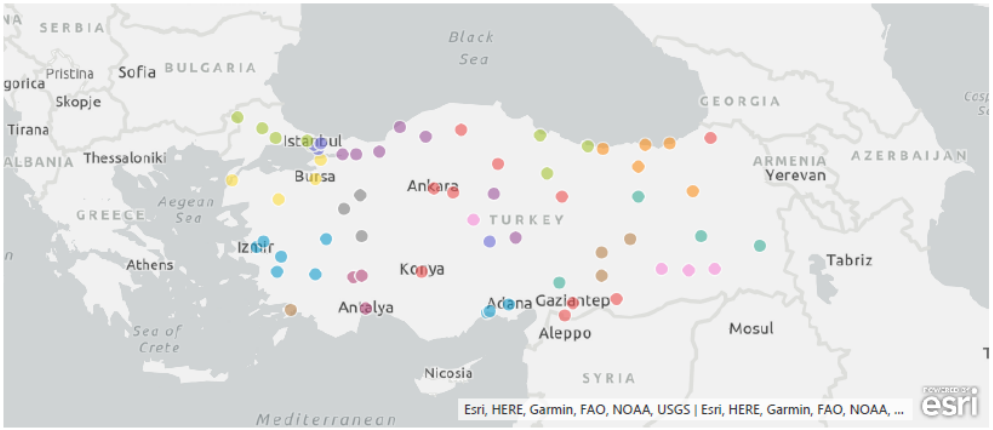


ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE

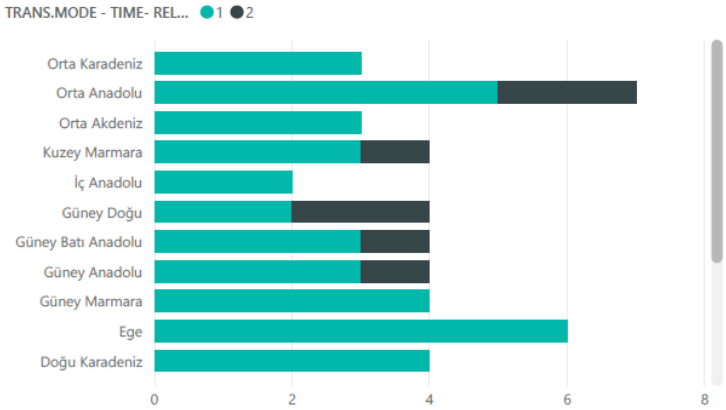


APPENDIX-24: Comparison maps of BDC-RBC assignment between Relaxed System and Time Min. Model

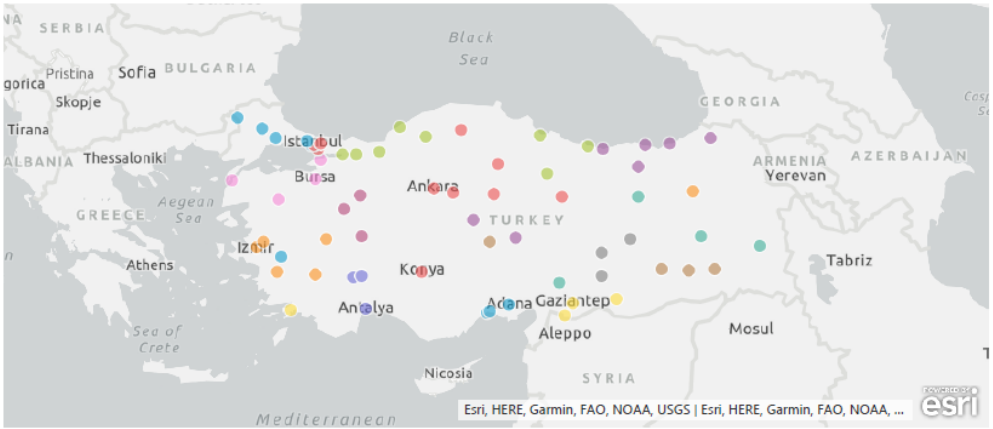
BDC-RBC ASSGN. IN RELAXED SYSTEM



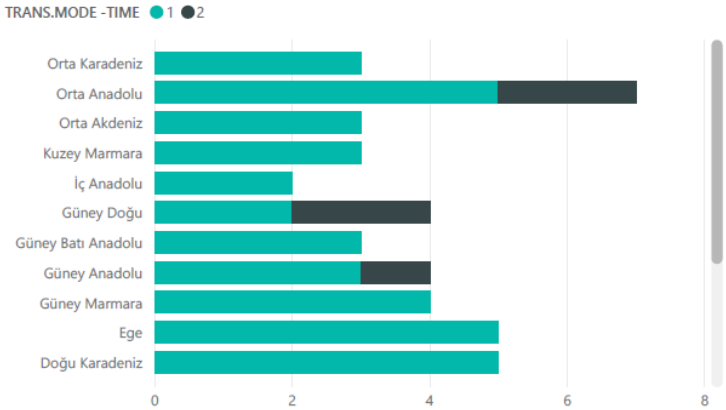
ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE



BDC-RBC ASSGN. IN TIME MIN MODEL

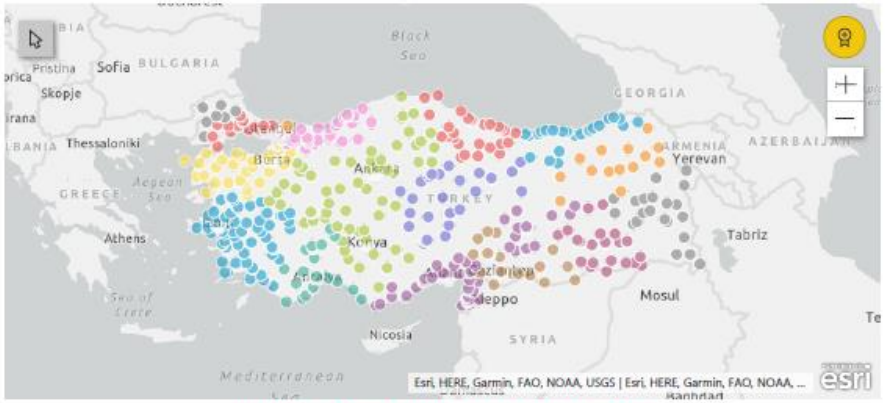


ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE

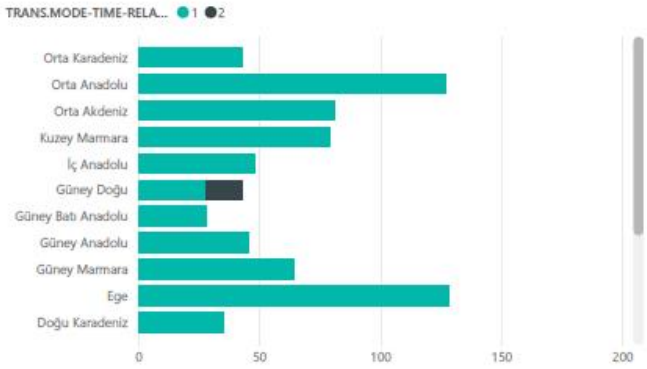


APPENDIX-25: Comparison maps of RBC-TC assignment between Relaxed System and Time Min. Model

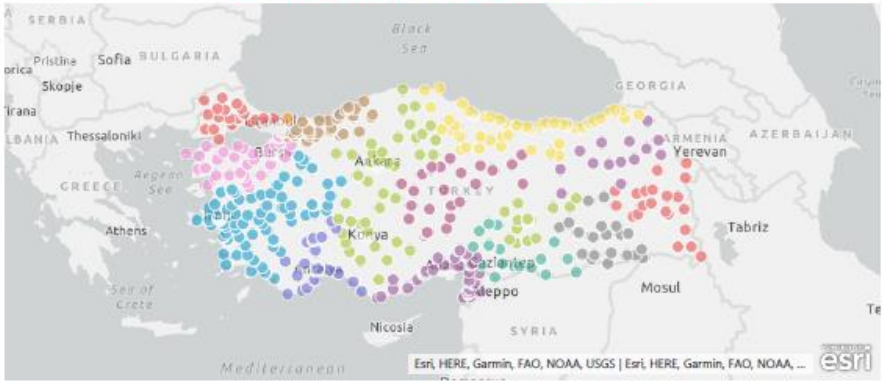
RBC-TC ASSGN. IN RELAXED SYSTEM



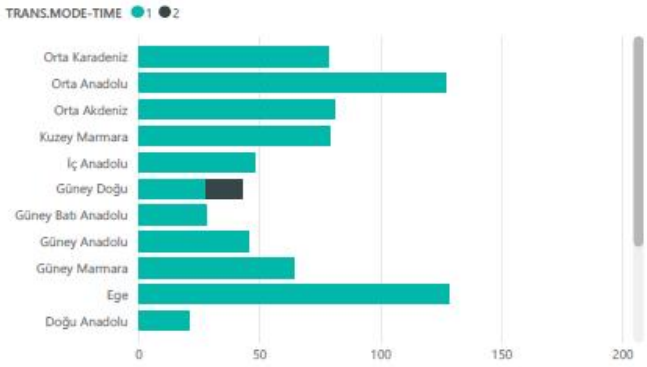
ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE



RBC-TC ASSGN. IN TIME MIN MODEL

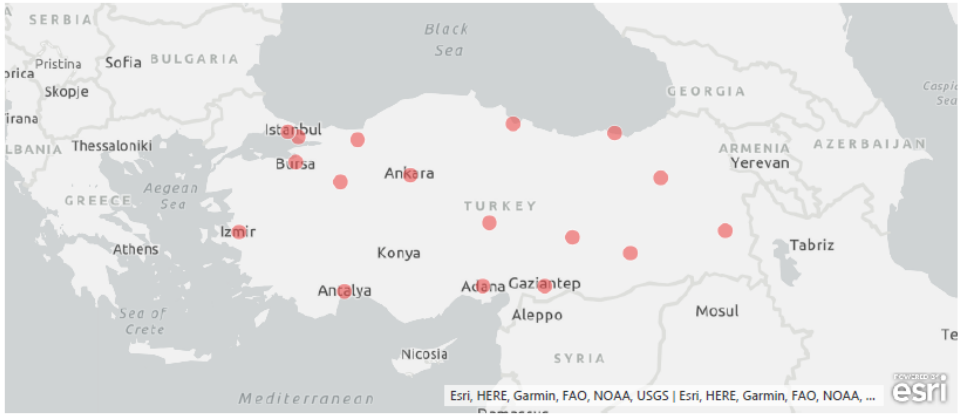


ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE

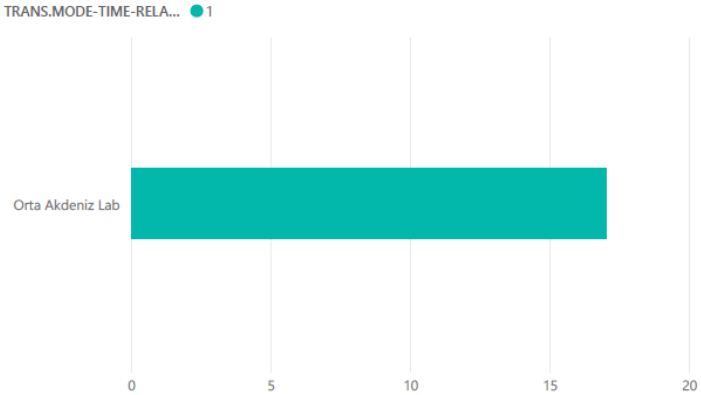


APPENDIX-26: Comparison maps of RBC-LAB assignment between Relaxed System and Time Min. Model

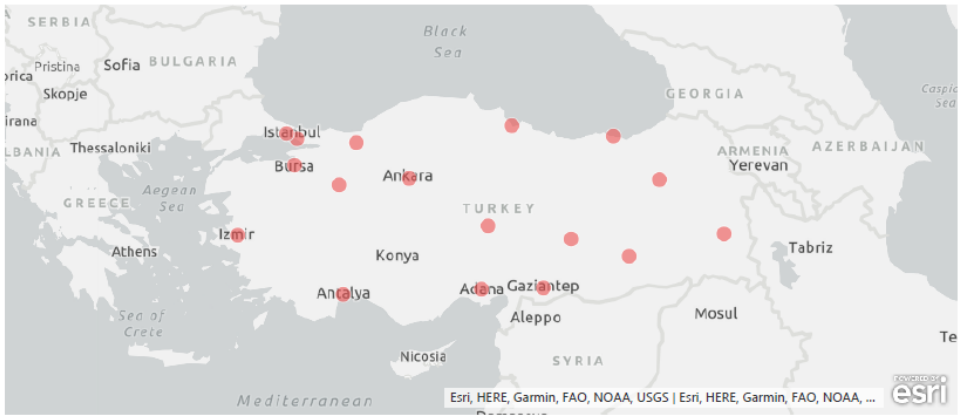
RBC- LAB ASSGN. IN RELAXED SYSTEM



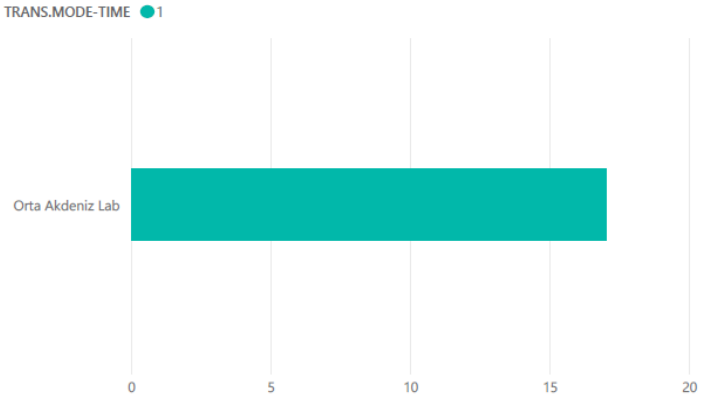
ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE



RBC- LAB ASSGN. IN TIME MIN MODEL



ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE



APPENDIX-27: Bi-Objective Model Boundaries and Solution Results according to Objective Functions

SOLUTIONS ACCORDING TO COST			
	MINTIME	**MINCOST**	**DIFFRENCES**
TOTAL COST (on the basis of TL)	648.246.921,14	559.137.222,89	89.109.698,26
BDC-RBC Blood Transportation Cost (on the basis of TL)	4.100.570,60	3.970.316,70	130.253,90
RBC-RBC Blood Transportation Cost (on the basis of TL)	5.459.384,81	2.349.531,67	3.109.853,14
RBC-TC Blood Transportation Cost (on the basis of TL)	10.459.350,25	5.298.246,60	5.161.103,65
RBC-LAB Blood Transportation Cost (on the basis of TL)	5.495.498,40	435.014,30	5.060.484,10
Total Units of T&B Bag used (on annual Basis)	801.227,91	1.590.345,09	- 789.117,18
Total Units of T&T Bag used (on annual Basis)	1.225.709,00	1.165.864,00	59.845,00
Total Cost of Collection with T&B Bag Type (on the basis of TL)	34.452.800,09	52.705.502,64	- 18.252.702,55
Total Cost of Collection with T&T Bag Type (on the basis of TL)	71.565.529,09	52.463.863,64	19.101.665,45

Continuation of Appendix 27

SOLUTION ACCORDING TO TIME			
	MINTIME	**MINCOST**	**DIFFERENCES**
TOTAL AMOUNT AT THE END OF THE SHELF LIFE (liters / shelf life)	1.286,24	4.569,60	3.283,36
Total LOST TIME of TS transported amount from BDC to RBC (in liters x min)	458.222,89	8.213.140,55	7.754.917,66
Total LOST TIME of ES transported amount from BDC to RBC (in liters x min)	34.206.772,61	108.145.846,68	73.939.074,07
Total LOST TIME of FFP transported amount from BDC to RBC (in liters x min)	2.070.471,75	33.781.131,50	31.710.659,75
Total LOST TIME of TS transported amount from RBC to TC (in liters x min)	2.282.597,63	6.343.953,15	4.061.355,53
Total LOST TIME of ES transported amount from RBC to TC (in liters x min)	41.108.293,20	103.122.856,60	62.014.563,40
Total LOST TIME of FFP transported amount from RBC to TC (in liters x min)	11.372.735,48	29.949.775,22	18.577.039,75
Total LOST TIME of TS transported amount from RBC to RBC (in liters x min)	-	103.466,71	103.466,71
Total LOST TIME of ES transported amount from RBC to RBC (in liters x min)	1.821.254,22	2.379.561,94	558.307,72
Total LOST TIME of FFP transported amount from RBC to RBC (in liters x min)	-	-	-
Total LOST TIME of TS transported amount (in liters x min)	2.740.820,52	14.660.560,41	11.919.739,90
Total LOST TIME of ES transported amount (in liters x min)	77.136.320,03	213.648.265,22	136.511.945,19
Total LOST TIME of FFP transported amount (in liters x min)	13.443.207,23	63.730.906,72	50.287.699,50
Ratio of LOST TIME of TS amount to TS shelf life (lt/ shelf life)	380,67	2.036,19	1.655,52
Ratio of LOST TIME of ES amount to ES shelf life (lt/ shelf life)	892,78	2.472,78	1.580,00
Ratio of LOST TIME of FFP amount to FFP shelf life (lt/ shelf life)	12,79	60,63	47,84

APPENDIX-28: Assignment of BDC and RBC according to Objective Function of Bi Objective Model

ASSIGMENT & TRANSPORTATION MODE						
BDC	**RBC (CURRENT)**	**TRANS. MODE**	**RBC (MINCOST OBJ)**	**TRANS.MODE**	**RBC (MINTIME OBJ)**	**TRANS. MODE**
ADANA	ORTA AKDENIZ	GROUND	ORTA ANADOLU	AIR	ORTA AKDENIZ	GROUND
ISKENDERUN	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
MERSIN	ORTA AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	ORTA AKDENIZ	GROUND
ÇORUM	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
KIRIKKALE	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
KONYA	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
KASTAMONU	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
ANKARA	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	ORTA ANADOLU	GROUND
ANTALYA	BATI AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	BATI AKDENIZ	GROUND
BURDUR	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND
ISPARTA	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND
BALIKESIR	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
BURSA	GUNEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY MARMARA	GROUND
ÇANAKKALE	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
YALOVA	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
BATMAN	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
DIYARBAKIR	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
SIIRT	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
DUZCE	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
KARABUK	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND

Continuation of Appendix 28

SAKARYA	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
ZONGULDAK	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
1KOCAELI	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND	BATI KARADENIZ	GROUND
ERZINCAN	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND	GUNEY DOĞU	AIR
ERZURUM	BATI KARADENIZ	GROUND	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND
AFYON	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND
ESKIŞEHIR	BATI ANADOLU	GROUND	ORTA ANADOLU	AIR	BATI ANADOLU	GROUND
KUTAHYA	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND
K.MARAŞ	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	GUNEY DOĞU	AIR
GAZIANTEP	DOĞU AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU AKDENIZ	GROUND
KILIS	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
ŞANLIURFA	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
KARTAL	KUZEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR	KUZEY MARMARA	GROUND
Z.KAMIL	KUZEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR	KUZEY MARMARA	GROUND
ÇEKMEKÖY	KUZEY MARMARA	GROUND	ORTA AKDENIZ	AIR	KUZEY MARMARA	GROUND
ÇAPA	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
ÇORLU	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
EDIRNE	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
LULEBURGAZ	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
BAŞAKŞEHIR	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
AYDIN	EGE	GROUND	EGE	GROUND	EGE	GROUND
DENIZLI	EGE	GROUND	EGE	GROUND	EGE	GROUND
IZMIR	EGE	GROUND	GUNEY BATI ANADOLU	AIR	EGE	GROUND

Continuation of Appendix 28

MANISA	EGE	GROUND	EGE	GROUND	EGE	GROUND
MARMARIS	EGE	GROUND	EGE	GROUND	DOĞU AKDENIZ	GROUND
ÖDEMIŞ	EGE	GROUND	EGE	GROUND	EGE	GROUND
UŞAK	EGE	GROUND	EGE	GROUND	EGE	GROUND
KAYSERI	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	IÇ ANADOLU	GROUND
KIRŞEHIR	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
NEVŞEHIR	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	GUNEY ANADOLU	AIR
SIVAS	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	ORTA ANADOLU	AIR
YOZGAT	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
ELAZIĞ	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
MALATYA	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
ADIYAMAN	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
ORDU	ORTA KARADENIZ	GROUND	GUNEY BATI ANADOLU	GROUND	ORTA KARADENIZ	GROUND
SAMSUN	ORTA KARADENIZ	GROUND	GUNEY BATI ANADOLU	GROUND	ORTA KARADENIZ	GROUND
TOKAT	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
ARTVIN	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
GIRESUN	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
GUMUŞHANE	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
RIZE	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
TRABZON	DOĞU KARADENIZ	GROUND	ORTA KARADENIZ	AIR	DOĞU KARADENIZ	GROUND
MUŞ	GUNEY DOĞU	GROUND	GUNEY ANADOLU	AIR	GUNEY DOĞU	GROUND
VAN	GUNEY DOĞU	GROUND	BATI AKDENIZ	AIR	GUNEY DOĞU	GROUND

APPENDIX-29: Assignment of Lab and RBC according to Objective Function of Bi Objective Model

ASSIGMENT & TRANSPORTATION MODE						
RBC	**LAB (CURRENT)**	**TRANS. MODE**	**LAB(MINCOST OBJ)**	**TRANS. MODE**	**LAB (MINTIME OBJ)**	**TRANS. MODE**
ORTA AKDENIZ	ORTA AKDENIZ LAB	GROUND	ORTA AKDENIZ LAB	GROUND	ORTA AKDENIZ LAB	GROUND
ORTA ANADOLU	ORTA ANADOLU LAB	GROUND	ORTA ANADOLU LAB	GROUND	ORTA AKDENIZ LAB	GROUND
BATI AKDENIZ	ORTA ANADOLU LAB	AIR	ORTA AKDENIZ LAB	AIR	ORTA AKDENIZ LAB	GROUND
GUNEY MARMARA	KUZEY MARMARA LAB	GROUND	ORTA AKDENIZ LAB	AIR	ORTA AKDENIZ LAB	GROUND
GUNEY ANADOLU	KUZEY MARMARA LAB	AIR	ORTA AKDENIZ LAB	AIR	ORTA AKDENIZ LAB	GROUND
BATI KARADENIZ	KUZEY MARMARA LAB	GROUND	KUZEY MARMARA LAB	GROUND	ORTA AKDENIZ LAB	GROUND
DOĞU ANADOLU	ORTA ANADOLU LAB	AIR	ORTA AKDENIZ LAB	AIR	ORTA AKDENIZ LAB	GROUND
BATI ANADOLU	ORTA ANADOLU LAB	GROUND	ORTA ANADOLU LAB	GROUND	ORTA AKDENIZ LAB	GROUND
DOĞU AKDENIZ	ORTA AKDENIZ LAB	GROUND	ORTA AKDENIZ LAB	AIR	ORTA AKDENIZ LAB	GROUND
KUZEY MARMARA	KUZEY MARMARA LAB	GROUND	KUZEY MARMARA LAB	GROUND	ORTA AKDENIZ LAB	GROUND
AVRUPA	KUZEY MARMARA LAB	GROUND	ORTA AKDENIZ LAB	AIR	ORTA AKDENIZ LAB	GROUND
EGE	EGE LAB	GROUND	EGE LAB	GROUND	ORTA AKDENIZ LAB	GROUND
IÇ ANADOLU	ORTA AKDENIZ LAB	GROUND	ORTA AKDENIZ LAB	AIR	ORTA AKDENIZ LAB	GROUND
GUNEY BATI ANADOLU	ORTA ANADOLU LAB	AIR	ORTA AKDENIZ LAB	AIR	ORTA AKDENIZ LAB	GROUND
ORTA KARADENIZ	KUZEY MARMARA LAB	AIR	ORTA AKDENIZ LAB	AIR	ORTA AKDENIZ LAB	GROUND
DOĞU KARADENIZ	KUZEY MARMARA LAB	AIR	ORTA AKDENIZ LAB	AIR	ORTA AKDENIZ LAB	GROUND
GUNEY DOĞU	ORTA ANADOLU LAB	AIR	ORTA AKDENIZ LAB	AIR	ORTA AKDENIZ LAB	GROUND

APPENDIX- 30: Assignment of TC and RBC according to Objective Function of Bi Objective Model

ASSIGMENT & TRANSPORTATION MODE						
TC (CITY)	**RBC (CURRENT)**	**TRANS. MODE**	**RBC (MINCOST OBJ.)**	**TRANS. MODE**	**RBC (MINTIME OBJ.)**	**TRANS. MODE**
ISTANBUL(ANATOLIA)	KUZEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR	KUZEY MARMARA	GROUND
ADANA	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND	ORTA AKDENIZ	GROUND
ADIYAMAN	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
AFYON	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	BATI ANADOLU	GROUND
AĞRI	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU KARADENIZ	GROUND
AMASYA	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
ANKARA	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
ANTALYA	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND	BATI AKDENIZ	GROUND
ARTVIN	DOĞU KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU KARADENIZ	GROUND
AYDIN	EGE	GROUND	GUNEY BATI ANADOLU	AIR	EGE	GROUND
BALIKESIR	GUNEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY MARMARA	GROUND
BILECIK	BATI ANADOLU	GROUND	DOĞU ANADOLU	GROUND	BATI ANADOLU	GROUND
BINGÖL	GUNEY ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY ANADOLU	GROUND
BITLIS	GUNEY DOĞU	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU KARADENIZ	GROUND
BOLU	BATI KARADENIZ	GROUND	GUNEY ANADOLU	GROUND	BATI KARADENIZ	GROUND
BURDUR	BATI AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	BATI AKDENIZ	GROUND
BURSA	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND	GUNEY MARMARA	GROUND
ÇANAKKALE	GUNEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY MARMARA	GROUND
ÇANKIRI	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	ORTA ANADOLU	GROUND
ÇORUM	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	ORTA ANADOLU	GROUND
DENIZLI	EGE	GROUND	GUNEY BATI ANADOLU	AIR	EGE	GROUND

Continuation of Appendix 30

DIYARBAKIR	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND	GUNEY ANADOLU	GROUND
EDIRNE	AVRUPA	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY DOĞU	AIR
ELÂZIĞ	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
ERZINCAN	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU ANADOLU	GROUND
ERZURUM	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND	DOĞU ANADOLU	GROUND
ESKIŞEHIR	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND	BATI ANADOLU	GROUND
GAZIANTEP	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND	DOĞU AKDENIZ	GROUND
GIRESUN	DOĞU KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU KARADENIZ	GROUND
GUMUŞHANE	DOĞU KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU KARADENIZ	GROUND
HAKKÂRI	GUNEY DOĞU	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU KARADENIZ	GROUND
HATAY	ORTA AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	ORTA AKDENIZ	GROUND
ISPARTA	BATI AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	BATI AKDENIZ	GROUND
MERSIN	ORTA AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	ORTA AKDENIZ	GROUND
ISTANBUL(EUROPE)	AVRUPA	GROUND	AVRUPA	GROUND	AVRUPA	GROUND
IZMIR	EGE	GROUND	EGE	GROUND	EGE	GROUND
KARS	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU ANADOLU	GROUND
KASTAMONU	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	ORTA ANADOLU	GROUND
KAYSERI	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND	IÇ ANADOLU	GROUND
KIRKLARELI	AVRUPA	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY DOĞU	AIR
KIRŞEHIR	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	IÇ ANADOLU	GROUND
KOCAELI	BATI KARADENIZ	GROUND	GUNEY ANADOLU	GROUND	BATI KARADENIZ	GROUND
KONYA	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	ORTA ANADOLU	GROUND
KUTAHYA	BATI ANADOLU	GROUND	DOĞU ANADOLU	GROUND	BATI ANADOLU	GROUND

Continuation of Appendix 30

MALATYA	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND	GUNEY BATI ANADOLU	GROUND
MANISA	EGE	GROUND	EGE	GROUND	EGE	GROUND
KAHRAMANMARAŞ	DOĞU AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU AKDENIZ	GROUND
MARDIN	GUNEY ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY ANADOLU	GROUND
MUĞLA	EGE	GROUND	GUNEY BATI ANADOLU	AIR	EGE	GROUND
MUŞ	GUNEY DOĞU	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU KARADENIZ	GROUND
NEVŞEHIR	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	IÇ ANADOLU	GROUND
NIĞDE	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	IÇ ANADOLU	GROUND
ORDU	ORTA KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	ORTA KARADENIZ	GROUND
RIZE	DOĞU KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU KARADENIZ	GROUND
SAKARYA	BATI KARADENIZ	GROUND	GUNEY ANADOLU	GROUND	BATI KARADENIZ	GROUND
SAMSUN	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND	ORTA KARADENIZ	GROUND
SIIRT	GUNEY ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY ANADOLU	GROUND
SINOP	ORTA KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	ORTA KARADENIZ	GROUND
SIVAS	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	IÇ ANADOLU	GROUND
TEKIRDAĞ	AVRUPA	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY DOĞU	AIR
TOKAT	ORTA KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	ORTA KARADENIZ	GROUND
TRABZON	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND	DOĞU KARADENIZ	GROUND
TUNCELI	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU ANADOLU	GROUND
ŞANLIURFA	DOĞU AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU AKDENIZ	GROUND
UŞAK	EGE	GROUND	GUNEY BATI ANADOLU	AIR	EGE	GROUND
VAN	GUNEY DOĞU	GROUND	IÇ ANADOLU	AIR	DOĞU KARADENIZ	GROUND
YOZGAT	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	IÇ ANADOLU	GROUND

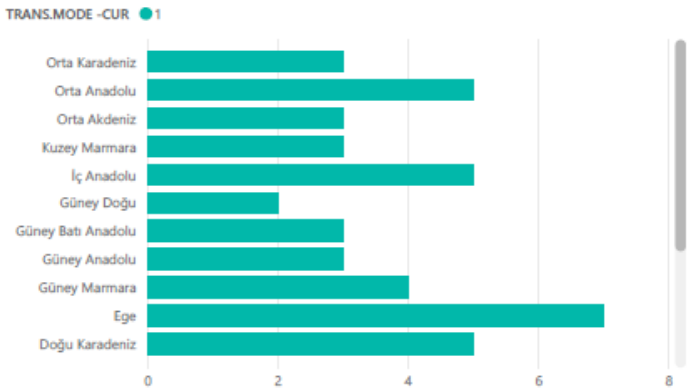
Continuation of Appendix 30

ZONGULDAK	BATI KARADENIZ	GROUND	GUNEY ANADOLU	GROUND	BATI KARADENIZ	GROUND
AKSARAY	IÇ ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	IÇ ANADOLU	GROUND
BAYBURT	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU ANADOLU	GROUND
KARAMAN	ORTA ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	ORTA ANADOLU	GROUND
KIRIKKALE	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND	ORTA ANADOLU	GROUND
BATMAN	GUNEY ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY ANADOLU	GROUND
ŞIRNAK	GUNEY ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY ANADOLU	GROUND
BARTIN	BATI KARADENIZ	GROUND	GUNEY BATI ANADOLU	AIR	BATI KARADENIZ	GROUND
ARDAHAN	DOĞU ANADOLU	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU ANADOLU	GROUND
IĞDIR	GUNEY DOĞU	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU KARADENIZ	GROUND
YALOVA	GUNEY MARMARA	GROUND	GUNEY BATI ANADOLU	AIR	GUNEY MARMARA	GROUND
KARABUK	BATI KARADENIZ	GROUND	GUNEY ANADOLU	GROUND	BATI KARADENIZ	GROUND
KILIS	DOĞU AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	DOĞU AKDENIZ	GROUND
OSMANIYE	ORTA AKDENIZ	GROUND	GUNEY BATI ANADOLU	AIR	ORTA AKDENIZ	GROUND
DUZCE	BATI KARADENIZ	GROUND	GUNEY ANADOLU	GROUND	BATI KARADENIZ	GROUND

APPENDIX-31: Comparison maps of BDC-RBC assignment between the Current System and MINCOST Obj. Fcn.

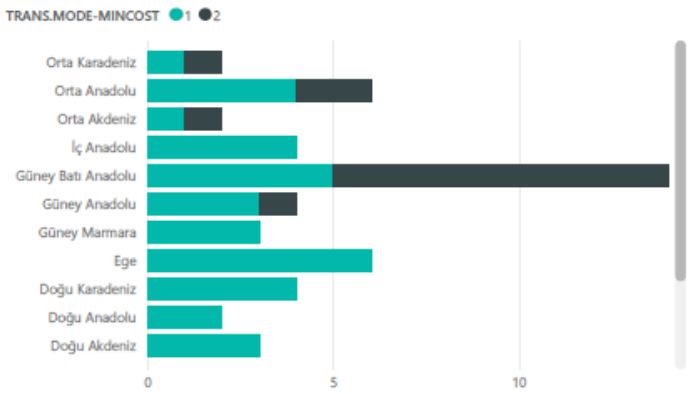
BDC-RBC ASSGN. IN CURRENT SYSTEM

ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE



BDC-RBC ASSGN. IN MINCOST OBJECTIVE

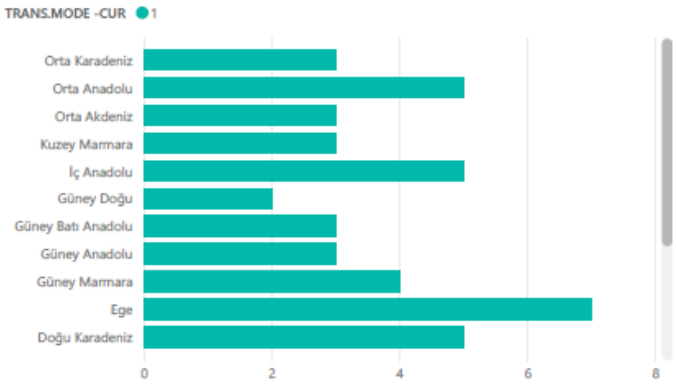
ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE



APPENDIX- 32: Comparison maps of BDC-RBC assignment between the Current System and MINTIME Obj. Fcn.

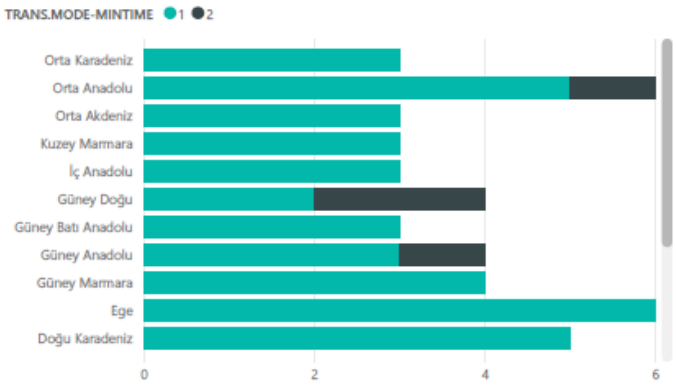
BDC-RBC ASSGN. IN CURRENT SYSTEM

ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE



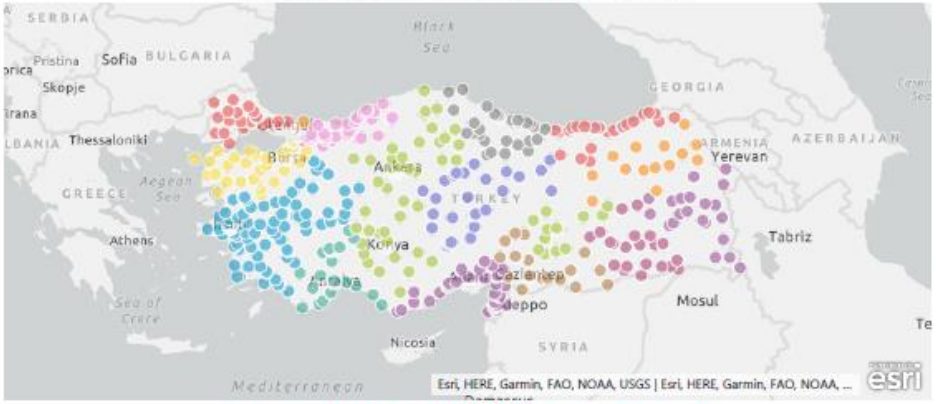
BDC-RBC ASSGN. IN MINTIME OBJECTIVE

ASSIGN. CHANGES IN BDC ACC. TO TRANS. MODE

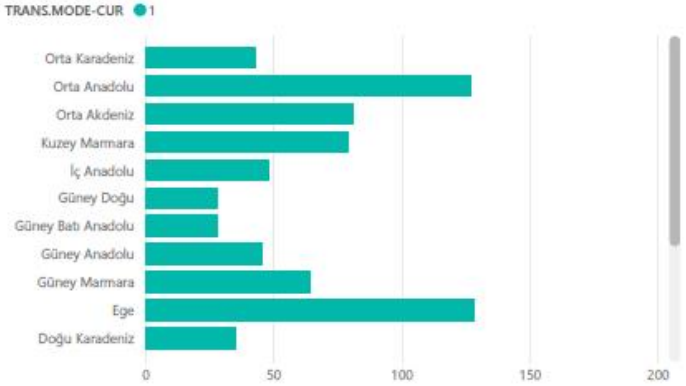


APPENDIX- 33: Comparison maps of RBC-TC assignment between the Current System and MINCOST Obj. Fcn

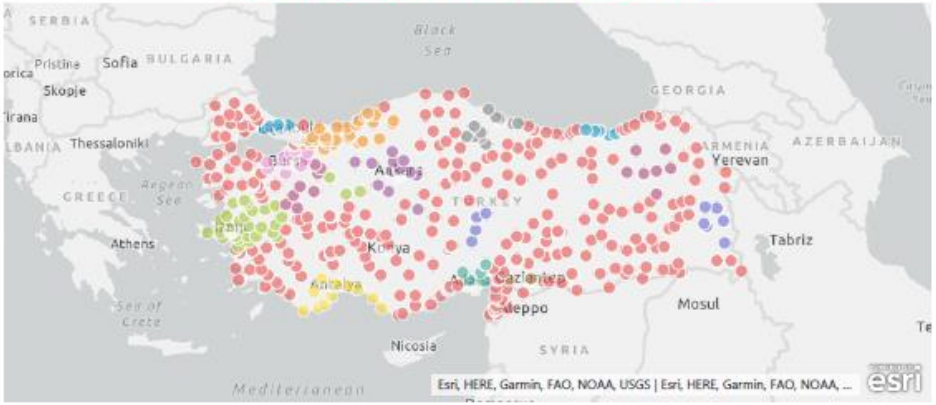
RBC-TC ASSGN. IN CURRENT SYSTEM



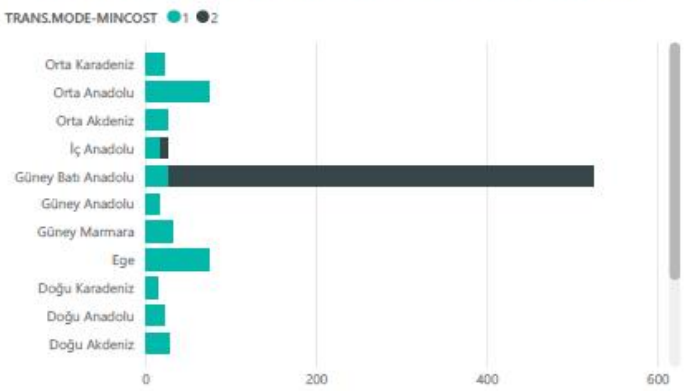
ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE



RBC-TC ASSGN. IN MINCOST OBJECTIVE

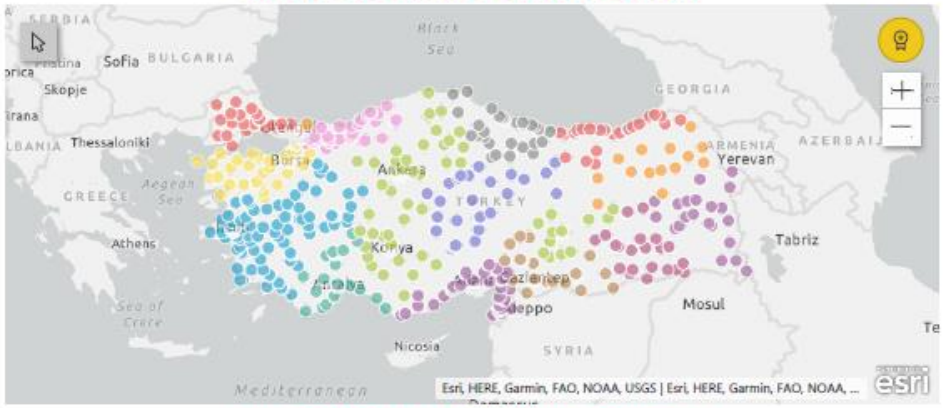


ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE

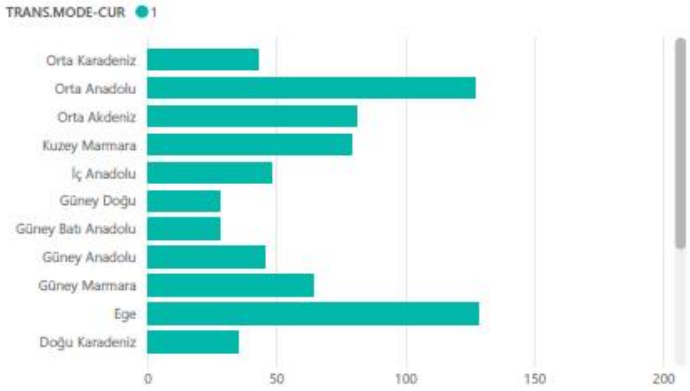


APPENDIX- 34: Comparison maps of RBC-TC assignment between the Current System and MINTIME Obj. Fcn.

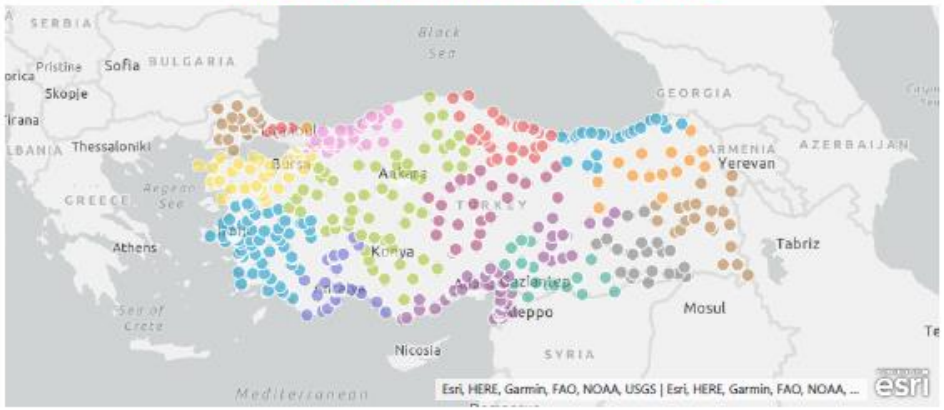
RBC-TC ASSGN. IN CURRENT SYSTEM



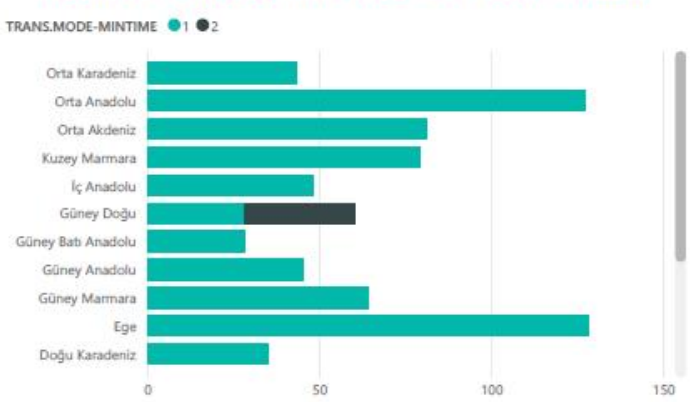
ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE



RBC-TC ASSGN. IN MINTIME OBJECTIVE

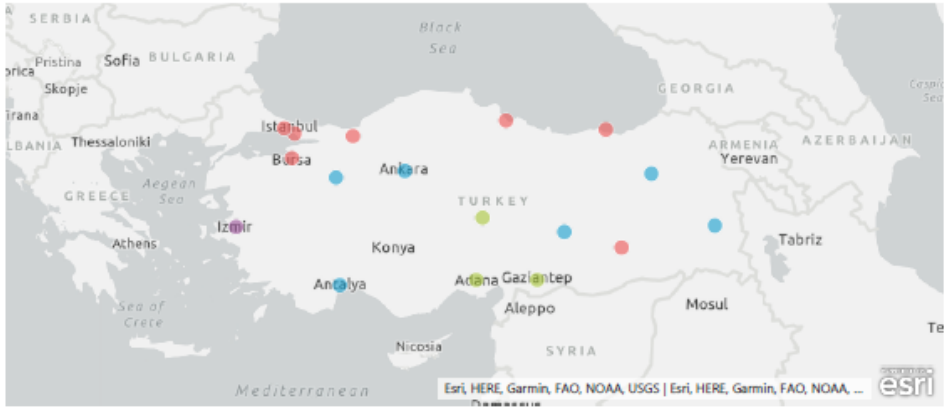


ASSIGN. CHANGES IN TC ACC. TO TRANS. MODE

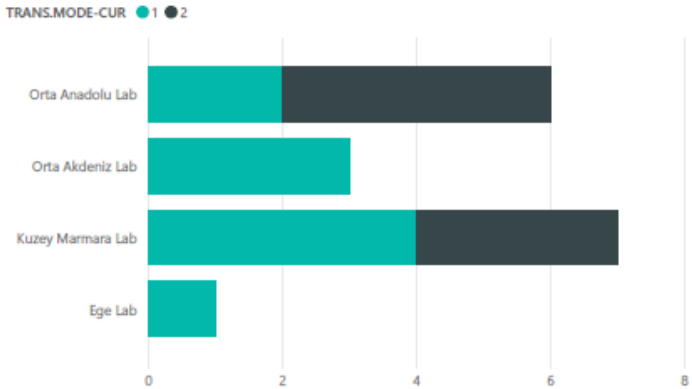


APPENDIX-35: Comparison maps of RBC-LAB assignment between the Current System and MINCOST Obj. Fcn.

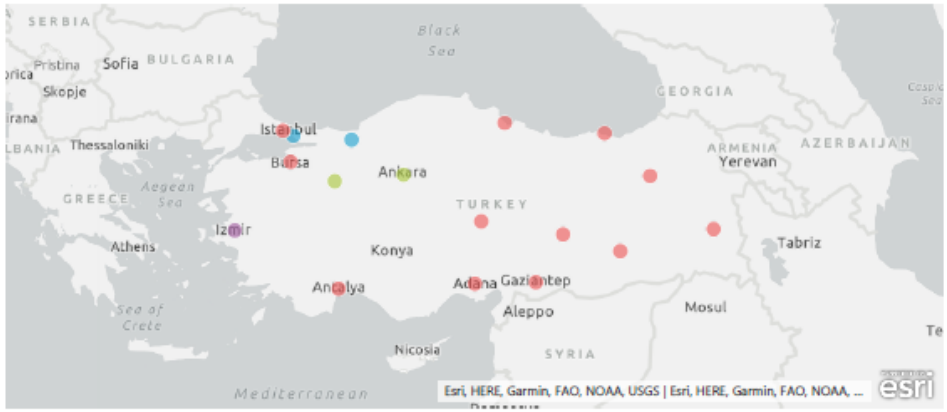
RBC- LAB ASSGN. IN CURRENT SYSTEM



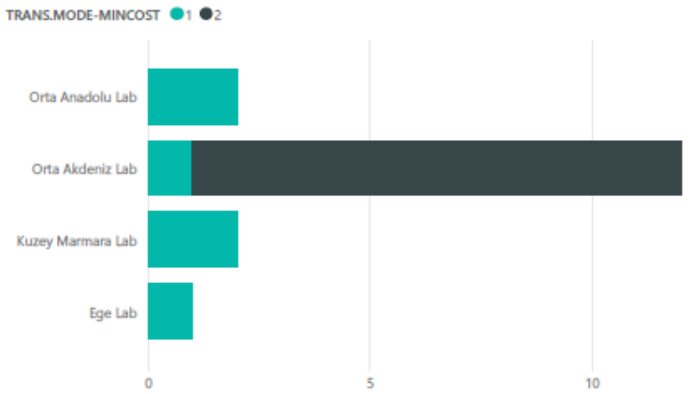
ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE



RBC- LAB ASSGN. IN MINCOST OBJECTIVE

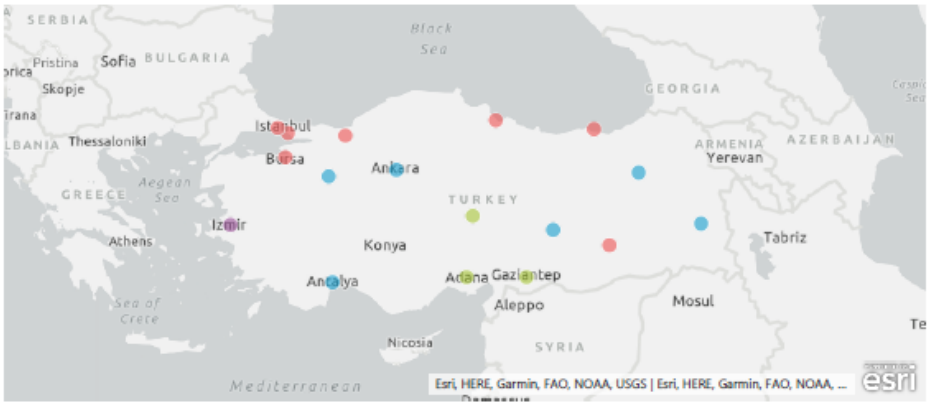


ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE

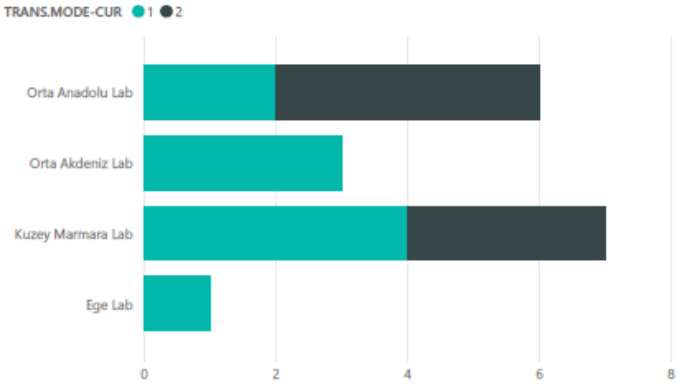


APPENDIX-36: Comparison maps of RBC-LAB assignment between the Current System and MINTIME Obj. Fcn.

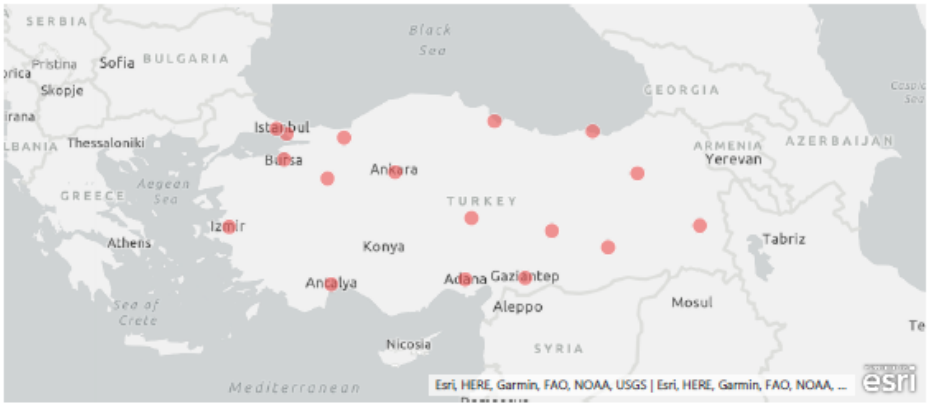
RBC- LAB ASSGN. IN CURRENT SYSTEM



ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE



RBC- LAB ASSGN. IN MINTIME OBJECTIVE



ASSIGN. CHANGES IN RBC ACC. TO TRANS. MODE