北京師範大學

专业学位研究生
学位论文

论文题目： Cost-Benefit Analysis of High Speed Railway Projects in Turkey: The Case Study of Ankara-Istanbul Line

作　　者：**ONOL Omer Faruk**

导　　师：**HU Biliang**

系别年级：**新兴市场研究院(经济与资源管理研究院)**

学　　号：**201729700005**

学科专业：**工商管理**

完成日期：**2018 年 5 月**

北京师范大学研究生院

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Cost-Benefit Analysis of High Speed Railway Projects in Turkey: The Case Study of Ankara-Istanbul Line

ABSTRACT

High speed railway (HSR) projects are known as most expensive transportation investments. Indeed, according to geographical conditions and infrastructure circumstances, construction expenses are considerably high. For Ankara-Istanbul HSR, which was finished to build in 2014, was also similar situation in terms inputs. However, it is the fact that, there are some certain social benefits such as time saving, reliability, pollution reduction and safety improvement. In addition to these measurable variables, there are also some long term benefits contribute the development of both national economy and international accessibility.

In this study, firstly information of high-speed railway technology, railway history of Turkey and HSR experiences of different countries were given. Following these, the social values which were mentioned will be estimated by using net present value. Since, time after launching of the project is not sufficient to observe the outputs, net present value method which is used for feasibility reports, is used in this study. While applying this method, conducting cost-benefit analysis was aimed. In the result part of the research, in addition to the estimated social benefits other incommensurate impacts and geopolitic significance of the project location also indicated.

KEY WORDS：Ankara-Istanbul High Speed Railway Line, Cost-Benefit Analysis, Railway Projects In Turkey, Belt And Road Initiative

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Acknowledgement:

I am grateful to my supervisor Prof. HU Biliang for his encouragement, valuable advice and comments. I appreciate to Prof. TU Qin for his supports, valuable advice and comments. I am thankful to my mother, my father, my sisters and my brother who provided me through moral, spiritual and emotional support during all my life. I am also appreciative to Ministry of Commerce of the Republic of China (MOFCOM) for sponsoring my one year master study in Beijing Normal University.

Chapter 1

Introduction

1.1.Background of study

After the Ankara-Istanbul HSR launch to public at 2014, mode of transportation between two biggest cities of Turkey changed. However, this investment made by huge investment costs, also this line takes place part of international railway and it is difficult to predict its sustainability and social benefits. Therefore, I decided to use cost-benefit analysis method while using 2016 variables and calculate net present values to examine efficiency of the line.

1.2.Problem Statement

Around the world, in general and in Turkey in particular it is experienced strong shift from the nation market to global markets; and this shift will strengthen with the integration of Turkey to the BRI and European Union Zone. Therefore, trade volume freight and passenger transportation will grow strongly. Transportation system hence need to be more efficient, reliable, timely, flexible and visible. So, Turkey aims to give importance to the HSR constructions although construction has huge costs. Main economic problem is whether social benefits compensate the infrastructure and operation costs or not.

1.3.Research Objective

The aim of this study is to make the cost benefit analysis of the high speed train between two biggest cities of Turkey and find out if it is economically sustainable to allow Turkey to get benefit from the globalization also the integration to BRI and EU Zone.

1.4.Significance of research

This case study is the only one case study focusing on Ankara-Istanbul HSR and making cost benefit analysis while taken into consideration different social benefits and making present valuation. Also, this is the only research examining the case within the context of Belt and Road Initiative and Europe - Caucasus - Asia Transport Corridor. On the other hand, this study is showing that, Ankara-Istanbul HSR Line, constructed by Chinese investors is very significant in terms of BRI and Middle Corridor strategies. These could promote connectivity of Asia and Europe in terms of economic aspects and development of the region and Turkey itself.

1.5.Research Questions

Is the Ankara-Istanbul HSR Line economically sustainable (cost-benefit analysis)?

What are the opportunities and challenges of Ankara-Istanbul HSR Line?

Chapter2

Literature review

2.1General frameworks on high speed train and its relations with economic development

2.1.1 Definition

For the international union of railway, there is no single standard definition of high speed rail. It depend on the criteria used since that corresponds to a complex reality.

The high-speed train is not only a technical issue, it covers a range of technical aspects such as infrastructure, wagons and operations, as well as a complex fact covering inter-sectorial issues such as financial, commercial, managerial and educational issues. The high-speed rail system combines these different elements with highly sophisticated technology. This rapidly expanding new mode of transport is often defined as a mode of transportation that will arrive for a number of reasons. In addition to improving railway services, it promotes a modern image that promotes greater customer satisfaction, as well as high-speed trains, which play an important role in ensuring regional integration and creating socio-economically balanced societies around the world. This highly productive mode of transport makes important demands in terms of investment, technology, industry, environment and political and social aspects.

A high-speed rail is a type of railway transport that uses an integrated system of special rolling and special pallet systems that work much faster than traditional rail traffic. Although there is no a single worldwide standard, new lines with more than 250 kilometers per hour (160 miles per hour) and existing lines over 200 miles per hour (120 miles per hour) are considered high speeds. Some of the definitions extend to include lower speeds in areas where these speeds still represent significant improvements. (International Railway Association (UIC) 20 November 2015.)

The first such system started in 1964 in Japan and was widely known as a bullet train. High-speed trains normally operate on the road, which, as standard, has a large radius of rotation over the graded, continuously welded rails. Many countries such as: Austria, Belgium, China, France, Germany, Italy, Japan, Netherlands, Poland, Portugal, Russia, South Korea, Spain, Sweden, Taiwan, Turkey, America Kingdom, United States and Uzbekistan have developed a high-speed train to connect big cities. Only in Europe is HSR crossing international borders. China has 22,000 kilometers (14,000 miles) of HSR by the end of December 2016, making up two-thirds of the world's total (China's high-speed railway crosses 20,000 kilometers, China Daily, September 10, 2016. It was reclaimed on January 6, 2017.)

While high-speed trains are often designed for passenger travel, some high-speed systems also offer limited freight service. Due to the fixed costs as well as maintenance costs, horseback riding realities and the flexibility to work with existing railways, a fair percentage of projects and nations that initially showed great interest in HSR are opting for a high-speed rail. Many countries with historically high-speed rail have invested in the existing network to allow higher speeds before major new constructions begin.

2.2 Type of high speed railway

The International Union of Railways (UIC) identifies three categories of high-speed rail:

Category I – New tracks specially designed for high speeds, allowing a maximum travel speed of at least 250 km / h (155 mph)).

Category II – Existing tracks specially designed for high speeds, allowing a maximum travel speed of at least 200 km / h (124 mph).

Category III – Existing lanes specially designed for high speeds, allowing a maximum speed of at least 200 km / h (124 mph), but some sections of which have a lower permitted speed (for example due to topographic constraints or passage in urban area)

2.1.2 Advantages of the High Speed Rail

- On demand rather than scheduled: Although air travel moves at higher speeds than the high-speed train, total destination time can be increased by traveling to / from remote airports, check-in, baggage handling , security and boarding. can also increase the cost of air travel (Smith, Oliver, Trains or Planes - The Great European Travel Test)
- Short-Term Benefits: Trains may be preferable in short-to-medium distances, as railway stations are generally closer urban centers than airports. (High-speed train VS plane, by Eli Elderkamp, May 26, 2010) Similarly, air transport needs longer distances to gain a speed advantage, given both the processing time and the transit to airport.

- Urban centers: Especially for dense urban centers, short hop flights may not be ideal for serving these areas, as airports are often far from the city because of shortage of land, runway limitations, and construction and airspace problems.
- Weather: Travel by train also requires less time dependence than air travel. A well-designed and operated rail system can only be affected by extreme weather conditions, such as heavy snow, heavy fog and a major storm. However, flights often face cancellations or delays under less severe conditions.
- Comfort: High-speed trains also have the advantage of comfort, because train passengers are allowed to move freely about the train at any point during the journey. Rail seats may also have fewer planes and more fill and leg space for weight constraints, as complicated calculations have been made to help airlines save fuel to save the most or to save on certain runway lengths. Technology advances such as continuously welded rails, vibrations on slower railways are the least, while air travel continues to be affected by turbulence when adverse wind conditions occur. Trains can also meet energy costs at lower times than intermediate stops and airplanes, but this is less for HSR than slower conventional trains.
- Delays: Especially on busy air routes - the most successful of the HSR historically - trains are also less prone to delays caused by tight airports. A train that is a few minutes late will not have to wait for another slot to open, unlike the planes in crowded airports. In addition, many airlines are seeing increasingly less economical short-haul flights, and in some countries airlines rely on high-speed trains instead of short-haul flights for connecting services. (Examples include Air France and Lufthansa AIRail, and SNCF, which co-operates with DB)
- Defrosting: The HSR does not need to be time-consuming but time-consuming, as time-shifting as airplanes; airplanes can improve airway profitability and pay airport

fees per hour, lowering parking space and contributing to congestion delays. (*"The Time-Consuming But Extremely Critical Process of Deicing Aircraft in the Winter"*. *29 December 2017.)*

- Hot and High: Some airways are forced to cancel their flights due to hot and harsh conditions, or to act on them overnight. This is the case for Hainan Airlines in Las Vegas in 2017, which moved the long-distance departure slot after midnight. Similarly, Norwegian Airlines canceled all European flights in the summer due to heat. The high-speed rail can complete airport operations during hot weather, when departures are not economical or otherwise become problematic.
- Noise and pollution: Large airports are heavy pollutants, doubling LAX particle pollution and even adding LA / Long Beach maritime transport and heavy motorway traffic to the account. Trains can operate on renewable energy and electric trains do not create local pollution anywhere in critical urban areas. Of course, this effect can be alleviated by aviation biofuels. Noise is also a concern for residents.
- Ability to serve more than one stop: Spends time loading and unloading important quantities such as an airplane, cargo and / or passengers, as well as landing, taxiing and resuming. Trains spend only a few minutes at intermediate stations, often increasing the business situation with little cost.
- Energy: high-speed trains provide greater fuel savings for more passenger space from a distance. Moreover, they usually work with electricity that can be produced from a wider source than the kerosene.

2.1.3 Disadvantages

- HSR usually requires land acquisition in Fresno, which is captured in the legal context.

- HSR is subject to land degradation, where expensive fixes result in rising costs in Taiwan.
- HSR can be costly due to the required tunnel with mountainous terrain as well as earthquake and other security systems.
- Passing mountain ranges or large water bodies with HSR requires expensive tunnels and bridges, or slower rovers and train ferries, and cannot cross the HSR oceans. Airlines can add or drop HSR services by leveraging more than 3,000 new routes in 2016, adding and dropping rovers frequently and aggressively due to demand and profitability, but the railway itself can represent a major sinking cost. For passengers, this may offer an advantage because of the low likelihood of services being withdrawn for railways.
- Cities do not always lie on a straight line, so any orientation will naturally include curves and folds that contribute significantly to the length of a journey. This may increase inefficiency compared to point-to-point transit flights.
- Railroads require the security and cooperation of all relevant geographies and governments. Political affairs can fly in politically sensitive areas while rovers become impossible, and / or can be redirected with relative ease.

2.2 Frameworks of the railway project in Turkey

2.2.1 History of railway investments in Turkey

Turkey, which has a strategic importance because of its geography, has an important place in the transport sector. Linking Europe to Asia, the Middle East's key countries of Turkey, is particularly provides land and sea links. It is therefore, transportation investments in Turkey substantially important not only for region but also other parts of the world.

In the 1950s, with the start of Marshall Assistance, the importance given to building highways has increased steadily. However, highway is the most expensive type of transportation in the world. The reason why the roads are preferred more than the other transportation types is that they can be transported in a non-transferable manner. However, the fact that it is a costly transportation system and the transportation costs are reflected in the prices of especially commodity goods cause the policy makers to move to cheaper and safe transportation systems. In the period from 2004 until the present day, the activation of railway transportation has been turned into a state policy and this policy has been reflected in the development of balanced and integrated ways of all transportation modes.

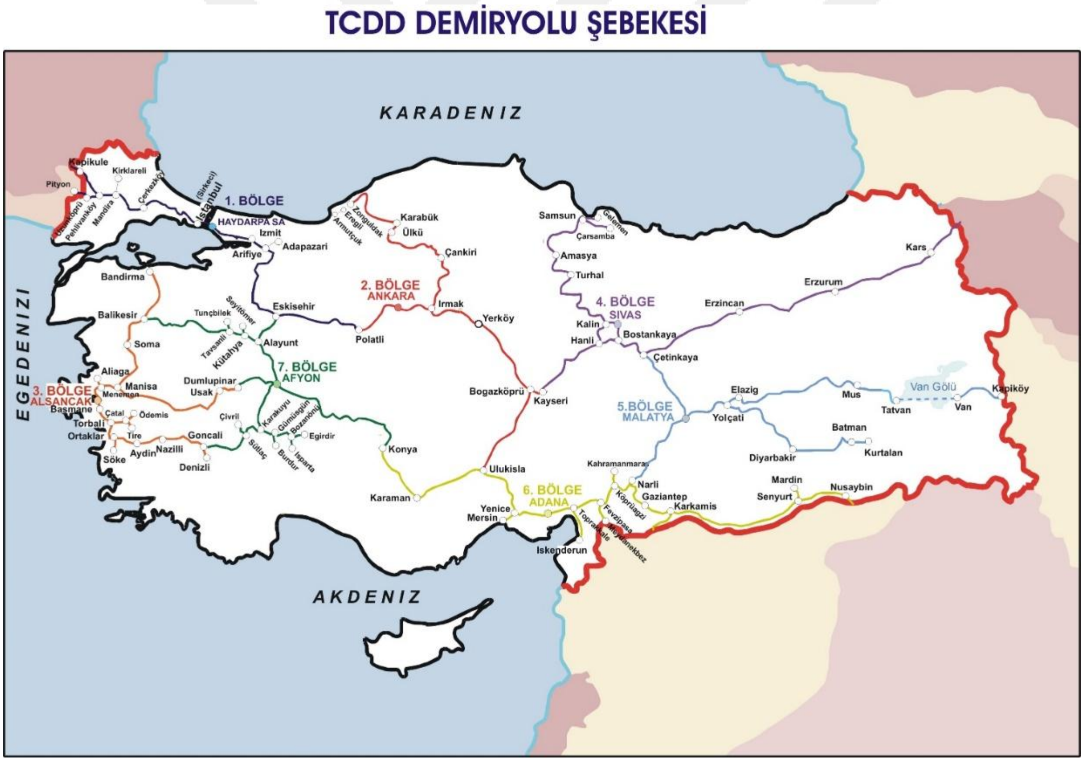

Figure 2.1: Current railway line map of Turkey

2.2.2 The Reasons behind the High Speed Train Project

Similar to developments in economy, industry and commerce, urbanization has been ongoing in big cities like Istanbul and Ankara, and migration from rural areas to such urban centers has been speeded.

Given these the need to improve transportation systems becomes imperative. Therefore, all transportation modes are in search of ways to increase their shares in the Ankara – Istanbul corridor which has the highest potential countrywide. In the past, the railways have always lost their share in market due to lack of financial support to compete with other transportation systems, especially highway transportation. For example, by the completion of Bolu Tunnel which is an important part of the Istanbul – Ankara roadway project, there will be a reduction of one hour in travel time. Because of this reason, the railway with its minimum 6.5 hours of travel time will have smaller chances of attracting passengers. TCDD (Turkish Republic State Railways) is aiming to diminish the travel duration in this line and to increase its share in market and its competition power by improving the parameters that affect passenger potential, like safety and comfort. The high speed train project of Ankara – Istanbul railway line was started to realize these objectives.

2.3 Ankara-Istanbul railway project

2-3-1 Ankara – Istanbul rail line (before HSR)

Ankara, located in the Central Anatolia Region, is the capital city of Turkey, with a population of about 5 million. On the other hand, Istanbul is the biggest city of Turkey with a population of nearly 14 million. Due to their large population, there were many trips to and from these cities. Especially, travels between these two cities constitute the most crowded travel corridor in the country. Moreover, four city centers and many towns located on this rail line making the line more crowded. The past Ankara – Istanbul rail line had a total of 576 km, with double lines of 110 km. Although all sections of this line were electrified, the quality of the line was below standard. In addition to this, there were many narrow curves on this line making high speeds impossible.

2-3-2 Ankara- İstanbul High Speed Railway Line

The main purpose of the Ankara – Istanbul high speed train project was to decrease travel time to about 3 hours of safe, comfortable and rapid transportation. Initially this project started as “the rehabilitation project of the existing Ankara – Istanbul railway” in 1994. The rehabilitation project covered the rehabilitation of the existing line and construction of an additional new line parallel to the existing one. With its relatively low project cost, this project would be completed in two stages. The first stage would be constructed between Ankara – Eskisehir, with project duration of 34 months and cost of 459 million euros. As a result of upgrades in substructure and superstructure, the total travel distance would be shortened by 9 km. The second stage of the rehabilitation project was a rail line of 180 km between Eskisehir and Kosekoy near Kocaeli. By rehabilitation of this section, 25 km would be saved in total travel distance. The cost and duration of the project were estimated around 701 million euros and 36 months, respectively. By completion of the two stages of project, travel time between Ankara and Istanbul would be reduced from 6.5 hours to 3.5 hours by HSR at speed of 200 km/h. Details of project will be examined later chapters.

In May 2005, the Turkish Government gave up the rehabilitation project of existing Ankara – Istanbul railway due to very old superstructures and low geometric standards. The newly proposed Ankara – Istanbul high speed train project replaced the above mentioned rehabilitation project. In this project, a new two-line for high speed trains will be constructed increasing the project speed from 200 to 250 km/h. The old line is left untouched for use of freight and other trains. With the high speed train project, the total length of the line will be reduced from 576 to 533 km (see Fig). The total travel time between the two cities will also decrease from 6.5 to 3 hours. The project was being built in two main phases. First, 251 km section from Sincan to Inonu and second, 158 km from Inonu to Kosekoy. The remaining sections of Ankara – Sincan (24 km) and Kosekoy – Gebze (56 km) was completed in 2008. Being included in the Marmaray project the Gebze – Istanbul section of 44 km will be completed under this project.

The construction cost of the section between Sincan and Inonu was 747 million euros. By December of 2006 it was completed. The section between Inonu and Kosekoy is 158 km, was completed in June of 2008. Because of 39 tunnels and 33 bridges and viaducts, the cost of this section is about 1.27 billion dollars. The remaining sections from Ankara to Sincan, and from Kosekoy to Gebze were completed in 2008 as well. The latter costed 106 million euros. Meanwhile, 10 high-speed trains were manufactured by CAF, Spain, to be used in this railway line. They consist of six cars with a capacity of 419 passengers, suitable for 250 km/h.

The Ankara-Istanbul High Speed Train Project was completed in two stages. On April 23, 2007, between Ankara and Eskişehir, the first port of the line, started its trial services and on March 13, 2009, the first passenger services were made. With the 245 km km/h Ankara-Eskisehir line has reduced its travel time to 1 hour and 25 minutes. After the launching of the Ankara-Eskisehir High Speed Train line, construction of Eskişehir-İstanbul line, the second stage of the project, was completed and started on July 25, 2014.

The High Speed Train Project, independent from the existing line between Ankara and Istanbul, consists of the construction of a new double line high speed railway, all electrical, signalled, and suitable for 250 km / h speed. The total length of the project is 533 km. and the segments of the Project are Ankara-Sincan (24 km), Sincan-Esenkent (15 km), Esenkent-Eskisehir (206 km), Eskisehir-Inönü (30 km), İnönü-Vezirhan (54 km), Vezirhan- Köseköy (104 km) Km.), Köseköy - Gebze (56 km) as shown in Figure 4.8.

Figure 2.2: Ankara-Istanbul high speed train route and project departments

The 44 km Gebze-Haydarpaşa segment has not been included in the Ankara-İstanbul High Speed Train Project since it will be transformed into a superficial metro with the Marmaray project. Also included in the project are Ankara High Speed Rail Construction and 10 sets of high speed train construction works.

With the completion of the project, the journey time between Ankara and Istanbul was targeted to be reduced to three hours. It is aimed to increase the share of railway passengers on this route from 10% to 78%. Ankara- Istanbul High Speed Line will be integrated the total line of Edirne Kars High Speed Railway Line and Baku-Kars Railway Line. And with Marmaray which is Bosporus underpass in Istanbul and uninterrupted transportation from Europe to Asia will be provided. Indeed, in addition to importance for Turkey, from this point of view this project is one of the key transportation project within the Middle Corridor of BRI. It is aimed to increase the social, economic and cultural exchanges between these cities with the completion of this project which connects the two largest cities of Turkey and make not only Turkey but also all region ready for accession infrastructure both Europe and Asia. Ankara - İstanbul High Speed Train Project was completed in two stages. The Ankara-

Eskisehir High Speed Train line, the first stop of the project, was opened in 2009. The rehabilitation of the conventional line has been completed at the construction of the Eskişehir-Istanbul line, the second stage of the project, and all of the high-speed line manufacturing continues. The foundation of Köseköy-Gebze stage was thrown on 28.03.2012 and works are continuing. The Ankara-Istanbul high-speed rail line, which started on July 25, 2014, uses conventional lines upgraded in certain areas (between Vezirhan and Gebze). For this reason, the target duration of transport has not yet been achieved.

Also, Ankara High Speed Rail Station Construction and 10 sets of high speed train supply works included to the project.

The Ankara-İstanbul High Speed Train Project is one of the biggest projects carried out by the Ministry of Transport. The main purpose of the project; is to increase the share of the railway in transportation by providing fast, safe and comfortable transportation by decreasing the travel time between our two major cities of Ankara and Istanbul. It is another goal to increase the share of railway in this region from 78% to about 10% in passenger transport.

With this project; social and cultural interaction between the cities will be increased and integrated with Marmaray to make uninterrupted passenger transportation from Europe to Asia and when other high speed train projects enter into operation, high speed train networks will be formed in important lines of Turkey, will enhance the capacity of existing lines protected for high-speed trains, freight and other trains, which will also be positively reflected in other lines. Turkey will be prepared for this process with its transportation infrastructure, which will be an important step in the 21st century and the "New Railway Age".

It will increase the competitiveness and transportation share with the catching of the most modern transportation system in public transportation, which is not dependent on petroleum, has low construction cost, has a long service life, uses less land than the highway and does not cause environmental pollution. Balanced transportation system, economic, social and cultural life as well as many positive effects are thought to make.

The project will be carried out in two stages. The first phase of the project is between Esenkent and Eskişehir of 206 km. The 2nd phase is 158 km and it is projected as two sections as Köseköy -Vezirhan and Vezirhan-İnönü. The high-speed train project covers all the infrastructure works between Ankara-Istanbul (Köseköy). In addition to this, project works of 56 km Köseköy-Gebze section will be completed together with 2nd stage construction works. When the Ankara-İstanbul High Speed Train Project is completed, a double-line, electrified and signalled 250 km / h speed rail will be built between the two major cities. The construction of the Ankara-Eskişehir section on the Ankara- Istanbul metropolitan area is the cornerstone of further investments to be made especially in the direction of İzmir.

The Ankara-Eskişehir section can actually gain meaning and value in addition to connecting to Istanbul, contributing to Ankara's connection with Izmir and the Aegean. Because İzmirBandırma line is a line that is on the agenda to improve İzmir by taking into account the connection with Thrace, Europe and Istanbul. The improvement of the Eskisehir-Balıkesir line has also been programmed. It seems that these studies overlap with the Ankara-Eskişehir section of Ankara in connection with Izmir and Aegean

2-3-3 Ankara - Konya High Speed Railway Line

Konya city requires both the presence of high-speed train technology and geographical availability of this technology. Konya; population is one of the largest cities of Turkey in terms of agriculture and industry. The proximity to the capital Ankara and the cultural values it has influenced by the civilizations that it has hosted in history are some of the factors that make Konya important.

Ankara-Eskişehir-Afyon corridor over Ankara-Konya current conventional railway line is 687 km and Ankara-Konya highway line length is 258 km. As the passenger and cargo transportation made on the existing railway line between Ankara and Konya took a long time, transportation by road was generally preferred.

By making Ankara-Konya line from Konya city to Turkey's three largest cities (Istanbul, Ankara, and Izmir) is intended to provide a shorter transportation time. After completion of Ankara-Konya and Ankara-İstanbul High Speed Train Projects: 10 hours 30 minutes travel time between Ankara and Konya decreased to 1 hour 40 minutes, 12 hours 25 minutes travel time between Istanbul and Konya decreased to 4 hours 15 minutes. This line, which is tendered as 2 cuts as seen in Figure 6.2. The first section is defined as 100 km, the second section (100 + 00 -212 + 50 km) is 112.5 km.

Total length is 306 km. Construction length is 212 km. Line number and type are double line, electrical, signalling. Speed is 250 km / h. Axle Load is 22.5 tons. Ekartman is 1.435 mm. Min. Kurp Radius: 6.500 meters. Maximum Slope is ‰ 16. Maximum Dever is 130 mm. Vertical gauges is 6.72 mm. Rail type is UIC-60. Rail length is 36 meters. Welded length is Continuous welding. Rail quality is 900 A. Traverses are pre-gauge, pre-traction monobloc B70 type concrete.

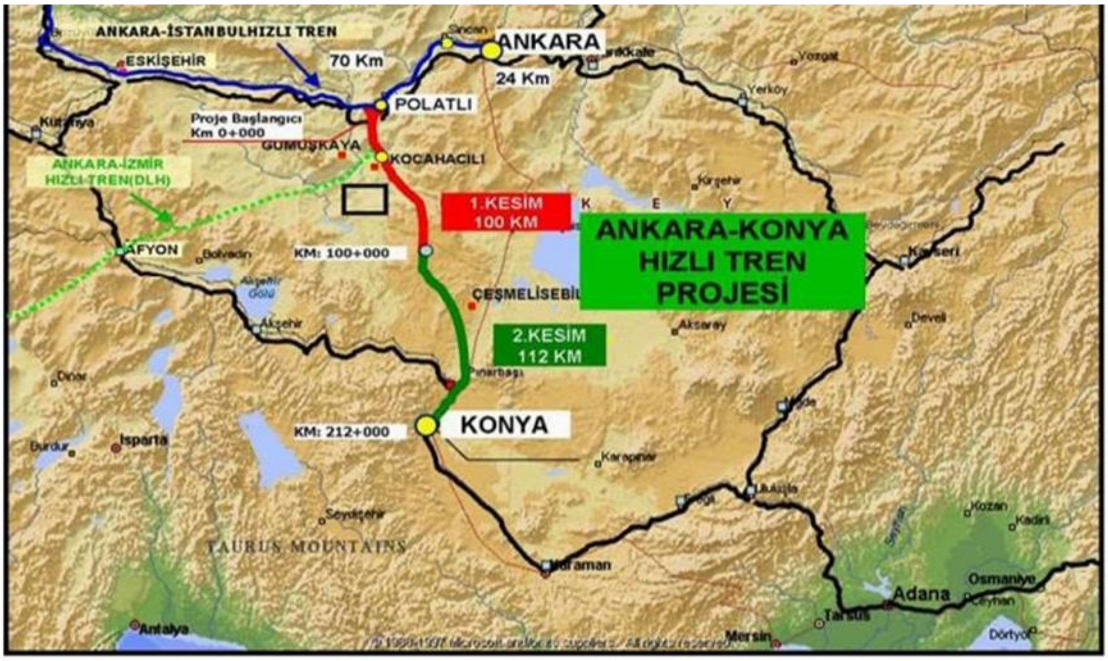

Figure 2.3: Ankara-Konya high-speed train route and project departments

The 212 km line to be built in order to complete the infrastructure works on time and to create competition by increasing the number of participants in the infrastructure tendering is divided into 2 sections.

The first phase, the 1st sector construction tender, covers 0 + 000-0 + 100 kms and Netyapı İnşaat Inc. constructed by. The 2nd part construction tender covers 100 + 000-212 + 500 km. Applications Öztaş İnşaat Malzemeleri Inc.-Mustafa Özcan İnşaat Inc. business partnership. The infrastructure works carried out by the contractor were completed at the end of 2007 and due to the increase in discovery, the 1st section construction was reissued under the name of supply construction. Between 2008 and 2009, the replenishment construction was completed. The first part of the project construction generally includes excavation work, basic excavation and backfilling, route fillings, art works and drainage works. The total excavation amount on the route is about 27.000.000 m3 and the total fill amount is about 13.000.000 m3.

Since the High Speed Train projects were completed with wire fence, art works were designed and created for irrigation purposes, road crossing purposes and vehicle passing purposes in the sections where the high speed train passes along the route.

Within this scope, the first 100 km section, 5 bridges, 8 overpasses, 38 underpasses for agricultural underpasses and roads and 83 culverts are built. Figure 4.3 shows an overpass in this section as construction continues.

Figure 2.4: Ankara-Konya highway 1. Overpass construction (Km: 0 + 000Km: 100 + 000).

The second part of this context includes 2 bridges, 17 overpasses, 26 underpasses and underpasses for highways, 49 culvert constructions, 7500 meter retaining wall completed, Bozdağ Tunnel was completed on the line as shown in Figure 4.4 '. as art works

Figure 2.5: Bozdağ tunnel in Ankara-Konya line

Design Speed is 250 km / h, Maximum Deburr is 130 mm, Minimum Curve Radius is 6.500 m, Maximum Slope is ‰ 16, Maximum Axle Load is 22.5 t, Lane Clearance is 1435 mm, Distance between Road Axes on Double Lane Distance is 4500 mm, Vertical gauges are 6.72 m., Traverse Type is Pre-germ monoblock type B70 concrete traverse (shown in Figure 6.5 when B70 type traverses are placed), Distance between traverse is 600 mm, Ballast is 3-6 cm cubic, Rail Tipler is 60 E1 (UIC-60), Rail Length is 36 meters, Welded Length is Continuous welding, Rail Quality is 900 A

Figure 2.6: B70 type concrete sleepers used in Ankara-Konya line.

ERTMS / ETCS Level 1 train control systems are used in accordance with the European Train Control System. 6 high speed train sets ETCS Level 1 on-board system installed. CTC Sand Center and Electronic Installations, 4 wheel detector systems, neighbouring signalling and telecommunication systems have been completed.

High Speed Train Project between Ankara and Konya Electrification studies for energy supply;

Temelli-Konya 243 Km power transmission line was built together with TEİAŞ. Route detection studies have been completed. For the feeding of catenary systems, 4 Transformer Centers, 6 Stations, 4 Neutral Zone Post; For Control of Control Systems, 1 Unit (SCADA) Telecommunication Center; For energizing the catenary in towing and towed vehicles, 212 Km 250 km / h High Speed Catenary Line, 7900 Centrifugal Concrete Piers, 1200 Portal Centrifugal Multiway Piers, 1500 Km Convoyed Conveyor, Portable Cone, Return Conducting Conveyor, 212 Km Line Fitting and Assembly are constructed.

Figure 2.7. Figure shows the completed line of electrification and signalization work

2.4 Comparisons Between High Speed Railways in Turkey with Other Countries

High-speed railway investments have continued for many years worldwide, especially in countries such as European countries, Japan, and China. In fact, many countries have completed their investments in this area and are only in maintenance and repair activities. When we look at the high-speed railway lines in Turkey, we can talk about the existence of Ankara-İstanbul, Ankara-Konya lines.

High-speed railway networks, which will be owned by Turkey on both the east-west and north-south axes, will be built on the other side of Ankara-İzmir, Bilecik-Bursa-Bandirma, Ankara-Sivas lines and Sivas-Erzincan and Ankara- Kayseri lines will improve connectivity between Asian and European countries. Especially the high speed train line between Ankara and Eskişehir was completed in a shorter time compared to many other high speed train lines in Europe.

If we want to make an assessment for the lines in Turkey, it would be more beneficial and more beneficial between existing lines in developed countries and Turkey lines instead of doing this in themselves.

When we want to compare the lines, it is best to start with two factors which are closely related to both construction and operation costs, namely 'speed and distance'. Obviously speed is a very critical part of the characterization of the high-speed train line. However, since economic implications must be taken into account separately, there are more than one technical description of speed. Above all, the maximum project speed is generally a technical parameter that depends on the infrastructure. The radii of the curves and slopes are determined accordingly during the design phase. It is inversely proportional with train’s speed and its turn of curves and it’s climbing steep slopes. For this reason, a HSR line is faced with tough construction constraints and more line length is needed to increase the maximum speed of the project.

A second concept is the maximum operating speed, depending on the technical characteristics of the trains and how they are operated. This operating speed grows with technology and generally increases with time, limited only by the maximum project speed.

The latest (and most commonly used) speed concept is simply the calculated (average) commercial speed by dividing the line length by the total journey time. It should be taken into account that this is not just a technical concept determined at the speed of operation and project, it is also an economic concept. It's not just technical factors that affect the length of the trip. Other (non-technical) factors such as the commercial tariff, the number of stops, the quality of the customer, etc. affect the duration of the trip.

When we look at the newly constructed lines in Turkey, maximum operating speed is seen as 250 km / h. If we look at average speeds:

- Ankara - Konya HSR (306 km - 1 hour and 40 minutes): 184 km / hour
- Ankara - Eskişehir HSR (245 km - 1 hour and 20 minutes): 184 km / hour
- Ankara - Istanbul HSR (533 km - 3 hours 50 minutes): 139 km / hour
- Konya - Istanbul HSR (651 km - 4 hours 15 minutes): It is seen that it is 153 km / h.

When we look at the maximum speeds in other countries; French TGV 300-320 km / h, German ICE trains 280-330 km / h, Italy ETR 250-300 km / h and Spanish AVE trains 300 km / h. The Japanese Shinkansen line runs at a speed of 270 km / h.

It is seen when examining the examples in the world that the distance range of high-speed railway investments is most efficient is around 200-800 km. When we examine the existing and new lines in Turkey;

- Ankara - Konya HSR Line: 306 km
- Ankara - Eskişehir HSR Line: 245 km
- Ankara - Istanbul HSR Line: 533 km
- Konya - Istanbul HSR Line: 651 km
- Ankara-Sivas HSR Line: 466 km
- Ankara-İzmir HSR Line: We see that it is 624 km.

All of these lines are within a reasonable range in terms of distance. When we look at some of the world's empirics, for example in countries such as Japan, France, Germany and China, the distances are also consistent with the intervals in Turkey. Depending on the distance, it is desirable that the duration of the journey is between 1.5 hours and 4 hours. The expected time period of high-speed rail line, which has been held and will be held in Turkey are Ankara-Istanbul 3 hours, Ankara-Konya 1 hour 15 minutes, Ankara-Sivas 2 hours 50 minutes and Ankara-İzmir 3 hours 20 minutes. The Ankara-Konya line is very convenient in terms of travel time. The other lines are close to the 3-3.5 hour interval, which is the efficiency limit for travel time.

It is a good idea to start by examining the costs of completed construction lines in Turkey. We have already said that the total cost for the 212 km Ankara-Konya line is 800,677,415.30 TL. We can say that the mileage cost for this line is 3,776,780.26 TL.

It is true to examine the Ankara-Istanbul line in two parts in terms of cost. The total cost of the 247.2 km Ankara-Eskişehir part is 2,350,000,000.00 TRY. Accordingly, the average mileage cost is 9,506,472.49 TL. The cost of Eskişehir-İstanbul part of 267 kilometers was quite high compared to the other parts and it cost 6,604,000,000 TRY. Accordingly, the average cost of this section is 24,734,082,39 TL.

If we combine the sections and evaluate the Ankara Istanbul line as a whole, the total cost of this line of 514.2 kilometers is TL 8,954,000,000.00. The average mileage cost is 17.413.457,79 TL.

The reasons for these differences in costs are undoubtedly land conditions. Costs have increased as a result of the passage of the Ankara-Istanbul route through the residential areas and the difficulty of the land conditions of the region, while the distance between Ankara and Konya is both distant from the settlement areas and low costs of excavation.

When we examine the examples in the world, we see that there are quite high differences between the kilometers costs. (Table 7.1)

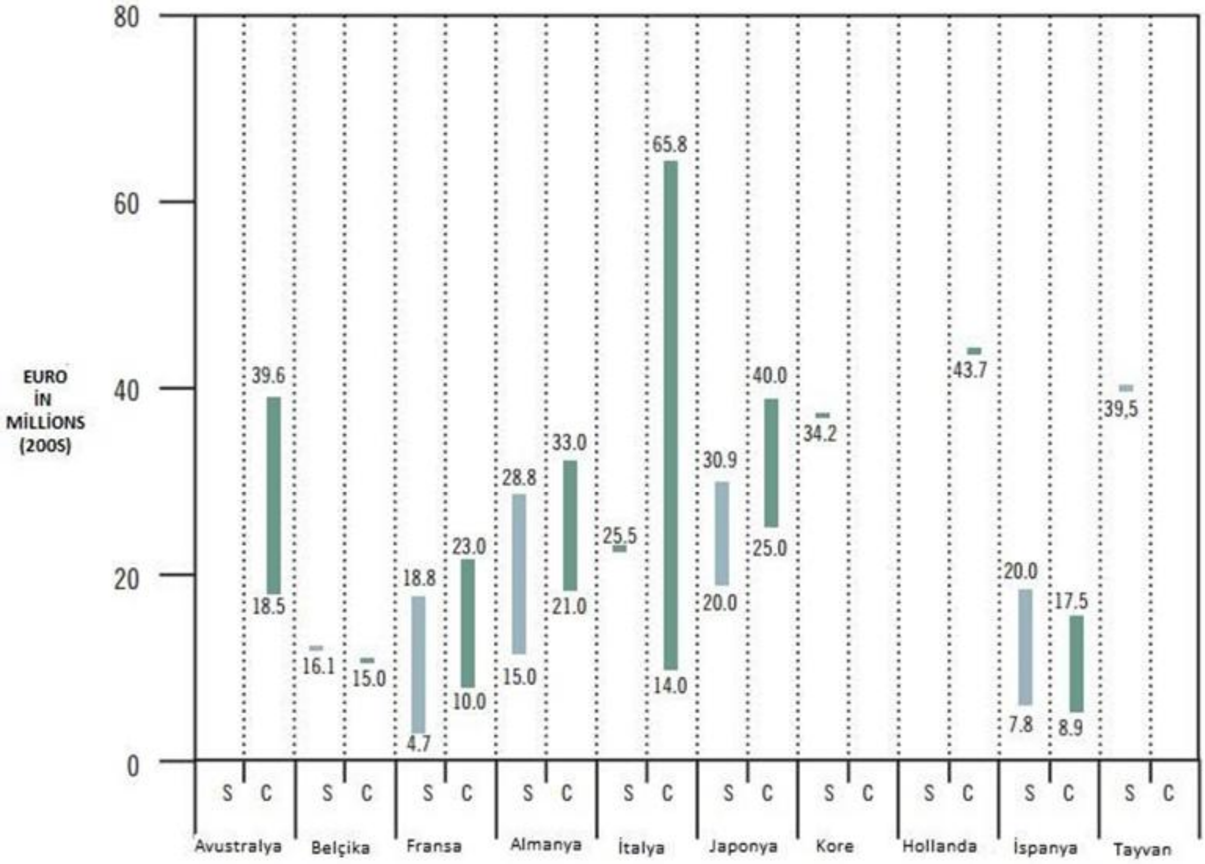

Table 2.1: World-wide high-speed rail new-line average mileage construction costs.

The graph summarizes the average cost for constructing a kilometer high-speed railway infrastructure. Values including planning and land use infrastructure and superstructure costs are given in million Euros. As a result, the average cost of 45 projects is between 6 and 45 million kilometers (average 17.5 million). Except for China, the construction of high-speed railways in other Asian countries is more expensive than in Europe. According to the data of Japan; the high costs indicate that studies on the development of traditional lines in Taiwan and South Korea have been carried out [7].

There are two group countries in Europe: France and Spain; Compared to Germany, Italy and Belgium, there are very few construction costs. This is not only manifested by the lesser of the population and similar geographical conditions surrounding large urban centers, but also with the construction procedures. In France, for example; the cost of construction is minimized by adapting to steep inclines by making tunnels or viaducts. Since the TGV (France-high-speed rail) lines are allocated to passengers, the slope is used from 3.5%, 1-1.5% in mixed traffic. Despite the fact that the upgrades are more expensive to make low-line calls, the minimum operating and maintenance costs can be compensated by the reduction in line construction as much as the costs. In other European countries, high-speed rail is much more expensive, because building on areas that are heavily populated does not provide an area economy [7].

In Japan, the Tokyo-Osaka Shinkansen line (starting in 1964) (including land costs) is lower than the others. (5.4 million euros, with 2005 values), but continuing to complete the projects in the years to come, these values are 3 or 4 times higher. In Paris and Lyon, which started in France in 1981, each kilometer construction on the TGV Sud-Est line required an investment of € 4.7 million. On the other hand, each kilometer of the TGV-Medditeranne line, which started in 2001, required investment of 12.9 million Euros [7].

The Ankara-Istanbul line in Turkey is currently the most costly line, but it is in average values compared to the costs of other countries as it seems.

The 212 km Ankara Konya line is 250 km / h double line, electrical, signalled. Considering the geometric standards that must be considered for this line, the maximum slope is 16 ‰ and the maximum is 130 mm. and a minimum radius of curvature of 6.500 meters. When you look at the art structures made on the line route; 7 bridges, 25 overpasses, 64 agricultural underpasses and underpasses for the use of highways, 132 culvert and 7500 meters retaining walls were completed.

The 533 km Ankara Istanbul line was constructed as 250 km / h double line, electrical, signalled. Considering the geometric standards that must be considered for this line, the maximum slope is 16 ‰ and the maximum is 130 mm. and a minimum radius of curvature of 3.500 m. When you look at the art structures made on the line route; 620 culverts, 212 underpasses and overpasses, 27 14.5 kilometers viaducts, 31 40.8 kilometers of tunnels and 52 bridges were built.

Turkey is also carried out and planned in line HSR maximum slope is taken as 0.16%. When the slope is kept low, it is possible to transport freight as well as passenger transportation safely.

In Germany, this slope was set at 1.25%, and even this value was inclined to the maximum. In France, the maximum allowable slope is 0.25%, but in exceptional cases it can be around 0.35%. The maximum slope in Japan is only due to passenger transport.

It can be determined as% 2. In Germany and Japan, the HSR lines have reached the maximum slope, obliquely overhanging high dimensions as the whole of the country has been hovering, and in this context, the artworks have reached very large dimensions.

For example; In Shinkansen-Joetsu line in Japan, 60% bridges-viaducts, 39% tunnels, 99% arts in total were used. In France, the slopes could be kept low in France, since the places where the lines crossed were geographically flat; again the art structure is not used much the same reason.

Turkey too HSR 'height difference between the regions in which the bonds could be used in low slope because it is smaller in size but due to geographical factors, in some line art structures have been used more than the other lines. According to the conventional art structure in line HSR in Turkey in Turkey to provide adequate speed is about 10 times more.

If the inclination is kept low, convenience and advantage are provided in terms of the power that is spent.

A classical railway line is composed of the "road frame" which rails and traverses form, the ballast which is laid under this frame, the crushed stone layers called under the ballast and the different ground layers or underground bridges, viaducts and tunnels under them. art structures. Road frame and ballast layers are also called "superstructure".

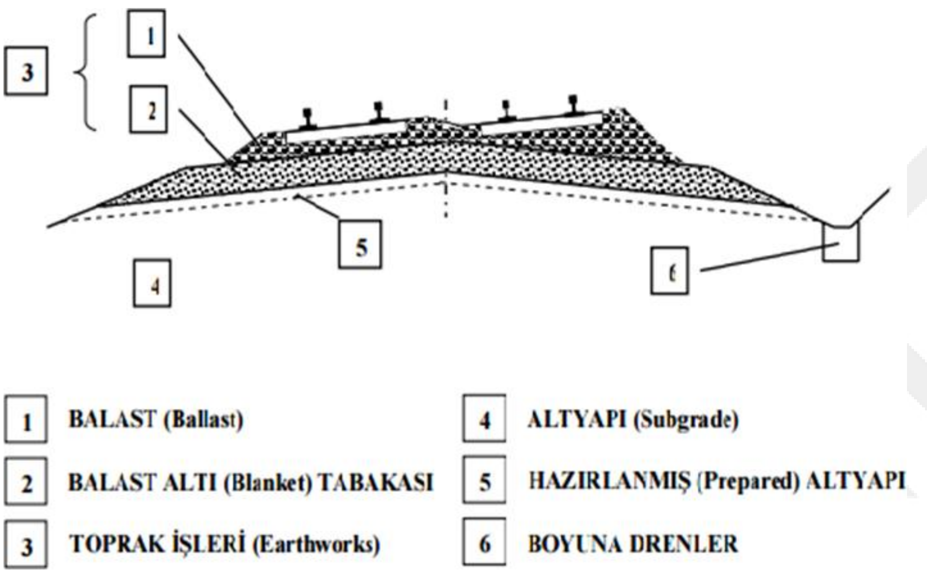

Figure 2.8: Section of the classic railway superstructure.

In the railway, the layer between the road frame and the infrastructure and connecting between these two structures is between 2 and 7 cm. The reason for the use of the ballast structure is to protect the infrastructure and ensure that the loads are evenly distributed on the proper level. The fact that the ground is not very well in Turkey conditions has made it possible to use ballast superstructure for projecting.

Using 3-6 cm cubic ballast material in Ankara-Konya line, total 988,000 m3 of ballast has been laid. On the Ankara-Istanbul line; 2.911.040 m3 ballast was used.

The type of superstructure used in Japan and Germany is mostly superstructure without ballast. The type of ballast superstructure is made in France and Turkey. The ballast-free superstructure is more disadvantageous in terms of cost, but maintenance costs are more advantageous than balustrades in places where there are artifacts. Due to the large number of art structures, the ballastless superstructure ratio in Japan and Germany reaches 90%. However, like everywhere in France it will be ballasted art structures, although in some lines more than the cost of superstructure in Turkey was preferred.

The transverses, which prevent the destruction of the ballast material and meet the static and dynamic loads coming from the railway vehicles and transmit it to the lower layers and form a smooth rolling surface to the vehicles, are used as concrete traverses with B70 type preforms in both Konya and Istanbul lines. The distance between traverses is 600 mm. In order to produce the traverses to be used in the Ankara-Konya line, the Travers factory was established at Pınarbaşı area and 137,687 usable traverses were produced. 1,686,512 traverses were laid in Ankara-Istanbul line.

The elements that receive the axle loads transmitted by the wheels as a beam sitting on the elastic center and transmit them to the traverses are the rails. 60 E1 type steel rails are used in the lines in Turkey. 56,135,47 tons of steel rail were used in Ankara-Konya line. On the Ankara-Istanbul line, 1,857 kilometers of rail was laid.

The railway line gap defines the distance between two railway carriages that form a railway line and carry a load. 60% of the world's railway lines use a distance of 1.435mm as standard line spacing. Line openings at different distances are called wide or narrow. Where the lines with two different line widths meet, the line breaks. Thus, in some transition regions, a number of lines are constructed to allow easy switching between different line widths. Turkey is using 1.435 mm openings which are widely used in countries such as Europe and

America. Thus, in the future, especially if the European lines are integrated with the lines of Turkey, the line will be a problem.

The carrying capacity of high speed trains of HT65000 Series used in Turkey is 419 persons. These vehicles are used in the existing lines. For the Ankara-Konya line, this line, which is considered to operate at 70% occupancy, is the expected number of passengers per year (294 persons * 365 days * 14 flights), 1.502.340 persons. Ten flights a day are made in Ankara Istanbul line. This line can be calculated to carry 919,800 people per year (252 persons * 365 days * 10 times) with the assumption that it operates at 60% occupancy with a decrease due to the regional use of the conventional line. In Ankara-Eskişehir line, there are 22 flights a day.

This line (336 people * 365 days * 22 times) is considered to operate at an efficiency of 80% 2,698,080 passengers can be calculated. These assumptions in the light passenger-carrying capacity in Turkey is approximately 5.12022 million people annually.

High-speed trains are efficient among populated city centers. From this point of view, unlike Europe and Japan, the reason why high-speed train transportation does not spread in the USA is revealed. The population density of the US high-speed railway potential market is very low compared to the market intensity of successful high-speed railway companies in France and Japan. By train every six minutes from Tokyo Station.

The Japanese Tokaido-Shinkansen Line, which has 23,000 passengers, is located in the most favorable region of the world in terms of high population density and high-speed train operation.

Among the examples in Europe, passenger transport capacities in France and Germany are approximately 115 million and 24 million per year. In Japan, 342 million passengers are transported annually with train sets with an average seat of 871. In the light of this data, it can be said that Japan has the most advanced HSR when compared to other countries. Turkey has seen passenger values that is less when compared with other countries for the moment.

2.5 Significance of the project within the Europe -Caucasus -Asia Transport Corridor and Belt and Road Initiative

Goals and expecting outcomes of BRI are strengthening policy communication, such as taking forward regional cooperation, strengthening transport linkages, from the Pacific to the Baltic, improving basic trans-border transport infrastructure and forming a transport network linking East, West and South Asia (including through SCO discussions of an agreement to facilitate transport), strengthening trade flows. The commentary claimed that the Silk Road Economic Belt has a population close to three billion, with 'market scale and potential next to none', and that countries should simplify trade and investment, remove trade barriers and reduce the costs involved in trade and investment, strengthening monetary flows through measures to enhance currency circulation and (trade) settlement, thus reducing costs and financial risk and raising the international competitiveness of the region, strengthening popular support across the region for the Silk Road plans.

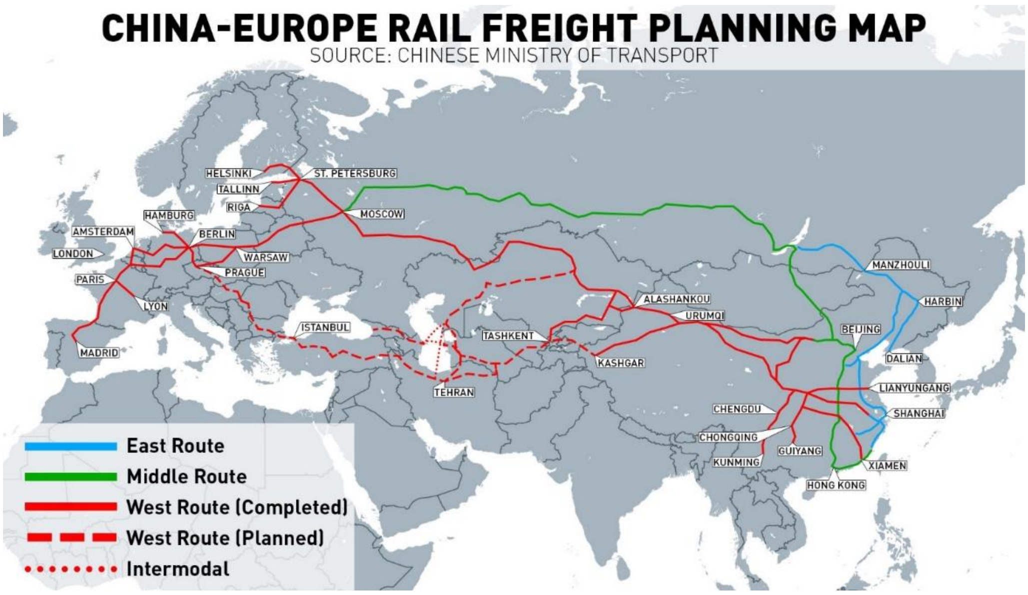

Figure 2.9: China –Europe Rail Planning Map

The case of this research which is Ankara- Istanbul High Speed Railway Project is one of the key section under the Middle Corridor of the Belt and Road Initiative and is strengthening transportation linkages between Asia to Europe. On the other hand, Europe - Caucasus - Asia Transport Corridor (TRACECA) is complementary to the Pan-European Transport Corridors and aims to regulate international transport. The TRACECA project was initiated in May 1993 in the framework of studies on the development of new transport corridors for the Caucasus and Central Asian Republics, alternatives to routes to Russia in the north and Iran in the south. This project starts from Almaty on the Silk Road, Kyrgyzstan-Uzbekistan- Turkmenistan routes traversing the roads and railways of the Caspian Sea via Baku and Georgia's Poti and Batumi ports via Azerbaijan - Tbilisi - Kars with the completion of the railway project to connect to the Turkey railway network and ports , it is foreseen to connect to the ports of Ukraine, Romania and Bulgaria via sea-line connection and link them with Pan-European Transport Corridors.

Under the project, the Port of Samsun involved in the TRACECA between Russia's Kavkaz Harbor Ferry Link Railway Transport Making Project with Turkey and the Russian Federation forming a train-ferry line on the Black Sea between transit to Russia our our country from Russia and countries in Samsun and The port of Kavkaz (Russian Federation) was intended to be transported by creating a bridge between the ports and the Samsun-Kavkaz Train Freight Line was opened to service on 19 February 2013. "The boats of the wagons loaded from the port of Kavkaz to the ferries were provided at the port of Samsun by transit to the Mediterranean, Europe, Asia and Middle East countries via rail. An uninterrupted, fast, economic railway connection from Europe to Asia, west to east, will be provided with the opening of the Marmaray Project on October 29, 2013, the opening of the Ankara-Istanbul High Speed Train on July 25, 2014 and the Baku-Tbilisi-Kars Railway Project.

Chapter 3

Methodology

The Cost Benefit Analysis (CBA) has been widely applied to feed the assessment of potential social and economic impacts of transportation in the (medium) decision-making process (Tudela and Al., 2006). According to Auzannet (1997), the purpose of the CBA is to assess the financial and non-financial implications of projects that have been directly and indirectly affected, rather than an investment in an established economic agent. These impacts are combined after a financial assessment, to confirm the social and economic balance, which determines the return on investment (ROI), where such returns are valued on the base of particular indicators. The use of the CBA dates back to 1930: The US Congress stated that the federal government would progress hydropower navigation given to flood control that exceeded one of the expected benefits of the estimated costs (flood control law of 1936). Over the past decade, the correctness of this method has greatly enhanced with new assessment measures such as computing the willingness to drive passengers who would likely reduce carbon emissions, accidents, risks, etc. At present, the CBA has developed as the most widely recognized and practical methods of evaluating projects for investments in the field of large-scale infrastructure in the public sector (Nickel et al., 2009)

The research proposed under this paper is in the below Fig. shows that Cost Benefit Analysis assessment method is separated into 3 steps. The first is to evaluation the total cost of infrastructure costs and external operating costs. All future values are discounted in Present Value (PV) and total aggregate PV of total cost (TC). By implementing the same cumulative principle PV total social benefits (T), consisting of five key elements that can be formulated in the second step. The third is subtracting TC from the Total Social Benefit (TSB) so that the project can be obtained at present net value for the project evaluation.

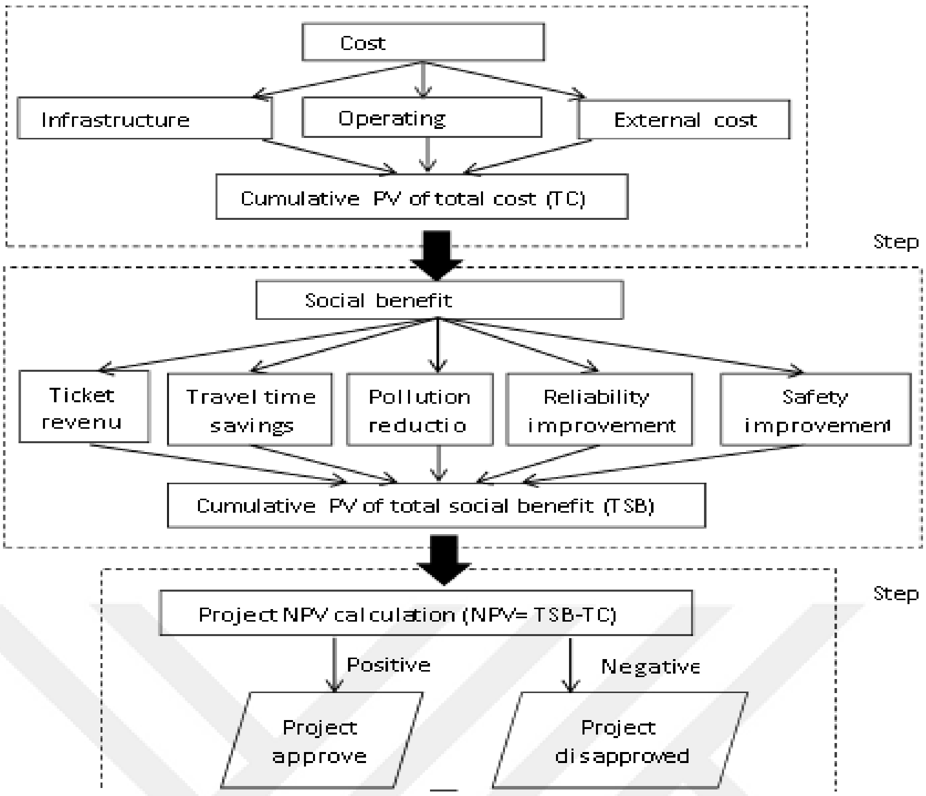

Table 3.2:. The proposed research framework

Chapter 4

Description of Findings

4.1. Cost Estimation

The total cost of construction and operation of a HSR line involves three key parts, namely infrastructure costs, operating costs and external cost (De Rus, 2008). The cost valuation of Ankara-Istanbul HSR line is detailed below.

4.1.2. Infrastructure costs

The infrastructure costs of a new HSR involve: project costs, infrastructure construction costs and superstructure costs (Turkish Railways, 2016). The planning and land costs contain the feasibility works, technical design, land acquisition, legal and administrative fees etc., and usually take up 10% of the total infrastructure costs. Infrastructure building costs involve topography groundwork and platform construction that is one of the major costs of the HSR investment and range from 15% to 50% of the total cost. Lastly, the rail specific elements such as tracks, sidings along the line, signaling, electrification communication and safety, which are critical to make sure the HSR can reach a high speed 250km per hour, are shortened as superstructure costs (De Rus, 2008). Therefore, according to annual report of Turkish Railways investment cost of Ankara-Istanbul HSR is 4.088.584.475 USD.

Table 4.3: Construction cost

ANKARA- İSTANBUL PARTS	**TOTAL AMOUNT (USD) ***	**COST PER KM (USD)**
Ankara-Sincan North Line (24Km.)	42.009.132	1.750.380
Sincan-Esenkent (15 Km.)	52.968.037	3.348.554
Esenkent- Eskisehir (206 Km.)	844.292.237	4.098.505
Eskişehir-Gar Transit (2.2 Km.)	133.789.954	60.813.616
Eskisehir-İnönü (30 Km.)	76.712.329	2.557.078
İnönü- Vezirhan (54 km)	985.321.1001	18.163.368
Vezirhan- Köseköy (71 Km.)	1.273.972.602	17.943.276
Geyve-Arifiye (36 km)	76.712.328	2.130.898
Köseköy- Gebze (56 km)	389.954.338	6.963.470
Gebze- Pendik (20 km)	217.351.598	3.881.279

AVERAGE COST PER KM (514,2	**4.088.584.475**	7.951.350

Source: Turkish Railways

*Total cost refers to the sum of the projecting, infrastructure, superstructure, electrification, signalization, telecommunication and vehicle cost of the line.

4.1.3. Operating costs

HSR operation costs consists of some elements. Firstly, for the continuation of the service of HSR some elements are needed such as, materials and electricity. Also, salaries and allowances and outsourcing, other activities included costs. Another important element is depreciation because the costs of train sets included under this parts. Therefore as indicated in the table, rolling stock maintenance and infrastructure maintenance costs are included under the depreciation costs.

Therefore, according to the table 4.4, total annual operation cost of Railways is 1.083 million USD. And we estimate the Ankara-Istanbul HSR operation cost while this cost by the ratio of the amount of passengers in the project and the amount of all railway lines. This ratio can be calculated as, 2.131.248/89.023.000= 0,024. So, we will use this ratio both calculating the annual operation cost and also annual ticket revenue. Therefore, we calculate the operation cost of the case project as, all operation cost x0,024= 1.083.000 x0,024=25.923

4.1.4. External costs

Construction of HSR and works of trains will have adverse environmental impacts in terms of land regeneration, barrier impacts, visual interruption, noise, air pollution and effects on climate change. All of these various effects will bring environmental expenses, called external costs. De Russ (2008) argues that, 1000 passengers' per km external cost is 14.13 US dollars per year. The annual cost of this project is about 0.07 USD million, as 5.920 people used the 533-kilometer long Ankara-Istanbul-HSR line per day (Turkish Railways, 2016). Then, the cumulative PV of the external cost (PV) is 0.06 USD million.

Table 4.4 :Turkish Railways Financial Performance (USD millions)

YEAR 2016	USD Million
TOTAL REVENUE	302
Passengers	86
Tickets	83
Other	215
Total operation revenues	302
TOTAL EXPENDITURE	1083
Materials	66
Electricity	207
Salaries and allowances	474
Outsourcing and other services	24
Depreciation	117
NET INCOME	(925)

Source: Turkish Railways.

Calculation of the present value of operation cost = $\sum_{t=1}^{n} C/(1+i)^t$

n= lifespan of the project estimated as 40 years,

C= total operating expenditure,

i= inflation rate in Turkey which is determined by Central Bank is 2016 is 8 percent.

Therefore,

$\text{Cost} = \sum_{t=1}^{n40} 25.923/(1+0{,}08)^t$= 309.121 USD

1- Infrastructure Cost (I): 4.088.584.475 USD

2- Present Value of Operation Cost: 309.121 USD

3- External Cost 60.000 USD

Therefore total cost is: 4.088.953.597 USD

4.2. Social Benefits:

4.2.1. Ticket revenue:

According to the report of Turkish Republic State Railways Institution (TCDD), number of passengers in Turkey according to type of trains they use showed below. 2014 is the year of launching Eskişehir-Istanbul HSR line which is the second part of Ankara-Istanbul Line. Therefore, number of used HSR line increased after this year.

According to the report of Turkish Railways, between July 27, 2014 and December 31, 2016, within 29 months, 9,781 flights were made, 5,150,517 passengers were transported. The number of flights from Ankara to Istanbul-Ankara was increased from 12 (6 departures, 6 arrivals) to 14 (7 departures, 7 arrivals), starting from March 10, 2017.

To calculate annual ticket revenue, we will multiply the average ticket revenue of this line which is 23 USD, with annual number of passengers in 2016 which is 2.131.248 and we find 50.439.536 USD. Than we estimate passenger number increase ratio as 1,16 for next years and we multiply the total revenue with this ratio and find 58.846.125 as an annual ticket revenue.

4.2.2. Travel time saving benefit (TS)

The duration of the travel of the total user contain access and exit the standby time and the time of the vehicle. Before the HSR between Ankara-Istanbul, passengers were preferring to use highway instead of railway. Travel conditions and time was not reliable for this high volume passenger distance. Even it has low cost, passengers were not prefer to use conventional line since highway gives comfortable and cheap journey opportunity. Therefore, for the travel saving HSR will be compared with highway in this line.

While the private car or public bus journey, with the speed of 100 average, will cost 5 hours average HSR will save 40 mins with the distance of 533 km. It is assumed that they both has same egress and waiting time. According to Rotaris (2010), value of travel time saving (VTTS) is 17,11 USD. It is estimated that other methods of transport bus and car costs 5 hours journey between these two cities. On the other hand, HSR line cost 3 hours 50 mins as average. Therefore, travel time difference between highway and railway is 40 mins. Number of passengers yearly is 2.131.248. Therefore, gain of hours as social externality calculated as 1.420.832 hours. With the method of Rotaris (2010), average annual social benefits of travel time saving calculated as multiplying this variable to total time saving which has been calculated as 3.196.872 hours, we found **24.310.435 USD.**

4.2.3. Pollution reduction

Table 4.5. Pollution measures of HSR

DATA	**Unit**	**Ankara-Istanbul HSR**
Average train occupancy	Passenger	419
Passenger Loading Factor	Percent	82,9
Total Trips	Trip/years	4047
Line Length	Km	533
Average Electricity Usage	kWh/km	10,40
CO2emission factor for electricity	KgCO2/kWh	0,5459
RESULTS		
VKT	Vehicle-km travelled	2.157.051
Trip Electricity Use	kWh/trip	5.543
Annual Electricity Use	kWh/ year	22.433.330
HSR Annual CO2E Emission	KtCO2/year	**12.246**

Table 4.6. Pollution measures of other transportation modes

TOTAL RIDERSHIP	UNIT	ANKARA-ISTANBUL HSR

MODAL SPLIT		
Private Car	%	13
Bus	%	81
Conventional Railway	%	3
No travel	%	3
ESTIMATE RIDERSHIP		
Private car	Passengers	450.508
Bus	Passengers	312.220
Conventional Railway	Passengers	57.635
No Travel	Passengers	57.635
BUS EMISSIONS		
Trip Fuel Use	liters	133.25
Total Fuel Use	liters	11.849.123
Total CO2 Emission	liters	**37.75**
CAR EMISSION		
Total CO2 emission		**32,87**
CONVENTIONAL RAIL EMISSION		
Total CO2 emission		**2,5**

- Trip fuel use for bus: 25/100 x 533 km= 133,25

  Total fuel use: 133,25 x 88,924= 11.849.123

  Bus total CO2 emission= **37,75 ktCO2/year**

- Total car CO2emission= 249,754(trip) x533(km) x(0,3 x8,2/100 x0,0443 x69,30 +0,4 x10,2/100 x 0.0473 x63,10 +0.3 x5,9/100 x0,043 x74,10)=32,87 ktCO2/year
- Conventional Rail Total CO2 Emission

  =287 (trips) x533(km.) x5(liter/train-km) x0,043 x74,1= **2,5 ktCO2/year**

Therefore, total CO2 emission of these 3 transportation modes is

=37,75 +32,87+ 2,5= 73,12 ktCO2

Difference between HSR and other transportation lines CO2 emission is 73,12-12,25=60,87

According to the method of Maicbach (2007) the average value of pollution reduction in CO2 emission in big cities is 33,95 USD per tone. Since the amount of CO2 reduction of the

Ankara-Istanbul HSR project is 60,87 kt, which is 60870 tones, the average social benefit of pollution reduction is **2.066.536,5 USD.**

4.2.4. Reliability improvement

Unreliable travel is one of the biggest transportation problems. HSR can effectively decrease this ambiguity and increase the level of reliability to escape congestion and delays. Compared to road and conventional rail, HSR has the perfect reliability benefits that (Eliasson, 2009). The value of reliability improvement is estimated according to the ratio of VTTS which is about 13,7% (transport for London, 2007) 24.310.435 x0,137 =**3.330,47.**

4.2.5. Safety improvement

HSR is one of the safest types of passenger transport and can help diminish traffic accidents. The table shows total number of accidents and total number of loss of life and injuries. The total number of passengers who use railway lines is 89.038.000 during 2016. Therefore, comparison with the total number of railway passengers and total number of passengers who involved the accidents stays very low amount.

Table 4.7 . Railway Operating Accidents

Operating accidents	2012	2013	2014	2015	2016
Total number of accidents	147	89	93	101	120
Total number of fatalities	55	45	65	50	81
Total number of casualties	101	52	51	33	72

Table 4.3 shows the total railway operation accidents by years starting from 2012 to 2016

The table below shows that, percentage of motor vehicles in Turkey compared to population is increasing year by year and it reached almost 80% by 2016. The significant data is the ratio of accident to number of vehicles, shows that how many vehicles involved accident amount 1.000 vehicles. Especially the years of 2009 and 2011 are the years that traffic accidents started to decrease. Since during these years in Turkey, HSR Lines constructed and launched to service. This data shows clear evidence the contribution in the decrease the percentage in the motor vehicle accidents in Turkey.

On the other hand, when we compare both above and below table it can be clearly inferred that percentage of railway accidents while comparing to percentage of highway accidents stays low level.

Table 4.8 . Highway Accident Statistics

Number of traffic accidents and results

Year	Total vehicle	Population (Thousand)	Total: Number of traffic accidents	Total: Ratio of accident to number of vehicles'(‰)	Killed persons [1]: Number	Killed persons [1]: Ratio to population '(‰)	Injured persons: Number	Injured persons: Ratio to population '(‰)
2002	8 655 170	69 302	439 777	50,8	4 093	0,06	116 412	1,68
2003	8 903 843	70 231	455 637	51,2	3 946	0,06	118 214	1,68
2004	10 236 357	71 152	537 352	52,5	4 427	0,06	136 437	1,92
2005	11 145 826	72 065	620 789	55,7	4 505	0,06	154 086	2,14
2006	12 227 393	72 974	728 755	59,6	4 633	0,06	169 080	2,32
2007	13 022 945	70 586	825 561	63,4	5 007	0,07	189 057	2,68
2008	13 765 395	71 517	950 120	69,0	4 236	0,06	184 468	2,58
2009	14 316 700	72 561	1 053 346	74,0	4 324	0,06	201 380	2,78
2010	15 095 603	73 723	1 106 201	73,0	4 045	0,05	211 496	2,87
2011	16 089 528	74 724	1 228 928	76,4	3 835	0,05	238 074	3,19
2012	17 033 413	75 627	1 296 634	76,0	3 750	0,05	268 079	3,54
2013	17 939 447	76 668	1 207 354	67,3	3 685	0,05	274 829	3,58
2014	18 828 721	77 696	1 199 010	63,7	3 524	0,05	285 059	3,67
2015	19 994 472	78 741	1 313 359	65,6	7 530	0,09	304 421	3,86
2016	21 090 424	79 815	1 182 491	56,07	7 300	0,09	303 812	3,81

Source: Turkish Statistic Institution

According to De Rus (2008) the number of passengers died and injured while using highway predicted to decrease %14 with respect to using of HSR. Tao, Liu, Huang and Tam (2011) also used this method and they consider lifesaving value as 2,54 USD million and avoided injury benefit as 0,45 USD million. Since, social loss because of traffic accidents is related to the real GDPper capita, I took the ratio of GDPper capita of Turkey and Hong Kong and found the value of 0,434. Then, I multiply this value with lifesaving value and avoided injury benefit. Therefore, for Turkey I calculated lifesaving value as 1.1 USD million and avoided injury benefit as 0,45 USD million. According to Turkish statistics Institution, annual number of people died and injured are 7.300 and 303.812 respectively. Also, because table 4.8 shows all accidents in Turkey, to estimate accidents between Ankara-Istanbul, I took ratio of distance between Ankara-Istanbul and all roads in Turkey and I found the value of 533km./242.590km.= 0,002.

Therefore, annual social benefit and safety improvement calculated as, 0,14x(7.300x1.100.000USD+303.812x200.000USD)=9.630.936.000USDx0,002 **=21.160.348USD**

Total social benefit of HSR

$B_{tr} + B_{ts} + B_{pr} + B_{ri} + B_{si} =$ 58.846.125+24.310.435+2.066.536+3.330+21.160.348 =106.386.775 USD

n= 40 years

i= 0,08 (inflation rate)

Cumulative PV of Social Benefit = $\sum_{t=1}^{n}(B_{tr} + B_{ts} + B_{pr} + B_{ri} + B_{si})/(1+i)^{t}$ = $\sum_{t=1}^{40} 106.386.775/(1{,}08)^{40}$ **= 1.268.621.155,70 USD**

4.3. Net Present Value of HSR

Cumulative PV of social benefit – cumulative PV of total cost =**1.268.621.155,70-4.088.953.596,75= -2.820.332.441,05 USD**

investment cost	-$4.088.584.475,00
present value of operation cost	-$309.121,75
external value	-$60.000,00
total revenue	-$4.088.953.596,75
ticket revenue	$58.846.125,00
travel time saving	$24.310.435,00
pollution reduction	$2.066.537,00
reliability improvement	$3.330,00
safety improvement	$21.160.348,00
total annual revenue	$106.386.775,00
net present revenue	$1.268.621.155,70
total benefit	-$2.820.332.441,05

Chapter 5

Discussion and evaluation of results

Different transportation modes between Ankara-Istanbul has their own positive and negative aspects. Even while some features are advantage, for other transportation type it became challenge. For example, highway offers flexibility to the passengers, but this can cause time cost and traffic conjunction. While railway is perfectly reliable while comparing to others but for big cities reaching central station of the city can cost time.

In this study, while using cost benefit analysis, impact assessment and efficiency measurement of the project was done. As, it can be seen from data indicated in the 4th chapter, investment cost is seem as much higher than the operation cost even after the present valuation of the operation cost has been done, we observe that operation cost is less than investment cost. On the other hand, to evaluate benefits of the project, if only the ticket revenue is taken into consideration, like in the private sector, project considered clearly inefficient. Ticket revenue is almost half proportion of the all benefits. Because of this reason other social benefits, such as environmental benefits time saving and accident aspects are taken into consideration. Annual passenger number is 2.131.248 during 2016 and average fare of one ticket is estimated as 23 USD. Therefore, ticket revenue for the year of 2016 calculated as $58.846.125,00.

While the private car or public bus journey, with the speed of 100 average, will cost 5 hours average HSR will save 40 mins with the distance of 533 km. It is assumed that they both has same egress and waiting time. According to Rotaris (2010), value of travel time saving (VTTS) is 17,11 USD. It is estimated that other methods of transport bus and car costs 5 hours journey between these two cities. On the other hand, HSR line cost 3 hours 50 mins as average. Therefore, travel time difference between highway and railway is 40 mins. Number of passengers yearly is 2.131.248. Therefore, gain of hours as social externality calculated as 1.420.832 hours. With the method of Rotaris (2010), average annual social benefits of travel time saving calculated as multiplying this variable to total time saving which has been calculated as 3.196.872 hours, we found 24.310.435 USD.

On the other hand, according to the method of Maicbach (2007) the average value of pollution reduction in CO2 emission in big cities is 33,95 USD per ton. Since the amount of CO2 reduction of the Ankara-Istanbul HSR project is 60,87 kt, which is 60870 tones, the average social benefit of pollution reduction is 2.066.536,5 USD. Also, the value of reliability improvement is estimated according to the ratio of VTTS which is about 13,7% (transport for London, 2007) 24.310.435 x0,137 =3.330,47. Finally when we look at safety measurement, According to De Rus (2008) the number of passengers died and injured while using highway predicted to decrease %14 with respect to using of HSR. Tao, Liu, Huang and Tam (2011) also used this method and they consider lifesaving value as 2,54 USD million and avoided injury benefit as 0,45 USD million. Since, social loss because of traffic accidents is related to the real GDPper capita, I took the ratio of GDPper capita of Turkey and Hong Kong and found the value of 0,434. Then, I multiply this value with lifesaving value and avoided injury benefit. Therefore, for Turkey I calculated lifesaving value as 1.1 USD million and avoided injury benefit as 0,45 USD million. According to Turkish statistics Institution, annual number of people died and injured are 7.300 and 303.812 respectively. Also, because table 4.8 shows all accidents in Turkey, to estimate accidents between Ankara-Istanbul, I took ratio of distance between Ankara-Istanbul and all roads in Turkey and I found the value of 533km./242.590km.= 0,002. Therefore, annual social benefit and safety improvement calculated as,

0,14x(7.300x1.100.000USD+303.812x200.000USD)=9.630.936.000USDx0,002

=21.160.348USD

Cost-benefit analysis method is generally used before the starting of the project or the decision making stage of the project. However, in some reports or articles this method also used to measure the efficiency and to measure social benefits of the project. For Ankara-Istanbul HSR case, 2016 data taken into account for the measurements and calculations. The launch date of the project is July, 2014 and this study was conducted during the spring of 2018. Most of data related to the project was available only until the end of the 2016. 1,5 year passed after the start of the project.

Therefore, we can conclude that, under the lights of the calculations above Ankara-Istanbul HSR project cannot be considered as economically sustainable. Future social benefits are observed as quarter of the investment expenses which are considerable amount in the budget when we compare to other ones. Therefore, the net social loss as $2.820.332.441,05 calculated by excluding cumulative present value of social benefit which is $1.268.621.155,70 from cumulative present value of total cost which is -$ 4.088.953.596,75. Therefore, we can conclude that within the 40 years the project cannot recover its costs while taken into consideration ticket revenue, travel time saving, pollution reduction, reliability improvement, safety improvement factors.

On the other hand, there are still potentials and challenges that cannot be observed such as being located at the key position as increasing accessibility between Europe and Caucuses and Middle East and East Asia. From this point of view and as a result of the research, this project will provide economic development and advantage among the international arena to Turkey.

Chapter 6

Conclusion and Recommendations

Investing in a fast train is an important social decision. One of the biggest disadvantages of HSR is great investment expense. However, government authorities should focus not only on monetary expenses, but also on the possible positive effects on public. HSR can provide some social benefits in matters other than ticket revenue such as, time travel savings, pollution decrease, reliability and improved security. In this article, the cost-benefit analysis of the Ankara-Istanbul HSR line has been made. Net Present Value (NPV) of -$4.089 million, proves that the expenses of the Ankara-Istanbul HSR investment will stay higher than its benefits and the calculation, showed that its investment is affordable. In addition, other appropriate transport options (such as current highway and traditional railways) are examined and compared with the HSR investment. Especially, due to the flexibility of the highway transportation and closeness of Istanbul airports to the city center and fast check-in services of airline companies make makes other transportation mode more preferable comparing to HSR. As a result, HSR cannot be considered as economically sustainable way between the three options listed above for intercity transportation between Ankara and Istanbul.

Steps that makes this project more efficient are to finish suburban railway construction and to create reliable links between inner-city subway lines and HSR line. In addition to these works, also construction of Ankara HSR Station should be finished. Moreover, this inefficiency results gives opinion that because the HSR between cities in Turkey that has most interaction between them is not sustainable, HSR line between other cities in Turkey has high possibility to be also not inefficient. Therefore, cost-benefit analysis should be conducted for other lines to demonstrate the efficiency.

On the other hand, there are some unevaluable benefits of this kind of investments that is bought by increasing accessibility, such as creating new business fields and improvement of interconnectedness with neighboring countries. Therefore, it is obvious that to increase the efficiency of the Ankara-Istanbul HSR, improvement of operability of international railway lines is important and taking responsibility as a country in the international transportation initiatives such as TRACECA and BRI. .

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