Independent Final Report

Development of Bullet Train in India using Shinkansen Model

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Certificate

I, SHARMA Divyank (Student ID 52117009) hereby declare that the contents of this Independent Final Report are original and true and have not been submitted at any other university or educational institution for the award of degree or diploma.

All the information derived from other published or unpublished sources has been cited and acknowledged appropriately.

SHARMA Divyank

2018/11/26

Acknowledgment

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Abstract

The Independent Field Report is about the bullet train project in India. Indian Railways is the third largest network in the world. Britishers has started Indian railways 172 years ago, so it is a quite old railway. It's still run on the system installed by the Britishers which needs upgradation to keep the pace of the economy. The maximum speed of the passenger train in India is 160km/hr while the average speed is 55km/hr. Only 45% of the tracks of Indian Railways are electrified rest still run on the diesel engine.

To upgrade current rail networks and development of Shinkansen (Bullet Train) is very essential for the Indian economy. The Japan government is agreed for technology transfer of Shinkansen and making bullet train line from Mumbai to Ahmedabad. Japan government is also providing a soft loan of Rs 88,000 crores ($13.6 billion) to start the process which will lead the development of the region as well as the setting up of new manufacturing industries. It will create a highly skilled and trained work force.

The research question is Does the high-speed railway make a financial return? We can do comparison analysis with the high-speed rail project in different countries of the world to analyse this question. The other question is Does the high-speed rail make a social return, including quantified impacts on the air, road transport and wider economic benefits? This question helps us to figure out the other benefits which high-speed rail will provide to the economy and society.

In this Independent field report a Qualitative research method is used to describe why and what are problems, difficulties in implanting this project in India. The source of the Qualitative data is from secondary data, which includes company annual report and observations from the official websites.

Abbreviation

TWD- Taiwan Dollar

ICE- Inter City Express

LCC- Low Cost Carrier

NHSRC- National High Speed Rail Corporation

TGV- Train à Grande Vitesse

IR- Indian Railways

UIC- International Union of Railways

SNCF- Société Nationale des Chemins de fer Français

AVE- Alta Velocidad Espanola

KTX- Korea Train Express

THSRC- Taiwan High Speed Rail Corporation

JR- Japan Railways

INR- Indian Rupees

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Chapter 1. Introduction

Indian Railways (IR) is a national rail transport which is controlled and operated by the government of India. Indian Railway is the third largest railway network in the world comprised of 119,630Km of total tracks (Indianrailways, 2018) . It operates 13,313 passenger trains daily and carried more than 22 million passengers a day (Indianrailways, 2018). The Britishers has started the railways in India 172 years ago, which make it one of the oldest railway transports across the world.

The Indian Railways still run on the British system. It is divided into 17 railway's zone, which are further sub-divided into divisions so, in total there are 68 divisions. 94% of the entire track is broad gauge track. The maximum speed of the passenger train in India is 160km/hr while the average speed is 55km/hr (Indianrailways, 2018). So, India needs bullet trains to keep pace of its economy. The existing railway structure is quite an old and less updated structure. Only 45% of the tracks of Indian Railways are electrified rest are still running on diesel engines. (Indianrailways, 2018).

To upgrade current rail networks and development of Shinkansen (Bullet Train) is essential for the Indian economy. The Japan government is agreed for technology transfer of Shinkansen and making bullet train line from Mumbai to Ahmedabad. Japan government is also providing a soft loan of Rs 88,000 crores ($13.6 billion) to start the process (Mohan, 2018). This will lead to the development of the region as well as the

setting up of new manufacturing industries, which will lead to job creation. It will create a highly skilled and trained work force.

Shinkansen is an environment friendly technology and pollution caused by it is ¼ of a plane and below ⅓ of a car. But, the fare of Shinkansen is a major concern factor for this project. The average airfare on Mumbai to Ahmedabad route is Rs2000-Rs3000, but Shinkansen fare would be around Rs5000. So, it is almost double fare than airfare on that route. People in India are mostly price oriented and if the ticket fare is so high then people would adopt any other source of transportation. In other words, India really need this project now or they first upgrade their current railway structure with half of the money which is sanctioned for the Shinkansen project.

1.1 High Speed Rail Definition

According to the UIC (International Union of Railways), high speed rail defined as the combination of the rolling stock, infrastructure, equipment and operating conditions as mentioned below:

i. Rolling Stock: Trains should run above 250km/hr in the newly constructed tracks and in upgraded rail tracks above 200km/hr.
ii. Infrastructure: A special high-speed rail track should be constructed or upgrade the conventional tracks for high-speed rails.

iii. Equipment & operating condition should ensure quality and safety of the high-speed rail network (UIC, 2018).

1.2 Why India needs High-Speed Rail Network

India's fastest train runs at the speed less than 200 km/hr which makes the journey time much longer. There are many challenges which Indian railway is facing to improve its railway infrastructure. Around 40% of the existing tracks needs to be upgrade. These tracks carry 80% passenger traffic of Indian railways (Guruswamy, 2015). One fourth of the 131,000 railway bridges are over 100 years old (Guruswamy, 2015). Most of the maintenance and operational work still does by man. To make the efficiency in the work and to boost the speed of the train automatic signals as well as track crossings is required.

There are many countries like Japan, France which opted all new high-speed rail network to avoid delay, congestion and accidents. But German high-speed rail (ICE) using the existing tracks to run (Annu, 2015). This causes Intercity Express (ICE) to miss it potential top speed. High-speed trains need dedicated rail tracks with a minimum curve radius of 4km (Annu, 2015). The high-speed rail tracks required tunnels and no road crossing. This makes the cost of the project costlier.

Indian railways use the broad-gauge line of 1676mm whereas the other nation uses 1435mm gauge line. If India needs to adopt foreign country high-speed technology, it

should make the brand-new high-speed infrastructure. In the current scenario of the Indian railways it is impossible to run the high-speed train.

Country	Railway Body	Gauge
Japan	Shinkansen	Standard 1435mm
Germany	ICE	Standard 1435mm
France	TGV	Standard 1435mm
South Korea	KTX	Standard 1435mm
India	Indian Railways	Broad 1676mm

Table 1: Track Gauges for High Speed Railway (Miura, 1998) (Annu, 2015)

The signal system in the Indian railways depend upon the sighting the track signal while the Shinkansen, ICE, KTX etc others high-speed railways uses the cab signalling method which is more efficient. The Shinkansen uses the most advanced method which is the combination of wireless, magnetic and track circuit system (Annu, 2015). Signal jump is also one of the common reasons for the train accident in India. The key post of signalling and track maintenance workers is still vacant (Guruswamy, 2015).

The Indian railways uses vacuum brakes in each train bogie along with dynamic brakes. If there is faulty hose pipe, it leads to an accident. The Shinkansen, TGV, ICE and KTX trains uses the dynamic disc braking system (Annu, 2015). The dynamic disc brake provides more control, efficiency and less stoppage time as compared to the braking system used by Indian railways.

1.3 Test on High-Speed Rail Investment Viability

According to Preston, before making an investment in the high-speed rail there are various approaches by which we can analyse our investment. Like in China, the government followed make it and watch approach. With this approach, the government has developed high-speed network in the country irrespective of the demand (Preston, 2013). Preston suggests a four-stage test for high-speed rail investments.

1. Does the high-speed railway make a financial return?

   It is very important that the project should be financially viable to continue its operation. Till now very less high-speed rail projects are financially viable, for example Japanese Tokaido Shinkansen from Tokyo to Osaka and French TGV Sud-Est from Paris to Lyon. In China, only one route from Jinan to Qingdao among others is making a profit. The number of passengers using high-speed rail service is more than 20 million per year. Infrastructure and rolling stock need huge investment which would take a longer time to get financial returns.

2. Does the high-speed rail based on rail transport benefits only, make a social return?

   According to the Gines de Rus and Nash, the basis of social break-even approach assumes if the high-speed rail gets 9 million passengers per year it will pass the benefit cost ratio (BCR) of 1. But, all high-speed rail doesn't require a pass mark of 1 like in the United Kingdom due to constrained budgets it is 2 and in Germany it is 3.

3. Does the high-speed rail make a social return, including quantified impacts on the air, road transport and wider economic benefits?

Economic benefits can be seen in the United Kingdom in HS2 case. But, it requires modelling for the entire transport system for estimating these benefits. There is some uncertainty about labour market connectivity and supplier-consumers connectivity.

4. Does the high-speed rail make social returns while qualitative wider benefits are considered?

   In the case of Spanish high-speed rail in the initial years, the annual passengers using the service was 5 million per year but shows negative social return. But in contrast to that, the high-speed rail in Spain helps to modernize the economy and to develop advance technology.

Concluding Remarks

This introductory chapter explains about the definition of the high-speed rail and why India needs this project. Rapid industrialization, old railway tracks, manual signalling system, over crowded railways, old railway technology etcetera are the reasons why India need this project. But, the investment for the bullet train project is very high. The four-stage test for high-speed investment which was discussed in this chapter helps to explain its wider benefits and role.

Chapter 2. Literature Review

There are many cases of the High-speed railway network in the world which are running in profit or covering operational cost. (Kurosaki, 2014) states that in Japan, the Tokaido line from Tokyo to Osaka is making profit rest other JR lines like Tohuko line, Kyushu line and Sanyo lines are covering only operating cost not the capital cost. In Taiwan, the government is hugely subsidizing the railways to make it operational. China, which has the largest number of high-speed tracks in the world also has very less routes which are financially profitable.

(Kurosaki, 2014) in his paper explains about the operational and financial aspects of the high-speed trains which leads to my first research question that "Does high-speed rail makes financial return". This can be explained by studying various existing Indian Railways structure and the ongoing high-speed railways network in the world which (Annu, 2015) (Udayakumar, 2016) explains in their works.

The high-speed rail projects are primary for fast and easy transportation. But these investments also serve social return like (Okada, 1994) in his paper explains about the social returns of the Shinkansen on Japanese cities. The Shinkansen project in Japan attracted many investments to the areas which are either close to the Shinkansen line or accessible through Shinkansen. This leads to generation of new jobs, boost in the tourism and hospitality sector. (Indianrailways, 2018) In India, the Indian railway is making a social return on the investment by connecting rural areas to the main cities. This helps in

employment generation, reduction in urbanization and infrastructure upgradation. This study lead to my second research question that “Does the High-speed rail based on rail transport benefits only, make a social return”.

Apart from the social return which high-speed rail project makes, it also helps to improve the overall transport system. Due to the increase in connectivity to the cities by high-speed rail network the demand also increased which results in reduction of the fares among other mode of transport (Alejandro Ortega Hortelano, 2016). The reduction of the fares results in the economic benefits for the customers. This study helps to explain the third research question of this report “Does the high-speed rail make a social return including impacts on air, road transport and wider economic benefits”.

There are many advantages to invest in the high-speed rail networks. India is a big country which needs high tech infrastructure to meet its current growth. According to (Rus, 2012) there are numerous benefits of investing in the high-speed railways. Due to high frequencies of the trains, there will be a huge time savings. High-speed trains help to reduce congestion on roads which result in less accident. It also helps to decrease the greenhouse gases emission to the environment. There will be an increase of market share and revenue for the rail operators. The high-speed rail network area results in increase of taxes generation, high properties rate, less unemployment and other social returns. This study helps to answer the last research question of this report “Does the high-speed rail make social return while qualitative wider benefits are considered”.

(Guruswamy, 2015) Explains the financial requirement to modernize the infrastructure of Indian Railways. He points out the current infrastructure of the Indian railways, the challenges which the current system is facing and the new bullet train project with the Japanese partnership. It includes automation of the signalling system, electrification of the tracks, upgradation of the train coaches and infrastructure of the railway stations. Due to manual signals, the accident rate of Indian Railways is very high which include derailment and collisions. But the Shinkansen has zero record of accident rate from which Indian railways can learn. This could be done through technology sharing process.

(Udayakumar, 2016) In his works figure that, to develop a bullet train network in India is very complex, as India is a developing country. The main concern is about funds, it can be better utilized in other ways like upgradation of current railway structure. Although the Japanese government is funding 80% of the Shinkansen project but it has many complexities like land acquisition and environmental issues.

This project will connect the most populous city of India, Mumbai to the seventh populous city, Ahmedabad. The length of this corridor will be 500km and it will help to boost the economic and industrial development of that region. It will reduce the journey time from 8hr to 2hr. This is the first phase of the bullet train project which will finally connect Mumbai with the national capital New Delhi.

(Okada, 1994) Explains about the benefits and social effects with the Shinkansen project. He also compared the environmental benefits of the shinkansen among other means of transport. There were many challenges which Japan had faced in making the

shinkansen route. Along with the transportation business, JR companies earn more profits from the other business which include station lease, rent, hotels, advertisements, etc. Shinkansen also helps to improve the area and to generate new employment.

(Preston, 2013) In his work describes about various high-speed rail projects in the world like Shinkansen in Japan, TGV in France, AVE in Spain, ICE in Germany. It discusses the objective of high-speed train, which is different in different nations.

1.1 High-Speed Rail Network Objectives

There are many objectives behind the launch of the High-speed rail network in the country. Many developed countries as well as developing countries have high-speed railways. Mostly the government in that countries want high-speed rail network for the economic as well as industrial growth. High-speed rail network is also environment friendly and helps to increase occupancy in the public transport. The various objectives of the high-speed train in different countries is shown in the Table below.

	Japan	France	China	Italy	United Kingdom	Chinese Taipei (Taiwan)	Spain	India
Speed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capacity	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Reliability				Yes	Yes			
Economic Development			Yes		Yes	Yes		Yes
Environment					Yes			
Supply Industry	Yes	Yes	Yes				Yes	Yes
Prestige		Yes	Yes	Yes			Yes	Yes
Political Integration			Yes				Yes	Yes

Table 2: High-Speed Rail Objectives in Different Countries (Preston, 2013)

The high-speed railways have direct competition with the air transport in speed and capacity. The average speed of the high-speed trains is 250km/hr, which makes it comparable to the flights if we calculate the city centre to city centre travel time. The speed and capacity factors are one of the main reasons to build Tokaido Shinkansen (Okada, 1994). In other HSR operating countries speed, and capacity are the vital reason to start high-speed services.

Before the Shinkansen launched the capacity of the route from Osaka to Tokyo was overloaded. It was difficult to introduce new trains on the existing tracks which leads to create a brand-new track for the high-speed rail network (Okada, 1994). But Intercity

express (ICX) high-speed train in Germany still using the conventional rail tracks for its operations. In India, 80% of the train traffic load is carried by 40% of the total tracks which leads to the only option of building new tracks for high-speed railways (Guruswamy, 2015).

The dedicated passenger rail service which has on-time performance and reliability is the vital motivation in the United Kingdom and Italy for helping to replace market for old trains operating on conventional lines (Preston, 2013). The high-speed railways also contribute to the economic development of the countries. It can be seen in all countries which has high-speed rail network. It can be seen in Japan that the Shinkansen helps to boost the adjacent area economy where it passes. Industries can become assessable and easy to do business as it is located near the Shinkansen station. There is a boost for local tourism near the places on the Shinkansen route (Okada, 1994). In Chinese Taipei, the Shinkansen helps to connect the capital city with the rest of the country which helps to boost domestic trade as well as connecting under developed areas of the country (Shima, 2007).

China connects all major city with the high-speed rail network which helps various Chinese cities to get economic advantages. Earlier only big cities in China has these advantages. High-speed trains help to connect labour markets in the country. It also connects supplier and consumers which helps to improve the national economy (Preston, 2013). The average price of the land also increases by coming of high-speed rail. The rent business in the station helps to increase the profit of the high-speed rail companies.

Environmental objective is also an important objective of high-speed rail. The high-speed railway networks run on electricity while automobiles, ships and aircraft emit harmful

emission to the atmosphere. Due to rise in global warming the transport objectives of the developed nations are to use the eco-friendly mode of transport (Preston, 2013). High-speed railways provide the best alternative to reduce emission of greenhouse gases. The United Kingdom (UK) government has a transport policy which aims to cut carbon dioxide gas emissions (Preston, 2013).

Japan already have the experience of running Shinkansen technology for more than 50 years without any accident. France also developed high-speed rail technology, which help these countries to export its technology to other nations. Chinese Taipei's high-speed train technology is based on Japanese Shinkansen (Shima, 2007).Japan also won the contract from the Indian government to make high-speed train in the country (Guruswamy, 2015). France helps South Korea to build KTX high-speed trains. China is the world largest high-speed rail operator, and it is exporting rail technology to Thailand, Malaysia (Liang, 2017).

The project prestige is one of the objectives of the government to push the high-speed projects in the country. In China, it was included in the Five-Year Plans of the government (Liang, 2017). The Spanish government also used political integration to make high-speed rail network in the country (Preston, 2013). The Indian prime minister also promises before election to run a bullet train in the country. He promised in the election manifesto about it (Guruswamy, 2015). The bullet train project in India connects Mumbai to Ahmedabad the home state of the prime minister. To gain the political gains in the country the high-speed rail is the objectives for the government.

2.2 High Speed Train Projects in Different Countries

I. Japan

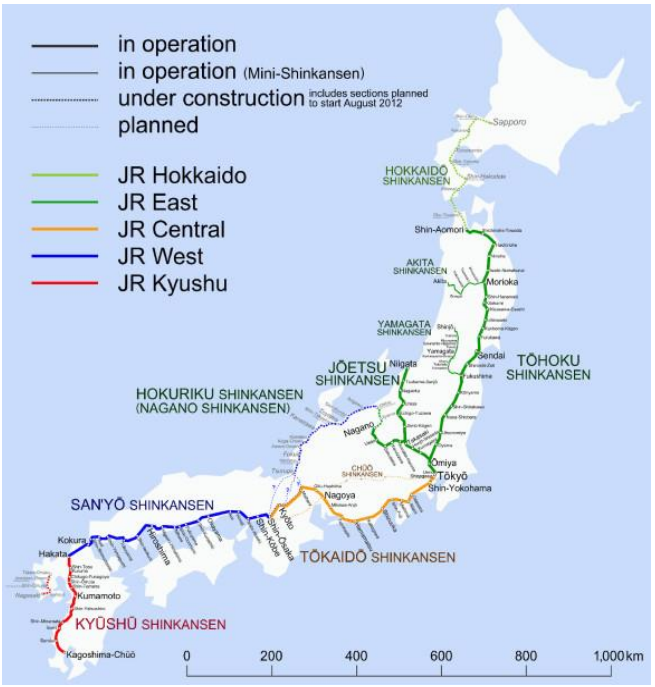
In Japan high speed trains known as Shinkansen which connects capital city Tokyo to the other main cities of the country. The first Shinkansen started in 1964 between Tokyo and Shin Osaka, which is known as Tokaido Shinkansen is 515.4km long (jr-central, 2018). This route passes through highly populated and developed area of Japan. Due to different broad-gauge lines used in the Shinkansen network, some of the cities got the new station like Shin Osaka as it was difficult to connect the main station. However, the main city station has well-connected accessibility to the Shinkansen station.

In 1987, the Shinkansen network was privatised from Japan National Railways with the formation of JR Group (Okada, 1994). The Shinkansen network uses the 1435mm standard gauge railway line for the efficient run. Earlier Japanese railways were using 1067mm narrow gauge line. In narrow gauge line high speed and efficiency is not possible (Miura, 1998). Since 1964, the Shinkansen has the zero fatality record and injury to the passenger onboard (jr-central, 2018).

The Shinkansen can help to reduce air pollution as it produces only 16% of the amount of passenger car produces (Okada, 1994). The Japanese Shinkansen has an annual average delay of 0.2minutes per operational train in FY 2015, which include uncontrollable delays caused by natural disasters (jr-central, 2018). Other reasons like

suicides, heavy snow also causes delay in the service. In FY 2016, 420 million passengers used the Japanese Shinkansen (Ministry of Land, 2018).

Figure 1: The Shinkansen route of Japan



Source: (Hisagi, 2018)

Cost:

1. High construction cost of building a new Shinkansen line which is around 20-30.9 million euro per route km (Kurosaki, 2014).
2. Less availability of space in the cities for new stations and tracks.
3. Noise and vibration sound of trains
4. Less excited market except Osaka to Tokyo route.

Benefits:

1. Highly efficient and on time performance
2. Have social return on places near shinkansen route
3. Zero fatal accident record and

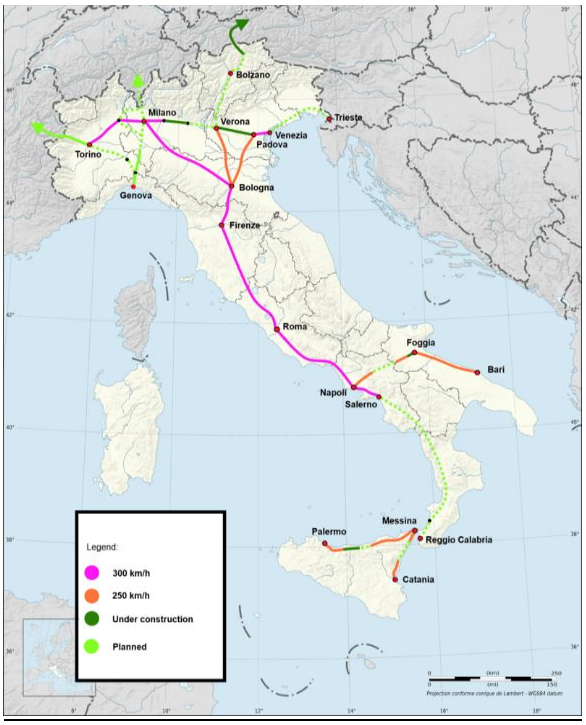
4. Made financial return on short routes

II. Italy

In 1977, the first high-speed rail lined opened in Italy which connects the capital city Rome to Florence (railwaygazette, 2007). The top speed of the train is 300km/hr, which runs between Rome and Milan. The government owned Trenitalia and privately owned NUV are the two rail companies which do operations in the high-speed railway network in the country (Paolo Beria, 2016). High-speed railway network of Italy is shown in the figure 2.

The competition between the two rail companies help to improve the service. This causes an increase in the passenger ridership and decrease in the train fares (Crozet, 2013). There is huge corruption in the project allocation and construction in the proposed railway projects. It suffered from increase in construction cost and project time delays (Locatelli, Mariani, Sainati, & Greco, 2017). Both high speed as well as normal trains runs on the same track.

Figure 2: The High-speed rail route of Italy



Source: (Sinigagl, 2018)

Cost:

1. High corruption in making high-speed rail lines
2. High infrastructure maintenance cost per km which is around 1 million euro per year (Kurosaki, 2014)

Benefits:

1. Well connected with the European high-speed rail network
2. Making social return and have quantified impacts on other mode of transport
3. Economic benefits such as decrease in the fare

III. France

France national rail operator SNCF operates the high-speed rail service which is called TGV. SNCF started working on the high-speed rail project in 1966. After the 1973 oil crisis, SNCF involved electric trains in the project (Crozet, 2013). In 1981, the first high-speed rail opened which runs between capital city Paris and southern city Lyon. It covers the distance of 460km (Crozet, 2013).

The TGV trains of France has a zero fatal accident in their operational history. TGV trains are using electromagnetic impulses which are transmitted by tracks. It guides the driver of other trains to slow down their speed or if the driver doesn't respond it reduces the train speed automatically (Gruere, 1989). TGV train have the record of the world's fastest train in 2007 on the LGV Est, LGV Rhin-Rhone and LGV Mediterranee line (railwaygazette, 2007).

The high-speed rail project is considered among the high priority projects in the country (Crozet, 2013). TGV lines also connect France with other European countries. It directly connects to Italy, Germany, Luxembourg, Spain under the TGV line (sncf, 2018). It connects with the United Kingdom by Eurostar train service and to Switzerland by TGV Lyria in 3hrs from Paris (tgv-lyria, 2018).

Figure 3: The TGV route in France

Source: (Economist, 2017)

The design of the TGV trains helps them to keep the zero fatal accident rate. In case of derailment the train coaches remain upright (Gruere, 1989).

Cost:

1. High cost of making new high-speed rail lines around 4.7-18.8 million euro per km (Kurosaki, 2014)
2. High operating and infrastructure maintenance cost
3. Difficulties in finding export market for high-speed train technology, so less qualitative wider benefits

Benefits:

1. Highly reliable and efficient
2. Zero fatal accident record
3. Fastest trains in the Europe and well connected to other countries

IV. Germany

The high-speed train service in Germany is known as ICE (Intercity-Express). It started its operations on June 2, 1991 between Hamburg to Munich. ICE trains use the existing as well as new track lines for its operations (railway-technology, 2018). The InterCity Express trains (ICE3) runs at a maximum speed of 320km/hr (railwaygazette, 2007).

The railways of Germany are well connected with the other countries of Europe like France, Switzerland, the Netherland, Belgium, Denmark and Austria (eurail, 2018). The ICE trains are very convenient to commuters as they are using the same railway station (Crozet, 2013). The cities of Germany are not too far from each other, so the ICE trains are used for short to medium distances (Crozet, 2013).

But, on June 3, 1998 the ICE884 train derailed and crashed onto a bridge. The train was travelling at 200km/hr and it caused the death of 102 people. The accident was caused due to the internal cracking of the wheel ring of the train (Brumsen, 2011). This causes the negative image of ICE in comparison to others European railways companies like TGV which has zero fatal accident record (Brumsen, 2011).

Figure 4: ICE route in Germany

Source: (eurail, 2018)

Cost:

1. Huge investment is needed to make a new rail line in Germany
2. Difficult to build a new infrastructure at existing places
3. Accident causes bad reputation of the train in Germany

Benefits:

1. Well connectivity within the country and to other neighbouring cities
2. Runs on the existing rail tracks, so making a financial return
3. Less operating cost and have social returns

V. Spain

The high-speed train in Spain is known as Alta Velocidad Espanola (AVE), which is operated by Spanish national railway company Renfe. AVE runs up to maximum

speed of 310km/hr (railwaygazette, 2007). Spanish high-speed rail network is the longest in Europe while second in the world after China (Udayakumar, 2016). The signal system, infrastructure and track maintenance work are managed by other company, Renfe Operadora (Paolo Beria, 2016).

Spain also uses the traditional standard gauges to run the High-speed trains. In 2013 RENFE recorded surge in riders as well as in profits with the introduction of market-based fare structure system (Alejandro Ortega Hortelano, 2016). Occupancy is increased by 12% and ridership by 23.4% annually from February 2013 to February 2014 (Alejandro Ortega Hortelano, 2016) (eurail, 2018).

But, the AVE in July 2013, derailed near Santiago de Compostela railway station. It causes death of more than 79 people. The driver didn't decrease the speed of the train on a curve which caused an accident (cnn, 2013).

Figure 5: AVE route in Spain

Source: (eurail, 2018)

Cost:

1. History of accident in Spanish high-speed rail
2. High infrastructure and operational cost
3. Based on rail transport benefits only

Benefits:

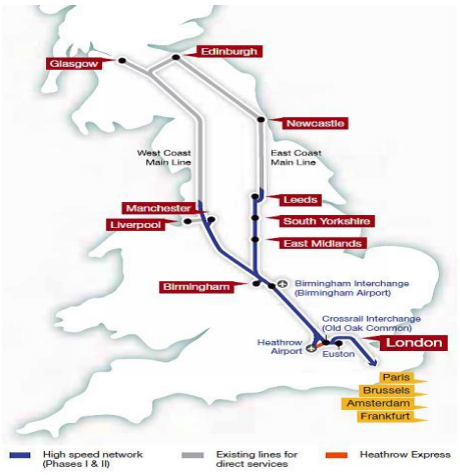
1. Longest network in Europe
2. Runs on existing tracks which covers financial return
3. Well connected to the major cities

VI. United Kingdom

The first high-speed train in the UK opened in 2003 with the opening of the tunnel under the sea. The train connects London with the rest of Europe. The Channel is 37.9km under the sea which is longest in Europe. The Eurostar provide daily service to Paris and Brussels from London (Dumitrache, 2010). The maximum speed of the train inside the tunnel is 160km/hr (Dumitrache, 2010).

The other cities in the United Kingdom is still not connected with the high-speed railways. There is a proposal to connect London with Manchester and Birmingham by high-speed trains.

Figure 6: high-speed rail route in United Kingdom



Source: U.K. Department for Transport

Cost:

1. High infrastructure cost will limit this project to small section only
2. Less demand for high-speed train in UK

Benefits:

1. It is well-connected to the other European countries
2. Eco-friendly project
3. Have qualitative wider benefits include environmental benefits

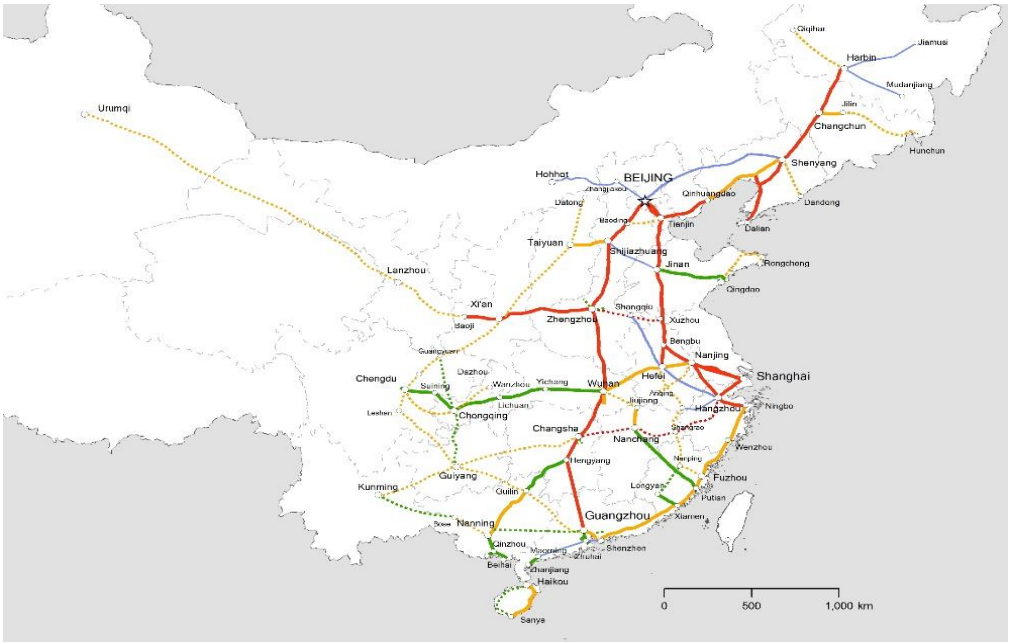
VII. China

China has the world's largest network of high-speed trains in the world. In the year 1997, the government started the railway upgradation campaign which was aimed to improve the speed of the trains and upgradation of the railway structure in the country (Gerald Ollivier, 2014). China's high-speed trains runs on Maglev (magnetic levitation)

technology. The trains running on Beijing to Tianjin have the speed of 350km/hr (ChinaTrains, 2018) (Gerald Ollivier, 2014).

China invested heavily in renovation of conventional rail lines, newly constructed passenger lines and high-speed rail lines. Two-third of the world's high-speed train network is in China (Barrow, 2018). The length of the tracks of high-speed rail is more than 19,000 km (Gerald Ollivier, 2014).

Figure 7: High-speed rail network in China



Source: (Gerald Ollivier, 2014)

With the help of the transfer technology, China is leading market for the high-speed trains. The technology transfer agreement with Siemens, Kawasaki Heavy Industries and Bombardier help China to locally manufacture the high-speed trains (Kanwal, 2018). Some trains are even capable of reaching up to 380km/hr (Kanwal, 2018). The rail network covers 29 out of 31 China's provinces. The high-speed rail put a huge impact on domestic sales of China's air carriers (Liang, 2017).

But in July 2011, the Chinese high-speed train met with an accident that killed 40 people and injured 191. Design flaws was the reason for the crash of the train (Simpson, 2018). This accident resulted the decrease in the speed of the trains.

Cost:

1. Less profitable routes of high-speed rail
2. Accident made bad image of Chinese technology
3. Difficult terrain

Benefits:

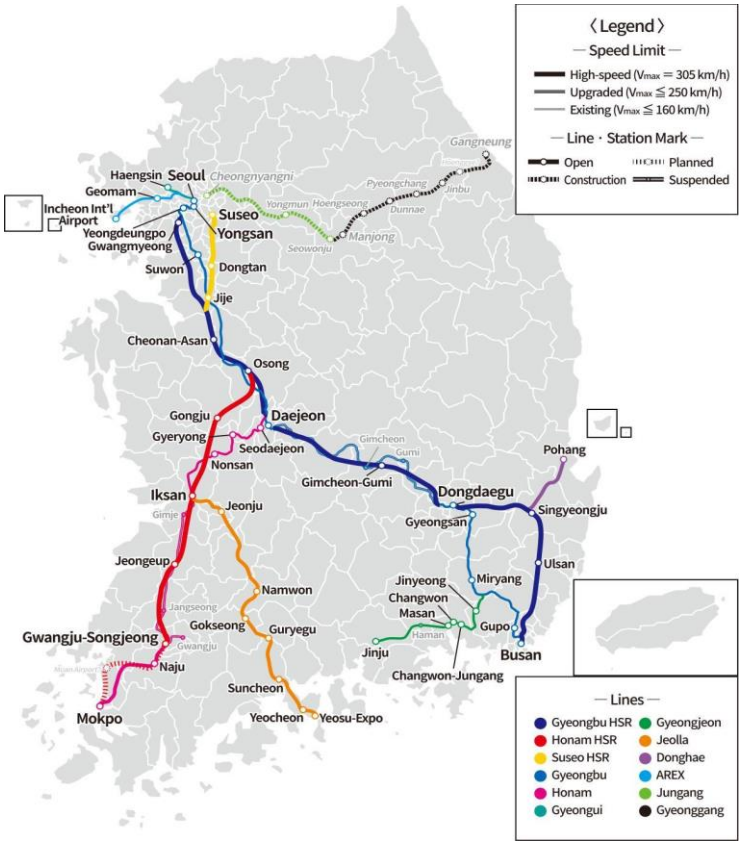
1. Transfer of Developed technology
2. Largest infrastructure of high-speed rails in the world
3. Eco-friendly and Fastest train in the world
4. Less infrastructure and operational cost

VIII. South Korea

In South Korea, the high-speed train is known by Korea Train Express (KTX). The state-owned company KoRail operates the South Korean high-speed rail KTX. In 1992, the construction began on 423 km long track from Seoul to Busan high-speed rail line which was launched on April 1, 2004 (Udayakumar, 2016). Korea Train Express runs on both newly-constructed track from Seoul to Dongdaegu as well as on the existing track which is from Dongdaegu to Busan (Udayakumar, 2016).

In the year 2004 to 2005, the average daily air passenger on the domestic routes of Seoul-Busan and Seoul-Deagu reduced 36.6% and 78.7% respectively (SUH, 2005).

Figure 8: KTX route in South Korea



Source: (Korea-train-map, 2018)

The Korean high-speed train based on the French technology.

Cost:

1. Expensive infrastructure cost
2. Less passenger traffic on the long routes

Benefits:

1. Runs on the existing tracks as well
2. Get developed French technology
3. High social return like Seoul is well connected to the whole country

IX. Chinese Taipei (Taiwan)

In January 2007, the high-speed train starts its operation which connects the capital city of Taipei to the southern city of Kaohsiung. It is based on the Japanese Shinkansen technology supplied by Kawasaki heavy Industries (Shima, 2007). Taiwan High Speed Rail Corporation (THSRC) is a private company which operates high-speed trains in the country. It helps to facilitate 90% of the population in the country (Shima, 2007).

Taiwan High Speed Rail Corporation suffered a loss in the early years of the operations due to high depreciation charges and tight financial conditions (Zhao, 2015). The company has given a huge tax to the government for its operations. Under the terms and condition THSRC had to pay the minimum of 108 billion TWD and pre-tax profits to the government (Zhao, 2015).

Figure 9: THSRC network in Chinese Taipei (Taiwan)

Source: (googlemap, 2018)

The Taiwanese government increased its stake in THSRC from 37% to 64% as a financial bailout (Zhao, 2015). The Taiwan high-speed rail effects domestic airlines. In January 2007, the air passenger dropped by 24% to 31% (Shima, 2007). The punctuality of the Taiwanese high-speed train is over 99% (Shima, 2007).

Cost:

1. Financial not viable as government is giving subsidies
2. Less passenger occupancy in the trains
3. High infrastructure cost of around 40 million euro per km (Kurosaki, 2014)

Benefits:

1. Eco-friendly
2. Cover the whole country from north to south Taiwan include wider benefits other than transport
3. Zero fatal accident rate of Taiwan high-speed train

Concluding Remarks

Second chapter has the research paper and the journal of various authors which help us in understanding the detailed view of this topic. There are various objective of the high-speed rail project which includes economic development, environment, industrial supply etc. which helped to implement this project in various countries. It helps us to analyse this project in different conditions and locations. The third chapter explains the data collection method and methodology.

Chapter 3. Research Methodology

In this paper, we are going to discuss the feasibility of the Shinkansen project in India. Although it has many advantages like:

- ✧ It is funded 80% by Japan Government at the interest rate of 0.1% only.
- ✧ The Shinkansen has a record of zero fatalities.
- ✧ An average delay of less than a minute
- ✧ It will reduce travel time from 8hr to 2hr.
- ✧ It will generate employment
- ✧ The technology transfer of Shinkansen will help India to develop it nationally.
- ✧ It is very convenient with a frequency of 1 train every 8 minutes.
- ✧ It is energy efficient and eco-friendly.

But India is a developing country where people are more concerned about the ticket price. The fare of Shinkansen will be more than airfare on that route so, may be the government would provide subsidies to run that project.

In this paper, we do comparative analysis between the operations and profits of Japan Railways under which shinkansen runs and Indian Railways under which new bullet train will run. Although Indian railways have large number of consumers, but the average consumer spend in travelling in trains is much less than Japan. There is a huge gap between per capita income of India $1680 and Japan $38000 (World Data bank). By implementing this project India will get the technology, but high train speed project is not very successful in many countries like South Korea, France.

But, at this time India will need investment in their railways which is very old and by getting Shinkansen technology, it will boost its economy like Shinkansen is doing to Japan. But the Indian railways must plan for getting the alternative revenue like Shinkansen. It is very difficult to get revenues only from the fares. The current revenue from non-fares of Indian railway is less than 5% while the world average is 10% (Indianrailways, 2018). The various revenue sources other than fares can be:

- Advertisement in commercial spaces, trains and stations.
- Leasing of the Indian Railway property which is present in the centre of the city
- Building hotels, restaurant and shopping malls in the stations
- Use of barren land in farming along the railway tracks
- E-auction of the railway tenders

Chapter 4: High-Speed Rail Benefits and Costs

The high-speed railway needs huge infrastructure which require separate division to manage the high-speed rail network. It can be seen in Japan as the different regions has different rail companies which manage rail operations like in the southern island of Japan, JR Kyushu is operating the high-speed rail (Shinkansen).

	Cost	Benefits
Rail Operator	Infrastructure Cost Operational Cost	Revenue increase Get grants & subsidies from government
Users	High fares	Easily accessible Fast & On-time service Comfortable journey Less security checks
Other Transport Users		Less traffic on roads and air services.
Transport Operators	Revenue Loss	Less investment on HSR routes

	Cost	Benefits
Government	Subsidies Grants Tax loss	Prestige Political Integration
Society	Noise Pollution Land Acquisition	Eco-friendly

Table 3: Cost & Benefits of High-Speed Rail (Preston, 2013)

The operators of the high-speed railway enjoy benefits from government in the form of grants & subsidies. In Chinese Taipei, the government eased the financial conditions to make the company sustainable in the business of running high-speed railways (Zhao, 2015). France and Japan have used the all new infrastructure for the high-speed trains which results to high infrastructure cost.

There are many operational benefits of operating high-speed rail like getting grants & subsidies from the government (Preston, 2013). Fare revenues will be the key benefit from high-speed rails. The fares of high-speed rail are generally higher than conventional trains. Rent and advertisements are the other source of income for high-speed rails. In Japan, the station developed like a city centre which included shopping malls and hotels that provide rent to the high-speed rail operator (jr-central, 2018).

The fares of using the high-speed trains are higher than using the normal trains. But it is lower than full carrier airfare (not LCC) in most of the cases. In India, fare cost factor is one of main reason to oppose high-speed rail project as airfare on that route is cheaper (Dhar, 2017). But there are many advantages of using high-speed rail to the users. The train station is highly accessible mostly in the centre place of the city which saves the time to board the train. There are less security procedures compare to airports in the train stations. The frequency of trains is high which help to board it easily.

Mostly the high-speed trains on-time performance rate are very high. Japanese Shinkansen has the operational time efficiency of more than 99% (jr-central, 2018). There is no direct tax for using rail service while we have to pay toll tax for using expressways. In India there is a special tax in air travel also (Airindia, 2012). High-speed railway helps to reduce congestion on other means of transport. The high-speed rail route resulted huge dip in the passenger volume for other mode of transport like in China, Japan and Chinese Taipei the domestic airlines volume decreases (jr-central, 2018) (Shima, 2007) (Liang, 2017).

The benefits for the other transporters that they should invest less on the high-speed rail routes. It can help airlines to use slots for long-haul flights rather for short-haul flights. It helps to reduce the air traffic on congested airport hubs. There is a smaller number of directly competing airlines which helps remaining airlines to earn profit (Preston, 2013). Without government grants and subsidies, the high-speed rail project in some countries is not profitably viable. In Chinese Taipei, the government decreases the tax and increases

the contract period for the Taiwan High Speed Rail Corporation (THSRC) to continue its operation (Zhao, 2015).

India is financing 81% of it project from Japan and the government would provide huge subsidies in the Shinkansen fare to meet the local conditions. It would be the one of the cheapest high-speed fares in the world (Guruswamy, 2015). The government will earn prestige by launching a high-speed rail network in the country. As high-speed rail network is the symbol of development in the country. The Indian prime minister promises to build bullet train in the country in his election manifesto which helped him to get votes (Guruswamy, 2015).

Noise pollution and vibration generates by high-speed rail are the main concern factor for the society and environment. The high-speed trains running at 300km/hr produces vibrations which is the concerned factor for nearby places. The noise pollution is the main challenge in developing an upgraded model of high-speed trains (N.I.Ivanov, 2017). To make a new high-speed rail corridor land acquisition is required, which is difficult in some countries like India. The rail operator requires to spend a huge sum of money in the land acquisition process.

The high-speed rail network is environment friendly technology as it runs on electricity. It has a positive contribution to the society by controlling air pollution. The

other mode of transport like automobile, aircraft releasing harmful emission in to the atmosphere.

Cost and Benefits of Bullet Train on India

1. Rail operators:

   The current rail operator of the Indian Railways is a government operated railway company which runs passenger as well as freight trains all over the country. To make an infrastructure for the bullet train, Indian railways need huge capital which Japan government will provide (Annu, 2015). Bullet train don't run on the existing tracks and infrastructure, so operating as well as maintaining cost required which relates to first stage question by (Preston, 2013).

   The benefits of implementing this project is that it will increase the revenue of the Indian railways. It will give the access of the bullet train technology, which will further be used for domestic production. New direct and indirect jobs would be created. There would be a rise in the earning of the rail operators by leasing and renting options on the stations. Easy to get the subsidies and grants from the government.

2. Users:

   The bullet train fare is the major concern for the Indian railway passengers. The normal trains are one of the cheapest modes of transport in India (Indianrailways, 2018) but bullet trains are expensive to cover its financial

return. But it has many benefits for the users like high frequency of the trains, on-time service, less security checks and zero fatal accident record. The bullet train service has wider economic benefits which (Preston, 2013) explains in his third stage question.

3. Other Transport Users:

   This project will decrease their market share and reduction in their profit (Locatelli, Mariani, Sainati, & Greco, 2017). Less congestion on the roads, flights are the benefits.

4. Transport Operators

   Normal Indian railways trains would lose their passenger that will upgrade to the bullet trains. This result in the revenue loss for Indian railway. The benefits would be to do less investment on the high-speed rail routes.

5. Government

   Indian government going to spend 19% of the project amount while Japan is providing a soft loan of $13.6 billion (Kanwal, 2018). To make this project attractive and viable government will give grants and subsidies. There are political benefits and prestige issues from this project. The government will try to get social return and wider qualitative benefits which (Preston, 2013) explained in his 3rd and 4th stage question.

6. Society

   The land acquisition problem is the major concern for this project. India has different laws in different states which would make it tougher to acquire land (Guruswamy, 2015). The noise pollution and vibration of the bullet trains are major concern for the society. The bullet train is the eco-friendly technology which help to control emission of harmful oxides into atmosphere. This project will create the infrastructure in the area, new job opportunities and investment on social return which (Preston, 2013) explained in his works.

Concluding Remarks

The chapter 4, explains about the cost and benefits of implementing Shinkansen project. The effect will cover not only on users but also on rail operators and government. This chapter enlightened various issues like land acquisition, track, fare structure, etc. which bullet train would face in India. More detail about this topic is explained in the next chapter.

Chapter 5: Issues of Bullet Train in India

There are various issues which National High-Speed Rail Corporation (NHSRC) would face to develop bullet train in India.

I. Bullet train route

There are six potential corridors for the high-speed rail network in the country which include all major cities of India. NHSRC has already prepared the route in which bullet train will run. It will connect Mumbai to Ahmedabad which would be the 508km stretch and have 12 stations. It will reduce the travel time from 8hrs to 2hrs. Due to high political interference, there would be more demand for intermediate stops which would increase the journey time.

The high-speed train is more viable in short journey like 500km. It starts losing the customer share for long distances. Like, Shinkansen has more passenger share in Osaka to Tokyo route than Fukuoka to Tokyo route (jr-central, 2018). So, Mumbai to Ahmedabad is the part of the Mumbai to Delhi route which might get stiff competition from airlines.

II. Technology Partner

There are many countries like Japan, France, Germany, Spain, China etcetera which has the experience of successfully operating the high-speed trains. But, among that the Japanese technology is the fastest, reliable and safest. The Japan has zero record of accident in operating high-speed trains (jr-central, 2018). The Japanese companies won the contract to build the first project of high-speed rail which will connect Mumbai to Ahmedabad 650km and reduce travel time by 6hrs (Guruswamy, 2015). To giving contract to other countries can cost Indian Railways technical issues. It is mandatory that there should be only one system with the same standards. In India, railways use broad gauge 1676mm track, while the high-speed railways using standard gauge 1435mm (Miura, 1998).

Indian railways have a poor record of safety and every year 25,000 people dies in the rail related accidents (Guruswamy, 2015). The feasibility report of Mumbai to Ahmedabad route has recommended ERTMS level second signalling as well as operational connectivity the existing rail network (Udayakumar, 2016). The Indian railways lags an emergency plan for natural disaster including earthquake.

III. Station Location

India is a densely populated country which has a station in every part of the city. So, to make a bullet train station we have many options. The first option is to use the existing

city centre station, the second option is to use the newly built station at the outskirt of the city and third option is to use the existing station at the outskirt of the city.

The first option which is to make the high-speed station at the city centre provide maximum accessibility to the passengers. But, it's difficult to construct a high-speed rail station at the city centre in India. There is less land available at the main station and further land acquisition & construction is difficult there (Udayakumar, 2016). To connect the outskirt city station with the city we need feeder buses, metros or local trains. The outskirt station helps to reduce the burden on the main station.

IV. Structure of the Track

There are less terrain and sea on the proposed Mumbai to Ahmedabad route. So, grade level track is the best way to save the project cost. In India, the land acquisition law is very strong, which make it very difficult to acquire land. This is one of the main reasons for the delay of the project (Mohan, 2018). The grade level track needs fencing cover which increases its construction cost.

The elevated track is the best option for laying high-speed tracks. This would help to solve the road crossing issues as well as land acquisition issue. The elevated track helps to increase the speed and decrease the chance of an accident (Udayakumar, 2016). The population density, topography of the area matters the structure of the track. The underground track is only viable in high population density area or sea. It is decided that

92% of the route will be elevated, 6% through tunnels and 2% on the level track. (Mohan, 2018)

V. Revenues

The bullet train project cost about 14.7 billion US dollar and it's necessary to earn revenues to make this project viable. The ticket price of the high-speed railway is the important factor in getting the number of passengers in the bullet train. Government subsidies and grants are helpful in attracting passengers to use this service, but it will increase the burden on the government. In 2021, 12 million passengers are estimated in Mumbai to Ahmedabad route according to the pre-feasibility report. The economic internal rate of return on the project is expected to be 12.8%. Return on investment is expected to be less than 1% in the first fiscal year of 2021 (Udayakumar, 2016). The report shows that it required at least 50% government subsidies to run a viable unit. India per capita GDP in 2020 would be same as Japan's GDP in 1965 (when Japan started first Shinkansen) (Udayakumar, 2016).

The JICA (Japan International Cooperation Agency) will provides 80% funding of this project at 0.1% interest rate with 50-year loan repayment period. But on the conditions that India must purchase 30% Japanese equipment (Guruswamy, 2015). The Indian government bears the remaining 20% of the project cost.

VI. Stock

Indian railway is using 1676mm broad gauge while the Japanese high-speed rail using the standard gauge 1435mm. If India will adopt the standard gauge, it cannot use the conventional rail tracks for high-speed trains. In Germany, Spain and Japan, high-speed trains also run on the conventional lines (Preston, 2013). The current railways of India are highly packed and overburdened so it will need all new dedicated infrastructure for the bullet trains.

5.1 Shinkansen Model of Japan

It can be seen in many projects of the high-speed rail that the number of passengers varies according to the distance between their destination. In the short distance journey, the high-speed rail seems to be a better option. We can take an example of Japanese Shinkansen, if we can compare the travel time from Tokyo to Osaka which is 552.6km away it will take 2hr 22min by Shinkansen and 2hr 40min approximately by air (if we include transfer and access time from city centre to the airport). Due to the city centre station advantage to Shinkansen the airline operates less than half the number of Shinkansen in this route. In this route Shinkansen has the clear advantage.

Tokyo (operating Km)		Osaka (552.6km)	Okayama (732.9km)	Hiroshima (894.2km)	Fukuoka (1174.9km)
Travel Time	Shinkansen	2hr 22min	3hr 9min	3hr 44min	4hr 46min
	Airlines	1hr 5min (approx. 2hr 40min)	1hr 10min (approx. 3hr)	1hr 20min (approx. 3hr 10min)	1hr 35min (approx. 2hr 50min)
No. of services & departure /arrival per day	Shinkansen	250	128	99	67
	Airlines	108	20	34	110

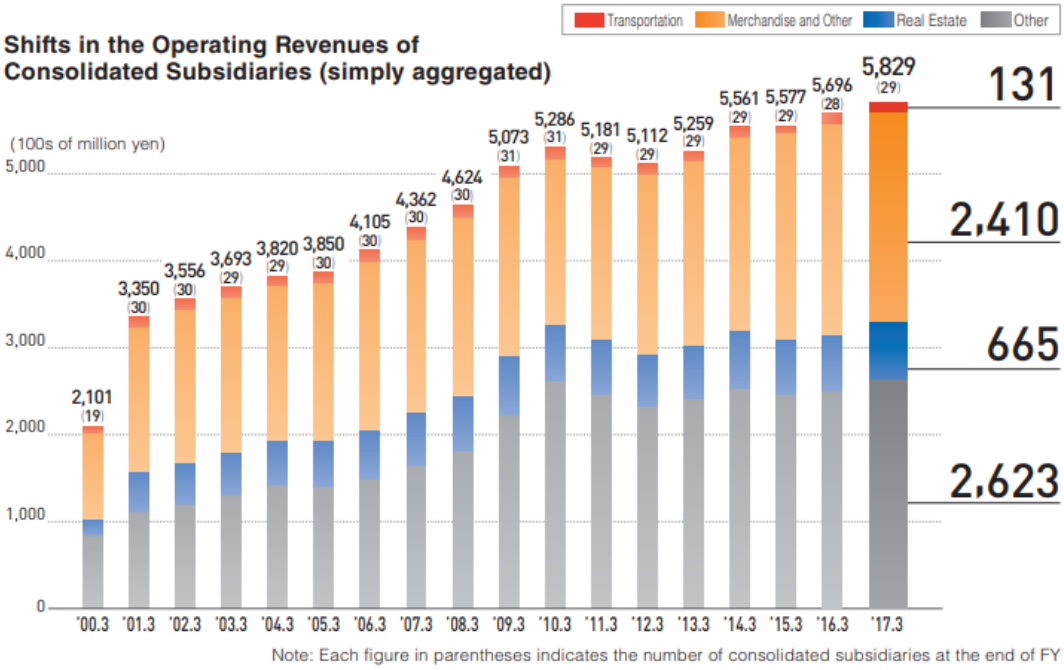
Figure 10: Comparison of Tokaido Shinkansen with Airline Service

Source: (jr-central, 2018)

From Tokyo to Okayama which is 732.9km, Shinkansen has an advantage as it takes 3hr 09min while airline takes approximately 3hrs. Shinkansen operates more than six times that the number of flights on that route per day. In this route, Shinkansen has a slight advantage than flights. From Tokyo to Hiroshima, the Shinkansen will take 3hr 44min while the aircraft will take 3hr 10 min approximately. The number of flights per day is one third of that Shinkansen service per day. In this route, the airline has a slight advantage than Shinkansen.

If we travel from Fukuoka to Tokyo, which is 1174.9km long it will take 4hr 46min by Shinkansen and 2hr 50min by plane to travel. The number of flights on that route is double of that Shinkansen operated per day. In this route the airlines have the clear advantage.

Figure 11: Revenues Share of JR Central Group



Source: (jr-central, 2018)

The figure shows the JR Central Group business in the field of transportation, merchandise and other, real estate and other. In FY1989, the revenue of the group was 52.6 billion yen & in FY2016 it reached 582.9 billion yen. In 1989 the JR Central group had 3 companies and now it has 29. Only from the transportation business it is not financially viable to run the entire business.

If we analyse the JR Central group, the operating revenues comes from four segments. First is the transportation segment which compose of train and bus business. In FY 2017, the transportation segment contributed 13.1 billion yen revenue and had a 2.24% profit share. Second is the merchandise and other segment which operates

department stores in the station premises. It also provides goods and food in the trains and stations. It has contributed 41.3% profit share in FY 2017. This segment provides huge potential in earning revenues because of the prime location of the stations in the city centres.

JR Central group has the real estate business which contributed 66.5billion yen revenue in the FY 2017. Under this segment of business, the company develops commercial facilities at stations and under the elevated tracks like parking spaces etcetera. It has contributed 11.4% share of revenues in FY2017 while in FY2000 it had contributed less.

In the other segment, the JR Central group earns the revenue from the advertising business, managing hotels, travel agencies. The company also manufacture, repair and inspect the new rolling stocks in the railway facilities.

Cheapest flights - November 2018 Mumbai to Ahmedabad						
Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
			1 1563 INR	2 2522 INR	3 2724 INR	4 2136 INR
5 2136 INR	6 2366 INR	7 1627 INR	8 1780 INR	9 2260 INR	10 3144 INR	11 4255 INR
12 3564 INR	13 3577 INR	14 3144 INR	15 3564 INR	16 3144 INR	17 3144 INR	18 3144 INR
19 1936 INR	20 1936 INR	21 1627 INR	22 1936 INR	23 1627 INR	24 1565 INR	25 1627 INR
26 1627 INR	27 1565 INR	28 1565 INR	29 1565 INR	30 1565 INR		

Table 4: Airfare Chart of the Month from Mumbai to Ahmedabad

Source: (MakeMyTrip, 2018)

The figure shows us the airfare cost from Mumbai to Ahmedabad for the November 2018. The cheapest airfare in this month is just 1562 INR (Indian Rupee) and the highest is 4255 INR. It states that the proposed bullet train would have very stiff competition from the air carriers on that route. If the bullet train project wants financial return, the project should expect revenues other from transportation.

The other mode of revenue for the Indian Bullet train would be the advertisement, which plays an important role in earning extra revenues for the company. The prime location of the railway station is helpful in attracting customers. The Freight generated the highest revenues for the Indian railways in the past. It accounts for 65% in the revenues for the Indian railways while advertisement accounts only 3% in the revenues. Other coaching earning which includes luggage & parcel transfer contribute 2.5% in the revenue share.

We cannot use high-speed train corridor in India for freight purposes. The upper-class passengers have 8.5% share in the Indian railway revenue. The upper-class passenger in the Indian Railways would be the easiest target for the proposed bullet train. To increase the revenue share, the proposed Indian bullet train should follow Japanese Shinkansen model. Shinkansen model generates their revenue mostly from the side business other than transportation.

It would be better for the Indian high-speed train project to consider other sources of revenues to make this project financially viable. The real estate business or rent business at city centre stations can earn huge profit as we had seen in the Shinkansen model.

Concluding Remarks

Chapter 5 explains about the issues which the bullet train project is facing in India. These issues can be solved if we implement the Japanese shinkansen model. Shinkansen model has many advantages which will help Indian bullet train project to succeed. The Japanese government will also transfer the shinkansen technology which would help India to fully explore this technology.

Chapter 6: Conclusion

Indian Railways is the lifeline for the growing Indian economy which will need essential inflow of advanced technology to carry out its operations. It really helps to boost the Indian Railway infrastructure after the agreement signed between the Indian and Japanese government for making the high-speed rail project. This project will use the Japanese Shinkansen technology which has a zero accident fatality record. The bullet train project has many challenges in India for its operations.

India is a democratic country, so the land acquisition law is different in different areas (states) which make it difficult for the administration to acquire the proposed land under one law. The bullet trains will get the competition from the existing trains, airlines, and even buses. The main challenge of this project is to overcome its financial operations. The expenditure forecast of the Shinkansen project is very high and to overcome that expenditure the fares of the bullet train will even exceed the normal rail fare, and even airfare on that route as explained in the report.

The transfer of the shinkansen technology to India would be the best advantage for Indian railways. This will help to further use this technology domestically as well as exporting to other nations. It will help to create new jobs, market and improve the infrastructure in the country. To make the project financial operational in the long run, the Indian Railways should opt the Japanese Shinkansen model which generates most of

the revenues from other sources like rent & lease, advertisement, shopping malls, etc. The railway stations in India is located in the prime location of the city. To generate the revenues from the other sources will help this project to fulfil the financial obstructions.

Apart from the financial challenge, the bullet train project has the challenge to meet the target for the passengers who will use this service. Indian passengers on that route have many options which are cheaper, quicker, so it will be the challenge for the authority to positively implement this project by using a Japanese model of Shinkansen.

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