

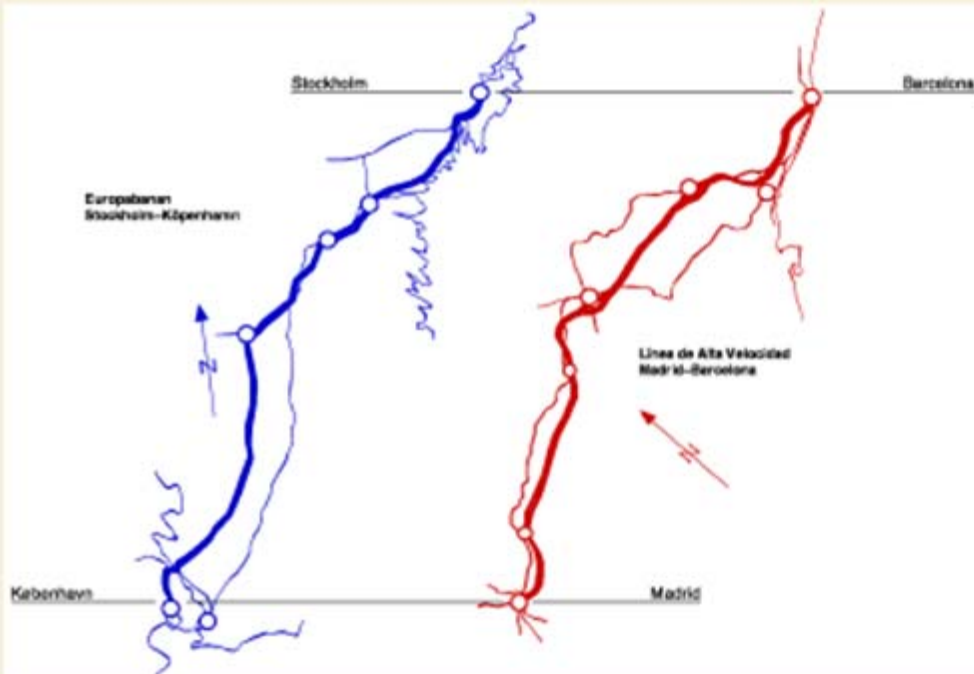
Comparison of High-Speed train market between Spain and Sweden

Madrid-Barcelona vs Stockholm-Copenhagen

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COMPARISON OF HIGH-SPEED TRAIN
MARKET BETWEEN SPAIN AND
SWEDEN:
MADRID-BARCELONA VS STOCKHOLM-
COPENHAGEN

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Foreword

This thesis is the result of my research work as a part of my university education in order to achieve the degree in Civil Engineer. The work was carried out from September 2010 to May 2011 at the Division of Transport and Logistics of the Royal Institute of Technology (KTH) Railway Group, in Stockholm.

I would like to express my sincere gratitude to my supervisor Oskar Fröidh for his advice and guidance along the thesis work, as well as to the rest of the research team for their help, especially to: Bo-Lennart Nelldal, Anders Lindahl and Josef Andersson. I would also like to express my gratitude to Spanish teacher Armando Ortuño for his help and inspiration during my work.

I would like to thank my family, friends and boyfriend for their support through this year in Sweden from Spain, as well as my home university Universidad Politecnica de Valencia (UPV) to let me study abroad and live a fantastic Swedish experience. Finally, thanks to the new people I have met during this year for all their company, who have become friends.

Stockholm, May 2011

Marta Martinez Camara

Summary

In this work, several aspects have been studied and compared between Spain and Sweden in what respects to planned and existing High-Speed (HS) line, respectively: Stockholm-Malmö/Copenhagen and Madrid-Barcelona AVE.

Population aspects have been studied with the result of a big difference between both corridors; however, it has been also found out that the impact of the lower populated Swedish cities along the corridor is not as negative as it is expected because of the regional and medium distance service that the new HS line will provide. In relation with the economic aspects, although indexes like GPD and income per inhabitant are similar along both corridors, the service sector is more developed along the Swedish HS line. This results in a better predisposition of the Swedish regions to take advantage from the HS.

On the other hand, it has been realized a study about the Spanish AVE supply along the corridor, analysing it from before the HS starts up to nowadays, paying special attention to its competition with the plane. According to the studied data, the high speed became the railway from an obsolete mode of transport into a competitive one along the corridor, competing directly versus the plane.

The research about the previous situation of the Spanish corridor before the HS and the research made on the Swedish current scenario, involving the reason that brought Spain to the construction, have been analyzed and concluded that the picture in both countries was and is different between each other; both in the previous conditions of the track and the supply intentions toward the future.

Both in the Spanish and Swedish corridor, a comparison based on the transport variables: cost, time, accessibility, comfort and frequency have been done attending three different passenger profiles: business, leisure and low-fare. The results from the Swedish cases: current line and future HS, show some changes of the different modes suitability, where the train goes from the second place to the first one.

Besides, a simple accessibility analysis on the southern main Swedish railway line has been carried out in order to see how the HS will change accessibility. They show that the line will reinforce the north/south connection and substantially increase the accessibility in some regional centres. Finally, in order to complete the future impact of the high speed in Sweden, several international experiences from well established high speed lines have been gathered and compared with the Swedish scenario.

1. Background

Since the starting of the development of high speed trains (HST) over Europe, many countries have reached an extensive rail network: France (1,872 km in 2010), Germany (1,285 km in 2010) and Spain (2,200 km in 2010); even more, at the beginning of 2008 there were around 10,000 km of HST line in operation over the world (Campo, J. 2009; De Rus, G. 2009). HST is considered by politicians like an investment to develop the country, get better connexions and offer a better supply of train service.

More in detail, Government in Spain has a very ambitious plan and compromise of building a bigger HST network in the future: with 2,200 km of HST lines constructed, in ahead of countries like France whose HST network has always been a reference; and the compromise, as a part of the Strategic Infrastructures and Transport Plan PEIT, that at the end of 2020 Spain will have 10,000 km of High Speed Line. In other words, every provincial capital will have a connection with the HS line, what involves that 90 per cent of the population will have a High Speed Station closer than 50 km.

In Sweden, there is no similar plan but there are some initial plans for constructing HS railways. The future HS railway is been studied¹ under the premises of improving the supply along the two most important corridors in Sweden: from Stockholm to Malmö/Copenhagen and from Stockholm to Göteborg. For this matter, the track will consist in three parts: one main common track from Stockholm to Jonköping and two branches from there, one to Göteborg and another to Malmö/Copenhagen.

In 2008 the existed Madrid- Barcelona HS line was completed. It has been decided to compare this HS line and the Stockholm- Malmö/Copenhagen HS line due to the similarities that exist between the lines. Sweden and Spain have a similar location in respect to the European Continent; they are both peripheral areas to the core of EU, what makes them to have a good transport system to let them establish relationships with others continental countries. Both lines have about 600 km length and although cities population differs from one line to the other, being more populated cities along Madrid-Barcelona line, the lines link large regions. There are also similar submarkets in between and an international market to France from Barcelona and to Germany from Copenhagen.

The construction of high-speed lines provides faster accessibility to cities that already had connection to conventional lines, as well as let the smallest cities in the line take advance of their faster connection to large cities, which becomes in a significant economical market

¹ High-speed lines in Sweden, traffic forecasts and socioeconomic calculations using the Samvips method for expanded main lines and separate high-speed lines. 2010. Traffic and logistics department, KTH, Stockholm 2010.

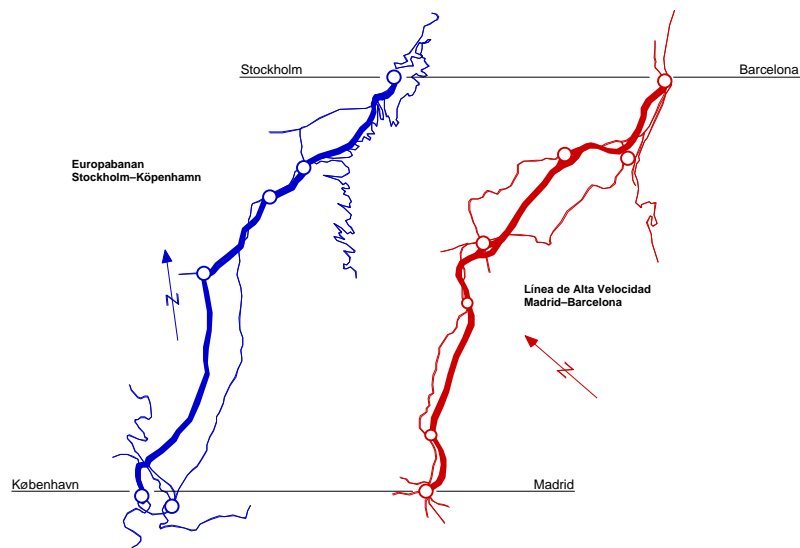
influence. On the other hand, in some cases, towns with no previous rail connection are included in the HST route, which create new opportunities for their development².

1.1. Aim

This thesis makes a comparison between the high-speed line in Spain: Madrid-Barcelona and the planned high speed line in Sweden: Stockholm- Malmö/Copenhagen. Basing on the comparison, the aim is to find out if the prerequisites of both lines are similar or different, and what could be learned of Spanish High-Speed experience for a possible Swedish High Speed line along the Stockholm-Copenhagen corridor.

The comparison will involve geographical aspects, population, economical aspects and passenger demand. In addition, a comparative study will be done about the decision process in each country and the reasons of the construction of the new line; as well as comment the investment in the Madrid-Barcelona line and how a similar investment could be taken on by Sweden.

Finally, as a part of the aim, and using the comparisons mentioned, it will be tried to find answer to the hypothesis presented in the next section.



Figur 1 Comparison of both HS routes³.

² Source: SOU2009:74

³ Nelldal, Bo-Lennart; Troche, Gerhard; Jansson Kjell. Europakorridoren, Ett bredband för fysiska transporter, Utbud, prognoser och samhällsekonomi. Reference: TRITA-INFRA 03-052 ISSN 1651-9051 ISRN KTH/INFRA—03/052—SE. Institutionen för infrastruktur, Kungl Tekniska Högskolan (KTH) Stockholm, Sweden.

1.2. HYPOTHESIS

In order to develop this project, some hypotheses have been established. Taking these hypotheses as a starting point, the following analysis will try to confirm or reject them.

Induced Demand

1. Line Madrid-Barcelona joins larger cities than Stockholm-Copenhagen -> more demand-> more journeys-> more benefits; what justify the huge investment.

Supply factors

2. Saving time will enable higher fares and/or higher demand.
3. The new travel time is determinant to build a new track: save of time.

Decision

4. The decision process in Spain is shorter.
5. Limited capacity in the existing track is an important reason for constructing the new HS line.

2. Method and delimitation

In the project, in order to reach the aim, a systematic investigation will be carried out studying the most important factors which affect a high speed line, making a comparison between the two lines under study.

Territorial aspects-comparison

It involves a comparison of the distribution of population along both lines and find out how this can affect to the demand.

Firstly, the population of the cities where the train stops as well as those considered under its influence will be compared. Apart from the cities, the population of the regions where the train passes through will be compared as well. The conclusion will bring up how the distribution of inhabitants along both lines is.

Secondly, a study about the population in the endpoint cities in important HS lines over Europe will be done. It will be studied the population in relation with the market share of each line in order to find out if it exists any relation between them.

Economy aspects

The economy will be studied starting with an analysis of the economic sectors and getting a productivity index of the influenced regions of both lines. The productivity index will be in consonance with the suitability of each region to take advantage from the HS.

In order to calculate the index, *Nelson method*⁴ is going to be calculated previously. With the coefficient from this method, the index will be calculated attending the different synergy of each sector (different weights will be used for each sector) in order to estimate the potential impact of the HS in each region. The weights have been chosen attending to different studies where it is shown that the previous situation before the HS appears influences on the possible changes that the train could bring (Feliu Torrent,J. 2008).

The service sector has been considered with a weight of 2 because of results from many authors (Ortuño A. 2009; Feliu torrent,J. 2008) that point out that the specialized cities in tertiary sector, especially high quality services, are the most likely to take advantage from the HS. Industry and construction service has been weighted with 1 because attending different

⁴ It lies on the establishment of grades of specialization on the base of how many times the percentage of employees in a sector is higher than the sum of the average and the standardize deviation of the group of regions.

studies it is only known that they have less synergy with the HS than the tertiary sector. Finally, the agriculture sector has been weighted with -1.

Besides the sector analysis, some rates like the disposable income and GDP per inhabitant will take part of the work because of their relation with the HS train market. Historically there has been a correlation between the demand of passenger traffic and freight and GDP (Baanister, D. 2001; Berechman, Y. 2001) and, apart from that, the supply must adopt a fare structure that is affordable for the middle income population in order to attract the required volume of passengers (Amos, P. 2010; Bullock, D. 2010; Sondhi J. 2010).

The values for the economy sector distribution will be got from the statistic institutes in each country, while the rates figure will be got from Eurostat. Eurostat gives the different economic index by using an artificial currency unit (PPS purchasing power standard) in order to make the comparison between different countries possible eliminating "the effect of the price level differences across countries created by fluctuations in currency exchange rates"⁵; therefore, these values will be used for the study.

Decision process and investment

A survey about these subjects will be carried out to define the way of proceed of each country, signaling the reasons that each country has in its argumentation.

On the other hand, there will be investigated the investment in the Spanish line case and the origin of different European funds.

Alternative modes of transport

A study of transport supply regarding the different modes of transport in each corridor will be done: private car, bus, and plane; comparing their travel time, price, accessibility, comfort and frequency. In addition, an analysis cost-time will be done once the demand market has been divided into three profiles of passengers: business, leisure and low-cost. The purpose is to find out which is the most suitable mode for each passenger profile along each corridor, base the study on the previous variables. The division of the market has been made based on the passenger profile that RENFE has studied on the line Madrid-Barcelona: person with university education (72%) who travels because of work (56,4%) or leisure and /or family reason (41,9%)⁶. Family reason can be identify with the low-cost profile.

In order to make a qualitative study of the modes of transport attending the previous variables, a *structuring travel standard* (Fröidh, O. Et al., 2009) will be done. A *structuring travel standard* is a measure of attractiveness of the modes of transport where different relevant factors are chosen to describe the transport supply. Once the factors are chosen: travel time, price, accessibility, comfort and frequency, it is need to decided what involves each one and the different levels of quality that the factor can offer to the passenger. This way, once the different levels are selected in each factor, the same scale is going to be ascribed regarding the

⁵ Eurostat < <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/>>

⁶ RENFE press release: "El AVE Barcelona-Madrid celebra su tercer aniversario con casi 17 millones de viajeros en todo el corredor". Madrid, 20 February 2011.

levels of supply: very favourable, in favour, indifferent, disadvantaged and very disadvantaged.

The variables have been chosen according to some researches that point out that those are the ones that can affect more on the market share between modes of transport. The travel time is the one with the most direct effect (Nelldal-Troche, 2001; Transek, 2002; Jorritsma, 2009); in addition, there could be changes on the market shares rail/air because of the variables: frequency, access time, price and service quality (Gleave 2006).

Up to now, it is possible to have a qualitative classification of the different modes:

EVALUATION OF TRANSPORT MODES ATTENDING DIFFERENT VARIABLES.

Once the qualitative analysis is done for each variable on every mode it is time to aggregate the effect of each variable on each mode attending to the different demand requirements of each profile. To do that, the quality classification will turn into numbers:

- Very favourable: 2
- In favour: 1
- Indifferent: 0
- Disadvantaged: -1
- Very disadvantaged: -2

When it comes to aggregate the effects and in order to take into account the synergy of the variables, there will be given different weights to the variables, also distinguish between the different profiles because each one has its own priorities and necessities when it comes to choose a travel mode.

The evaluation of the importance (weights: 0.5; 1; 2) of each variable for each profile has been made attending the priorities of each profile when it comes to travel.

- 0.5: the passenger is not enough sensitive to this variable changes.
- 1: the degree of sensitiveness relating to this variable changes is high.
- 2: it is a crucial variable when it comes to choose the mode of transport.

In order to attribute the weights to the variables for each profile, the decision has been made based on the different profile description in: the chapter 7.3 “*Differences between travel purpose and groups*” in “*Compendium in train Traffic Planning*” (Fröidh, O. Et al., 2009) and some of the conclusions about passenger behavior that appear along the work: “*Incidencia de las líneas de alta velocidad en el desarrollo del corredor Madrid-Castilla La Mancha-Comunidad Valenciana-Murcia*” (Ortuño A. 2009). The numbers that result from multiplying the classification (-2,-1,0,1,2) and the corresponding weight will turn into a final quality rank for each mode in each passenger profile: high, medium, low.

The final quality rank will show the competitiveness of each mode of transport along the corridor in relation with each profile.

Regarding the different variables, the time means the total travel time that the trip involves, taking into account waiting and commuting travels to the respective stations or airport, beside price makes reference to the total price that the trip involves. Accessibility can be seen as a

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proxy for measuring welfare, if we accept that the welfare of individuals is related with the ease which they can access essential services (HAY, 1993); in this case it involves the easiness to reach the departure point by the passenger. Comfort makes reference to the facilities that the passenger has during the travel time and, finally, frequency involves the number of journeys per day by each mode and the time in between them.

Coming back to the assignment of weights, in business travelers time and comfort have a weight of 2 because they usually have a tight schedule to carry out their purpose of the trip, and in addition, they work in average 25% of the travel time by train, and 14% by plane (Fröidh, O. Et al., 2009). Business travelers are not very sensitive to price variation (López Pita, A. 2001), that why it has been decided a weight of 0,5 to price in this profile. Regarding the accessibility, taking the airport as a reference, it is often the farther departure point from the city center, what means that you have to travel there by using another mode. The easiest, convenient way to reach the airport is the car or taxi, which normally have a lower time door to door and create less travel distortions; in this way, according to some passenger profiles of mainly business airports like Bromma (Stockholm), the passenger access to it by car or taxi principally⁷, so, it has been decided to attribute a weight of 1 to the accessibility because it is not a big issue for the travelers. Finally, due to the long distance between end points in both lines under study, when it comes to consider the frequency, the importance of it is that the mode can deal with peak hours (early morning and evening) with a good service and the appropriate frequency; that is why it has been assumed a weight of 2.

Leisure travelers require lower level of comfort than the previous ones, although they need space to leave their luggage, besides some are price sensitive and it can turn into a critical variable (Fröidh, O. Et al., 2009.), that is why comfort and price weight is 1. Relating with the time, some of this kind of passenger prefers long-distance bus travels in front of faster modes due to cost reason⁴, that is why the time has been valued with 1. As the time is not a priority for travel and these travelers are not held to a tight schedule, the accessibility and frequency have been valued with 0,5. Table 1

Variables	WEIGHTS		
	BUSSINESS	LEISURE	LOW-FARE
Time	2	1	0,5
Price	0,5	1	2
Accessibility	1	0,5	0,5
Comfort	2	1	0,5
Frequency	2	0,5	0,5

Table 1 Weights of the variables for each different profile.

Finally, it has been decided to create a third profile which includes the rest of the travel purposes as family reasons. It has been given more importance to the price (2) and the rest of

⁷Information obtained from the Passenger profile, Bromma Stockholm Airport available at: <<http://www.brommaairport.se/en/Bromma/Business--services/Airport-advertising/Passenger-profile/>>

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the variables has been valued by (0,5) because it is assumed that this kind of trips are not regular and the rest of variables are not essential when it comes to choose between modes.

Effects of the High Speed

The study of the effects of the High speed will be carried out collecting information from different researches about the influence of HS line currently running. It will be focus on the Spanish line Madrid-Sevilla and the French HS train TGV.

Apart from that, the suitability transport mode from the variable analysis along the Swedish corridor will be compared attending the current and HS line results; as well as carrying out an accessibility (travel time measurement) study along the Swedish corridor in order to find out the impact of the HS on it. The process to get the time matrix starts building a net with the cities involves and gathering the direct times between the cities that are directly jointed; the second step, to full fill the matrix, is carried out by “Floyd algorithm”, which finds the minimum time between two points in a net. Once the algorithm is run, the matrix is completed. The times considered are direct, so, the waiting times and connection time between trains are not taking into account.

3. Effects of the high speed

3.1. Introduction

Before starting talking about High Speed Lines it is necessary to describe which the complete definition of them is. According to the ANNEX I of the Council Directive 96/48/EC about the interoperability of the trans-European high-speed rail system, to delimit the high speed railway infrastructure characteristic and rolling stock are used, but also the compatibility of both of them. Regarding the High-speed line infrastructure, specially built lines must be equipped for speed equal or greater than 250 km/h, meanwhile upgraded lines must be equipped for speeds around 200 km/h. In the Directive it is also said that upgraded lines which have “special features as a result of topographical, relief or town-planning constraints”⁸ could adapt speed to the requirements of the route layout. In attention to the rolling stock, on new lines “it shall be designed in such a way to guarantee safe and uninterrupted travel at the speed of 250 km/h”⁸, letting speeds of over 300 km/h when the conditions are favourable. Meanwhile, on upgraded lines it shall be designed at a speed of the order of 200 km/h. In any case, the HST service must be the one that guarantee an excellent compatibility between rolling track and infrastructure⁹.

To sum up the Directive indications in speed ranges terms, less than 200 km/h corresponds to conventional lines, between 200 and 250 km/h to upgraded conventional lines and more than 250 km/h to high speed lines. Recently, the term “very high speed” is using to refer to those lines in which trains can run over 300 km/h. (Menéndez, J. M., 2005; Guirao, B., 2005)

Depending on the circumstances of each corridor, the governments have to decide how to improve their rail way network, either building new track or adapting the current ones; which is exactly the discussion that takes place in Sweden about the line Stockholm-Copenhagen.

Since the first HS train appeared for the first time in Japan in 1964 connecting Tokio and Osaka, many other countries have followed its trail, been the most relevant ones: France, Germany, Spain and China. As a result of the big expansion of the HS all over the world many authors have written about the territorial consequences as well as the economic and social impact of the new mode of transport. In attention to what Bellet (Bellet, C. 2000) says about the Spanish situation, the social-economic impact of the AVE depends on factors like the characteristics of the service supply, location of the station and accessibility to the rest of

⁸ Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system. *Official Journal L 235* , 17/09/1996 P. 0006 – 0024

⁹ Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system. *Official Journal L 235* , 17/09/1996 P. 0006 – 0024

the territory, characteristics of the territorial environment, socioeconomic and the local and regional agents strategies¹⁰.

The effect of the high speed that is easier to measure and the first that appears is the change in the mobility behaviour, since effects on the territorial structure, apart from been more difficult to measure, are related to changes whose pace is slower than those related to mobility and traffic (Plassard, F. 1990); the strategies that the city follows to receive the high speed are considered a leading role.

The following descriptions of different HS lines attending different studies will bring some conclusions about the impact of the HS. These conclusions can be used to define the possible impacts of the future HS line from Stockholm to Copenhagen.

3.2. Madrid-Sevilla

It was the first chosen route to construct a high speed line in Spain. Although it could seem less logic as the one that join Madrid-Barcelona, some factors turned it into the favourite option. Before 1986 to travel between these two cities by train involved to cover a large and indirect route along a single track, as International Relations Director of ADIF, Joaquín Jiménez, says “Technically, we were facing the most important bottleneck of the National railway network”, “this stretch was the one that, with the less investment, could have reduced drastically its distance with the highest number of passengers, building a new hole line which was not parallel to the current one”. In addition, the Expo’92, which took place in Sevilla in 1992, became into a time objective to finish the construction.

On the other hand, there were practical economic reasons to choose Sevilla as first destiny. That same year, 1986, Spain took part of the European Union, acceding to the European Fund that had to be earmarked for infrastructure development, and the Government decided to invest in Andalucia, a relatively poor region.

The line is 471 km long and its construction only took 6 year. Once the line was finish the travel were reduced up to 2 hours and 20 minutes, with an average speed of 250 km/h (Comín, F.; Martín, P.; Muñoz, M. ; Vidal, J. 1998), while in the previous year it was 6 hours. In a few time it turned into a crucial link for the economic development of the region.

The volume of passenger has been increasing since the start of the line, although the rate of growth has been different for each O-D. The most demanded stretch is the Madrid-Sevilla, with 2.243.255 passenger in 2002, twice the volume as it was in 1993. The railway increases its market share from 13% in 1990 to 41% in 2000 (Menéndez, J. M. 2005; Guirao, B. 2005).

The HS brought a considerable reduction of the travel time, but not in every city had the same impact. Regarding the intermediate stops: Ciudad Real (171 km from Madrid), Puertollano (209 km from Madrid) and Córdoba (345 km from Madrid), it can be said that the first two were better off with it than Córdoba. The reason was that these two cities had been excluded

¹⁰ The strategies can be resumed in: measures of plan, management and promotion. (Ribalaygua, C. 2006)

from the main communication routes in the XVIII century while Córdoba had always been part of it (De Ureña, J. M^a. et al.2005) In the same way, road communication is so much better in Córdoba with the highway than in Ciudad Real and Puertollano.

This means that the previous accessibility in the future HS stop city makes the HS impact effects inversely decreasing with it (Ortuño A. 2009).

The difference of size between cities and the different kind of opportunities in each one, jointly with the fast connection between them, make the cities take advantage of it. Big cities like Madrid offer small cities new markets of services, while small cities like Ciudad Real offers big cities a better quality of life under cheapest prices (Ortuño A. 2009).

From the experience of this line it is possible to notice that the prominence economic activity in the city can help or limit the impact of the HS. As in the conclusion extracted from studies on France lines, HS is more probably to be on the side of cities with a larger service sector than industrial cities (Bonnafous, A. 1987). This way, the economy activities in Ciudad Real are mainly focus on tertiary sector; the development of its University as well as residential developments have profited from the HS. On the other hand, the prominence petrochemical industry in Puertollano has not taken advantage from the HS. Apart from that, in the latest years, about a hundred of families moved out to Madrid or Ciudad Real followed by a decrease in trade and services (De Ureña, J. M^a. et al.2005).

The incidence of the HS in Puertollano is a practice case of the negative effects on the urban development and the economy of the cities with a low endogenous potential when it comes to an improvement of transport infrastructures. In the cities connected to the HS line, certain kind of activities can suffer as they are less competitive in their economy sector than in the line neighbor cities (De Ureña, J. M^a. Et al. 2005).

The city bonds between Ciudad Real and Madrid were tighter after the arrival of the HS. As the travel time was reduced until less than one hour, Madrid influence increase on Ciudad Real and its central role goes reinforced.

To summarize the experience of the Madrid-Sevilla, the conclusions that can be obtained are:

- The previous accessibility of the city has an important role in the impact of the new HS train. As long as the city was well connected either by train or road, the impact of the HS will be lower than in cities where the previous accessibility was poor. In the same way, a poor access by road to the city is more relevant than the previous train access.
- The difference sizes of the cities connected with the HS line makes the cities take advantage of the different kind of opportunities in each one.
- The productive specialization can explain the possible impact of the HS on the city. Cities with a high specialized tertiary service have more potential to make most of the HS in relation to those with prominence secondary sector.
- According to France authors, the connection in less than 1 hour to a big city can contribute to the decentralization of tertiary activities, and on the same way, the can become in the new cities of the future (Arduin, J. 1991).

3.3. France

The two first regions joined by TGV in France were the region of Paris and Rhône-Alpes, whose capital is Lyon, 409 km from Paris. The relation between them can be explained by the effects: contrast and centrality (Arduin, J. 1991).

The contrast makes reference to possible imbalance that the TGV could cause between the two different developed regions due to the fast connection between them (improvement in supply transport). However, the region of Rhône-Alpes could take the pressure and their business remained in the region.

The centrality makes reference to the central role that Paris exerts to the surrounded cities, and thanks to the TGV, the influence area extends forward; nevertheless, the central role of Paris in the region of Rhône-Alpes started before the TGV appeared (Ortuño A., 2009). Therefore, although the tertiary sector and important business in the region gained in value, the role of the TGV was secondary, under the prominence of the territorial organization.

Due to the proliferation of the railway HS net, the stations were set in many different locations. Many of them were set in the periphery of different size cities attending different reasons: because the central station of big cities could not hold any enlargement; to concentrate functions of communication and be a link up point around middle size cities; around small cities to try to improve the accessibility and attractiveness of the surrounded territory, besides the public pressure of those intermediate territories along main TGV lines. Talking about small cities, the city itself is the one that has noticed the improvement in accessibility but the TGV has not brought any other development to the regions despite the multiples promotion strategies the cities followed. Examples of those latest cities are: Vendôme, Mâcon and Le Creusot, with less than 50000 hab¹⁸.

The reasons why there was no proliferation of these cities were: the limited frequencies of supply, the stations were not well integrated in the local transport network beside the lack of inter-municipality relations; finally, the lack of attraction capacity of the cities, which were forced to attract activity without any urban or structure previous history (Facchinetti, M., 2005). The station resulted in just some new volume passenger contribution to Paris.

Other conclusions from the TGV Sud-Est are (Ortuño A., 2009):

- In those HS stretches with a travel time less than two hours hardly ever get passenger from the plane, their principal competitor is the private car.
- The interval between two and three hours of travel time is the threshold where the passenger are so sensitive to the gain of travel time and the TGV gain passengers from the plane and induction.
- From three hour of travel time there is no gain of passenger from other modes of transport and the new traffic is all induced.

Finally, some other conclusions attending mobility that the TGV has brought are (Ortuño A., 2009):

- Regarding the passenger choice of transport mode, the variable cost of the travel influences on it depending on the profile of the passenger. Business passengers are more concerned

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about the saving of time than to the price differences between modes. They are less sensitive to the price than passenger in leisure profile. (López Pita, A., 2001)

- Regarding the induction of passengers to the TGV, when it comes to business travelers it depends on the distance between O-D, frequency and price. On the other hand, for leisure passengers the induction has a market niche for longer distances than three hours and stays in destiny of two or three days. This way, the price is the prominence variable versus time C-C and frequency.

4. Territorial aspects, comparison of both areas

Both Sweden and Spain are two of the largest ten countries in Europe; meanwhile, Denmark is one of the smallest (Table3). They are located in the south and north side of Europe respectively; so, they have in common that they are in a peripheral location respect Europe (Figur 1).



Figur 2

This peripheral location makes them either being a strategic country, as Spain opens new windows to new markets: South America, North of Africa; or taking advance to expand their business power in Mediterranean Sea, Atlantic sea and Baltic Sea respectively, having a high quality business and transport relationship with the rest of Europe. The share of the shipping business in Europe is showed in the Table2.

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%	1970	1980	1990	2000
Atlantic Arc	12,4	11,4	12,9	16
Baltic Sea	6,7	5,8	6,2	7,1
North Europe	55,7	54,4	54,3	50,1
Mediterranean	25,1	28,3	26,6	26,4
TOTAL	100	100	100	100

Table 2 Shipping transport attending different geographical areas.¹¹

There is not such homogeneity when we talk about population, since Spain has five time more population (2009) than Sweden and 8,5 times more population than Denmark (Table3).

	AREA 10 ³ km ²	POPULATION (2009)	DENSITY /km ²
Spain	505	46,745,800	92,63
Sweden	450	9,340,700	20,76
Denmark	43	5,511,500	127,89

Table 3 Source: CIA World Factbook 2008

To be able to compare further on population in Spanish and Swedish, it is necessary to know which concept of population is going to be used in each country. In order to decide how to compare the population, the solution has been reached taking into account the area (km²) of each concept: region, city, län, tätort... choosing in each country concepts with a similar value area to result in a more reasonable comparison between each other.

Consequently, in the case of Spain, the used values are cities population and the concept of Tätort¹² will be used in Swedish population. Due to the fact that Tätort values are only available from the year 2000 and 2005, it has been decided to use values from 2005 both from Spain and Sweden.

Given that the line in Spain was not in service completely until 2008, 2005 is a good year to compare how the differences between the Spanish and the Swedish population are without the influence of the HS train. Even more, this comparison give us an idea of how the size of the cities in Spain was when it was decided to build a high speed train through them. For Spanish cities has been used the data from the national statistic institute on date 1st of January of 2006, to be able to be comparable to data from Swedish national statistics for 2005. In every comparison Copenhagen population has been included as it is the future end of the line.

¹¹ Fernando Gonzalez Laxe, University Institute of Maritime Studies. Universida de La Coruña, Spain Presentation at the 9th International Conference Cities and Ports. Lisboa, 5-9 Julio 2004 University Institute of Maritime Studies: New strategies of the port development in Europe.

¹² Tätort is the term used in Sweden, Norway, Denmark and Finland to define an urban zone with a minimum of 200 inhabitant and where the distance between the houses is less than 200 meters.

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In order to delimitate the area of study under the influence of the Spanish high speed line, I have chosen the influenced cities following the next criteria:

- Every city where the train stops: Madrid-Guadalajara-Calatayud-Zaragoza-Lérida-Tarragona-Barcelona.
- Each city that is a province capital and is situated no more than 100 km far from one of the previous cities in straight line; in addition, there must be a conventional train line connection between them: Ávila, Huesca, Segovia, Soria, Girona, Toledo, Logroño, Pamplona, Teruel.
- Each city that is a province capital and has connection with one of the previous cities by high speed line; moreover, it must be no more than 200 km far from it in straight line: Ciudad Real, Valladolid.

Since January 2009 Renfe has started running trains from different cities in Andalucía to Barcelona: Sevilla, Cordoba and Málaga. The purpose of this is to be able to reduce the travel time in more than a half between the two regions by using high speed trains without needing to pass through Madrid. Although this link is using the HS track infrastructure existing between Madrid and Barcelona, every train has a stop in Zaragoza, Lleida and Tarragona, these cities are not going to be taking into account in this thesis. On the other hand, Sevilla has direct connection to Madrid since 1992 (it was the first HS line in Spain) and this main line passes through Cordoba; the branch line that connects Málaga with the main line was open the 24th of December 2007.

Following the philosophy that has been used previously, in the case of Sweden the cities that have been considered to be influenced by the high line train are:

- Every city where the train stops: Stockholm, Södertälje, Nyköping (also Skavsta airport), Norrköping, Linköping, Jönköping, Värnamo, Ljungby, Helsingborg, Lund, Malmö, Copenhagen Kastrup, Copenhagen.
- Capitals of regions that are connected with the previous cities by conventional lines and they are not more than 100 km far from them. : Uppsala, Västerås, Örebro, Växjö Göteborg, Halmstad, Karlskrona, Kalmar,

Apart from make a comparison of the cities that are under the line influence, a comparison between larger areas is also done, in other words, a comparison of the region population where the Hs passes through. In this case, the concept of province has been chosen in Spain and Län in Sweden (following the extension of the territory criteria). Again, the chosen year has been 2005 and the data from Spain is on 1st January 2006 to be comparable to data from Sweden of 2005. There is also a planned city where the train will stop Hässleholm, but it is not introduced in the study because it is not in the main HS itinerary and its population would not have had a big repercussion (17730 inhabitants).

The chosen provinces in Spain result in: Madrid, Guadalajara, Zaragoza, Tarragona, Lleida and Barcelona. And the Län areas in Sweden are: Stockholm län, Södermanlands län, Östergötlands län, Jönköpings län, Kronobergs län, Skåne län; it will be also included Hovedstaden, Copenhagen region.

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The comparison of population is a good start that gives an idea of importance of the regions in both countries, but to be able to have a broad knowledge about them it is necessary to compare them by using others criteria that bring face to face other qualities and characteristics of the regions. To do that, data has been collected from Europe statistics where it is possible to find values of the different regions of Europe in different scale: NUTS, Nomenclature of Territorial Units for Statistics. In addition, a study of the market sectors will be also done using the data that the different statistics institutes in each country takes in.

NUTS is a standard geocode that refers to different subdivisions of the states members of the EU territory that has been developed and regulated by the European Union. In each country, three levels of NUTS are found attending population *Table 4*, then each region is studied separately. In consequence, due to the difference of population that has been mentioned before, we found big diversity of number of groups in each level among Spain, Denmark and Sweden.*Table 5*

Level	Minimum	Maximum
NUTS 1	3 million	7 million
NUTS 2	800000	3 million
NUTS 3	150000	800000

Table 4 Levels of NUTS. Source: eurostat

	NUTS 1	NUTS 2	NUTS 3
Spain	7	19	59
Sweden	3	8	21
Denmark	1	5	11

Table 5 Territorial division in Spain, Sweden and Denmark. Source: author made from eurostat

Most of the statistics that are studied over Europe are referring to NUTS2, in that case it is interesting to know how the countries are divided into NUTS 2. In the case of Sweden Stockholm Län is one NUT2, while Södermanlands and Östergötland belong to another NUTS2 that is composed by 5 län (included them) that is called East Middle Sweden. On the other hand, Jönköpings and Kronobergs fit in another NUTS 2, which is called Småland, plus another 2 län. And finally Skåne län belong to another NUTS2, called south Sweden, which is composed by two län. Each of the län makes up one NUTS 3. In the case of Denmark, Hovedstaden makes up a NUTS2 and Copenhagen is a NUTS3. Appendix I : IDENTIFICATION OF PROVINCES AND LÄN INTO NUTS SYSTEM

In the case of Spain, the province of Madrid is considered NUTS1; Guadalajara belongs to a different NUTS2 and it is itself a NUTS3; Lleida, Tarragona and Barcelona belong to the same NUTS 2 and they are themselves NUTS3. Finally, Zaragoza is the same case as Guadalajara. Appendix I : IDENTIFICATION OF PROVINCES AND LÄN INTO NUTS SYSTEM

4.1. Comparison of population in the areas studied

A simple comparison of both lines could be to look for the population of the cities where the train passes through and its influence area. The cities and regions have been explained before in order to standardize criteria, and they will bring us an idea of the region where both HS trains run through in each country. Finally, some conclusion will be drawn according to the similarities and differences found.

Starting with the cities where the train has a stop in, the population of the Spanish ones are 82,13% higher and if the group of the cities is divided into 4 groups, Madrid and Barcelona are in the first and second respectively by themselves while Stockholm and Copenhagen shared the third group. *Table 6*

CITY/TÄTORT		Train stops			
2005		IN ORDER		A	
1	Madrid	3128600	Madrid	3128600	1
2	Guadalajara	75493	Bacerlona	1605602	2
3	Calatayud	20001	Stockholm	1252020	3
4	Zaragoza	649181	Copenhagen	1084885	3
5	Lleida	125677	Zaragoza	649181	4
6	Tarragona	131158	Malmö	258020	4
7	Barcelona	1605602	Tarragona	131158	4
8	Stockholm	1252020	Lleida	125677	4
9	Södertälje	60279	Linköping	97428	4
10	Nyköping	27720	Helsingborg	91457	4
11	Norrköping	83561	Jönköping	84423	4
12	Linköping	97428	Norrköping	83561	4
13	Jönköping	84423	Lund	76188	4
14	Värnamo	18469	Guadalajara	75493	4
15	Ljungby	14810	Södertälje	60279	4
16	Helsingborg	91457	Nyköping	27720	4
17	Malmö	258020	Calatayud	20001	4
18	Copenhagen	1084885	Värnamo	18469	4
19	Lund	76188	Ljungby	14810	4
Madrid-Barcelona line population		5735712	INDEX	100	
Stockholm-Copenhagen line population		3149260		55	
Difference		82,13%			

Table 6 Population of the cities with HS stop

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	Population cities	% of the total with stop	INDEX	
Madrid + Barcelona	4734202	82,54%		
Stockholm + Copenhagen	2336905	74,20%		49
Difference		102,58%		

Table 7 Population of the ends in both corridors

	Population cities	% of the total with stop	INDEX	
M-B cities with stop; without Madrid and Barcelona	1001510	17,46%			100
S-C cities with stop; without Stockholm and Copenhagen	812355	25,80%		81
Difference		23,28%		

Table 8 Population of the intermediate stop cities in both corridors

If the classification is done taken into account all the cities influenced by the lines, the difference of population decreases up to 64,55 % and if we try to divide cities into groups Madrid is always by itself in the first one, and if the division is in 4 groups it is the same case as before: 2nd Barcelona and 3rd Stockholm and Copenhagen. *Table 9*

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CITY/ TÄTORT		Influenced by the line					
2005		IN ORDER		A	B	C	
1	Madrid	3128600	Madrid	3128600	1	1	1
2	Guadalajara	75493	Barcelona	1605602	2	3	2
3	Calatayud	20001	Stockholm	1252020	2	4	3
4	Zaragoza	649181	Copenhagen	1084885	2	4	3
5	Lleida	125677	Zaragoza	649181	3	4	4
6	Tarragona	131158	Göteborg	510491	3	5	4
7	Barcelona	1605602	Valladolid	319943	3	5	4
8	Ávila	53272	Malmö	258020	3	5	4
9	Segovia	55476	Pamplona	195769	3	5	4
10	Soria	38004	Logroño	147036	3	5	4
11	Toledo	77601	Tarragona	131158	3	5	4
12	Logroño	147036	Uppsala	128409	3	5	4
13	Pamplona	195769	Lleida	125677	3	5	4
14	Teruel	33673	Västerås	107005	3	5	4
15	Huesca	49312	Örebro	98237	3	5	4
16	Girona	89890	Linköping	97428	3	5	4
17	Ciudad Real	70124	Helsingborg	91457	3	5	4
18	Valladolid	319943	Girona	89890	3	5	4
19	Stockholm	1252020	Jönköping	84423	3	5	4
20	Södertälje	60279	Norrköping	83561	3	5	4
21	Nyköping	27720	Toledo	77601	3	5	4
22	Norrköping	83561	Lund	76188	3	5	4
23	Linköping	97428	Guadalajara	75493	3	5	4
24	Jönköping	84423	Ciudad Real	70124	3	5	4
25	Värnamo	18469	Södertälje	60279	3	5	4
26	Ljungby	14810	Halmstad	55688	3	5	4
27	Helsingborg	91457	Växjö	55600	3	5	4
28	Malmö	258020	Segovia	55476	3	5	4
29	Uppsala	128409	Ávila	53272	3	5	4
30	Västerås	107005	Huesca	49312	3	5	4
31	Örebro	98237	Soria	38004	3	5	4
32	Göteborg	510491	Kalmar	35170	3	5	4
33	Växjö	55600	Teruel	33673	3	5	4
34	Kalmar	35170	Karlskrona	32606	3	5	4
35	Karlskrona	32606	Nyköping	27720	3	5	4
36	Halmstad	55688	Calatayud	20001	3	5	4
37	Copenhagen	1084885	Värnamo	18469	3	5	4
38	Lund	76188	Ljungby	14810	3	5	4
Madrid-Barcelona population		6865812	INDEX	100			
Stockholm-Copenhagen population		4172466		61			
Difference		64,55%					

Table 9 Population under the influence of both railway corridors.

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	Population cities		
M-B influenced cities without Madrid and Barcelona	2131610	INDEX	100
S-C influenced cities without Stockholm-Copenhagen	1835561		86
Difference			16,13%

Table 10 Comparison of influenced cities without the ends cities of each corridor population.

	Population cities	% of the total of influenced cities		
M-B influenced cities with no stop	1130100	16,46%	INDEX	100
S-C influenced cities with no stop	1023206	24,52%		91
Difference		10,45%		

Table 11 Comparison of influenced cities with no stop population.

It could be said that the purpose of these two lines is to connect two large cities and, in addition, give smaller cities the opportunity to have a faster connection with them, which are more developed areas. The start and end city in both line differ highly to the cities in between, being Madrid and Barcelona 102% larger than Stockholm and Copenhagen *Table 7*. Apart from this difference, the cities in between are not so different from one line to the other; although the Spanish ones are still larger, the different only reaches 23,3 % when we talk about cities with stop *Table 8* and 16,13 % when we talk about every influenced city *Table 10* (without Madrid, Barcelona, Stockholm and Copenhagen).

The values have raised up that the difference of population between both line is always smaller when every influenced city is taking into account, what means that the population of the influences areas that are summed, apart from the cities with stop, are almost the same in both countries (only 10,4 % higher in Spain, *Table 11*). This brings to Sweden more freedom when it comes to decide the route of the line. If both line are studied separately, with their owns limits of population, the influenced cities with no stop make the population increase up to 19,7 % in the Spanish case and a 32,5% in the Swedish one. *Table 12*

	Population cities; train stops	Population cities; influenced by the line	Difference
Madrid-Barcelona population	5735712	6865812	19,70%
Stockholm- Copenhagen population	3149260	4172466	32,49%

Table 12 Relation between the cities influenced with stop and all of them.

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With the previous comparison it has been only taken into account population of the principal cities that are under the influence of each line, but the territory has many other settlements that must be studied to have a general number of influenced populations. To do that, there have been considered the regions explained in the previous section.

If we compare the regions in Sweden and Spain and divided them into 4 groups to study their size, Madrid and Barcelona share the first group and Stockholm and Copenhagen share the third group, not being any region in the second group. *Table 13*

LÄN - PROVINCE						
2005		In order			A	B
1	Madrid	6008183	Madrid	6008183	1	1
2	Guadalajara	213505	Barcelona	5309404	1	1
3	Zaragoza	917288	Stockholm län	1889945	3	3
4	Tarragona	730466	Copenhagen	1825814	3	3
5	Lleida	407496	Skåne län	1169464	3	4
6	Barcelona	5309404	Zaragoza	917288	3	4
7	Stockholm län	1889945	Tarragona	730466	3	4
8	Södermanlands län	261895	Östergötlands län	416303	3	4
9	Östergötlands län	416303	Lleida	407496	3	4
10	Jönköpings län	330179	Jönköpings län	330179	3	4
11	Kronobergs län	178443	Södermanlands län	261895	3	4
12	Skåne län	1169464	Guadalajara	213505	3	4
13	Copenhagen	1825814	Kronobergs län	178443	3	4
Madrid-Barcelona line		13586342		INDEX	100	
Stockholm-Copenhagen line		6072043			45	
Difference		123,75%				

Table 13 Population in the province along both corridor layouts.

If the data is analyzed it is found out that the weight of the first and last region in both lines is bigger than the weight of the sum of the intermediate ones. This means that the difference of population is rather big between the principal regions of both countries (the Spanish are 204% higher than the Swedish ones, *Table 14*), what had been showed also in the previous analysis of cities. However, this weight is more important in Spain than in Sweden: 83,3 and 61,19 % respectively what, in contrast, gives more prominence to the Swedish intermediate regions (*Table 15*): 38,81 %.

Län/province	Population regions	% of the total	INDEX	
Madrid + Barcelona	11317587	83,30%			100
Stockholm + Copenhagen	3715759	61,19%		33
Difference		204,58%		

Table 14 Population in ends provinces.

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	Population regions	% of the total	INDEX	
Regions between Madrid and Barcelona	2268755	16,70%		
Regions between Stockholm and Copenhagen	2356284	38,81%		104
Difference		3,86%		

Table 15 Population in intermediate regions along both different corridors.

In addition, it appears the first case where the sum of Swedish population is higher than in Spain *Table 15*, showing that Swedish intermediate areas of the line are 3,86% more inhabited.

In view of the partial conclusions of both previous comparisons between cities and between larger regions, they bring about the assumption that the distribution of population differ between both lines.

Once, the population along the influenced territory of the Swedish line, although most of it is located in both ends, is distributed more uniformly than in Spain. In Spain the population is more concentrated in the main cities, the ones which have been considered in the first section, while, paying attention to the second section, it results that we found more dispersed population all over the regions where the train passes through in Sweden.

As a final conclusion, if the route mainly depended on the population, the layout of Swedish line would be less limited than the Spanish. This is an advantage for Sweden because the more freedom you have to layout the route, the easier to avoid orographic complications.

4.1.1. Line population over Europe

As it has been mentioned before, both line areas in Spain and Sweden differ highly in the number of inhabitants; in order to find out if this difference of population will be a inconvenient for the Swedish HS line demand, a study of different lines over Europe is going to be done comparing the sum of inhabitants in the first and last city of the each line.

Taking into account the experience of high speed in different countries, it is a fact that the population of the cities where the train has a stop and, above all, the population of the first city and the last one of the line, is one of the determinate factors to decide the route of the line. However, each country has its own different distribution of population on its territory, what makes the high speed be adapted depending of the circumstances.

If we start observing the high speed train in France, the TGV has been constructed giving priority to those cities that have a large population to generate high demand (first line: Paris-Lyon), in other words, it is needed cities that generate demand enough to justify the investment in a new line. With this approach, the high volume of traffic is more feasible to reach with Paris, what explained the star-shaped of the high speed network (Rodríguez Bugarín, M. Et al. 2005). In addition, a stop of the TGV that is running at 205 km/h causes a loose of 10 minutes, up to 30 minutes if it is in a central station of a big city (Rodríguez 2005,

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Novales 2005; Orro 2005). In that case, stops must be limited to get competitive travel times against the plane travel time.

The case of France is an example of centralist structure of population distribution, while Germany is quite the opposite case. The population is spread out all over the country what results in several sizes of cities without big agglomeration able to generate as much traffic demand as Paris in France (Rodríguez Bugarín, M. Et al. 2005).

Under these premises, it is going to be tried to find out if there is a direct relation between the population of the city and the market share that the train obtains. It had been better to compare the population with the volume of demand per year (pass/year) and look for any direct relation between them that could exists, but due to the difficulties to get those kinds of data, market share has finally been chosen for the study.

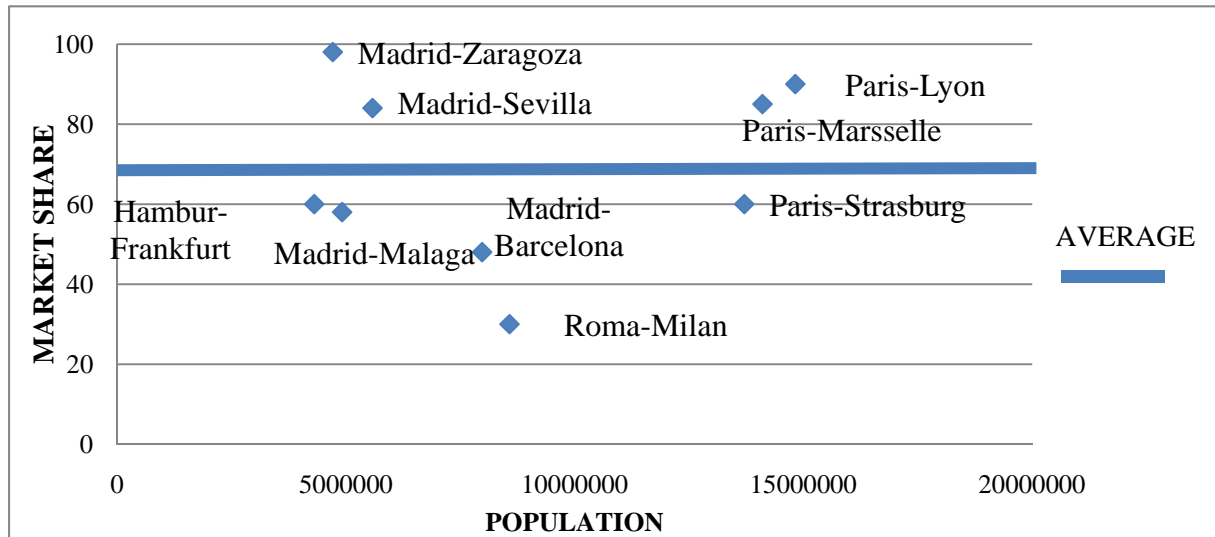
To have a sampling of some lines around Europe, they have been selected in France, Germany, Italy and Spain with different characteristics: length, market share (Lundberg,A., 2011) (only considering train and plane), travel time and size of first and last cities *Table 16*. At first sight, having the sum population of the first and last city in the line in order, there is no relation between it and the market share, since the four highest percentages are either related with the largest cities or not *Figur 3*. So, this does not prove that biggest cities get more market share, although the case of big metropolis like Paris is very significant.

A relation between travel time and market share does exist when we talk about trains, as some studies about competition between train and plane show (Lundberg,A., 2011). Taking advance of this relation in our case of study, the comparison between population and market share will be also done taking into account the length of the line, divided the lines into two groups: less than 400km length and more than 400 km.

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CITY	POPULATION	DISTANCE straight line / railway line ; km	MARKET SHARE %		TRAVEL TIME ; min
Paris	13067000	14824180	391 / 409	90	1st
Lyon	1757180				
Paris	13067000	14105521	660 / 862	85	3rd
Marselle	1038521				
Paris	13067000	13708853	397,3/493	60	5th
Strasbourg	641 853				
Rome	3715000	8576000	478/607	30	8th
Milano	4861000				
Madrid	4072000	7977300	507 / 621	48	7th
Barcelona	3905300				
Madrid	4072000	5580605	390 / 472	84	4th
Sevilla	1508605				
Madrid	4072000	4916000	415/500	58	6th
Malaga	844000				
Madrid	4072000	4711000	273/307	98	2nd
Zaragoza	639000				
Hamburg	2550000	4306000	395 ¹³ /	60	5th
Frankfurt	1756000				
Stockholm	1252020	2336905	519/		
Copenhagen	1084885				
Stockholm	1252020	1510040	512/		
Malmö	258020				

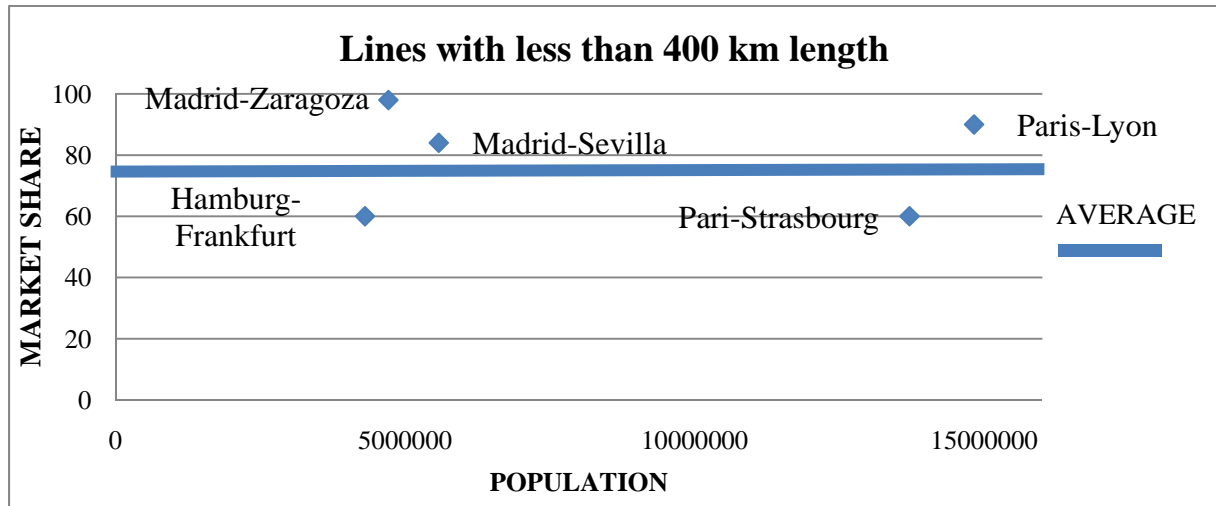
Table 16 Population of metropolitan area in cited countries (2006)



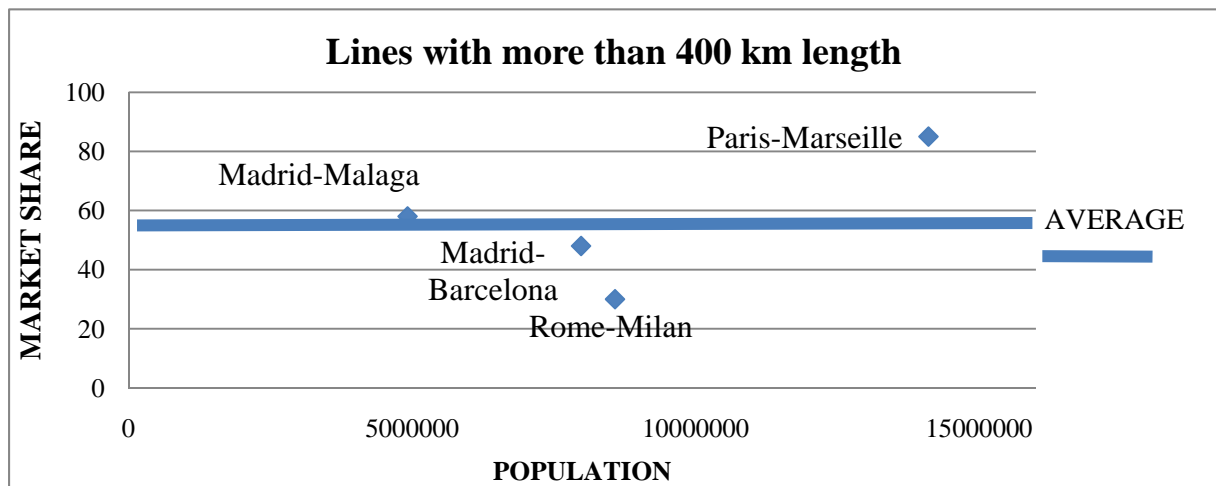
Figur 3 Distribution of market share regarding population of the ends.

¹³ For these lines the length considered is the straight distance because of the lack of information about the track length.

Comparison of High-Speed train market between Spain and Sweden:
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Figur 4 Distribution of market share regarding population of the ends in lines shorter than 400 km length.



Figur 5 Distribution of market share regarding population of the ends in lines longer than 400 km length.

Analyzing the previous graphs *Figur 3* it is not possible to find a relation between the population and the market share that explain every case. However, another conclusion brings up if the length of the line is considered; the lines whose length is less than 400 km (*Figur 4*) have a higher average market share 78% that the ones that have more than 400 km length (*Figur 5*): 55%, although lines with Paris involved are exceptions.

On the other hand, this is not a deciding comparison because the values only take into account train and plain, what means that in “less than 400 km” the road is the main competitor of the train and not the plane. Therefore, the most reliable figures of market share are in the second graph “more than 400 km” where it does not seem like a big amount of population bring the line the opportunity of having a high market share, but cases with Paris involved.

The Stockholm-Copenhagen line would be in the second group with more than 400 km length and in addition, this line would have less population than the rest of the lines represented, what is negative for the line if we accept these conclusions. However, trip generation is different depending on the size of the cities; people travel more in smaller cities and towns

compared to large cities. There is also a strong influence of the supply offered, in terms of travel time, frequency and ticket price, compared to other modes. Therefore, as in the population comparison was showed, the intermediate travels along the Swedish corridor will have high importance in relation to the ends travels. In other words, although the biggest cities are the ends, the goal of the corridor is not only to join them, but also to provide intermediate cities with a high quality supply.

4.2. Economic sectors

The structure of the economic sectors in the regions where both lines run is going to be studied. In order to do that a standardization of the data must be done due to every country has the economic market divided into different number of groups. It must be also said that the comparison will be in % of people employed in each sector.

In Spain the economy market is divided into 4 sectors: primary: agriculture, stockbreeding, forestry, apiculture, shooting and fishing; secondary: industry and manufacturing; construction and tertiary: services. While, Swedish and Denmark statistics divides the economy market into more than four groups, which must be classified and grouped in a similar way as in Spain to be able to be compared between each other. The data from Spain is getting from INE¹⁴ with 2004 figures and the Swedish one from SCB¹⁵, of 1st January 2005, and Danish from DST¹⁶ 2004. As the data from Spain is groups by three month period, their average is used. *Table 17*

% Employed persons by sectors				
REGIONS	Primary	Secondary	Construction	Service
Barcelona	0,88	26,05	9,99	63,09
Guadalajara	6,14	18,46	13,27	62,13
Lleida	12,68	14,26	15,00	58,07
Madrid	0,80	13,78	10,90	74,53
Tarragona	6,14	20,38	16,71	56,77
Zaragoza	4,48	24,48	8,36	62,69
AVERGE	5,19	19,57	12,37	62,88
VARIANCE	19,24	25,94	10,10	39,37
TIPIC DESVIATION	4,39	5,09	3,18	6,27

Table 17 Percentage of employed persons in each economic sector in Spanish provinces.

¹⁴ Intituto Nacional de Estadística, viewed 17 October 2010, <www.ine.es>

¹⁵ Statistiska centralbyrån, Statistics Sweden <www.scb.se>

¹⁶ Statistics Denmark <www.dst.dk>

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% Employed persons by sectors				
REGIONS	Primary	Secondary	Construction	Service
Stockholm län	0,40	10,55	5,13	82,30
Södermanlands län	2,41	21,84	6,41	67,31
Östergötlands län	2,42	21,15	5,59	69,78
Jönköpings län	2,23	30,13	5,09	61,46
Kronobergs län	2,76	25,27	5,09	64,67
Skåne län	2,25	18,13	5,96	72,06
Copenahgen	0,82	11,32	5,64	82,25
AVERGE	1,90	19,77	5,56	71,40
VARIANCE	0,82	50,50	0,25	66,69
TIPIC DESVIATION	0,91	7,11	0,50	8,17

Table 18 Percentage of employed persons in each economic sector in Sweden provinces.

	MAXIMUM
	MINIMUM

To get some results from these figures, an analysis of functional specialization according to the sectorial structure of employment following *Nelson method*¹⁷ is going to be done. From this, it is possible to get a specialization coefficient for each sector in each region, *Table 19*. On the other hand, using these specialization coefficients, a “Potential Productive Index”¹⁸ is going to be calculated, paying attention to the different productivity and added value of each sector related to the high speed development; the purpose is to bring up a relative appraisal of the potential prerequisites in favour of a higher HS impact relating to each region. The potential productive index is going to be calculated for each line separately to show the distribution of the sector along it.

¹⁷ It lies on the establishment of grades of specialization on the base of how many times the percentage of employees in a sector is higher than the sum of the average and the standardize deviation of the group of regions.

¹⁸ To calculate this value, the four specialization coefficients are weighted summed in every region with weight -1,1,1,2 respectively.

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REGION	SPECIALIZATION COEFFICIENT				POTENTIAL PRODUCTIVE INDEX
	WEIGHT				
	-1	1	1	2	
	Agriculture	Industry	Construction	Service	
Barcelona		1		0	MEDIUM
Guadalajara	0		0		MEDIUM
Lleida	1		0		LOW
Madrid				1	HIGH
Tarragona	0	0	1		MEDIUM
Zaragoza		0			MEDIUM
Stockholm län				1	HIGH
Södermanlands län	0	0	1		MEDIUM
Östergötlands län	0	0	0		LOW
Jönköpings län	0	1			MEDIUM
Kronobergs län	0	0			LOW
Skåne län	0		0	0	LOW
Copenhagen			0	1	HIGH

Table 19 Specialization coefficient

	No specialized
0	Little specialized
1	Specialized
2	Quite specialized

If we pay attention to the specialization of the regions in every sector, *Table 19*, we find the most remarkable differences between the distribution of the specialization along the primary and service sector. Primary sector is more homogeneity distributed in Sweden than in Spain, and related with the service sector, there are more specialized regions in Swedish line than in the Spanish one.

Regarding the final results, when it is compared the potential productive index of each region in each line, the results are similar. There is found one region with high potential productive in Spain and two in Sweden but Sweden has more regions with low. *Table 20*

REGION	POTENTIAL PRODUCTIVE INDEX	POTENTIAL PRODUCTIVE INDEX	REGION
Barcelona	MEDIUM	HIGH	Stockholm län
Guadalajara	MEDIUM	MEDIUM	Södermanlands län
Lleida	LOW	LOW	Östergötlands län
Madrid	HIGH	MEDIUM	Jönköpings län
Tarragona	MEDIUM	LOW	Kronobergs län
Zaragoza	MEDIUM	LOW	Skåne län
		HIGH	Copenhagen

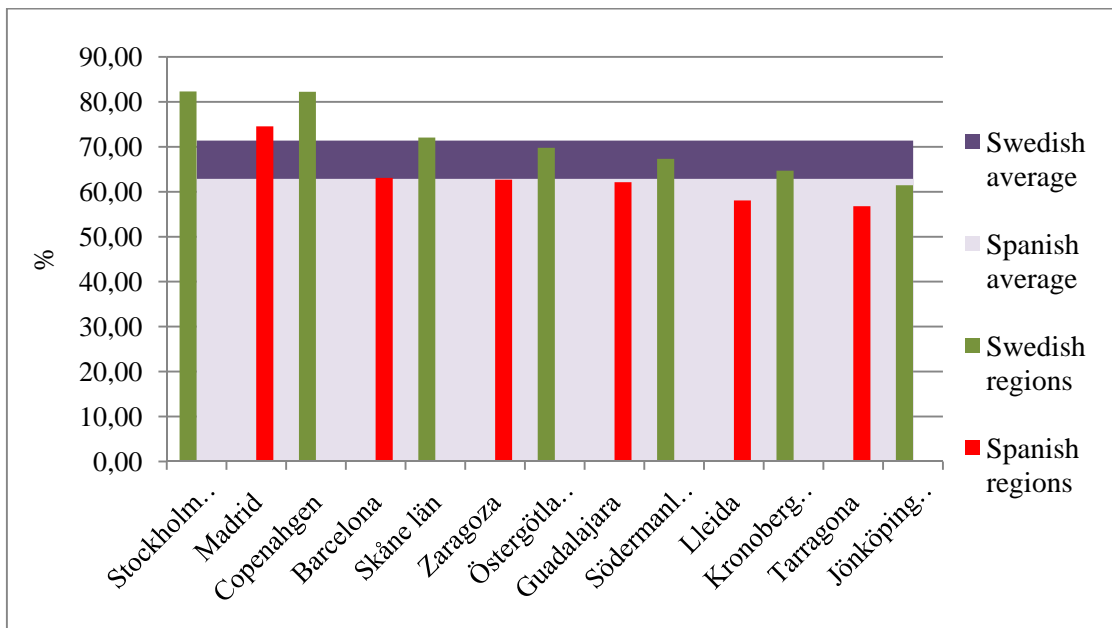
Table 20 Potential productivite index in relation to the possible impact of the HS

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Different authors have coincided in their theories (MARTÍ-HENNEBERG, 2000) about the accelerator role that the HST has in the processes that are already on and in the dynamics already existed over the territory before it appears, without expecting new dynamics in the economic localization. What this comes to mean is that the consequences of the HST depends highly on the territory characteristics and it is just another element in the socioeconomic dynamic (FELIU TORRENT,2008).

Feliu Torrent (2008) points out in his study of the influenced of the HS lines that “the HST involves a more efficient business running, especially in those sectors with the most qualified services” and on this respect, BERG Y POL (1998) reaches the conclusion that the activities related with advanced services take more advance from the HST, like business, urban tourism, conferences and fairs; activities that have in common to be a mix of information, communication and entertainment (Feliu Torrent,J., 2008).

Putting into practice these arguments, and taking into account that I could not have access to specific values of advanced tertiary sector in the lines cities, the comparison of the tertiary sector in the regions will give us an idea of which one, in theory, takes more advance from the HS.



Figur 6 Representation of the percentage of the service sector in every region

Attending to the results of the comparison of the tertiary sector Figur 6, every Swedish region stand out against the Spanish ones; Madrid is the only exception that can be at their same level. Taking into account the good result of the HS train in the Madrid-Barcelona corridor and the conclusion that the Swedish regions could take more advantage because of the tertiary sector, the HS in Stockholm-Copenhagen corridor has a positive factor on its favour. However, although this is a good prerequisite for the HS, to make the most of the HS it is necessary that the cities create economic dynamics that could be given a boost by the HS: to prepare the city for the arrival of the HS (Feliu Torrent,J., 2008).

4.3. Other criteria

After comparing population and economic sector, there are more fields that can be compared and are related with the HS in some way.

The HS train involves a high investment to be constructed; in consequence, when it is in operation the fares must be in accordance with that and with the quality of the service, these mean that the HS train fares are high. In Spain, because of the characteristics of the HS service, studies¹⁹ made by RENFE have brought out the profile of the passenger of the Madrid-Barcelona corridor: person with university education (72%) who travels because of work (56,4%) or leisure and /or family reason (41,9%), with an average frequency of 38 travels per year, with a fidelity to the train of 81%. Because of this special characteristics of the HS train, and due to the fact that the line Madrid-Barcelona is been operating during three year successfully, a comparison of the next fields will show if the Swedish regions have similar characteristics to hold a HS line.

- Disposable income 2006; as it has been said, the fares are higher and create a definite profile of passenger. The structure of the fares must be in consonance with the medium income population.
- GDP per inhabitant 2006; because of the big investment needed, the wealthy of the regions is important to be considered. Besides, “historically, there has been a close correlation between the growth in demand for freight and passenger traffic and economic growth, as measured by GPD” (Baanister,D., 2001; Berechman,Y., 2001)
- European Funds.

The indexes are given in PPS, an artificial currency unit (PPS purchasing power standard) in order to make the comparison between different countries possible eliminating “the effect of the price level differences across countries created by fluctuations in currency exchange rates”²⁰.

¹⁹ RENFE press release: “El AVE Barcelona-Madrid celebra su tercer aniversario con casi 17 millones de viajeros en todo el corredor”. Madrid, 20 February 2011.

²⁰ Eurostat < <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/>>

4.3.1. Disposable income (2006)

According to a study of the World Bank focus on the China's HS development (Amos,P., 2010; Bullock,D., 2010; Sondhi J., 2010), in order to generate the required volume of passengers it is not only needed to achieve the most possible affluent of travellers but also to implement a fare structure affordable for the average income population. "The overall financial performance of high-speed train services depends on enough people being able to pay a premium to use them"; what in other word could be "in countries of low incomes and low growth in incomes, affordability by a sufficient number of full-fare passengers will be a critical constraint".

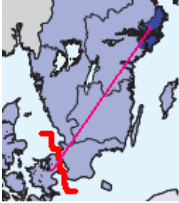
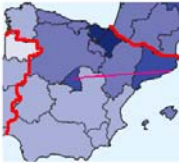
REGIONS		PPS per inhabitant				
		<=10,000	10,000-14,000	14,000-16,000	16,000-18,000	>18,000
 SWEDEN	Stockholm					
	Södermanlands					
	Östergötlands					
	Jönköpings					
	Kronobergs					
	Skåne					
DENMARK	Copenhagen					
 SPAIN	Madrid					
	Barcelona					
	Zaragoza					
	Tarragona					
	Lleida					
	Guadalajara					

Table 21 Disposable income in PPS per inhabitant.

The previous table shows the disposable income from inhabitant after the transactions of paying taxes on income and wealth (pay their social contributions and effect transfers). The case of Sweden is one of the lowest disparities comparing to Europe, and it is also shown when it is compared with Spain.

4.3.2. Gross domestic product GPD (2006)

“In developed countries, where there is already a well-connected transport infrastructure network of high quality, further investment in that infrastructure will not on its own result in economic growth” (Baanister,D., 2001; Berechman,Y., 2001). But on the other hand, the presence of positive economic externalities is essential to allow the new infrastructure investment to have an economic development impact. These externalities must be going with other two conditions in order to have any representative impact on the economic development: investment factors and political factors

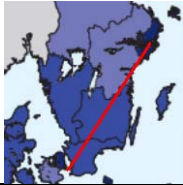

REGIONS		GPD per inhabitant				
		<=15,000	15,000-20,000	20,000-25,000	25,000-30,000	>30,000
SWEDEN 	Stockholm					
	Södermanlands					
	Östergötlands					
	Jönköpings					
	Kronobergs					
	Skåne					
DENMARK	Copenhagen					
SPAIN 	Madrid					
	Barcelona					
	Zaragoza					
	Tarragona					
	Lleida					
	Guadalajara					

Table 22 GPD per inhabitant in PPS

Spain and Sweden have two of the most “equitable” distribution of GPD in Europe. On the other hand, the GPD value is influenced by the commuting travelling of every day, which is why the biggest cities with more power of attraction, as the capitals, have the highest GPD.

4.3.3. European funds

In the case of Spain, it has been given two different European funds: cohesion funds and Trans-European Transport network funds. The first one is given to the south European countries from the north ones to encourage the economic and social cohesion and the solidarity between the states members. It is used for finance works related with the environment and transport infrastructures with a common interest jointly. Therefore, Spain is a receiver country while Sweden is not.

	2000-2006		2007-2013	
	Cohesion Funds	TEN-T	Cohesion Funds	TEN-T
Spain (TOTAL)	12,357		3,242	
Madrid-Barcelona line	3,389	70.9		
Line toward France				6.1

Table 23 Different origins of the funds that Spain has received.

“The Trans-European Transport Network Executive Agency's mission is to support the European Commission and TEN-T project managers and promoters, by ensuring the technical and financial management of the projects and the successful implementation of the TEN-T Programme”²¹. The line Madrid-Barcelona-France border is part of the Priority Project 3: High-speed railway axis of southwest Europe, belonging to the Mediterranean branch.

²¹ European Commission, Trans-European Transport Network Executive Agency
< <http://tentea.ec.europa.eu/en/home.htm> >

5. Spain

5.1. Decision process and investment

Nowadays, the Spanish HS railway net is, at the end of 2010, 2665 km, becoming the one of the largest HS network in Europe and in the world behind China; being 621 km of the total amount, from the Madrid-Barcelona line, object of study. On the other hand, Sweden has none HS line in operation but it is planning to construct 750 km of HS track between Stockholm- Malmö/Copenhagen including a branch from Jönköping to Gothenburg.

In 1988 the Madrid-Barcelona line was decided to be built as exclusive use of passenger trains, the same way as the Madrid-Sevilla line which was being building at that time and was inaugurated in 1992; but it was not until 1996 when the construction started. These two first lines were the begging of what lately was gathered in the PEIT in 2004 (Strategic Plan of Land Infrastructures). This Proposal document will expose the “establishment of a high assistance network that will be designed essentially for mixed traffic”, as a specific directive action for the development of railway politics. In addition, “it will pay special attention to improve interconnections with high potential traffic and to the lack of regional accessibility. Finally, in itineraries highly requested by its volume and demand traffic characteristics, the new infrastructures will be dedicated exclusively to passenger traffic”²²

The start of the planning of an upgraded line Madrid-Barcelona started in 1987 when the PTF (Railway Transport Plan) was approved as a consequence of RENFE bad and weak situation (Spanish National Railway Network; operator and manager of the railway structures at that time). At the beginning of the 80’s RENFE was in a critical situation involving predicted losses around 600 billion of *pesetas* (3.6 billion €) in 1986 if no measure was taken. Under this circumstances, the 1st of January of 1985 several km of lines were closed and another 933 km were dedicated to freight transport; despite the closures, the deficit in 1985 was four times larger than the investment in railway that year.

In this context, the PTF came up as a “breaking point” investment with the aim of modernized the railway transport, improving the quality of the service and achieving a return on the service. The amount of 2.1 billions of *pesetas* (13,000 million €) was planned to invest from 1987 to 2000, which was a very high sum comparing to the less than 50000 million of *pesetas* per year (300 million €) of investment at that time. In this document, the possibility of construct the new lines with standard guage (1435 mm) is rejected in favour of the Iberian guage (1668 mm). In the same way, different works were planned in order to permit speeds of 200 km/h in double track in: the triangle Madrid-Valencia-Barcelona and lines Madrid-

²² PEIT, Strategic Plan of Land Infrastructures; *Secretary of State of Infrastructures and Planning, General Management of Planning and Territorial Coordination; Govern of Spain.* December 2004

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Ciudad-Real-Sevilla, Madrid-Vitoria-Alsasua and Valladolid-León. To sum up, in what this document respects, there is no talk about neither speeds at 300km/h nor change to standard gauge.

Although this document was not revoked, not all its parts were put into practice. In 1988 the cabinet meeting decided to start the construction of a High Speed Line with standard gauge, following the good results of the HST in France, what involved a huge concentration of investment on these HS lines: from Andalucía (Sevilla) to France border passing through Madrid and Barcelona. As the line that links Andalucía to Madrid was already under construction attending the PTF specifications, this project was changed and adapted to become the first HS line in Spain with exclusive use of passengers. After this decision in 1988, works began on the Madrid-Barcelona HS line and 3 stretches: turnoff of Calatayud, by-pass of Zaragoza and turnoff between Zaragoza and Lleida, which were under designed or construction because of the PTF, had to be assimilated by the new project.

Apart from the causes explained before, the decision to make headway from conventional train and broad gauge to high speed was taken, in some way, to clear airport traffic and to redress the market share between the means of transport: plane, train, road; the ministry of Economy and Transport concluded that the high speed train represented the most economic and ecologic alternative to do it. Moreover, the railway gave the best way to push the economic development in peripheral areas of the country by providing fast and direct connection between cities (Abbott,J. et al.,2007).

Respecting the investment, it has been impossible to me to find a complete sum inverted in the line Madrid-Barcelona but there are some estimated figures that give us an idea of its magnitude. During the period 1997/1999 the Ministry of Public Works made a sketchy estimation of 6,611 millions of euro but during the incoming years it was growing, been in 2003 the estimated sum of 9,119 millions of euro. At the end of the construction the sum rose up to more than 9,000 million euro. Apart from the State budget, the investment was consisted of other amounts from different institutions. During the period 2000-2006, 3,389 million euro from the Cohesion fund was assigned to the line works and 70.9 millions from the TEN-T, Trans-European Transport network. During the period 2007-2013 the works of the extension of the line toward France will receive 6.1 million euro from TEN-T as well (*Table 24*). On the other hand, the European Investment Bank collaborates on the funding of the project.

Million EURO	2000-2006		2007-2013		SUM
	Cohesion Funds	TEN-T	Cohesion Funds	TEN-T	
Spain (TOTAL)	12,357		3,242		12360,2
Madrid-Barcelona line	3,389	70.9			3,5
Line toward France				6.1	6,1

Table 24 Different aids from European organizations^{23 24}

²³ Source: European Commission <http://ec.europa.eu/regional_policy/funds/procf/cf_en.htm> 2000-2006; <<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:243:0037:0043:ES:PDF>> 2007-2013.

²⁴ Source: ADIF <www.adif.com>

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Having a look at the path of the Spanish State budgets it is possible to differentiate the big support of the PEIT for the railway development. Taking into account that it came into force in 2005, the investment along the successive five year (2005-2009) doubles the previous one (2000-2004) *Table 25*. In addition, from 2005 on, the railway investment means more than a half of the total. *Table 26*

PUBLIC SECTOR INVESTMENT IN RAILWAY (million of euro)			SUM
	2000-2006	2007-2009	
TOTAL	31,126	25,848	56974
	2000-2004	2005-2009	
TOTAL	17,765	39,209	56974

Table 25 Public investment in Railway over Spain during different periods ²⁵

PUBLIC INVESTMENT (million of euro)											
Year	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TOTAL	4,112	5,373	6,758	8,477	9,693	10,083	11,443	13,021	15,597	16,415	17,471
PUBLIC SECTOR INVESTMENT IN RAILWAY: Adif, Renfe operadora, Ministry of Public Works, Autonomous Region, FEVE, Companies of Autonomous Regions sector in railway (million of euro)											
Year	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TOTAL	1,080	2,050	2,809	3,882	4,186	4,837	6,245	7,117	8,236	8,253	9,359
Track and other investments	767	1,840	2,456	3,652	3,791	4,220	5,443	6,088	7,070	6,961	8,084
Rolling stock	313	210	353	231	395	617	802	1,029	1,167	1,292	1,275
ADIF	Total	926	1,410	2,392	2,158	2,312	3,518	3,837	4,706	4,458	5,281
	%	45	50	62	52	48	56	54	57	54	56
% of railway investment of the total	26	38	42	46	43	48	55	55	53	50	54

Table 26 Comparative table of the railway investment in relation with the total public investment over Spain²⁶

The public investment makes reference to: road, railway, airport, port and hydraulic infrastructure investment: urban infrastructure, drainage and water quality; hydraulic resources regulation infrastructure.

²⁵ Source: Statistic Yearbook from the different year the study concerns (from 2003 to 2009) <http://www.fomento.gob.es/MFOM/LANG_CASTELLANO/>

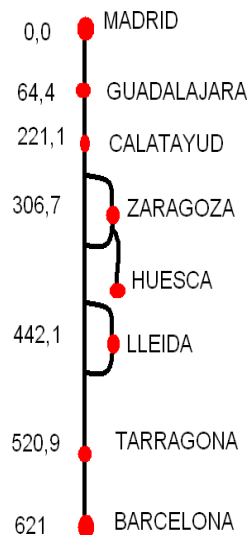
²⁶ Source: Statistic Yearbook from the different year the study concerns (from 2003 to 2009) <http://www.fomento.gob.es/MFOM/LANG_CASTELLANO/>

5.2. Railway Service

5.2.1. Description of the line

The corridor Madrid-Barcelona is part of a longer line that goes until the French border. The total length is 804 km, what will become it in one of the longest HS lines in the world; the line is 621 km between Madrid and Barcelona. Thanks to the construction parameters and the security system, the line permits 350 km/h in nearly the 86% of it. Regarding the rolling stock, it is used the AVE serie 103 which, jointly with a ETCS level 2 signalling system and the design characteristics of the line, allow the top speed of 350 km/h. We are talking, thou, about a double track with the latest technology in high speed trains.

The line was constructed in international gauge (1435mm) and it counts with 7 stops along it. However, it has by-pass in Zaragoza and Lleida in order not to penalize the travel time in those trains that do not stop in these cities. Figur 7



Figur 7 Sketch of the line Madrid-Barcelona

The station that houses the AVE (Spanish high speed) terminal in Madrid is the centrally situated Atocha Station, as well as the Barcelona Sants Station. Both are the mean stations in Spain, being Atocha the first station in national journeys and second in international journeys while Barcelona is the other way around. This line involved the HS arrival to Barcelona, the incursion of new railway lines into the centre was a tough part during the construction due to the centrally situated station.

From Madrid, the second station in the line is located in a town 8km far from Guadalajara city, Yebes. The station in question was constructed for this line and nowadays is also part of the Madrid-Zaragoza-Huesca service and some other long route travel to the north of Spain, but the majority of the trains do not stop at the station. It does not count with any other kind of railway service and the only way to reach Guadalajara from it is by private car or public bus service from and to Guadalajara bus station. All of these circumstances have not been on the side of the development neither the station or Guadalajara. On the other hand, although the

third stop is in Calatayud, which is not a big city, its train station has a considerable activity, involving regional, medium distance and long route services.

The station in Zaragoza is located in the centre of the city and it is the result of a new construction quiet near where the old one. As the previous described stations, but Guadalajara, it houses Iberian gauge and international gauge tracks. In Lerida the station is also located in the city; it is composed of two buildings, the new one for international gauge and HS service and the one that existed before for the conventional lines and Iberian gauge. Finally, the last intermediate station in the line is the one that is located 10 km far from Tarragona -station Camp de Tarragona- and it only has international gauge track.

To sum up, the line counts with 7 stops, of which 5 of them are located in the centre of the cities and two of them are some kilometres far from the main city of the area. One of these, Camp of Tarragona, is located in a strategic position to connect with other lines in the future – Mediterranean corridor- and it has some long and medium services, besides the case of Guadalajara station.

5.2.2. Evolution of AVE supply and comparison with plane.

The improvement of the railway service along Madrid-Barcelona corridor has been a process of many years; both the investment involving HS in the line, about 9000 millions of euro, and the changes of frequency, travel time and speed have brought about an increase of number of passengers and have achieved the goal of becoming it in a competitive solution against the others means of transport in the corridor. To study the evolution of railway supply it will be considered the period of time since the conventional track was the principal before 2003 up to nowadays. All of the information has been obtained from RENFE²⁷

Before October 2003 the connection between Madrid and Barcelona (621km) along the railway network was by Talgo train and the journey took 7 hours long with a frequency of 8 trains per day, 4 in each direction. That results in a average speed of 88,7 km/h joining the two biggest cities in Spain with the sum of 4.675.497 inhabitants at the beginning of 2003. While this was the situation in Spain, in 2003 the two largest cities in France, Paris and Lyon, were already connected by HST, running 410 km in 1hour 55 minutes with a top speed of 300 km/h, that means an average speed of 214 km/h. Comparing these two cases it is showed the necessity of upgrading the Spanish line. In addition, when the upgraded line started to be constructed in 1995 the market share of the railway between Madrid and Barcelona was 8 % against the 64% of the plane, what left the train in a merely token mode of transport (Fernandez Gil,A., 2008).

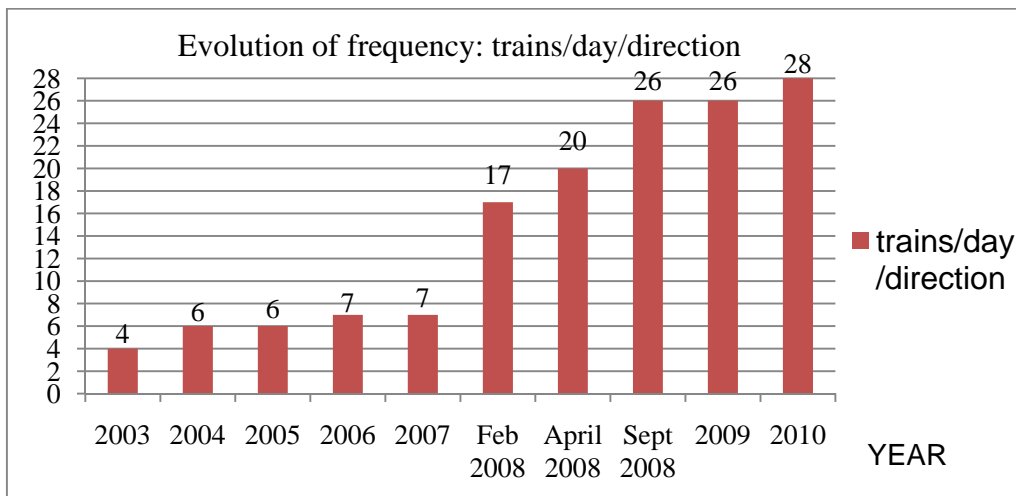
In October 2003 the new HS line was opened between Madrid and Lleida, and the AVE train started to run along it with a top speed of 200 km/h. Thanks to the new stretch, Altaría trains run the distance between Madrid and Barcelona reducing its travelling time up to 4 hours 35 minutes. It was in May 2006 when it was possible to run AVE trains at 250 km/h as the new

²⁷ National Network of Spanish Railway , it is equivalent to SJ

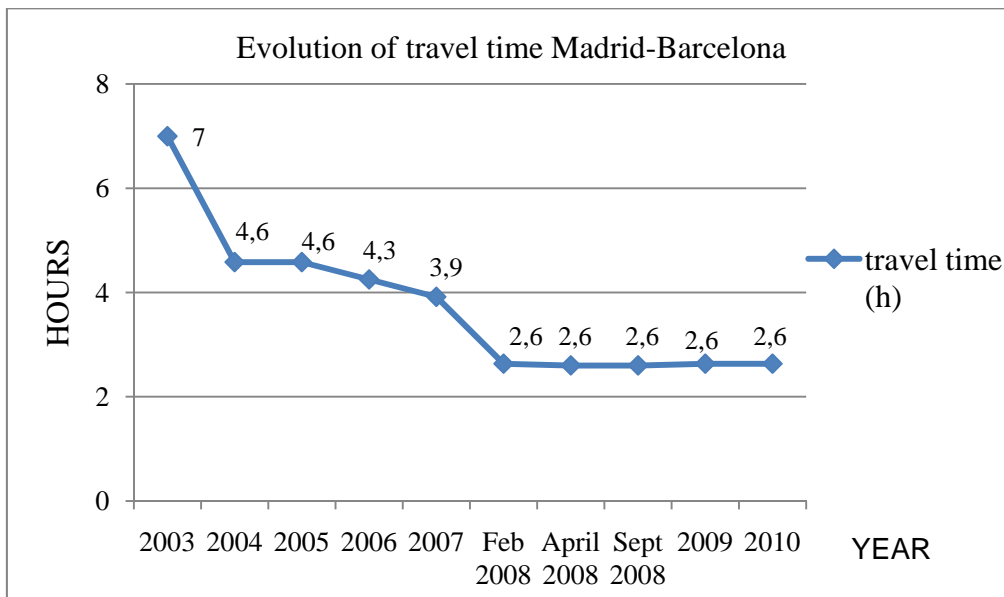
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signalling system ERTMS was installed on the line, what also made Alvia trains got a top speed of 200km/h from Madrid to Barcelona, reducing the travelling time in 20 minutes up to 4 hours 15 minutes. Seven months later, December 2006, one new stretch of HS line was opened between Lleida and Tarragona, what reduce Alvia travelling time up to 3 hours 55 minutes.

Finally, in February 2008, the last stretch of the new line Madrid-Barcelona was opened between Tarragona and Barcelona giving a final direct travelling time of 2hours 38 minutes and a frequency of 17 trains in each direction, what increase the number of available seats per day in 142 %. Since that final step the main change that has been occurred in the line is the continuous variation of frequency. *Figur 8*

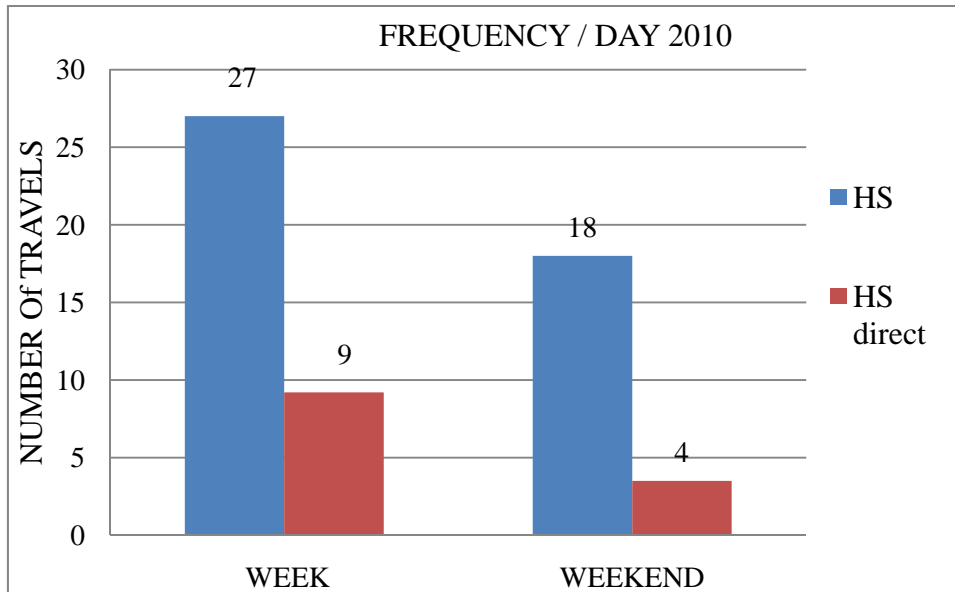


Figur 8 Evolution of railway frequency between Madrid and Barcelona.



Figur 9 Evolution of railway travelling time between Madrid and Barcelona.

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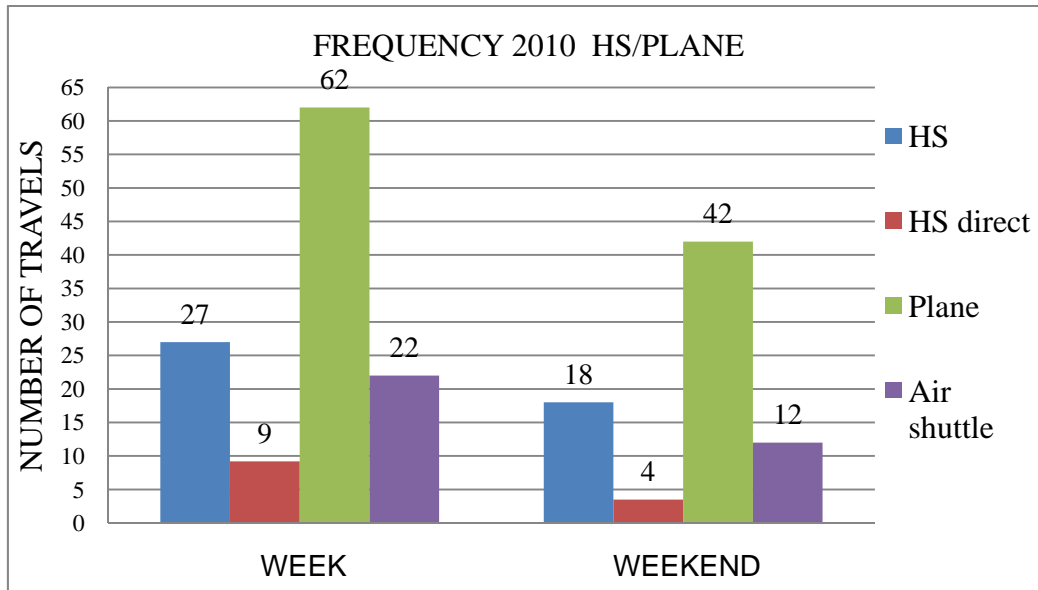


Figur 10 HS frequency: day/direction between Madrid and Barcelona distinguishing direct trains.

Nowadays the service counts with 171 travels per direction in a week with 53 direct trains with no intermediate stops. On weekends, the service is 73% lower; this gives an idea of the passenger demand that is created because of work reason during the labour days. Figur 10.

The plane service between Madrid and Barcelona is operated by four companies: Iberia, Spanair, Aireuropa and Vueling, where Iberia has more than a half of the supply; it is operating with the conventional service and with the shuttle service. Due to the high importance of the work travels along this corridor, the supply of the “air shuttle” has been considered separately as well. The data has been got from the WebPages of each company, but the values do not cease to be by way of guidance.

The frequency in HS supply varies between fifteen minutes, thirteen minutes and one hour along the day, having the rush hour in the early morning and at the end of the afternoon; while the plane frequency varies between fifteen minutes and one hour; with the rush hour in the morning. Figur 11



Figur 11 Comparison of frequency per day between HS and plane between Madrid and Barcelona.

5.2.3. Evolution of passenger demand up to nowadays.

The corridor Madrid-Barcelona is one of the corridors with highest demand in Europe, having before the starting of the HS in 2008 the highest volume of air passenger in Europe: just about 5 million/year. The high demand of passenger since the 70's makes Iberia establish, besides its conventional service, a new service called "air shuttle" in 1974. The service consisted in 13 flights per direction each day introducing the novelty in the Spanish air-service of the no need of seat reservation and one hour frequency. Due to the good air-service in the corridor and the very poor train service, it took 9 hours to run 720 km between Madrid and Barcelona, in the incoming years the demand of the air-service increased considerably in the 70's, from 1.2 up to 1.53 million passengers in 1979 (Rodríguez Bugarín, M. Et al., 2005).

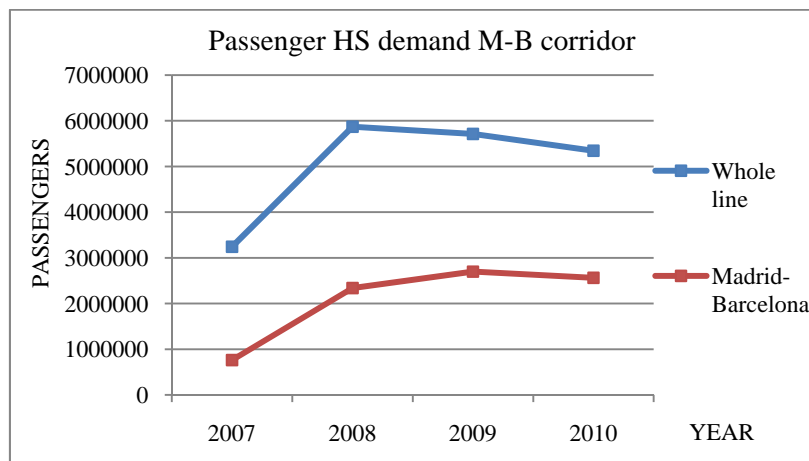
During the first half of the 80's the traffic demand was characterized by a downward trend due to the economic crisis, period that contrasts with the 90's. In 1994 the air-service was liberalized and two more companies started to operate in the corridor, whose attractiveness was the low fares in comparison with Iberia. This change in the air market, which brought about competitiveness and high supply, made the demand increase even more; it went from 1.92 million in 1993 to 3.09 in 1997 and to 4.1 in 2003 (Rodríguez Bugarín, M. Et al., 2005). The figures of the air market show that it overshadows the rest of modes of transport along corridor Madrid-Barcelona, and confirm the nearly lack of importance of the train in the corridor.

As a consequence of the transport picture in the Madrid-Barcelona corridor, the construction of a new high speed line along it had a double challenge: improve the features of the poor railway transport and make it attractive to passengers, besides be competitive against a big air market already well-established.

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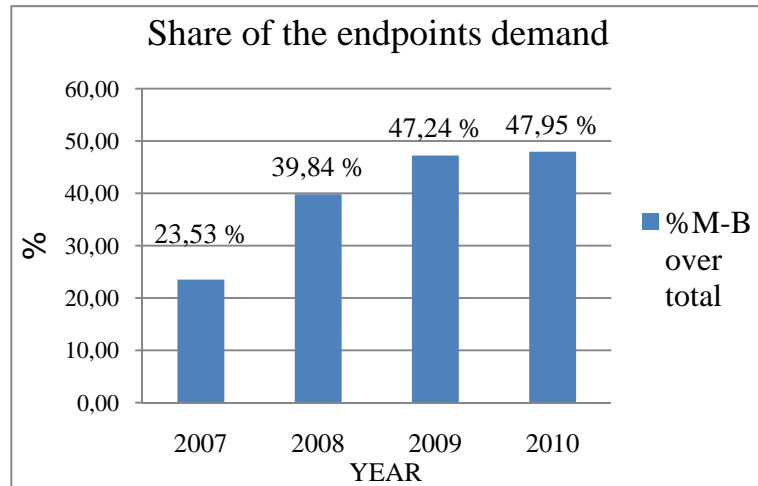
Right after the opening of the line, the first studies about the impact of the train on the passengers started to appear. The first statistic made reference to the two first months of use of the HS and its results showed a passenger increase in respect of the same period of the previous year both in total number of passenger in the line and passengers that travel between endpoints: 73,4% and 246% respectively. If it is considered the period until August 2008, the total amount of passengers that had used the line regarding the same period of 2007 was 84,5% higher, what means that the increase of passenger was going up.

It is important to figure out the development of passenger on the first anniversary of the line Feb 2009, which brought about a difference of 81% (regarding the whole line) and 206,4 % (from start to end of line) comparing to the same period of the previous year. That % indicates that the increase of passengers kept on positive but with a slight fall. If we continue collecting data about the relation of passenger in this way, between the second year of use 2009 and the first one 2008, the increase turns into decrease in what the whole line respects: -2,7 %; however, the number of passenger that go from Madrid to Barcelona stabilizes and continues growing, in comparison to the first year of use, in 15,4%. These mean an increase in the number of passenger regarding the previous conventional line of 76,12 % on the whole line; and an increase of 253,6% in passenger from Madrid to Barcelona. The latest figures of passengers in the line make reference to the year 2010, the third one in use. The figures reflect a generalize decrease of the demand along the line comparing to the previous year: 6,43% in total, and 5% just between the endpoints. Figur. 12.



Figur 12 Development of passenger demand along Madrid-Barcelona corridor since the start of the HS.

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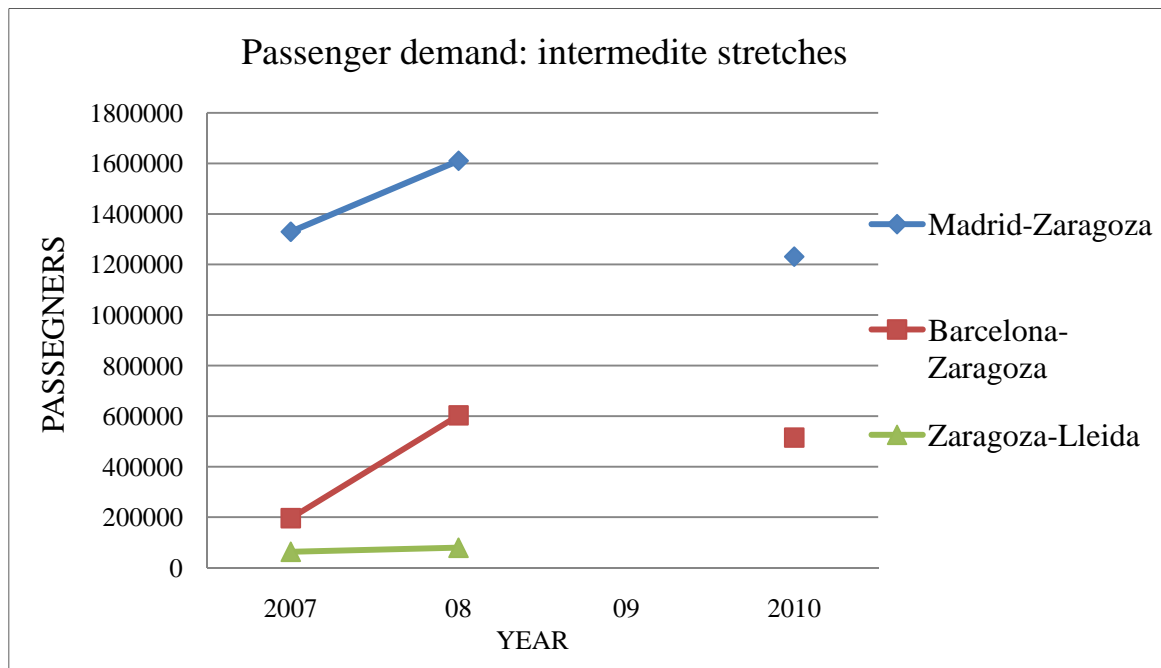


Figur 13 Share of the endpoints demand over the total demand along Madrid-Barcelona HS corridor

However, the life of this line is still pretty short to be well established but, up to now, the HS has managed to become in a good alternative mean of transport along the corridor and has got a competitive service that makes it able to be competitive against the other means, plane in particular as it will be show in the next section. In relation with that, the stretch more demanded in the corridor, and that is one justification of its construction, is the one between Madrid and Barcelona, which has a passenger share in the corridor near 50% of the demand. *Figur 13*

If we pay attention to the rest of the intermediate stretches, although there are only values of the first and third year of the line (*Figur 14*), they show that the second stretch more demanded is Madrid-Zaragoza; however, this is not the passenger demand that has increased more, but Barcelona-Zaragoza. Considering the evolution of the demand, during the first year with the HS train running along the complete corridor, it increases along both stretches, being the development of the stretch Barcelona-Zaragoza completely spectacular, comparatively (208%). During the second year of HS service there are no values but during the third year of service (2010) the picture changes completely. The demand falls and it falls drastically in the case of Madrid-Zaragoza, where the number of passenger is even lower than in 2007. Along Barcelona-Zaragoza the demand also decreasing (15%) but the influence of the HS is still positive comparing to 2007.

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Figur 14 Development of intermediate stretches demand along the HS corridor Madrid-Barcelona

The characteristics of each stretch are:

Madrid-Zaragoza:

308 km

Travel time: 1h18min – 1h30min

Ticket fare: 24 - 88,5€

Barcelona-Zaragoza:

314km

Travel time: 1h 26min – 1h47min

Ticket fare: 26,3 - 98,6€

Zaragoza-Lleida:

146km

Travel time: 43 – 47 min

Ticket fare: 12 – 29,3 €

It can be deduce from the values that the HS has made the relation change between each pair of cities. The relation by train involving Barcelona and Zaragoza has strengthened bonds; while between Madrid and Zaragoza is the opposite case. Due to the fact that the distance is around 300 km there is no plane market between each pair of cities so the diverted flow of passenger must be gained by the road: private car or coach.

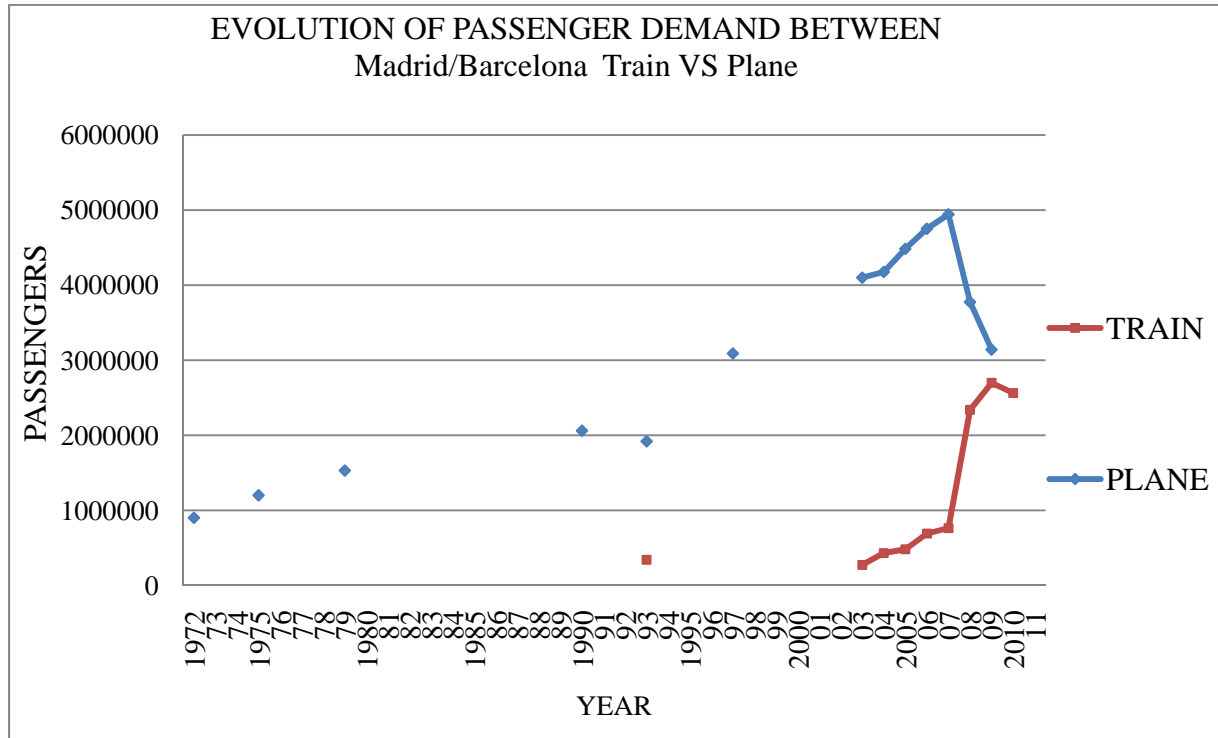
Competition with the plane: Madrid-Barcelona

The total amount of passenger in the corridor split between road, train and plane depending on their necessities and the expectations of the travel, this distribution defines the market share of each mode. The incorporation into a corridor of a new transport mode changes the well-establish equilibrium between them; in the case of the HS train, its establishment in a corridor changes the existing equilibrium competing with the road in distances less than 300 km and with the plane in distance between 300 and 600 km (De Rus,G., 2008.). Under this affirmation the Madrid-Barcelona HS train goes into direct competence with the plane.

As I explained before, the plane market was going through a profitable spell, being the corridor with the highest volume of passenger in Europe: near 5millions in 2007. Right after the inauguration of the HS service along the whole corridor, the plane market started felling

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its influence losing the 23,6% of the demand from 2007 to 2008, what coincides with the train gain of passenger of 206,4%. *Figur 15*



Figur 15 Evolution of Train and Plane demand along the corridor Madrid Barcelona²⁸.

If we calculate the loss and the gain of each mode of transport, it can be deduced that the train gained passenger from the plane and got an induced demand as well. Attending to the continuous increasing demand of the plane since 2003 there is no reason that brings us to think that the loss of demand from 2007 to 2008 was inducted by any other reason but the HS. Besides that, the gain of HS demand exceeded the plane decrease, what means that the HS gain passenger from other modes and generated passenger demand by itself: induced demand that appears when a new mean of transport is established. *Table 27*

2007/2008 Madrid-Barcelona		Passengers
Plane loss		1,168,643
HS gain		1,574,932
HS	Gain from the plane	1,16 million
	Others	0,4 million

Table 27 Changes of demand distribution 2007-2008 between HS and plane.

²⁸Source: López Pita, A., 2010. High Speed Rail Modal Split on Air Traffic Density Routes. In: *Proceedings 7th World Congress on High Speed Rail*. Beijing, December, 2010. Press notes from RENFE.

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If we continue with the comparison between 2008 and 2009 (*Table 28*) the plane keep on loosing demand while the HS increase its more. Otherwise, in the general count the demand along the corridor decreases in 0,27 million passenger; these passenger are losses from the plane and the train did not gain them. The decrease of demand along the corridor is in concordance with the full economy crisis. *Table 29*

2008/2009 Madrid-Barcelona		Passengers
Plane loss		634,312
HS gain		360,087
HS	Gain from the plane	0,36 million

Table 28 Changes of demand distribution 2008-2009 between HS and plane.

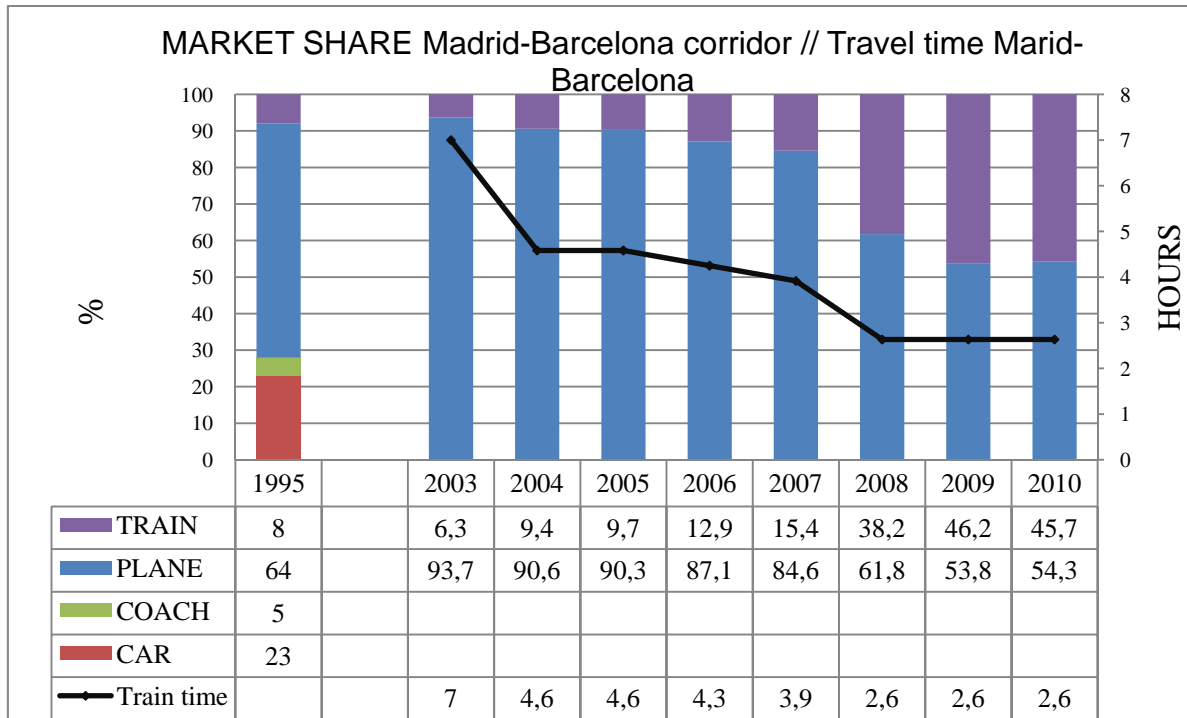
2008/2009 Madrid-Barcelona	
Decrease of demand from Madrid to Barcelona	0,27 million

Table 29 Calculated decrease of demand along the corridor Madrid-Barcelona between 2008 and 2009.

The study of the competition cannot be made comparing 2009/2010 because of the lack of values from the plane for 2010. The values of the train clearly show losses of passengers, presumably accompanied with losses in plane passengers as well, because of the economy crisis.

All these figure result in the different percentages of market share that every mode gets. It is because of that, that the market share of the plane will start being paramount and as the train track was upgraded since 2003 to 2008 it was gaining share. During these years of upgrading, the main change that the passengers principally perceive was reduction of travel time thanks to the new track and the HS; wherefore, the increase of the railway market share is in keeping with it. *Figur 16*

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Figur 16 Market share along the HS operation.

Although the highest reduction of time (2,4 hours) was between 2003 and 2004, the largest advance in the market share (22,8 %) took place between 2007 and 2008 due to the start of the complete service of the HS trains along the corridor in 2,6 hours. From 2008 on the market share has kept the position. These values correspond with the results of official Spanish studies where it is said that to attract passenger to the train is easy when the travel time is no longer than 2 hours and a half; any other higher reduction of time, once it is under 2 and a half hour does not increase the passenger demand significantly.

Contrast with the expected figures

The new track was built expecting to attract 3.3 million passenger a year from the road (private car) and 1.3 million from the plane; as well as be able to induce 4.4 million journeys by the new infrastructure. These would increase the modal share from 20% to 47 % and would involve annual saving in externalities as follows (Abbott,J. et al.,2007):

- Noise, pollution, accidents, climate change: €325 million per year
- Energy: €50 million per year
- Travel time reductions: €170 million per year

In the analysis of the gain volume of passengers in the previous chapter, every passenger that the plane has lost has been added as gained passenger by the HS from the plane; in addition, other modes of transport have not been considered (i.e. private car), in consequence, the comparison is limited. However, the passengers gained from the plane can only come from the Madrid-Barcelona stretch because it is the only long enough stretch for plane passenger transport, so that, the previous calculated value must be the same for the total of the stretches

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as well. Apart from that, the comparison is also limited because the expected values refer to the total amount of passenger, while the previous chapter only takes into account the passengers from Madrid to Barcelona. Therefore, new relations between the total passengers of the line must be done. *Table 30*

HS Madrid-Barcelona (total stretches)	
YEAR	Gain
2007/2008	2625924
2008/2009	-157478
2009/2010	-367155

Table 30 Passenger along the total stretches of the line Madrid-Barcelona

Once the values are clear, the expected values announced (Abbott,J. et al.,2007) are twice as much as the real changes that took place between 2007 and 2008, as it can be observed in *Table 31*. On the other hand, the prediction that is more close to the reality is the gain of passenger from plane.

PERIOD	Expected				Reality			
	Changes			Total	Changes			Total
		Gain	Induced			Gain		
2007/2008	From road	3.3	4.6	9.0			1.16	5.9
	From plane	1.3			From plane	1.16		
	Induced	4.4	4.4		Other	1.5		

Table 31 Comparison of demand changes between expected values and reality along the total stretches of the corridor Madrid - Barcelona.

5.3. Modes of transport today

In view of the fact that the service of the High Speed train between Madrid and Barcelona is the interest of the thesis, it is needed to compare it with the rest of the other means of transport along this corridor: car, coach and plane. In order to do so, in the case of the road the shorter and reasonable itineraries will be studied. With regard to the bus, the main company in this route ALSA is considered. Finally, to study the air transport it will be take into account planes from Iberia, Vueling, Spanair, AirEuropa, being the main operator Iberia, whose weekly supply is bigger than the sum of the other three.

The first part of the comparison will focus on the most important factors: travelling time and cost. On the other hand, several interview surveys have showed that the journey's attractiveness depends on at least six factors: high frequency of service, direct services, comfort, good service, travel time and price (Fröidh,O. Et al.,2009) and we can also include accessibility as factor.

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Firstly, there will be done a comparison just taking into account the travel time and the cost separately, which are two of the most decisive variables that determine travellers' transport mean choice; also calculating the parameter €h and €km that each mode involves. Then, the travel time will be adjusted adding the access and waiting time for each mode of transport and they will be compared again between each other in order to make the comparison more comprehensive. Secondly, an analysis cost-time model will be done in order to find out how a passenger can behave opposite the modes supply, distinguishing between different passenger profiles. Finally, it is going to be studied on each mode if the variable: time, fare, accessibility, comfort and frequency make them come up as a suitable chosen mode along the corridor.

COMPARISON OF TRAVELLING TIME AND FARES BETWEEN MODES

MODE		TRAVEL TIME (min)		COST €			Km	MAP
Car	A	376 (6h16)		toll	gas	82,6	622	
				24,6	58			
	C	499 (8h19)		12	55	67	603	
Coach	A	455 (7h35)		35			622	
		470 (7h50)		28,85				
Train	Min time	158 (2h38)	First class	203,5	125	621		
			Tourist	138,8	55,5			
	Max time	199 (3h19)	First class	176,5	105,9			
			Tourist	117,6	47,1			
Plane	70 (1h10)		35 - 255			505		

Table 32 Comparison of travelling time and fares between modes. Author made from: Adif, RENFE, IBERIA, ALSA, ViaMichelin

Taking the *Table 32* as a starting point to compare the different ways of transport, it is possible to make a simple analysis. Regarding the travel time there are two groups that differ from each other significantly: car/bus and train/bus, so if the time was priority it is clear that the first group would not be chosen, in any case time is less than 6 hour, while in the second group is at least half less of the time. On the other hand, if we pay attention only to the cost the chosen mode would be either the bus or the plane, where it is possible to find the lowest costs around 30 €. It seems that the comparison is on the side of the plane. The €h and €km values, that each mean involves, do not bring many information when it is considered on its own; they will be more useful when it comes to compare Spain and Sweden supply in section 7. **Appendix V : CALCULATION OF €H AND €KM**

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In relation with the adjustment of the travel time, it is needed to take into account the access time to and from the station/airport, as well as the waiting time in there. Given that the train stations are in the centre both in Madrid and Barcelona cities, as well as the bus stations, the additional time is only going to be considered for the plane. The fact that both airports are located some kilometres far from the cities and the needed time in advance that you have to be at the airport before the departure involve a considerable increase of time. On the other hand, attending to the “Glosario de movilidad sostenible” “Sustainable mobility glossary” edited by ISTAS in Spain, the mean occupancy of private car is 1,2 people/vehicle, in that case the cost of the private car must be corrected, as well as the plane cost.

Barajas airport in Madrid is located 12 km at the northeast of the city. It is possible to get there by: private car, taxi, metro and bus. *Table 33*

BARAJAS	Time (min)			Price €		
	fr centre to airport	Waiting time at airport				
Private car	20-40	35	Air shuttle	20	-	7
Taxi	20-40				25	
Metro	40-50		60		2	
Bus					1	

Table 33 Information about how to get to Barajas airport in Madrid.

El Prat airport in Barcelona is located 15 km at the southwest of the city. It is possible to get there by: private car, taxi and bus. *Table 34*

EL Prat	Time (min)			Price €		
	fr centre to airport	Waiting time at airport				
Private car	25-35	30	Air shuttle	20	-	9
Taxi	25-35				25-30	
Bus (exclu. service)	25-35		60		5	
Train	25				3	

Table 34 Information about how to get to El Prat airport in Barcelona.

When it comes to show the last figures that will be evaluated, the car options C and B are going to be omitted in favour of the option A and coach option is going to be showed as an average of both of them. *Table 35*

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SUMMARY OF TRAVELLING TIME AND COST

MODE	TRAVEL TIME (min)		Cost €		
Car	376		69		
Coach	463		32		
Train	Min time	158	First class	204	125
			Tourist	139	56
	Max time	199	First class	177	106
			Tourist	118	47
Plane	155		51-271		
	195				

Table 35 Summary of travelling time and cost attending every Spanish mode of transport.

Once the travel time has been corrected, the train start being more competitive with the plane, where the conventional airplane travel time is even longer than the shorter train travel time.

COST TIME MODEL

To study the choice between means of transport the cost-time model is going to be used, which establishes that passengers choice between means of transport depending on the value they attach to time, cost and journey time features of each mean (López-Pita,A. and Robusté F.,2005). Therefore, they end up selecting the lowest generalized cost according to their value of time.

$$Cg_1 = P_1 + h_j \cdot T_1$$

P_i : total cost of the travel between two points

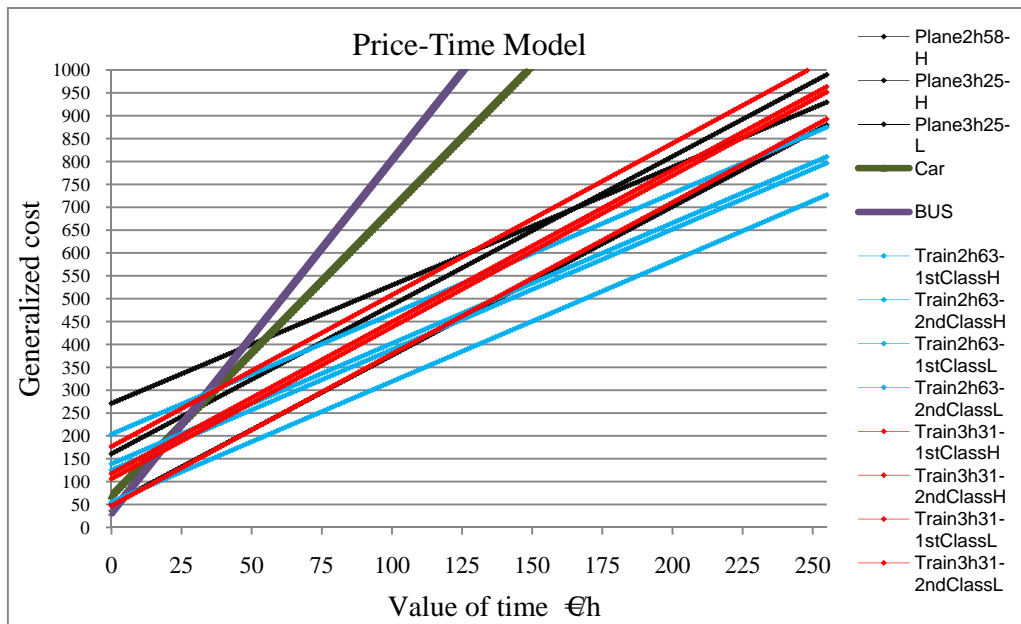
T_i : total time of the travel between two points

h_j : time value; represent the valuation that the passenger attributes to the travel time, in other words, the price that he agrees to spend in one hour of journey. The higher it is, the more the time is valorised and, in consequence, the more in favour the passenger will be to travel in a fast mean obviating the price. Being the other way around when it is low: he will consider the price criteria before the speed.

Cg_i : generalized cost

The representation of “time value/generalized cost” shows the choice between modes. If we consider all of the options at the same time, the train in its shortest travel time is the option that will get a higher market share in its different fares. On the other hand, the train longest travel time is in competence with the plane, needing this last one a higher time value to be chosen except for the lowest plane fare. The plane is an intermediate option between both different train journeys. Depending of the value of time of each passenger the first selected options will be coach and low flight fare, but as soon as the time value is increasing (less than 25€), the train is the outstanding option. *Figur 17*

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Figur 17 Price-time model along Spanish corridor.

Trying to make a deeper analysis of the train and plane supply, and to be able to take into account the different fares of the train and plane, some passenger profile are going to be made: BUSSINESS/WORK, LEISURE, LOW-COST: student, family issues... being the options car and coach the same for all the profiles. The division of the demand market has been done this way because the planning, freedom of timing and expectations of the travel are not the same for each kind of profile; in addition, they are found in RENFE study²⁹ about the passenger profile as it was said in the *Method chapter*.

- For the BUSSINESS/WORK profile the options with less travel time have been chosen. On the other hand, the train cost has been chosen in first class and without any discount thinking that when you have to travel for work the timing is stricter and you have less possibilities of choosing offers. In the case of the plane, to take advantage of the waiting time facilities it is needed to travel with the “air shuttle”, what means higher price.
- For the LEISURE profile it has been decided to choose the short travel time option for train in tourist class with discount due to the fact that the travel is possible to be prepared in advanced. For the plane, the travel time results adding the regular waiting time and the cost is an average of both because of the fluctuations in flight fares.
- For the LOW-COST profile it has been chose the long travel time for both means, as well as the most economic fare.

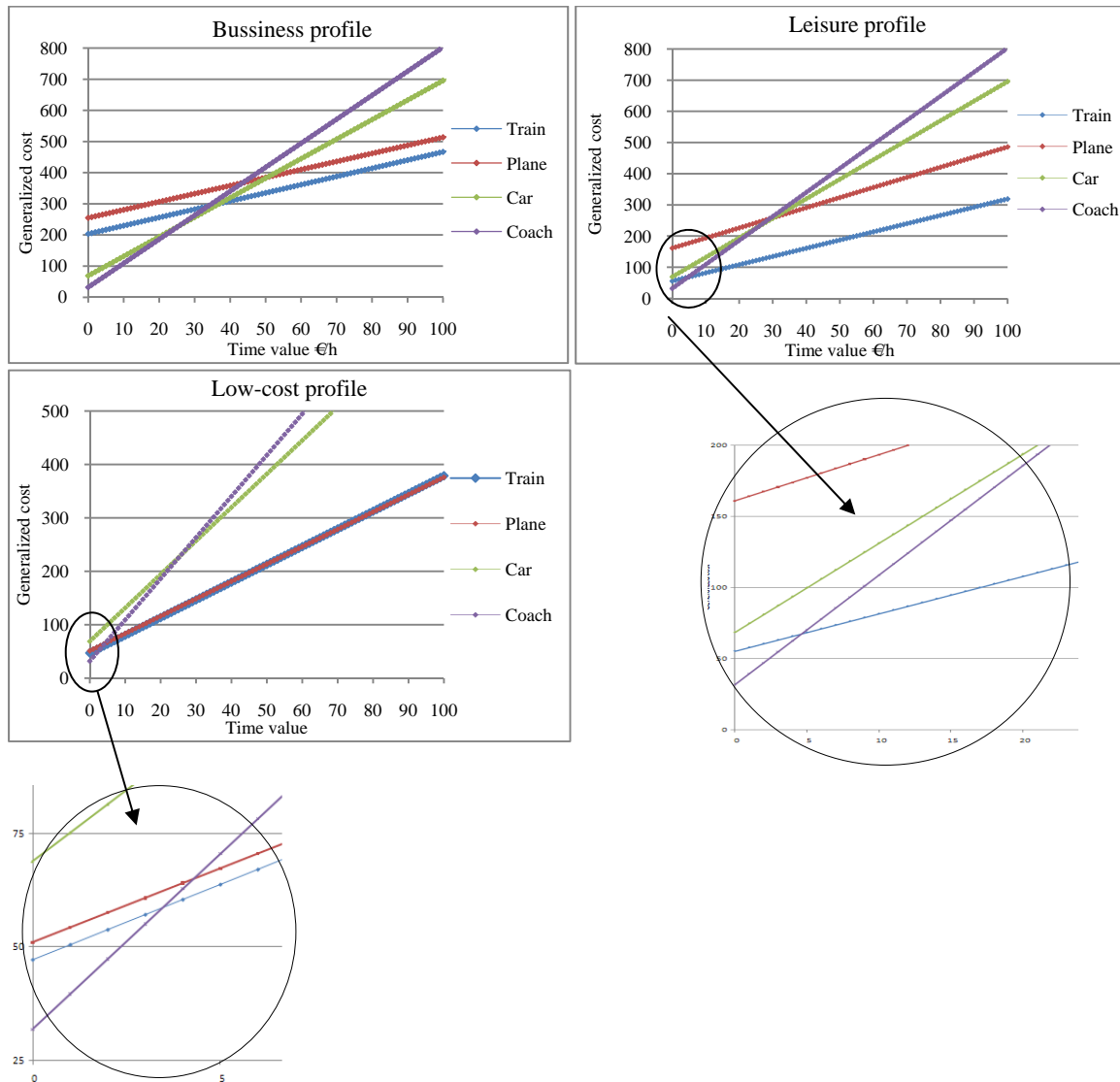
²⁹ RENFE, press release: “El AVE Barcelona-Madrid celebra su tercer aniversario con casi 17 millones de viajeros en todo el corredor”. Madrid, 20 February 2011.

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BUSSINESS/WORK			LEISURE			LOW-COST		
MODE	Time (min)	Cost	MODE	Time (min)	Cost	MODE	Time (min)	Cost
Car	376	68,83	Car	376	68,83	Car	376	68,83
Coach	462,5	31,9	Coach	462,5	31,9	Coach	462,5	31,9
Train	158	203,5	Train	158	55,5	Train	199	47,1
Plane	155	271	Plane	195	161	Plane	195	51

Table 36 Representation of the time and cost chosen for each profile of passenger

Once the division is done and we have decided the different time and cost for each mode, in order to find out the variation of the generalized cost according to the time value, it is going to be represented separately each profile. *Figur 18*



Figur 18 Representation of the time/cost model for each profile in Madrid-Barcelona corridor.

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As an orientation, the typical values in euros of time valuation in 2002 were (López-Pita, A. and Robusté F., 2005):

Motivation of the journey	Car	Airplane	High-Speed Railway
Obligatory €h	16	46	34
Non-obligatory €h	14	28	22

Table 37 Represented figures of time value depending of the motivation of the journey.

Attending these graphs, there are some conclusions that can be brought about of any of them. The coach is the most economic mode although it loses this principal position soon, as the passengers give more importance to the time: time value increases. As one reason of this profile division was the planning in advance and the freedom of timing, it is possible to say that the more time at our disposal the more favoured the plane results. On the other hand, in strict timing travels and leisure the time value must be so high to make the plane the chosen mean. The car has not relevance in this analysis due to the fact that it does not result in the most economic one and its travel time is pretty large; the reasons to choose this mode must be related with its accessibility and comfort when it comes to door to door stretches.

If we pay attention to the time valuation in *Table 37* both train and plane satisfy the time valuation of obligatory trips, however the train is more favourable than the plane because the time value is lower. Attending the leisure profile, the train is the one which is done the best out under the time value limit. Finally, the low-fare profile shows the tightest result where, although the train has a lower time value, the plane and train could be chosen without distinction.

Once the variables time and cost have been studied and some conclusions have been extracted, some other variables are going to be introduced in the study and classified attending their quality, for each mean, to get a deeper analysis: time, fare, time/cost, accessibility, comfort and frequency. The complete classification of each case is gathered in the **Appendix VI: EVALUATION OF TRANSPORT MEANS ATTENDING DIFFERENT VARIABLES: SWEDISH CORRIDOR STOCKHOLM-COPENHAGEN**; the levels of supply quality are defined as the scale:

- Very favourable
- In favour
- Indifferent
- Disadvantaged
- Very disadvantaged

Regarding the variables time and cost, some levels are going to be attributed to them and then transform into the scale:

- Level 5: Very favourable.
- Level 4: In favour.
- Level 3: Indifferent.
- Level 2: Disadvantaged.
- Level 1: Very disadvantaged.

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Regarding the time/ cost relation, the influence is going to be attributed regarding:

- Very favourable: it is a clear chosen mean of transport in the majority of the profiles
- In favour: it has prominence in the analysis.
- Indifferent: it has prominence in the study but it is lost because of the other means easily.
- Disadvantaged: it has no prominence in the study.
- Very disadvantaged: the combination time/cost makes it not competitive for passenger transport along the corridor.

Regarding the accessibility, the influence is going to be attributed regarding:

- Very favourable: the passenger has the control of the travel.
- In favour: the stations are in the center of the city and it is possible to find different departure places.
- Indifferent: the station has one position in the center of the city or nearby it not to be a problem for the total travel time.
- Disadvantaged: the time to access the station is so relatively large to influence on the total travel time in around 30 minutes.
- Very disadvantaged: the time to access the station is so relatively large to influence on the total travel time in more than 30 minutes.

Regarding the comfort, it involves only the comfort during the travel:

- Very favourable: the passenger has the travel time at his own disposal for work or leisure, having access to the new facilities as wifi zone, bistro/bar; apart from enough space to have a pleasant travel. (business and train)
- In favour: the passenger has the travel time at his own disposal, having access to the new facilities as wifi zone, bistro/bar.
- Indifferent: the travel time is not longer enough to make comfort an import variable.
- Disadvantaged: the passenger has the travel time at his own disposal for work or leisure.
- Very disadvantaged: it is not possible for the passenger to use to travel time.

Regarding the frequency, the classification will be done attending to the number of the departure during one day and the intervals of time between them, as well as the capacity to adapt to rush hours.

- Very favourable: number of daily supply higher than the average with capacity to adapt itself to rush hour
- In favour: number of daily supply around the average with capacity to adapt to rush hour.
- Indifferent: daily supply around the average with no capacity to adapt itself to rush hour.
- Disadvantaged: daily supply lower than the average with no capacity to adapt itself to rush hour.
- Very disadvantaged: deficient supply with not capacity to adapt itself to rush hour.

EVALUATION OF TRANSPORT MODES ALONG THE CORRIDOR ATTENDING THE VARIABLES

Mean	Time	Cost	Accessibility
Car	Disadvantaged	Very favourable	Very favourable
Coach	Very disadvantaged	Very favourable	In favour
Train	Very favourable	Indifferent	Indifferent
Plane	Very favourable	Indifferent	Disadvantaged

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Mean	Comfort	Frequency	Time/Fare
Car	Vey disadvantaged	Very favourable	Disadvantaged
Coach	Disadvantaged	Disadvantaged	Indifferent
Train	Very favourable	In favour	Very favourable
Plane	Very favourable	Very favourable	In favour
	In favour		

Table 38 Evaluation of transport modes

In order to realize a more specific appreciation of the most suitable mean of transport along the corridor there have been ascribed punctuation to the previous appreciation:

- Very favourable: 2
- In favour: 1
- Indifferent: 0
- Disadvantaged: -1
- Very disadvantaged: -2

As it has been showed in the cost/time model, some different passenger profiles exist and each one has its own expectation of the journey, they attach different importance to each variable. To get a final result of the convenience of each mode of transport along the corridor, there have been ascribed different weights to each variable from 0,5 to 2 differing between profiles in order to be able to take into account the differences between them. This scale is used to differentiate the variables that are crucial to make the choice of mode (2) from the other which are not relatively important (0,5), as it was explained in the *Method chapter, Table 39*. In this analysis the variable time/fare is not going to be taking into account because there are already both factors separately.

Variables	WEIGHTS		
	BUSSINESS	LEISURE	LOW-FARE
Time	2	1	0,5
Price	0,5	1	2
Accessibility	1	0,5	0,5
Comfort	2	1	0,5
Frequency	2	0,5	0,5

Table 39 Chosen weights for each profile

Finally, the last step is to obtain the final result which takes into account the influence of each variable on each profile; the different modes of transport are going to be classified depending on the suitability for each profile. *Table 40*

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FINAL ESTIMATION OF SUITABLE TRANSPORT MODE ALONG THE MADRID-BARCELONA
 CORRIDOR

Madrid-Barcelona (nowadays)				
	BUSSINESS	LEISURE	LOW-FARE	
Car	MEDIUM	MEDIUM	HIGH	3
Coach	LOW	LOW	MEDIUM	4
Train	HIGH	HIGH	MEDIUM	1
Plane	HIGH	HIGH	LOW	2

Table 40 Final estimation of suitability along Spanish corridor.

Attending to the last result, the mode that has a completer supply for every of the profiles is the train, following by the plane, being the coach in last place. Although in the conclusion of the cost/time analysis the plane turned out to be most convenient mode for low-fare profile, when it comes to take every variable into account, the train option works out to be better. On the other hand, the car does well out in the low-fare profile, been the most favourable one, moreover, it has better result comparing to the coach in the others profiles.

6. Sweden

6.1. Decision process

Since the separation of the railway sector into two different bodies in 1988, the proliferation of new tracks in the following years made the train demand, both passenger and freight, increase setting new records in Sweden in 2008. This concluded in congested and overload lines according to the Swedish Rail administration (Jansson, K., 2010; Nelldal, B., 2010). The Swedish National Rail Administration has carried out several studies in order to evaluate how to solve these problems attending different options; the last study in September 2009 considered the options: expanding Stockholm-Gothenburg and Stockholm-Malmö main lines to accommodate express train running at 250km/h; construction of a new High Speed line with an alternative route as the current one³⁰.

The conclusions of the study show that although the Hs option is more expensive, it has the highest socioeconomic profitability with a net present value of 0.9 over a calculation of 40 year, opposite to 0.4 of the other option. The HS option brings more capacity as well as highest travel time reductions³⁰. However, the final decision is still not clear.

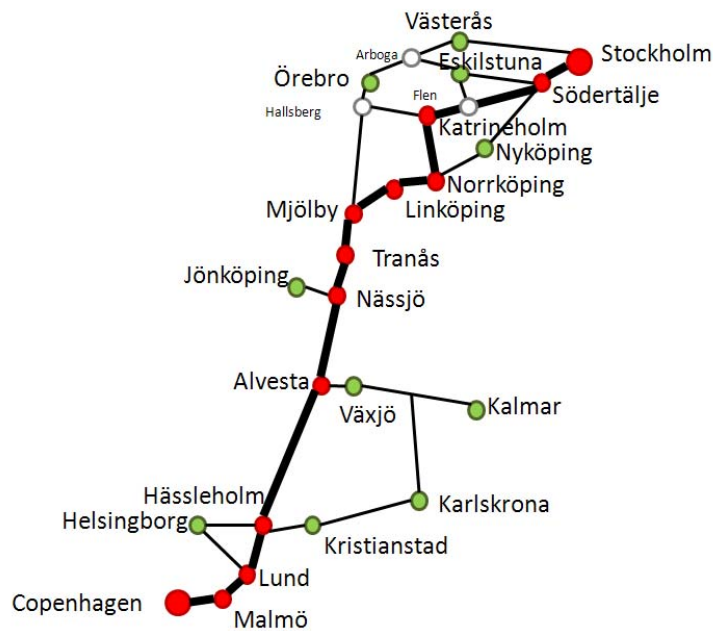
6.1.1. Description of the line

Nowadays trains in Sweden run at 200 km/h on classic lines. According to the Annex I of the European Union Directive 96/48/EC³¹, they can be categorized high-speed because they are in the group of trains that run between 200 and 250 km/h on improved track. However, due to the fact that they do not run on a new high speed track, the travelling times are not as short as in the Spanish case. The most important rolling stock used along the corridor Stockholm-Copenhagen is the X2000. It is design for a top speed of 210 km/h, although it only reaches up to 200 km/h along the corridor.

The line is a double track with 17 stop, but there is not the case that the train stops in all of them in the same service. Apart from that, there are 10 connections to other cities with a coordinated schedule. *Figur 19*

³⁰ High-speed lines in Sweden, traffic forecasts and socioeconomic calculations using the Samvips method for expanded main lines and separate high-speed lines. 2010. Traffic and logistics department, KTH, Stockholm 2010.

³¹ Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system. *Official Journal L 235*, 17/09/1996 P. 0006 – 0024



Figur 19 Sketch of the current Swedish Southern main line.

6.2. Modes of transport today

In the case of Sweden it is interesting to study the different modes of transport that exist in the corridor Stockholm- Malmö/Copenhagen: coach, plane and private car, to be able to compare them with the current train and to the future HS line. With these both comparisons we will find out how the HS could influence on the corridor and if it makes any changes in relation with the current line. In order to do it, in the case of the road there will be chosen those itineraries that are shorter and more convenient. Regarding the coach, the company Swebus has been chosen as the principal one and its supply will be part of the analysis. Finally, to study the air transport it will be take into account the supply of the companies SAS and Norwegian due to fact that are the only ones that make the route Stockholm-Copenhagen.

The analysis will be in the same way as it was in the Spanish case, but there will be two: the first one with the current line and a second one with the High Speed line characteristics. There will be done the time fare analysis separately; then the travel time will be adjusted and adding the accesses and waiting time. Secondly, the analysis cost -time model will be done in order to find out how a passenger can behave opposite the means supply, distinguishing between different passenger profiles. Finally, it is going to be studied on each mean if the variable: time, fare, time/fare, accessibility, comfort and frequency make them come up as a suitable chosen mean along the corridor.

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COMPARISON OF TRAVELLING TIME AND FARES BETWEEN MODES OF TRANSPORT



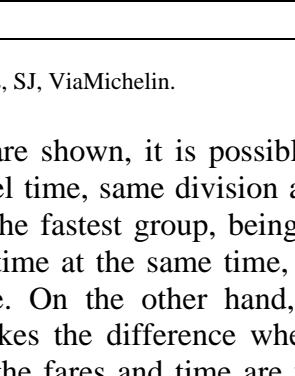
MODE		TRAVEL TIME (min)		FARE €		Km	MAP	
Car	A	412(6h52)		toll 40	gas 60	100	611	
	B	443 (7h23)		51	51	51		
Coach	A	530 (8h50)		40		611		
		560 (9h20)						
Train	Min time 0 change		Max time 1 change		1 st Class	From 79...to...206	630	
	317 (5h17)		341 (5h41)		2 nd Class	From 62...to...153		
Plane		70 (1h10)		36 - 233		520		

Table 41 Author made from: SAS airlines, Norwegian airlines; Swebus, SJ, ViaMichelin.

Attending the *Table 41* where the time and fare of each mode are shown, it is possible to divided the modes of transport into 2 group because of their travel time, same division as in the Spanish case but with the difference that the plane is alone the fastest group, being 4,5 times faster than the train. Paying attention to the fares and the time at the same time, it is clear that in return journeys, the plane is principle alternative. On the other hand, the importance that the passenger gives to the variable comfort makes the difference when it comes to choose between the road means and the train because the fares and time are very similar.

The time showed in the table above is only related to the travel time what means that it must be corrected by adding the access and waiting time at the station/airport. Due to the fact that the train and the bus station are located in the center of Stockholm and Copenhagen, the only considered additional time will be the one related with the travels that involves airport trips. Although there are four airports in the surroundings of Stockholm, flights to Copenhagen departure from one of them named Arlanda. Apart from that, the cost of the car will be change

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with a factor of 1,52³² passenger/car (long distance) (Millard-Ball, A., 2011; Cshipper L., 2011). The plane cost will be change as well, adding the price of the access to the airport.

The main airport in in Stockholm is Arlanda airport, which is located 42km at the north of the city; it is possible to get there by private car, taxi, bus and train. *Table 42*

ARLANDA	Time (min)		Price €		
	fr centre to airport	Waiting time at airport			
Private car	33	33	60	-	24
Taxi	33			56	
Train	20			27	
Bus	45			11	

Table 42 Information of how to get to Arlanda airport in Stockholm.

The main airport in Copenhagen is located 8 km from the city in the south. It is possible to get there by taxi, train, bus, metro and private car. *Table 43*

COPENHAGEN	Time (min)		Price €		
	fr centre to airport	Waiting time at airport			
Private car	20	19	60	-	8
Taxi	20			30	
Train	13			5	
Bus	25			3	
Metro	15			4	

Table 43 Information about how to get to Copenhagen airport.

To summary the data, the option B is going to be omitted because it involves a ferry; and both coach option will be reduced into one. *Table 44*

³² Swedish private car occupancy has decreased during 1970-2008 from 2,01 to 1,52 passenger/car. (Millard-Ball, A., 2011; Cshipper L., 2011).

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SUMMARY OF TIME AND COST

MODE		TRAVEL TIME (min)		COST €	
Car	A	412(6h52)		66	
Coach	A	545		40	
Train		Min time 0 change	Max time 1 change	1 st Class	Fr 79...to...206
		317 (5h17)	341 (5h41)	2 nd Class	Fr 62...to...153
Plane		182 (3h)		68 - 265	

Table 44 Summary of time and cost attending every Swedish mode of transport.

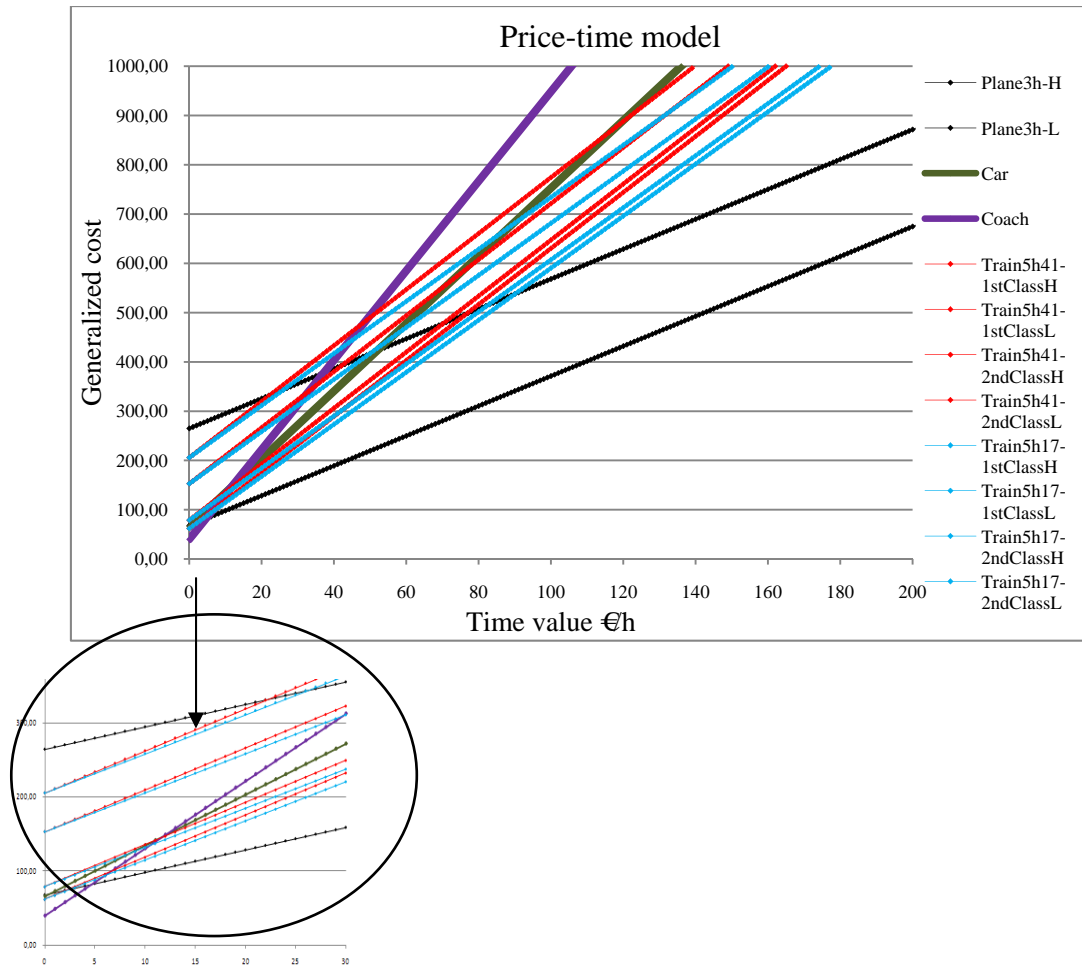
Once the travel time has been modified, the plane continues having a prominence position relating these variables.

COST TIME MODEL

In order to continue studying the variables, the same model as in the Spanish case is going to be used. The model analyze the pair of variables cost/time of a travel comparing each mean between them attending to the importance that the passenger brings to one hour of it: the amount of money that the passenger agree to pay for each hour of the journey. The explanation of the method is in the 5.3 section.

Although the costs of air travels change depending on the departure, as the train do, having a lower and upper limit the other possible costs will be drawn parallel to them, what means that there is no need of a very high price value to choose the plane instead of the train. On the other hand, according to the graph, the car has no prominence when the price value is low, as it is after the plane, coach and train, but the car passes behind the coach when the price value is still low, what means that depending on the circumstance of the trip these two means are in competition. In the same way, the coach starts competing with the train at low prices values, what becomes it in the mean that could compete with all the others. *Figur 20*

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Figur 20 Price-time model along Swedish current line.

As in the case of Spain in section 5.3, it is convenient to create some passenger profiles to study the prominence of each mode along the corridor taking into account different kinds of travels. To do it in correlation with the Spanish line the profiles will be the same: BUSSINESS/WORK, LEISURE, LOW-FARE: student, family issues... changing for each one the train option and being car, coach and plane option the same for all of them. The division of the demand market has been done this way because either the planning, freedom of timing or expectations of the travel are not the same for each kind of profile.

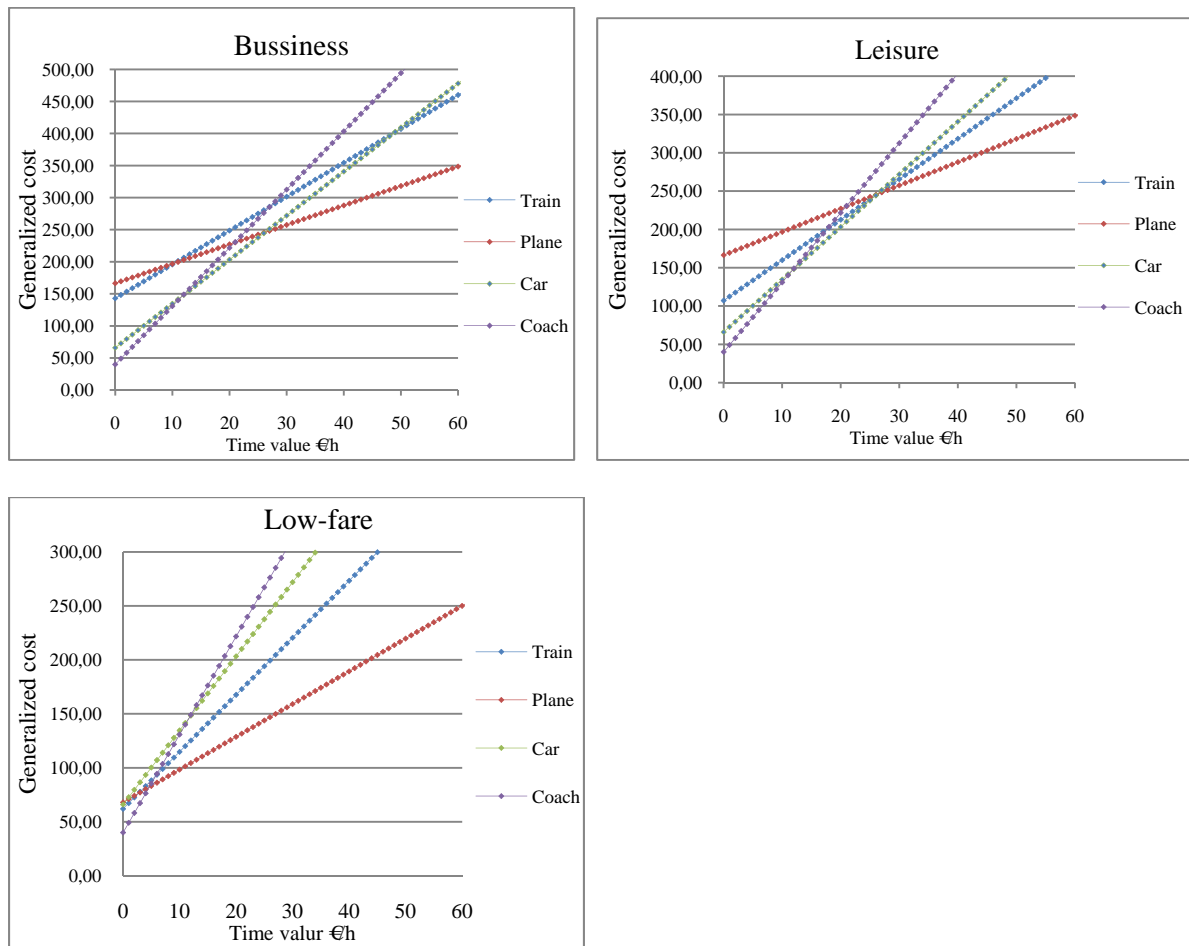
- For the BUSSINESS/WORK profile, the options with less travel time have been chosen. In the same way, for the train option, and due to the large variety of costs that is possible to find, it has been decided to use an average of the first class costs. Finally, for the plane option there is no option to take advantage of waiting time facilities as in the Spanish case therefore, it has been decided to use the average of the lower and upper costs.
- For the LEISURE profile, in the case of the train option it has been decided to choose the shortest travel time and an average of the second class prices, because of the large random possibilities of prices without any travel time distinction. For the plane, the option will be the same as in the business profile.
- For the LOW-FARE profile the characteristics will be the same as in the leisure profile but in the plane cost, which will be the most economic fare; and the train fare, which will be the most economic one as well.

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BUSSINESS/WORK			LEISURE			LOW-FARE		
MODE	Time (min)	Cost	MODE	Time (min)	Cost	MODE	Time (min)	Cost
Car	412(6h52)	66	Car	412(6h52)	66	Car	412(6h52)	66
Coach	545	40	Coach	545	40	Coach	545	40
Train	317	143	Train	317 (5h17)	107	Train	317 (5h17)	62
Plane	182 (3h)	166	Plane	182 (3h)	166	Plane	182 (3h)	68

Table 45 Representation of the time and cost chosen for each profile of passenger.

Once the division is done and we have decided the different time and cost for each mode, in order to find out the variation of the generalized cost according to the time value, it is going to be represented separately. Figur 21



Figur 21 Representation of the time/cost model for each profile in Stockholm-Copenhagen corridor

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Some orientated figures of time value in SEK are³³:

Motivation of the journey	Business	Leisure	Low-fare
Time value (SEK/h)	275	102	51 ³⁴

Table 46 Figures of time value in kr/h.

Attending to the graphs, the coach option results in the most economic one but it loses its prominence at low “time value” around 10-15 €/h. The car has its importance between the coach loses it and the plane gains it. Regarding the train, it is always over the plane option since the time value is 26 €/h in business and 10 €/h in leisure., when the plane gains prominence. On the other hand, if we take into account the car and coach, it needs a time value of 26 €/h in business and leisure profile to choose the plane; while only 5€/h in low-fare. Taking into consideration the time value in *Table 46* the chosen mode for business profile will be the plane, for leisure will be between the car and the coach and in low-fare profile the election will be between plane and coach.

As in the Spanish corridor, once the variables time and cost have been studied, some other variables are going to be introduced in the study and classified attending their quality, for each mean, to get a deeper analysis: time, fare, time/fare, accessibility, comfort and frequency. The complete classification of each case is gathered in the Appendix VI: EVALUATION OF TRANSPORT MEANS ATTENDING DIFFERENT VARIABLES: SWEDISH CORRIDOR STOCKHOLM-COPENHAGEN. The levels of supply quality, regarding each of the variables, are defined as the scale: very in favour, in favour, indifferent, disadvantaged, very in disadvantaged; and, to be able to make a future comparison between both corridors, the criteria ascribed to each step of the previous classification will be the same as in the Spanish case in 5.3 section. The only difference will be in how the variable frequency is estimated.

Regarding the frequency, the classification will be done attending to the number of the departure during one day and the intervals of time between them, as well as the capacity to adapt to rush hours. The train service has some direct trains from Stockholm to Copenhagen (and vice versa) complemented with some other connections with changes but with an established time table, these latest are going to quantify half.

- Very favourable: number of daily supply higher than the average with capacity to adapt itself to rush hour.
- In favour: number of daily supply around the average with capacity to adapt to rush hour.
- Indifferent: daily supply around the average with no capacity to adapt itself to rush hour.
- Disadvantaged: daily supply lower than the average with no capacity to adapt itself to rush hour.
- Very disadvantaged: deficient supply with not capacity to adapt itself to rush hour.

³³ Source: ASEK4

³⁴ It is an orientated figure deduced from the business and leisure values.

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EVALUATION OF TRANSPORT MODES ALONG THE CORRIDOR ATTENDING THE VARIABLES

MODES	Time	Cost	Accessibility
Car	Disadvantaged	Very favourable	Very favourable
Coach	Very disadvantaged	Very favourable	In favour
Train	In favour	In favour	Indifferent
Plane	Very favourable	Indifferent	Disadvantaged

MODES	Comfort	Frequency	Time/Fare
Car	Very disadvantaged	Very favourable	Indifferent
Coach	Disadvantaged	Disadvantaged	Indifferent
Train	Very favourable	Indifferent	In favour
Plane	Very favourable	Very favourable	Very favourable
	In favour		

Table 47

In order to realize a more specific appreciation of the most suitable mean of transport along the corridor there have been ascribed punctuation to the previous appreciation:

- Very in favour: 2
- In favour: 1
- Indifferent: 0
- Disadvantaged: -1
- Very in disadvantaged: -2

As it has been showed in the cost/time model, some different passenger profiles exist and each one has its own expectation of the journey, they attach different importance to each variable. To get a final result of the convenience of each mode of transport along the corridor, there have been ascribed different weights to each variable from 0,5 to 2 differing between profiles in order to be able to take into account the differences between them. This scale is used to differentiate the variables that are crucial to make the choice (2) of mode from the other which are not relatively important (0,5).

Variables	WEIGHTS		
	BUSSINESS	LEISURE	LOW-FARE
Time	2	1	0,5
Price	0,5	1	2
Accessibility	1	0,5	0,5
Comfort	2	1	0,5
Frequency	2	0,5	0,5

Table 48 Chosen weights for each profile

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Finally, the last step is to obtain the final result which takes into account the influence of each variable on each profile (fare/price jointly is not considered as variable); the different modes of transport are going to be classified depending on the suitability for each profile. Table 49

FINAL ESTIMATION OF SUITABLE MODE ALONG THE STOCKHOLM-COPENHAGEN CORRIDOR

Stockholm-Copenhagen (nowadays)				
	BUSSINESS	LEISURE	LOW-FARE	
Car	MEDIUM	MEDIUM	HIGH	3
Coach	LOW	LOW	LOW	4
Train	MEDIUM	HIGH	MEDIUM	2
Plane	HIGH	HIGH	LOW	1

Table 49 Final estimation of suitable mode along the Swedish current corridor

Attending to the results, the most competitive mean of transport along the corridor is the plane, followed by the train and car, with the coach in last position. The current train is competitive with the plane in leisure and low-fare, and with the car in business and leisure. However, the train could still be more competitive not only with the coach and car, but also with the plane until get the first place of the ranking.

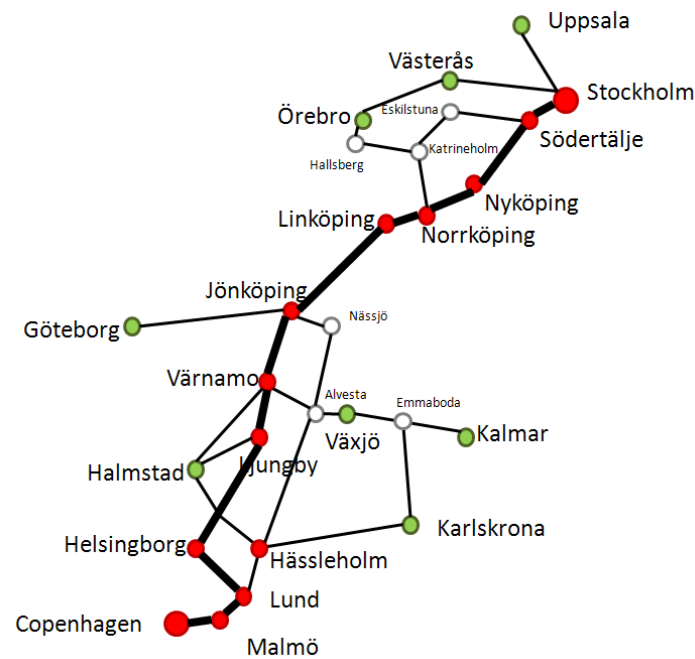
Regarding the train description of each variable, cost, frequency and travel time are most suitable to be changed and easier way to improve the service, increased attractiveness. Taking into account the section 7.2 in “*Compendium in train Traffic Planning*” (Fröidh,O. Et al.,2009) “for many private travelers lower fares is the single most important measure for them to choose the train. To reduce travel time and number of changes are also important” in consequence, the single most important factor to make travelers choose the train is the fare; so, that could be a good measure to improve the train position in low-fare profiles.

On the other hand, it has to be also taken into account the mode that the train is competing with. As the conclusion of the paper *High-speed trains in Sweden-a good idea?* (Jansson, K; Nelldal,B.; 2010) shows, when it comes to compete with the plane, as it is in business profile, the most important factor is the travel time; while if it is versus the car, as in leisure and low-cost profiles, it is most complex and factors like price and frequency come into play (Jansson, K; Nelldal,B.; 2010).

6.3. Approximation toward the High Speed service

The future HS railway in Sweden is planned to be constructed to improve the supply along the two most important corridors in Sweden: from Stockholm to Copenhagen and from Stockholm to Göteborg. For this matter, the track will consist in three parts: one main common track from Stockholm to Jonköping and two branches from there, one to Göteborg and another to Copenhagen.

Comparison of High-Speed train market between Spain and Sweden: Madrid-Barcelona VS Stockholm-Copenhagen



Figur 22 High Speed sketch in Sweden.

According to some research, the main variable that is related with the market share between plane and train is the travel time of the plane (Nelldal-Troche, 2001). The relation between them is quite direct when the train reduced its travel time, making the plane reduced its supply until the market establishes again (Jansson, K; Nelldal,B.; 2010). In consequence, and in relation with the previous section, it is convenient to study the possible influence of a future high speed railway service along the corridor Stockholm-Copenhagen carrying out the same analysis as in 7.1 section, but with the new HS supply. This way, it will be possible to see how the changes in factors³⁵, that affect the competence, modify the suitability of the different modes. As there is not available all the information about the future supply yet, the information that is not possible to find will be deduce from HS lines that are already running in other countries.

Travel time is one of the variables that the train can improve to be more competitive and become in another prominence mode of transport when it comes to return travels. The importance of improving the travel time is because it is “crucial to establish travel habits”. This is said because “it is often that the fastest mean of transport generates new travel” and “it is also the easiest to become the market leader which has the potential to charge a high enough level of prices” in order to reach a good profitability (Fröidh,O. Et al.,2009).

With high speed trains, the time along the whole corridor will be 2h51min³⁶. There are some criteria related with the travel time and the importance that the transport service could have on the increase of train passenger demand; although these values have been obtained from a

³⁵ There are other factors related and not related with the schedule that can influence on the market share: average access time, price, service quality, frequency. Steer Davies Gleave (2006)

³⁶ High-speed lines in Sweden, traffic forecasts and socioeconomic calculations using the Samvips method for expanded main lines and separate high-speed lines.2010. Traffic and logistics department, KTH, Stockholm 2010.

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Catalonia railway study (López Pita, A., 2005), they are a first indicator of the improvement of the service. In Table 50 and Table 51 the criteria is showed. It is based on two relations, involving the travel time and the useful time in destiny with the passenger description of it. In addition, the values are related to return train travels.

RELATION BETWEEN USEFUL TIME IN DESTINY AND THE PASSENGER DESCRIPTION

USEFUL TIME IN DESTINY	LEVEL
More than 7 hours	Very good
Fr 5 to 7 hours	Good
Fr 3 to 5 hours	Acceptable
Less than 3 hours	Insufficient

Table 50

RELATION BETWEEN THE TOTAL TRAVEL TIME AND USEFUL IN DESTINY, AND THE PASSENGER DESCRIPTION

TOTAL TRAVEL TIME / USEFUL TIME IN DESTINY	LEVEL
Less than 0,7	Very good
Fr 0,7 to 4 hours	Good
Fr 1 to 1,4 hours	Acceptable
More than 1,4	Insufficient

Table 51

As an example, taking a return travel which departure is at 8:00 in the morning and the return at 20:00 in the evening, the Swedish service changes from a GOOD/INSUFFICIENT opinion of the passenger to a VERY GOOD/VERY GOOD, comparing the conventional and the high speed train. *Table 52*

PASSENGER DESCRIPTION ATTENDING TRAVEL TIME

TYPE		TIME		Relation with passenger description	
				Useful time in destiny	Total travel time and useful in destiny
SWEDEN	Conventional	5h17min	2h26min 46%	6h40min GOOD	>1,4 INSUFFICIENT
	High Speed	2h51min		>0,7 VERY GOOD	<0,7 VERY GOOD
SPAIN	High Speed	2h38min		>0,7 VERY GOOD	<0,7 VERY GOOD

Table 52

Comparison of High-Speed train market between Spain and Sweden:
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When it comes to make the analysis as in section 7.1, the same values of time and cost are going to be considered but the train ones. For this matter, the time will be 2h51min³⁷ and the cost considered will be deduced as the average of the €/km figures from several HS lines over Europe with more than 400 km length *Table 53*; in **Attached VII: VALUES OF €/KM IN HIGH SPEED LINES OVER EUROPE** several values of the most economic prices of HS are compiled.

Once the new price is calculated, it results lower than the current lower one; therefore, the train prices are going to remain the same as in the previous section, facing the lack of future prices.

SUMMARY OF TIME AND COST

MODE		TRAVEL TIME (min)	COST €
Car	A	412	66
Coach	A	545	40
Train		171	62 – 153
			79 - 206
Plane		182	68 – 265

Table 53 Summary of time and cost in every Swedish mode

COST TIME MODEL

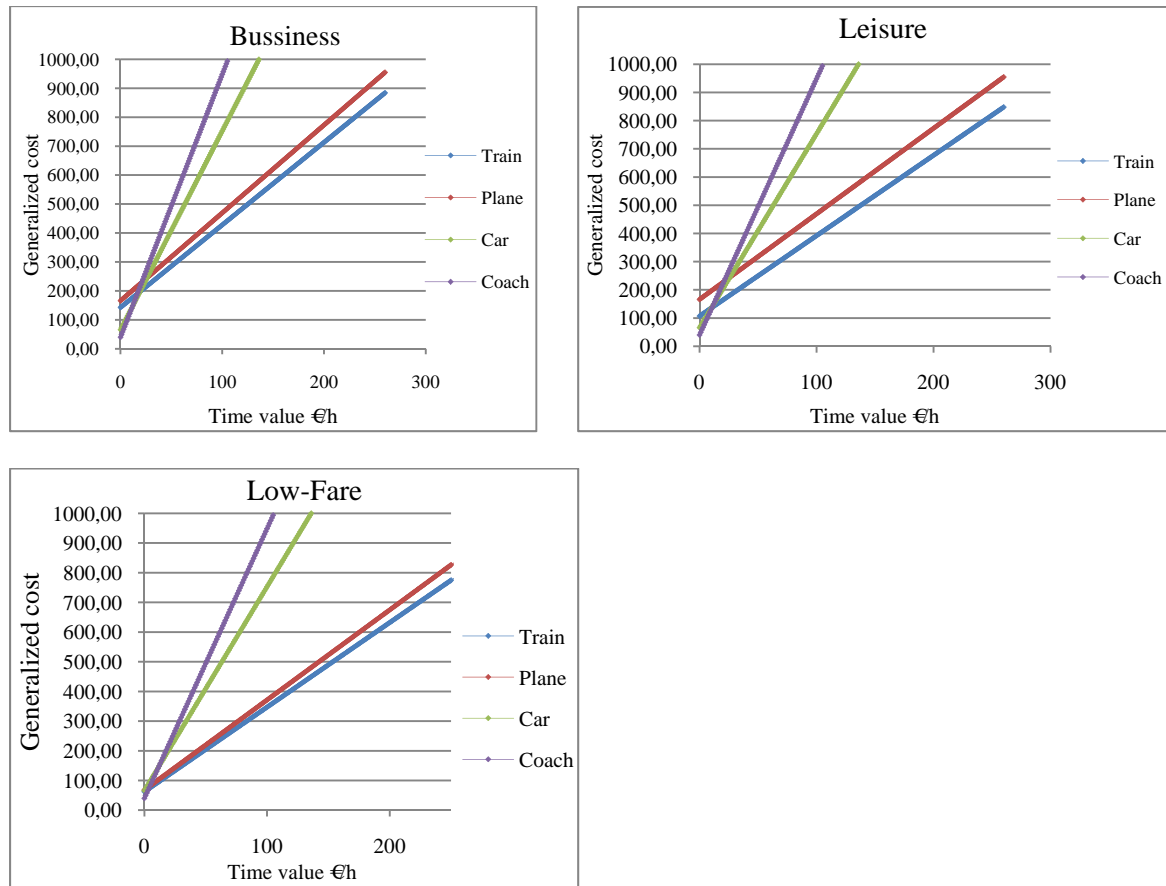
The same model as in the previous chapter is going to be used attending the division of passenger profiles. When it comes to choose the prices of the different modes in each profile, the same criteria as in 6.2 is used:

BUSSINESS/WORK			LEISURE			LOW-FARE		
MODE	Time (min)	Cost	MODE	Time (min)	Cost	MODE	Time (min)	Cost
Car	412(6h52)	66	Car	412(6h52)	66	Car	412(6h52)	66
Coach	545	40	Coach	545	40	Coach	545	40
Train	171	143	Train	171	107	Train	171	62
Plane	182 (3h)	166	Plane	182 (3h)	166	Plane	182 (3h)	68

Table 54

³⁷ High-speed lines in Sweden, traffic forecasts and socioeconomic calculations using the Samvips method for expanded main lines and separate high-spded lines.2010. Traffic and logistics department, KTH, Stockholm 2010.

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Figur 23 Cost-time model attending the different passenger profiles.

When it comes to analysis the previous figures, the car and coach options continue being the most economic ones, although the time value when the train becomes the prominence mode is so much lower than before.

Following the same order as in the previous analysis, it is needed to introduce the other variables that have influence on the market share and have been considered along the different chapters: time, cost, time/cost model, accessibility, comfort and frequency.

The new future frequency will be considered as “two high-speed services per hour and direction to Malmö-Copenhagen” (Jansson, K; Nelldal,B.; 2010). If we assume that the service starts and finishes as in Spain from 06:00 to 21:00, the total supply per day result in 30 HS trains per day per direction. The complete classification of each variable supply is gathered in **Appendix VIII: EVALUATION OF TRANSPORT MEANS ATTENDING DIFFERENT VARIABLES: SWEDISH CORRIDOR STOCKHOLM-COPENHAGEN WITH HIGH SPEED**

Comparison of High-Speed train market between Spain and Sweden:
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EVALUATION OF TRANSPORT MODES ALONG THE CORRIDOR ATTENDING THE VARIABLES

MODES	Time	Cost	Accessibility
Car	Disadvantaged	Very favourable	Very favourable
Coach	Very disadvantaged	Very favourable	In favour
Train	Very favourable	In favour	Indifferent
Plane	Very favourable	Indifferent	Disadvantaged

MODES	Comfort	Frequency	Time/Fare
Car	Vey disadvantaged	Very favourable	Disadvantaged
Coach	Disadvantaged	Disadvantaged	Indifferent
Train	Very favourable	Very favourable	Very favourable
Plane	Very favourable	Very favourable	In favour
	In favour		

Table 55

Once the first evaluation is done, the same calculations as in the previous chapters will be done.

FINAL ESTIMATION OF SUITABLE MODE ALONG THE HS STOCKHOLM-COPENHAGEN
CORRIDOR

Stockholm-Copenhagen (HS)				
	BUSSINESS	LEISURE	LOW-FARE	
Car	MEDIUM	MEDIUM	HIGH	3
Coach	LOW	LOW	LOW	4
Train	HIGH	HIGH	HIGH	1
Plane	HIGH	MEDIUM	LOW	2

Table 56 Final estimation of suitable mode along the Swedish HS corridor

The final Swedish results in both analyses *Table 49* and *Table 56* show remarkable differences of the classification of the modes. The train undergoes the best change, going up one position up to the first place. The decisive changes in its supply have been the travel time and the increase of frequency, what make it to have a HIGH repercussion in every profile. Finally, the plane goes down one place from the first position with still good classification in business and leisure profile. With this last result *Table 56* the train is in position to be competitive with every other mode considering any profile.

6.3.1. Expected demand

The study Höghastighetsbanor i Sverige³⁸ gathers the future values of expected demand along the future HS corridor. The study estimates the future passenger figures for 2020 when it is considered that the transport market will be recovered from the distortion of the appearance of the HS: well-establish market.

An influx of 20 million passengers has been estimated along the common track between Stockholm and Jonköping; and a demand of 11 million passengers along the branch Jonköping - Malmö/Copenhagen.

The document shows the total amount of passengers along the HS track but with no determinate origin or destiny, therefore, it is not possible to make a direct comparison between the passenger demand in the Spanish line and the Swedish.

On the other hand, using values from SAMVIPSMatris³⁹ it is possible to obtain the estimated passenger demand between the different Län where the future HS will run through *Table 57*.

TRAIN	Expected Demand (2020)
Stockholm län	6 843 262
Södermanlands län	2 661 538
Östergötlands län	2 355 964
Jönköpings län	894 179
Kronobergs län	656 614
Skåne län	2 757 795
Copenhagen	380 147
TOTAL	16 549 499

Table 57 Demand generated by railway (2020)

However, the demand figures of railway are calculated considering every kind of railway transport (commuter, regional, high speed...), what make them not comparable to Spanish figures.

³⁸ High-speed lines in Sweden, traffic forecasts and socioeconomic calculations using the Samvips method for expanded main lines and separate high-speed lines. 2010. Traffic and logistics department, KTH, Stockholm 2010.

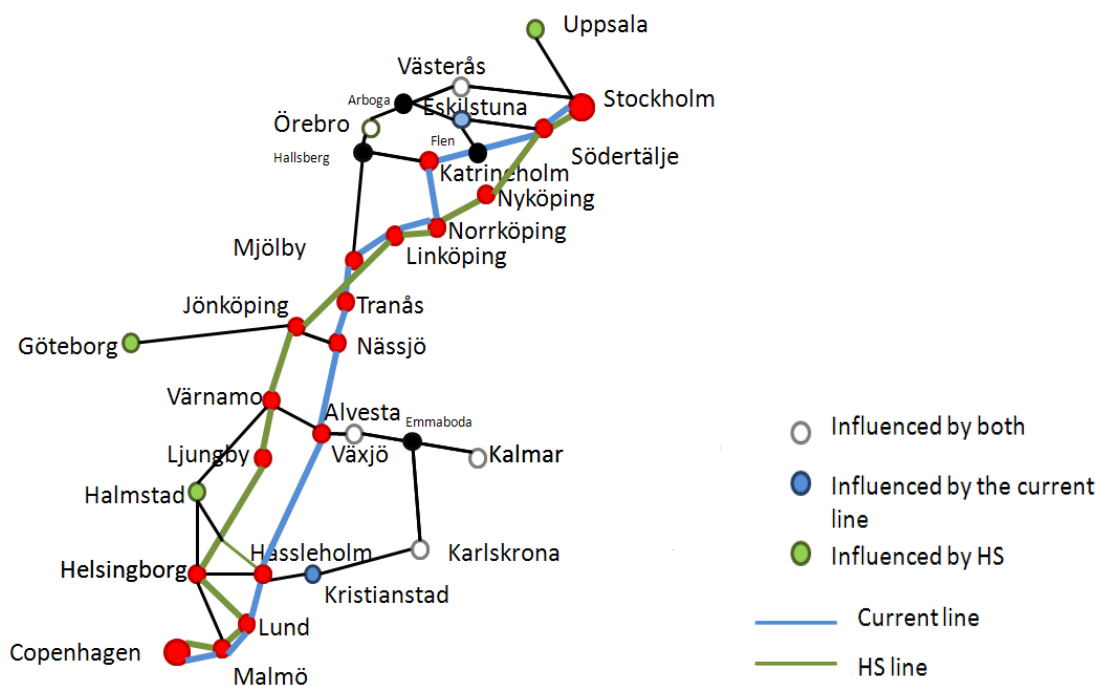
³⁹ Work elaborated by Josef Andersson, KTH Railway Group at the division of Traffic and Logistics, Royal Institute of Technology (KTH) Stockholm.

6.3.2. Accessibility

Most of the increases of demand shown in the previous chapter are due to the save of time that the HS will bring. It will reduce the travelling time not only along the southern line but also the surrounded territories will take advance of it.

In order to have some orientated figures about how accessibility⁴⁰ will change in the line and surrounded, a comparison between the current times and the planned futures travelling time will be done following the indication described in the *Method chapter*.

In the study, two nets are built: one with the current railway track and another adding the future HS railway tracks. The Figur 24 shows a sketch of how the net results when the HS is in it. On the other hand, the indicator of accessibility for each city is the result of summing the different travelling time to the rest of the cities multiplied by the respective city population and divided the final figure by the total amount of population considered; the study will bring up the accessibility to the main cities in the net. The cities with a higher level of accessibility will be those with lower indicator value. The matrixes with every figure are gathered in **ATTACHED IX**.



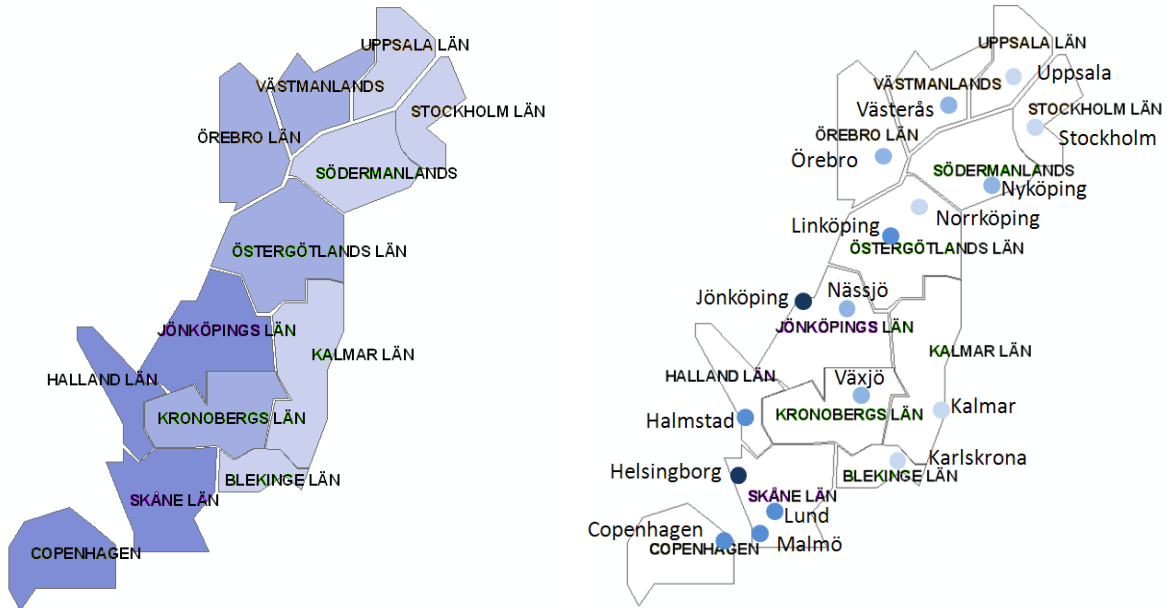
Figur 24 Sketch of the current Swedish line and the future HS line.

The result ACC. INDICATOR for each city will be used to compare the change of accessibility in each Län and main cities, as well as to see the general distribution of accessibility along the corridor with the current line and with the future HS.

⁴⁰ A proxy for measuring welfare, if we accept that the welfare of individuals is relates with the ease which they can access essential services (HAY, 1993)

Comparison of High-Speed train market between Spain and Sweden:
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The increase of accessibility has been calculated attending to the difference between the current accessibility and the future with HS; the increase of ACC is shown as a %, *Figur.25*. The centre-east part and north are the ones that will experiment a lower change in accessibility, as there is no HS branch to the centre-east and the north is already part of the present main line. On the other hand, south and Jönköping Län have the highest increase between 30-40 % because of Jönköping Län new incorporation to the southern main line and the several branches of HS lines in Skåne. Moreover, the Copenhagen accessibility increase to Sweden is completely expected since the new HS makes it closer to Sweden. Finally, Halland Län takes advance of the HS branch that will connect it with the main line.



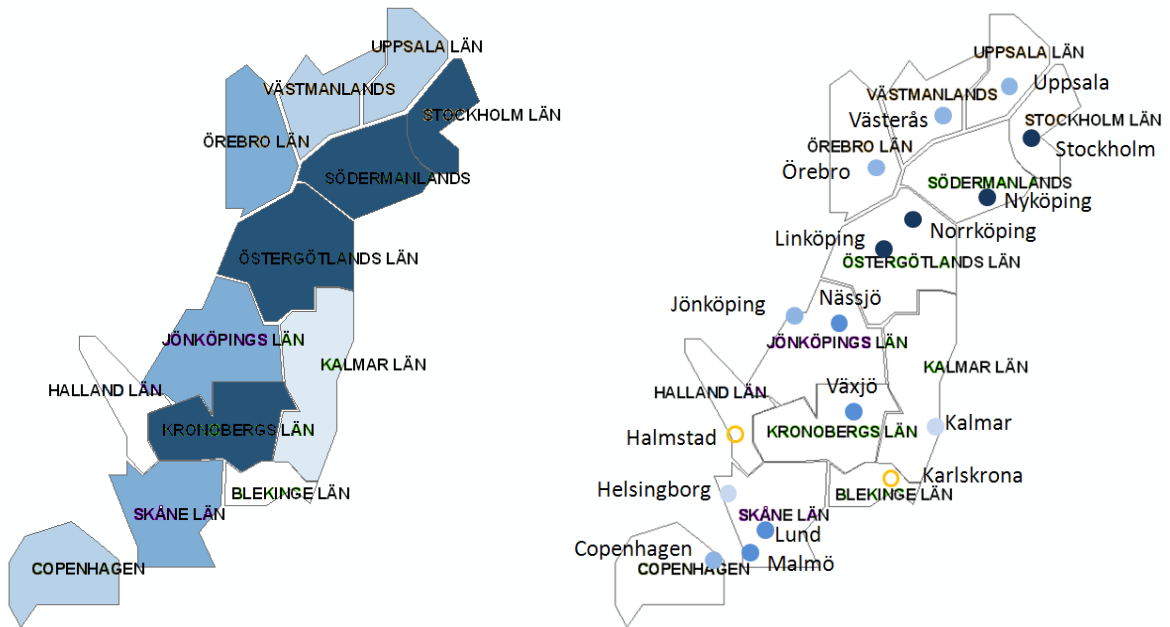
ACC increase (%)	
10 – 20	
20 – 30	
30 – 40	
40 – 50	

Figur 25 Increase of accessibility

Attending to the accessibility changes on the main cities, there are some of them whose accessibility is higher than in its Län. The most outstanding cases are the city of Jönköping, Linköping and Nyköping. Both Jönköping and Nyköping start to be part of the new HS main southern line.

Comparison of High-Speed train market between Spain and Sweden:
 Madrid-Barcelona VS Stockholm-Copenhagen

The current situation shows a high accessibility of the centre and north Län, making visible the lower accessibility of the east. The case of Copenhagen has an accessibility to Sweden on the average of the corridor.

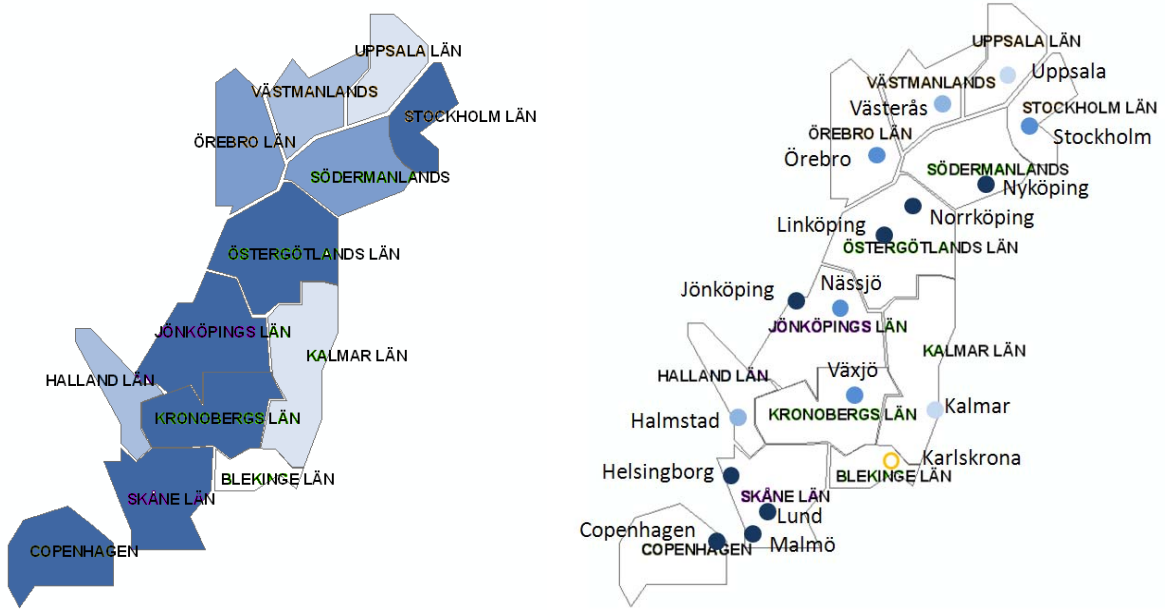


ACC with the present line	
Much lower than average	
Lower than average	
On the average	
Higher than average	
Much higher than average	

Figur 26 Current accessibility

Comparison of High-Speed train market between Spain and Sweden:
 Madrid-Barcelona VS Stockholm-Copenhagen

The HS line stands out the prominence of the centre Län, making higher the different in accessibility with the east regions. The south of Sweden and Copenhagen result reinforced with the HS while north Län like Uppsala brings out less favoured. In relation with the new HS situation and the better accessibility times, Stockholm Län remains with a higher accessibility than the average. *Figur.27*



Figur 27 HS accessibility

If we pay attention to the ACC to main cities, the distribution is similar to the Län.

7. Conclusion

7.1. Territorial aspects: population

The comparison of population has been done attending the cities along the line and those other cities that have been considered under the influence of it; the section 4.1 gathered all the information.

Regarding the population in the cities with HS stop, the Spanish line sums 82% more inhabitants than the Swedish one, principally, owing to the large difference of size between the ends (102%). The different between the intermediate cities is not so big (23 %), what means that the intermediate demand could be almost the same in both lines, but on the other hand, the ends cities in Spain will create more demand than in Sweden (just only taking into account population).

If we considered every city influenced by the HS, regarding the study classification, the difference of population goes down (64%). As the several population comparisons have brought about, the influenced cities, both with stop or without, have more weight in the Swedish line than the Spanish one.

The conclusions of the province comparison are similar to the previous ones. The regions of the ends city have more weight on the line and the Swedish intermediate regions have more inhabitants than the Spanish ones. The several differences between both lines are showed in *Table 58*.

Comparison of High-Speed train market between Spain and Sweden:
Madrid-Barcelona VS Stockholm-Copenhagen

FIELD	INDEX	
	Spanish line	Swedish line
Cities where train stops	100	55
Ends cities	100	49
Intermediate stop cities	100	81
Every city influenced by the line	100	61
Influenced cities without the ends	100	86
Influenced cities with no stop	100	91
Provinces	100	45
Ends provinces	100	33
Intermediate regions	100	104

Table 58 Population comparison using INDEX (Spain=100)

The final conclusions that could be extracted from both analysis are that the distribution of population differ from both territories: Sweden has a more uniform distribution than Spain. In Spain, the population is concentrated in the main cities (the ones considered individually in the first comparison), while, paying attention to the regions, it results that population are more dispersed over the regions where the train passes through in Sweden. The scenario results in more freedom to Sweden when it comes to build the line, since population in Sweden have a more uniform distribution.

On the other hand, attending the comparison of the European lines, those that are longer than 400km have an average railway market share lower than those shorter than 400km: 55% and 78% respectively, although lines with big cities like Paris involved are exceptions. The case of Stockholm-Copenhagen is one of the lines with more than 400 km long, and with no cities, but some towns, along it; according to the analysis, the line does not do well out of it.

7.2. Economy

7.2.1. Economy sectors

The complete analysis of the economy sector is gathered in section 4.2. Paying attention to the Specialization Coefficient, more specialized regions appear in Sweden than in Spain, with the prominence difference in the tertiary sector since there are two regions specialized in the Sweden line and only one in the Spanish line.

On the other hand, attending to the Potential Productive Index, which take into account the different synergy of each sector in relation with its influence on the impact of the High Speed, the Swedish line have two regions where the current situation is more favourable to allow the HS train to have higher impact: Stockholm and Copenhagen; while Spain only counted with one: Madrid. However, considering the rest of the regions, the Spanish line counts with more medium favourable regions than Sweden.

Comparison of High-Speed train market between Spain and Sweden:
Madrid-Barcelona VS Stockholm-Copenhagen

REGION	POTENTIAL PRODUCTIVE INDEX	POTENTIAL PRODUCTIVE INDEX	REGION
Barcelona	MEDIUM	HIGH	Stockholm län
Guadalajara	MEDIUM	MEDIUM	Södermanlands län
Lleida	LOW	LOW	Östergötlands län
Madrid	HIGH	MEDIUM	Jönköpings län
Tarragona	MEDIUM	LOW	Kronobergs län
Zaragoza	MEDIUM	LOW	Skåne län
		HIGH	Copenhagen

Table 59 Summary of potential productivity index in relation with the impact of HS

The previous analysis has been done attending every sector but the most important one, which bring more opportunities of HS impact to the regions that have it well established, is the tertiary sector: services. Attending only to the service sector figures, the Swedish regions are more prominence that the Spanish ones, with the only exception of Madrid.

This is a positive aspect of the Swedish line since from the good result of the Madrid-Barcelona line, in theory, the Swedish regions will have more opportunities of taking advantages from the HS train. On the other hand, the good previous situation before the start of the HS has to go with different alternatives economic dynamics in order to take the most of the HS.

7.2.2. Economy Index

In relation with the Indexes that have been compared: income and GPD in 2006, the values in Spain and Sweden are close to each other. While the disposable income seems to be a little bit high in Spain, the values of GPD have a higher uniform distribution along the Swedish line territory.

7.3. Comparison of both current supply

Comparing both corridor EVALUATION OF TRANSPORT MODES ALONG THE CORRIDOR ATTENDING THE VARIABLES in *Table 38* and *Table 47* the main differences between both supplies are in cost and travel time, what makes that the most outstanding difference appears in the variable fare/cost from the analysis COST/TIME model. The most improvable Swedish train variables are time and frequency in order to be more competitive with the plane, as in the Spanish case; as well as being more competitive with the car.

Attending the final results from the analysis in both corridors in FINAL ESTIMATION OF SUITABLE MODE ALONG THE CORRIDOR (*Table 40* and *Table 49*) the different characteristics of supply make the modes have diverse roles in each profile along the corridors. The prominence mode in the corridor Stockholm-Copenhagen is the plane, while in Madrid-Barcelona it results to be the HS train. On the other hand, the train has less influence on Stockholm-Copenhagen corridor than the plane in the corridor Madrid-Barcelona, what means that the competence is more direct in the Spanish case.

Comparison of High-Speed train market between Spain and Sweden:
Madrid-Barcelona VS Stockholm-Copenhagen

To improve the competence of the train in the Swedish corridor, attending to the results of EVALUATION OF TRANSPORT MODES ALONG THE CORRIDOR ATTENDING THE VARIABLES, it will be useful to get better results in time and frequency, to make progress in business and leisure profiles. Regarding the influence of the car, its role is as important in the Scandinavian corridor as in Spain, obtaining the best suitable position in low-fare profile. Finally, the coach remains to low suitability in every profile along Swedish corridor, while it has medium importance in Spanish corridor low-fare profile.

	Madrid-Barcelona (nowadays HS)			Stockholm-Copenhagen (nowadays)		
	BUSSINESS	LEISURE	LOW-FARE	BUSSINESS	LEISURE	LOW-FARE
Car	MEDIUM	MEDIUM	HIGH	MEDIUM	MEDIUM	HIGH
Coach	LOW	LOW	MEDIUM	LOW	LOW	LOW
Train	HIGH	HIGH	MEDIUM	MEDIUM	HIGH	MEDIUM
Plane	HIGH	HIGH	LOW	HIGH	HIGH	LOW

Table 60 Summary of current suitability of modes.

It can be also compared the values of €h and €km attending both corridor supply; however, we have to take into account that the prices in both countries are different; the Comparative Price Levels⁴¹ made by the *Eurostat* is going to be used to have some orientated figures about the general difference of prices between both countries.

Regarding the Comparative Price Levels in *Table 61* prices in Spain are 3 points lower than the average of the EU-27 while the Swedish prices are 7 points higher, what should be reflected on the €h and €km values.

⁴¹ “Comparative price levels across EU Member States are price level indices (PLIs) expressed as relative to the average price level of the EU-27. If the price level index of a given Member State is above 100, then prices in that country are, on average, higher than the EU average. On the other hand, a price level index below 100 shows that prices are, on average lower than the EU-27 average”. Source: European Commission, Eurostat <http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Consumer_prices__inflation_and_comparative_price_levels>

Comparison of High-Speed train market between Spain and Sweden:
Madrid-Barcelona VS Stockholm-Copenhagen

COMPARATIVE PRICE LEVELS

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
EU-27	100	100	100	100	100	100	100	100	100	100	100
Euro area (EA-16)	102	100	101	101	103	103	102	102	102	104	107
Belgium	107	102	103	102	107	107	106	108	108	111	114
Bulgaria	38	39	41	41	41	42	43	45	46	90	53
Czech Republic	46	48	50	57	55	55	58	61	62	73	71
Denmark	131	130	135	134	141	140	140	138	137	141	145
Germany	107	107	107	107	106	105	103	103	102	104	106
Estonia	57	57	61	61	62	63	65	69	73	78	75
Ireland	112	115	119	125	126	126	123	125	125	128	125
Greece	88	85	82	80	86	88	88	89	91	94	97
Spain	86	85	85	85	88	91	91	92	93	95	97
France	109	106	104	104	110	110	108	109	108	111	114
Italy	98	98	100	103	104	105	105	104	103	106	107
Cyprus	87	88	89	89	91	91	90	90	88	91	91
Latvia	52	59	59	57	54	56	57	61	67	73	75
Lithuania	47	53	54	54	52	54	55	57	60	65	68
Luxembourg	103	101	104	102	103	103	112	111	115	119	121
Hungary	47	49	53	57	58	62	63	61	67	68	66
Malta	71	73	75	75	72	73	73	75	76	79	81
Netherlands	103	100	103	103	108	106	105	104	102	104	109
Austria	105	102	105	103	103	103	103	102	102	105	108
Poland	52	58	65	61	54	53	61	62	62	69	59
Portugal	83	83	84	86	86	87	85	85	86	87	89
Romania	38	43	42	43	43	43	54	58	64	61	58
Slovenia	74	73	74	74	76	76	76	77	79	82	86
Slovakia	41	44	43	45	51	55	55	58	63	70	74
Finland	122	121	125	124	127	124	124	123	120	124	126
Sweden	126	128	120	122	124	121	119	119	116	115	107
United Kingdom	116	120	117	117	108	109	110	111	113	100	93
Iceland	127	144	128	135	139	138	153	145	149	117	102
Norway	134	138	142	151	142	135	141	140	138	139	137
Switzerland	140	143	146	147	144	141	138	135	125	131	138
Croatia	.	.	.	.	65	67	69	73	72	76	76
FR of Macedonia	.	.	.	.	44	44	43	45	44	47	46
Turkey	56	63	48	52	57	59	67	66	72	71	67
Japan	173	198	178	156	137	130	120	110	97	103	120
United States	106	121	126	120	101	93	93	93	85	82	89

(1) Break in series in 2005 for all countries except for Japan and the United States.
Source: Eurostat (tsier010)

Table 61 Comparative price levels (1) (final consumption by private households including indirect taxes, EU-27=100)

Every value can be compared but the train €/h because the travel time does not correspond to the same railway service. The Swedish values are slightly higher but in the case of the shuttle flight service. On the other hand, the railway service in Spain is HS (that is why every €/h figures are higher) and in Sweden is an upgraded track, however, this distinction does not have its reflection in the €/km values, where either the Swedish (first class) or Spanish (tourist) train has the higher values. *Table 62*

MODE		SPAIN				SWEDEN			
		€/h		€/km		€/h		€/km	
Car		13,18		0,13		14,56		0,16	
Coach	A	4,15		0,05		4,41		0,07	
Train	First class	31,93	77,28	0,17	0,33	13,9	38,99	0,13	0,33
	Tourist	14,2	52,71	0,08	0,22	10,91	28,96	0,10	0,24
Plane		30,00		0,07		30,86		0,07	
		218,57		0,5		199,71		0,45	

Table 62 Comparison between values: €/h and €/km along both corridors.

7.4. Effects of High Speed

Attending the conclusion from the line Madrid-Sevilla, the previous accessibility plays a principal role on the future impact of the HS. The HS impact is inversely decreasing with the previous accessibility to the city, being more relevant a previous poor road access than the previous train access. In that way, the future HS Swedish layout differs from the current principal one in its itinerary; in the north part, Nyköping will become part of the principal line instead of Katrineholm, which stay apart from the new main line; in the south part of the line, the itinerary changes from Linköping to the south, adding 4 cities to the main southern line: Jönköping, Värnamo, Ljungby and Helsingborg, which are not in the current main line. This new access to the main southern train line is a positive increase in accessibility for these cities, as it was for Ciudad Real and Puertollano in Spain (specially for Ljungby because it does not have railway station nowadays). Besides, Jönköping Län has been calculated as one of the most favoured in relation to accessibility increase.

But, on the other hand, the new cities that start being part of the HS main southern line are currently on the main southern road, as it was the case of Cordoba, and in consequence, they already count with good access by road; this could be a handicap as it was with Cordoba when it did not notice as much influence as Ciudad Real and Puertollano with the arrival of the HS.

Moreover, Ciudad Real, which was the intermediate city that took more advantage from the HS, is 171 km (51min) from Madrid but Jönköping (which is the first south city that starts being part of the HS train line) is 284km (83min) from Stockholm. In this case, the train from Stockholm-Jönköping will not have the travel time of commuter train as it has in the Spanish case or in other countries where two cities are jointed in less than 1 hour (López Pita, A. 2005), which could be not as positive as it was for Ciudad Real and its becoming closer relation with Madrid.

Regarding the consideration of French authors (Arduin, J. P. 1991), the cities connected with the capital in less than 1 hour could became in the cities of the future because the HS would help to decentralize the tertiary activities of the capital. In this case, the Swedish farther Swedish city will be Linköping, with 59 minutes of travel time. So, although up to Linköping (besides Nyköping) the cities are in the current main train line, the travel time to the capital in less than 1 hour gives them the possibility to be connected to the capital ordinary, it is probably that new dynamics of mobility and new opportunities appear in them (De Ureña, J. M^a. 2005).

Finally the cities with a more developed tertiary sector will take more advantage from the HS, in the Swedish case (apart from Stockholm and Copenhagen) the most favourable regions will be Skåne and Östergötland. Both last conclusions pointed out that Linköping and Norrköping are two of the more likely candidates to be influenced by the HS: less than one hour of travelling time and an already large tertiary service developed.

	Today (2010)	HS	Save of time
Stockholm-Malmö	276	147	2h9min
Stockholm-Copenhagen	325	171	2h34min

Table 63 Save of time between the main cities along the Swedish corridor.

Comparison of High-Speed train market between Spain and Sweden:
Madrid-Barcelona VS Stockholm-Copenhagen

	Before HS	HS	Save of time
Madrid-Sevilla	360	140	3h40
Madrid-Barcelona	420	158	4h22

Table 64 Save of time between the main cities along the Spanish corridor.

From the recompilation of different studies of HS influence on the cities, and from the French case in particular, it can be said that the HS station in small cities with less than 50000 habitants have not had a big impact and make any change on the city. These have happened because of the previous lack of attraction of these cities which were forced to have it without any previous urban or structure plan.

In order not to follow the French bad experience in these types of cities which normally have a peripheral station, it is needed a previous organization: the frequency must be adjusted to the necessities of the city and the station must be, at least, well integrated in the local transport network. These measures will help the city to be influenced by the HS: Nyköping, Värnamo, Ljungby.

In relation with the transport mode competition, attending conclusion from the TGV, in HS stretches with less than two hours of HS travel time, the main competitor is the car: up to Ljungby from Stockholm. In the Swedish case, this gets more importance because of the already said about the main south road: the main south road follow the same itinerary as the future HS track. Hence, it is predictable a noticeable competition between the road and HS in this stretch. Moreover, the competition with the plane will start between two and three hours, what leaves the line Stockholm-Copenhagen exposed to it.

Apart from the previous conclusions based on HS experience, the analysis related to the different modes of transport along both corridors brings up a new structure of them.

Stockholm-Copenhagen (nowadays)				Stockholm-Copenhagen (HS)		
	BUSSINESS	LEISURE	LOW-FARE	BUSSINESS	LEISURE	LOW-FARE
Car	MEDIUM	MEDIUM	HIGH	MEDIUM	MEDIUM	HIGH
Coach	LOW	LOW	LOW	LOW	LOW	LOW
Train	MEDIUM	HIGH	MEDIUM	HIGH	HIGH	HIGH
Plane	HIGH	HIGH	LOW	HIGH	MEDIUM	LOW

Madrid-Barcelona (nowadays)		
BUSSINESS	LEISURE	LOW-FARE
MEDIUM	MEDIUM	HIGH
LOW	LOW	MEDIUM
HIGH	HIGH	MEDIUM
HIGH	HIGH	LOW

Table 65 Summary of final result of modes suitability

The difference between the high speed in Spain and Sweden attending to the low-fare profile is a consequence of the better category that the variable fare (and frequency) obtained; however, as current prices have been used for the Swedish HS, it is predictable that, as in the Spanish case, the train will not be the most suitable mode in low-fare profile.

Comparing to the current southern main line, the HS manages to be competitive with all of the other modes. In relation with the plane, the train starts competing on commuter trips, and wins preponderance in relation to leisure trips.

Finally, paying attention to the accessibility increase, the new HS will reinforce the connection between the ends regions of the lines, increasing their accessibility in relation with the corridor. On the other hand, among the centres regions, Jönköping has an important role.

At other order of things, the track between Stockholm and Malmö will be what Freach authors call “magistral”, which means that with one double track it is possible to supply two different main corridor, in this case: Stockholm-Malmö and Stockholm-Gothenburg.

7.5. Reflexion on the hypothesis

The first hypothesis cited related to the induced demand “Line Madrid-Barcelona joins larger cities than Stockholm-Copenhagen -> more demand-> more journeys-> more benefits; what justify the huge investment”, after the work done it results to not be correct. Although the cities in Spain are larger, the Swedish HS line will be used not only by ends cities travellers but also with a higher volume of intermediate travellers than in Spain.

The Spanish line supplies the two most populated regions in Spain while the Swedish will carry out the role of the main railway in the south, providing the backbone of the railway demand between Stockholm, Skåne and Hovedstaden (Copenhagen) regions.

In relation with the second hypothesis “Saving time will enable higher fares and/or higher demand”, the several studies used in this work and the analysis made have show that the save of time is one of the important variables for a traveller to choose mode of transport. In this way, the HS save of time makes it competitive with the road in shorter distances up to 300 km and with the plane in longer distance up to 600km, what involves a future gain of passenger of the railway network in Sweden. Moreover, the figures around 11 million passenger supports it. On the other hand, although the fares in HS are higher because of high quality of the service, it is also possible to create a fare structure with more low-price seats.

The second hypothesis related with the supply factor “The new travel time is determinant to build a new line: save of time” is totally true as the international experience has showed. If the save of time is not relatively important in order to expect a higher increase of demand, the investment will not result profitable.

The hypothesis related to the decision process “The decision process in Spain is shorter” it is true but with some clarifications. The discussion started in 1987 and in 1988 it was decided to be constructed, although the completed construction project did not start until 1996. The fast

decision must be understood under the situation that the railway was living. The line, at that time, was already running at its high capacity and the HS, apart from increase the capacity, would bring a save of time of 4h22min from Madrid to Barcelona. On the other hand, Spain benefited from the European funds.

The Swedish scenario is not the same picture. The investment on HS will provide the capacity the current line cannot; however, the current line does not have as bad supply as it had the previous line in Spain, since the save of time will be of 2 hours. On the other hand, Sweden does not benefit from the European funds to the same extent as Spain.

Finally, the hypothesis that relates the lack of capacity to the decision of constructing a HS line: "Limited capacity in the existing track is an important reason for constructing the new HS line" is also true. As the several studies about HS used in this work have showed, the lack of capacity is one of the reasons that brings the countries to start thinking about constructing a new HS line or network. Once the current line run out of capacity, the alternative of building a new HS line usually will also involve a higher save of time what results in an increase of future demand. However, the conditions of every corridor are different and other agents take part of the picture: plane, road... It is necessary demand studies and passenger forecast to find out the possible induced changes that the HS will bring. In the case of Spain it was necessary to build a faster line because the previous one was obsolete, in the case of Sweden the save of time will be less; in both cases the increase of capacity is a reason to go for the HS.

7.6. Summary

TERRITORIAL ASPECTS: POPULATION

Difference distribution of population

Sweden : population is distributed more uniformly than in Spain

PROCESS OF DECISION

Save of time: more critical in Madrid-Barcelona line

Increase capacity: common

Clear airport traffic: Spain

ECONOMY ASPECTS: ECONOMY SECTORS

Swedish regions could take more advantage because of the tertiary sector

To make the most of the HS: cities need to create economic dynamics

TRANSPORT MODE SUPPLY ALONG THE CORRIDORS

HS makes the railway more competitive along Swedish corridor

EFFECTS OF HS

Gain of time: Conmmuter travels

Decentralize tertiary activities of the capital

Small cities: Nyköping, Värnamo, Ljungby

Competitors: ROAD ; PLANE

>10% accessibility increase

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APPENDIX

Appendix I : IDENTIFICATION OF PROVINCES AND LÄN INTO NUTS SYSTEM

NUTS1	NUTS2	NUTS3
SPAIN		
Madrid		
Center	Castilla La Mancha	Guadalajara
		+4
	+2	
North-east	Aragón	Zaragoza
		+2
	+3	
East	Cataluña	Lleida
		Tarragona
		Barcelona
		+1
	+2	
SWEDEN		
East Sweden	Stockholm	
	East Middle Sweden	Södermanland
		Östergötland
		+3
South Sweden	Småland and the islands	Jönköpings
		Kronoberg
		+2
	South Sweden	Skåne
		+1
	+1	
Denmark		
Denmark	Hovedstaden	
	+4	

Comparison of High-Speed train market between Spain and Sweden:
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Appendix II : EVOLUTION OF MADRID-BARCELONA LINE SUPPLY

		Frequency (num. Trains)	Last frequency	Travelling time		Supply increase: seats/day	Direct trains
				time	reduction		
Madrid-Barcelona							
February 2010		56 (28+28)				5,53% increase	
SEPT 2008		52 (26 + 26) (in more crowded days)				16,6% increase	B-M:11 M-B:11
APRIL 2008		40 (20+20)				17,6% increase	B-M:9 M-B:9
February 2008	AVE	34 (17 + 17)	7 + 7 Alvia	2:38	1:17 Alvia	142% seats	B-M:7 M-B:8
DIC 2006		7 + 7		03:55			
MAY 2006	Alvia 200km/h ERTMS	7 + 7	Altaria	04:15	00:20		
OCT 2003	Altaria	6 trains		4:35			
Before 2003	Talgo	4 + 4		07:00			
Madrid-Lleida							
MAY 2006	AVE 250 km/h ERTMS						
OCT 2003	AVE 200km/h	8 + 8					
Lleida-Camp Tarragona							
DIC 2006							
Zaragoza-Barcelona							
February 2008				1:29	00:39 Alvia		
Lleida-Barcelona							
February 2008				1:03	00:27 Alvia		
Camp de Tarragona-Bacelona							
February 2008				00:34			

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Comparison of High-Speed train market between Spain and Sweden:
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Appendix III : EVOLUTION OF PASSENGERS IN THE HS LINE

	Passenger increase %		Passengers		
	Regarding previous year	Comparing to period Feb07-Feb08	BEFORE; same period previous year	AVE	
After the two first months; April 2008					
Whole line	73,4		440634	764000	
Madrid-Barcelona	246			311077	
August 2008					
Whole line	84,5		1461977	2697900	
After the first year; February 2009					
Whole line	81		3242554	5868478	
Madrid – Barcelona	206,4		762981	2337913	
Barcelona – Zaragoza	207,7		195945	602914	
Madrid-Zaragoza	21		1329531	1610501	
Lleida – Zaragoza	25,5		79295	63176	
After two years; February 2010					
Whole line	-2,7	76,12	5868478	TOTAL	11579000
				2009-2010	5711000
Madrid – Barcelona	15,4	253,6	2337913	TOTAL	5131000
				2009-2010	2698000
First semester 2010					
Whole line	4,5			2880810	
Madrid-Barcelona	5,9			1369132	
Madrid-Zaragoza	1,52			693695	
Zaragoza-Barcelona	15,43			280750	
Tarragona-Madrid				156848	
Lerida-Madrid				130075	
March 2010 (M-B)			RECORD	276295	
Three years; February 2011					
Whole line	-6,43	64,80	5711000	5343845	
Madrid-Barcelona	-5,02	235,87	2698000	2562633	
Madrid-Zaragoza				1231008	
Barcelona – Zaragoza				514991	

Comparison of High-Speed train market between Spain and Sweden:
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Appendix IV: EVALUATION OF TRANSPORT MODES ATTENDING DIFFERENT VARIABLES: SPANISH CORRIDOR MADRID-BARCELONA

	Fare	Standardize	LEVEL	LEVEL
Car	69	-0,6	5	Very favourable
Coach	32	-1,1	5	Very favourable
Train	204	1,3	2	Indifferent
	125	0,2	3	
	139	0,4	3	
	56	-0,8	5	
	177	0,9	2	
	106	-0,1	4	
	118	0,1	3	
	47	-0,9	5	
Plane	35	-1,1	5		Indifferent
	255	2,0	1	
Mean	113,58			
Variance	5056,08			
Standard deviation	71,11			

	Time	Standardize	LEVEL	LEVEL
Car	376	0,9	2	Disadvantaged
Coach	463	1,6	1	Very disadvantaged
Train	158	-0,8	5	Very favourable
	199	-0,5	5	
Plane	155	-0,8	5	Very favourable
	195	-0,5	5	
Mean	257,67			
Variance	16801,47			
Standard deviation	129,62			

Spanish corridor	Average frequency per day	LEVEL
Car		Very favourable
Coach	16	Disadvantaged
Train	25	In favour
Plane	54	Very favourable
AVERAGE	32	Very favourable

Appendix IV (2) : EVALUATION OF TRANSPORT MODES ATTENDING DIFFERENT VARIABLES: SPANISH CORRIDOR MADRID-BARCELONA

MEAN	Time	Fare	Accessibility	Comfort	Frequency	Time/Fare
Car	Disadvantaged	Very favourable	Very favourable	Vey disadvantaged	Very favourable	Disadvantaged
Coach	Very disadvantaged	Very favourable	In favour	Disadvantaged	Disadvantaged	Indifferent
Train	Very favourable	Indifferent	Indifferent	Very favourable	In favour	Very favourable
Plane	Very favourable	Indifferent	Very disadvantaged	Very favourable	Very favourable	In favour
				In favour		

EVALUATION OF TRANSPORT MODES ALONG THE CORRIDOR ATTENDING THE VARIABLES

BUSSINESS								
WEIGHTS								
	2	0,5	1	2	2			
MEAN	Time	Fare	Accessibility	Comfort	Frequency	Importance	Normalization	Estimated suitable mean
Car	-1	2	2	-2	2	2	0	MEDIUM
Coach	-2	2	1	-1	-1	-4	-1	LOW
Train	2	0	0	2	1	8	1	HIGH
Plane	2	0	-1	2	2	9	1	HIGH
Average						3,8		
Variance						36,3		
Standard deviation						6,0		

Comparison of High-Speed train market between Spain and Sweden:
Madrid-Barcelona VS Stockholm-Copenhagen

Appendix IV (3): EVALUATION OF TRANSPORT MODES ATTENDING DIFFERENT VARIABLES: SPANISH CORRIDOR MADRID-BARCELONA

EVALUATION OF TRANSPORT MODES ALONG THE CORRIDOR ATTENDING THE VARIABLES

LEISURE								
WEIGHTS								
	1	1	0,5	1	0,5			
MEAN	Time	Fare	Accessibility	Comfort	Frequency	Importance	Normalization	Estimated suitable mean
Car	-1	2	2	-2	2	1	0	MEDIUM
Coach	-2	2	1	-1	-1	-1	-1	LOW
Train	2	0	0	2	1	4,5	1	HIGH
Plane	2	0	-1	1	2	3,5	1	HIGH
						Average	2,0	
						Variance	6,2	
						Standard deviation	2,5	

LOW-FARE								
WEIGHTS								
	0,5	2	0,5	0,5	0,5			
MEAN	Time	Fare	Accessibility	Comfort	Frequency	Importance	Normalization	Estimated suitable mean
Car	-1	2	2	-2	2	4,5	1	HIGH
Coach	-2	2	1	-1	-1	2,5	0	MEDIUM
Train	2	0	0	2	1	2,5	0	MEDIUM
Plane	2	0	-1	1	2	2	-1	LOW
						Average	2,9	
						Variance	1,2	
						Standard deviation	1,1	

Appendix V : CALCULATION OF €H AND €KM

SPAIN					
MODE			€h		
Car	A			13,18	
	B			14,52	
	C			8,06	
Coach	A			4,62	
				3,68	
Train	Min time	First class	77,28	47,47	
		Tourist	52,71	21,08	
	Max time	First class	53,22	31,93	
		Tourist	35,46	14,20	
Plane			30,00		
			218,57		

SPAIN					
MODE			€km		
Car	A			0,13	
	B			0,14	
	C			0,11	
Coach	A			0,06	
				0,05	
Train	Min time	First class	0,33	0,20	
		Tourist	0,22	0,09	
	Max time	First class	0,28	0,17	
		Tourist	0,19	0,08	
Plane			0,07		
			0,50		

Comparison of High-Speed train market between Spain and Sweden:
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Appendix V (2): CALCULATION OF €H AND €KM

SWEDEN				
MODE			€h	
Car	A		14,56	
	B		6,91	
Coach	A		4,53	
			4,29	
Train	First Class		13,9	38,99
	Second Class		10,91	28,96
Plane			30,86	
			199,71	

SWEDEN				
MODE			€km	
Car	A		0,16	
Coach	A		0,07	
Train	First Class		0,13	0,33
	Second Class		0,10	0,24
Plane			0,07	
			0,45	

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Appendix VI: EVALUATION OF TRANSPORT MEANS ATTENDING DIFFERENT VARIABLES: SWEDISH CORRIDOR STOCKHOLM-COPENHAGEN

	Fare	Standardize	LEVEL		LEVEL
Car	66	-0,73	5		Very favourable
Coach	40	-1,06	5		Very favourable
Train	206	1,07	2	4	In favour
	79	-0,56	5		
	153	0,39	3		
	62	-0,78	5		
Plane	265	1,82	1	3	Indifferent
	68	-0,70	5		
	166	0,56	3		
Mean	122,83				
Variance	6083,13				
Standard deviation	77,99				

	Time	Standardize	LEVEL		LEVEL
Car	412	0,4	2		Disadvantaged
Coach	545	1,4	1		Very disadvantaged
Train	341	-0,1	3	4	In favour
	317	-0,3	4		
Plane	182	-1,3	5		Very favourable
Mean	359,4				
Variance	17705,3				
Standard deviation	133,06				

Swedish corridor	Average frequency per day			LEVEL
Car				Very favourable
Coach	2			Disadvantaged
Train	DIRECT	WITH CHANGES	16	Indifferent
	7	17		
Plane	20			Very favourable
AVERAGE	13			

Attached VI (2): EVALUATION OF TRANSPORT MODES ATTENDING DIFFERENT VARIABLES: SWEDISH CORRIDOR STOCKHOLM-COPENHAGEN

MEAN	Time	Fare	Accessibility	Comfort	Frequency	Time/Fare
Car	Disadvantaged	Very favourable	Very favourable	Vey disadvantaged	Very favourable	Indifferent
Coach	Very disadvantaged	Very favourable	In favour	Disadvantaged	Disadvantaged	Indifferent
Train	In favour	In favour	Indifferent	Very favourable	Indifferent	In favour
Plane	Very favourable	Indifferent	Disadvantaged	Very favourable	Very favourable	Very favourable
				In favour		

EVALUATION OF TRANSPORT MODES ALONG THE CORRIDOR ATTENDING THE VARIABLES

BUSSINESS WEIGHTS						Importance	Normalization	Estimated suitable mean
2	1	1	2	2	Frequency			
MEAN	Time	Fare	Accessibility	Comfort	Frequency	Importance	Normalization	Estimated suitable mean
Car	-1	2	2	-2	2	1	0	MEDIUM
Coach	-2	2	1	-1	-1	-6	-1	LOW
Train	1	1	0	2	0	6,5	0	MEDIUM
Plane	2	0	-1	2	2	11	1	HIGH
Average						3,1		
Variance						53,7		
Standard deviation						7,3		

Comparison of High-Speed train market between Spain and Sweden:
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Attached VI (3): EVALUATION OF TRANSPORT MODES ATTENDING DIFFERENT VARIABLES: SWEDISH CORRIDOR STOCKHOLM-COPENHAGEN

EVALUATION OF TRANSPORT MODES ALONG THE CORRIDOR ATTENDING THE VARIABLES

LEISURE								
WEIGHTS								
	1	2	0,5	1	0,5			
MEAN	Time	Fare	Accessibility	Comfort	Frequency	Importance	Normalization	Estimated suitable mean
Car	-1	2	2	-2	2	1	0	MEDIUM
Coach	-2	2	1	-1	-1	-1	-1	LOW
Train	1	1	0	2	0	4	1	HIGH
Plane	2	0	-1	1	2	3,5	1	HIGH
						Average	1,88	
						Variance	5,40	
						Standard deviation	2,32	

LOW-FARE								
WEIGHTS								
	0,5	2	0,5	0,5	0,5			
MEAN	Time	Fare	Accessibility	Comfort	Frequency	Importance	Normalization	Estimated suitable mean
Car	-1	2	2	-2	2	4,5	1	HIGH
Coach	-2	2	1	-1	-1	2,5	-1	LOW
Train	1	1	0	2	0	3,5	0	MEDIUM
Plane	2	0	-1	1	2	2	-1	LOW
						Average	3,1	
						Variance	1,2	
						Standard deviation	1,1	

Attached VII: VALUES OF €/KM IN HIGH SPEED LINES OVER EUROPE

STRETCH	€/km
Less than 400km	
Paris-Lyon	0,1
Madrid-Seville	0,07
Paris-Strasbourg	0,08
Madrid-Zaragoza	0,12
Hamburg-Frankfurt*	0,17
More than 400km	
Madrid-Malaga	0,07
Madrid-Barcelona	0,08
Rome-Milan	0,15
Paris-Marseille	0,05

*Straight distance considered

Average €/km in more than 400km HS lines	0,0875
Average €/km in less than 400km HS lines	0,108

Estimated posible HS cost Stockholm-Copenhagen	55 €
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Comparison of High-Speed train market between Spain and Sweden:
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Appendix VIII: EVALUATION OF TRANSPORT MEANS ATTENDING DIFFERENT VARIABLES: SWEDISH CORRIDOR STOCKHOLM-COPENHAGEN WITH HIGH SPEED

Swedish corridor (HS)	Time	Standardize	LEVEL	LEVEL
Car	412	0,5	2	Disadvantaged
Coach	545	1,2	1	Very disadvantaged
Train	171	-0,9	5	Very favourable
Plane	182	-0,8	5	Very favourable
Mean	327,5			
Variance	33369,67			
Standard deviation	182,6737			

	Fare	Standardize	LEVEL	LEVEL
Car	66	-0,73	5	Very favourable
Coach	40	-1,06	5	Very favourable
Train	206	1,07	2	In favour
	79	-0,56	5	
	153	0,39	3	
	62	-0,78	5	
Plane	265	1,82	1	Indifferent
	68	-0,70	5	
	166	0,56	3	
Mean	122,83			
Variance	6083,13			
Standard deviation	77,99			

Swedish corridor (HS)	Average frequency per day	LEVEL
Car		Very favourable
Coach	2	Disadvantaged
Train	30	Very favourable
Plane	20	Very favourable
AVERAGE	17	

Appendix VIII (2): EVALUATION OF TRANSPORT MEANS ATTENDING DIFFERENT VARIABLES: SWEDISH CORRIDOR STOCKHOLM-COPENHAGEN WITH HIGH SPEED

MEAN	Time	Cost	Accessibility	Comfort	Frequency	Time/Fare
Car	Disadvantaged	Very favourable	Very favourable	Vey disadvantaged	Very favourable	Disadvantaged
Coach	Very disadvantaged	Very favourable	In favour	Disadvantaged	Disadvantaged	Indifferent
Train	Very favourable	In favour	Indifferent	Very favourable	Very favourable	Very favourable
Plane	Very favourable	Indifferent	Disadvantaged	Very favourable	Very favourable	In favour
				In favour		

EVALUATION OF TRANSPORT MODES ALONG THE CORRIDOR ATTENDING THE VARIABLES

BUSINESS								
WEIGHTS								
	2	0,5	1	2	2			
MEAN	Time	Fare	Accessibility	Comfort	Frequency	Importance	Normalization	Estimated suitable mean
Car	-1	2	2	-2	2	1	0	MEDIUM
Coach	-2	2	1	-1	-1	-6	-1	LOW
Train	2	1	0	2	2	12,5	1	HIGH
Plane	2	0	-1	2	2	11	1	HIGH
					Average	4,6		
					Variance	76,2		
					Standard deviation	8,7		

Appendix VIII (3): EVALUATION OF TRANSPORT MEANS ATTENDING DIFFERENT VARIABLES: SWEDISH CORRIDOR STOCKHOLM-COPENHAGEN WITH HIGH SPEED

EVALUATION OF TRANSPORT MODES ALONG THE CORRIDOR ATTENDING THE VARIABLES

LEISURE								
WEIGHTS								
	1	1	0,5	1	0,5			
MEAN	Time	Fare	Accessibility	Comfort	Frequency	Importance	Normalization	Estimated suitable mean
Car	-1	2	2	-2	2	1	0	MEDIUM
Coach	-2	2	1	-1	-1	-1	-1	LOW
Train	2	1	0	2	2	6	1	HIGH
Plane	2	0	-1	1	2	3,5	0	MEDIUM
						Average	2,38	
						Variance	9,23	
						Standard deviation	3,04	

LOW-FARE								
WEIGHTS								
	0,5	2	0,5	0,5	0,5			
MEAN	Time	Fare	Accessibility	Comfort	Frequency	Importance	Normalization	Estimated suitable mean
Car	-1	2	2	-2	2	4,5	1	HIGH
Coach	-2	2	1	-1	-1	2,5	-1	LOW
Train	2	1	0	2	2	5	1	HIGH
Plane	2	0	-1	1	2	2	-1	LOW
						Average	3,5	
						Variance	2,2	
						Standard deviation	1,5	

Appendix IX: ACCESSIBILITY MATRIX: CURRENT MATRIX TRAVELLING TIME (MIN)

CURRENT	Stockholm	Södertälje	Nyköping	Norrköping	Linköping	Jönköping	Värnamo	Helsingborg	Lund	Malmö	Copenhagen	Uppsala	Västerås	Örebro	Göteborg	Växjö
Stockholm	0	18	60	83	106	196	192	184	156	169	201	40	60	103	314	175
Södertälje	18	0	42	65	88	178	174	166	138	151	183	58	78	85	296	157
Nyköping	60	42	0	45	68	158	154	146	118	131	163	100	120	127	276	137
Norrköping	105	87	45	0	23	113	109	101	73	86	118	145	165	125	231	92
Linköping	128	110	68	23	0	90	114	124	96	109	141	168	153	102	208	97
Jönköping	202	184	158	113	90	0	70	154	126	139	171	242	185	134	118	75
Värnamo	226	208	182	137	114	70	0	116	88	101	133	266	209	158	188	37
Helsingborg	288	270	244	199	176	154	116	0	28	41	73	328	271	220	272	99
Lund	260	242	216	171	148	126	88	28	0	13	45	300	243	192	244	71
Malmö	273	255	229	184	161	139	101	41	13	0	32	313	256	205	257	84
Copenhagen	305	287	261	216	193	171	133	73	45	32	0	345	288	237	289	116
Uppsala	40	58	100	123	146	236	232	224	196	209	241	0	100	143	354	215
Västerås	60	78	120	129	152	185	209	230	202	215	247	100	0	51	303	192
Örebro	103	85	126	81	102	134	158	182	154	167	199	143	51	0	252	141
Göteborg	320	302	276	231	208	118	188	272	244	257	289	360	303	252	0	193
Växjö	209	191	165	120	97	75	37	99	71	84	116	249	192	141	193	0
Kalmar	270	252	226	181	158	136	98	160	132	145	177	310	253	202	254	61
Karlskrona	286	268	242	197	174	152	114	176	148	161	193	326	269	218	270	77
Halmstad	316	298	272	227	204	160	90	62	90	103	135	356	299	248	278	127
Eskilstuna	56	38	80	75	98	181	184	176	148	161	193	96	54	47	299	167
Mjölby	141	123	97	52	29	61	85	147	119	132	164	181	124	73	179	68
Nässjö	168	150	124	79	56	34	58	120	92	105	137	208	151	100	152	41
Alvesta	199	181	155	110	87	65	27	89	61	74	106	239	182	131	183	10
Hässleholm	234	216	190	145	122	100	62	54	26	39	71	274	217	166	218	45
Kristianstad	252	234	208	163	140	118	80	72	44	57	89	292	235	184	236	63
Katrineholm	54	36	74	29	52	142	138	130	102	115	147	94	100	52	260	121
Hallsberg	87	69	107	62	83	115	139	163	135	148	180	127	70	19	233	122
Arboga	81	63	105	100	123	156	180	201	173	186	218	121	29	22	274	163
Emmaboda	241	223	197	152	129	107	69	131	103	116	148	281	224	173	225	32

Comparison of High-Speed train market between Spain and Sweden:
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Appendix IX (2): ACCESSIBILITY MATRIX: CURRENT MATRIX TRAVELLING TIME (MIN)

CURRENT	Kalmar	Karlskrona	Halmstad	Eskilstuna	Mjolby	Nässjö	Alvesta	Hässleholm	Kristianstad	Katrineholm	Hallsberg	Arboga	Emmadoba	ACC TIME
Stockholm	236	224	246	56	135	162	165	130	112	54	87	81	207	3952
Södertälje	218	206	228	38	117	144	147	112	94	36	69	63	189	3538
Nyköping	198	186	208	80	97	124	127	92	74	78	111	105	169	3494
Norrköping	153	141	163	125	52	79	82	47	29	123	106	147	124	2989
Linköping	158	164	186	148	29	56	87	70	52	116	83	124	129	3133
Jönköping	136	152	160	181	61	34	65	100	118	148	115	156	107	3694
Värnamo	98	114	90	205	85	58	27	62	80	172	139	180	69	3612
Helsingborg	160	176	62	267	147	120	89	54	72	234	201	242	131	4734
Lund	132	148	90	239	119	92	61	26	44	206	173	214	103	4034
Malmö	145	161	103	252	132	105	74	39	57	219	186	227	116	4359
Copenhagen	177	193	135	284	164	137	106	71	89	251	218	259	148	5223
Uppsala	276	264	286	96	175	202	205	170	152	94	127	121	247	5032
Västerås	253	269	292	54	124	151	182	176	158	100	70	29	224	4555
Örebro	202	218	244	47	73	100	131	128	110	52	19	22	173	3597
Göteborg	254	270	278	299	179	152	183	218	236	266	233	274	225	6880
Växjö	61	77	127	188	68	41	10	45	63	155	122	163	32	3191
Kalmar	0	74	188	249	129	102	71	106	124	216	183	224	29	4710
Karlskrona	74	0	204	265	145	118	87	122	112	232	199	240	45	5114
Halmstad	188	204	0	295	175	148	117	116	134	262	229	270	159	5562
Eskilstuna	228	216	238	0	120	147	157	122	104	46	66	25	199	3721
Mjolby	129	145	175	120	0	27	58	93	81	87	54	95	100	2939
Nässjö	102	118	148	147	27	0	31	66	84	114	81	122	73	2888
Alvesta	71	87	117	178	58	31	0	35	53	145	112	153	42	2981
Hässleholm	106	122	116	213	93	66	35	0	18	180	147	188	77	3540
Kristianstad	124	112	134	231	111	84	53	18	0	198	165	206	95	3998
Katrineholm	182	170	192	46	81	108	111	76	58	0	33	71	153	2927
Hallsberg	183	199	225	66	54	81	112	109	91	33	0	41	154	3207
Arboga	224	240	263	25	95	122	153	147	129	71	41	0	195	3900
Emmadoba	29	45	159	220	100	73	42	77	95	187	154	195	0	3927

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Appendix IX (3): ACCESSIBILITY MATRIX: CURRENT MATRIX TRAVELLING TIME TO MAIN CITIES (MIN)

CURRENT	POPULATION														ACC TIME	ACC INDICATOR
	1252020	27720	97428	84423	258020	1084885	128409	55600	35170	32606	55688	510491	98237	107005		
	Stockholm	Nyköping	Linköping	Jönköping	Malmö	Copenhagen	Uppsala	Västerås	Örebro	Göteborg	Växjö	Kalmar	Karlskrona	Halmstad		
Stockholm	0	60	106	196	169	201	40	60	103	314	175	236	224	246	2130	128
Södertälje	18	42	88	178	151	183	58	78	85	296	157	218	206	228	1986	124
Nyköping	60	0	68	158	131	163	100	120	127	276	137	198	186	208	1932	127
Norrköping	105	45	23	113	86	118	145	165	125	231	92	153	141	163	1705	117
Linköping	128	68	0	90	109	141	168	153	102	208	97	158	164	186	1772	134
Jönköping	202	158	90	0	139	171	242	185	134	118	75	136	152	160	1962	168
Värnamo	226	182	114	70	101	133	266	209	158	188	37	98	114	90	1986	158
Helsingborg	288	244	176	154	41	73	328	271	220	272	99	160	176	62	2564	176
Lund	260	216	148	126	13	45	300	243	192	244	71	132	148	90	2228	149
Malmö	273	229	161	139	0	32	313	256	205	257	84	145	161	103	2358	153
Copenhagen	305	261	193	171	32	0	345	288	237	289	116	177	193	135	2742	167
Uppsala	40	100	146	236	209	241	0	100	143	354	215	276	264	286	2610	166
Västerås	60	120	152	185	215	247	100	0	51	303	192	253	269	292	2439	171
Örebro	103	126	102	134	167	199	143	51	0	252	141	202	218	244	2082	157
Göteborg	320	276	208	118	257	289	360	303	252	0	193	254	270	278	3378	284
Växjö	209	165	97	75	84	116	249	192	141	193	0	61	77	127	1786	140
Kalmar	270	226	158	136	145	177	310	253	202	254	61	0	74	188	2454	183
Karlskrona	286	242	174	152	161	193	326	269	218	270	77	74	0	204	2646	204
Halmstad	316	272	204	160	103	135	356	299	248	278	127	188	204	0	2890	212
Eskilstuna	56	80	98	181	161	193	96	54	47	299	167	228	216	238	2114	143
Mjölby	141	97	29	61	132	164	181	124	73	179	68	129	145	175	1698	141
Nässjö	168	124	56	34	105	137	208	151	100	152	41	102	118	148	1644	137
Alvesta	199	155	87	65	74	106	239	182	131	183	10	71	87	117	1706	133
Hässleholm	234	190	122	100	39	71	274	217	166	218	45	106	122	116	2020	143
Kristianstad	252	208	140	118	57	89	292	235	184	236	63	124	112	134	2244	160
Katrineholm	54	74	52	142	115	147	94	100	52	260	121	182	170	192	1755	115
Hallsberg	87	107	83	115	148	180	127	70	19	233	122	183	199	225	1898	140
Arboga	81	105	123	156	186	218	121	29	22	274	163	224	240	263	2205	161
Emmadoba	241	197	129	107	116	148	281	224	173	225	32	29	45	159	2106	162

Comparison of High-Speed train market between Spain and Sweden:
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Appendix IX (4): ACCESSIBILITY MATRIX: HS MATRIX TRAVELLING TIME (MIN)

HS	Stockholm	Södertälje	Nyköping	Norrköping	Linköping	Jönköping	Värnamo	Ljungby	Helsingborg	Lund	Malmö	Copenhagen	Uppsala	Västerås	Örebro	Göteborg
Stockholm	0	11	40	44	59	83	113	129	134	144	147	171	40	60	96	201
Södertälje	11	0	29	33	48	72	102	118	123	133	136	160	51	71	85	190
Nyköping	40	29	0	4	19	43	73	89	94	104	107	131	80	100	105	161
Norrköping	44	33	4	0	15	39	69	85	90	100	103	127	84	104	81	157
Linköping	59	48	19	15	0	24	54	70	75	85	88	112	99	119	96	142
Jönköping	83	72	43	39	24	0	30	46	51	61	64	88	123	143	120	118
Värnamo	113	102	73	69	54	30	0	16	21	31	34	58	153	173	150	148
Ljungby	129	118	89	85	70	46	16	0	5	15	18	42	169	189	166	164
Helsingborg	134	123	94	90	75	51	21	5	0	10	13	37	174	194	171	169
Lund	144	133	104	100	85	61	31	15	10	0	3	27	184	204	181	179
Malmö	147	136	107	103	88	64	34	18	13	3	0	24	187	207	184	182
Copenhagen	171	160	131	127	112	88	58	42	37	27	24	0	211	231	208	206
Uppsala	40	51	80	84	99	123	153	169	174	184	187	211	0	100	136	241
Västerås	60	71	100	104	119	143	168	152	157	148	151	175	100	0	51	261
Örebro	96	85	114	117	102	126	117	101	106	97	100	124	136	51	0	244
Göteborg	201	190	161	157	142	118	148	164	169	179	182	206	241	261	238	0
Växjö	150	139	110	106	91	67	37	53	58	68	71	95	190	192	141	185
Kalmar	211	200	171	167	152	128	98	114	119	129	132	156	251	253	202	246
Karlskrona	227	216	187	183	168	144	114	130	135	145	148	172	267	269	218	262
Halmstad	170	159	130	126	111	87	57	41	46	56	59	83	210	230	207	205
Eskilstuna	49	38	67	71	86	110	140	148	153	144	147	171	89	54	47	228
Mjölby	88	77	48	44	29	53	83	99	104	114	117	141	128	124	73	171
Nässjö	115	104	75	71	56	34	58	74	79	89	92	116	155	151	100	152
Alvesta	140	129	100	96	81	57	27	43	48	58	61	85	180	182	131	175
Hässleholm	159	148	119	115	100	76	46	30	35	26	29	53	199	217	166	194
Kristianstad	178	167	138	134	119	95	65	49	54	45	48	72	218	236	185	213
Katrineholm	47	36	33	29	44	68	98	114	119	111	114	138	87	100	52	186
Hallsberg	115	104	102	98	83	107	98	82	87	78	81	105	155	70	19	225
Arboga	74	63	92	96	111	135	139	123	128	119	122	146	114	29	22	253
Emmaboda	182	171	142	138	123	99	69	85	90	100	103	127	222	224	173	217

Comparison of High-Speed train market between Spain and Sweden:
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Appendix IX (5): ACCESSIBILITY MATRIX: HS MATRIX TRAVELLING TIME (MIN)

HS	Växjö	Kalmar	Karlskrona	Halmstad	Eskilstuna	Mjölby	Nässjö	Alvesta	Hässleholm	Kristianstad	Katrineholm	Hallsberg	Arboga	Emmadoba	ACC TOTAL
Stockholm	150	211	225	170	49	88	115	140	132	113	47	80	74	182	3248
Södertälje	139	200	214	159	38	77	104	129	121	102	36	69	63	171	2984
Nyköping	110	171	187	130	67	48	75	110	118	99	33	66	92	142	2627
Norrköping	106	167	183	126	71	44	71	96	114	95	29	62	96	138	2533
Linköping	91	152	168	111	86	29	56	81	100	110	44	77	111	123	2444
Jönköping	67	128	144	87	110	53	34	57	76	104	68	101	135	99	2368
Värnamo	37	98	114	57	140	83	58	27	46	74	98	131	165	69	2422
Ljungby	53	114	130	41	156	99	74	43	30	58	114	147	181	85	2646
Helsingborg	58	119	135	46	161	104	79	48	35	63	119	152	186	90	2756
Lund	68	129	145	56	171	114	89	58	26	54	129	162	196	100	2958
Malmö	71	132	148	59	174	117	92	61	29	57	132	165	199	103	3036
Copenhagen	95	156	172	83	198	141	116	85	53	81	156	189	223	127	3708
Uppsala	190	251	265	210	89	128	155	180	172	153	87	120	114	222	4368
Västerås	167	228	215	193	54	124	151	157	122	103	100	70	29	199	3872
Örebro	116	177	164	142	47	73	100	106	71	52	93	19	22	148	3046
Göteborg	185	246	262	205	228	171	152	175	194	222	186	219	253	217	5672
Växjö	0	61	77	94	177	68	41	10	45	73	135	122	163	32	2851
Kalmar	61	0	74	155	238	129	102	71	106	134	196	183	224	29	4431
Karlskrona	77	74	0	171	254	145	118	87	122	112	212	199	240	45	4841
Halmstad	94	155	171	0	197	140	115	84	71	99	155	188	222	126	3794
Eskilstuna	163	224	211	189	0	115	142	153	118	99	46	66	25	195	3488
Mjölby	68	129	145	140	115	0	27	58	93	87	73	54	95	100	2677
Nässjö	41	102	118	115	142	27	0	31	66	94	100	81	122	73	2633
Alvesta	10	71	87	84	167	58	31	0	35	63	125	112	153	42	2631
Hässleholm	45	106	122	71	186	93	66	35	0	28	144	147	188	77	3020
Kristianstad	64	125	112	90	205	112	85	54	19	0	163	166	207	96	3514
Katrineholm	130	191	178	155	46	73	100	120	85	66	0	33	71	162	2786
Hallsberg	97	158	145	123	66	54	81	87	52	33	112	0	41	129	2787
Arboga	138	199	186	164	25	95	122	128	93	74	71	41	0	170	3272
Emmadoba	32	29	45	126	209	100	73	42	77	105	167	154	195	0	3619

Comparison of High-Speed train market between Spain and Sweden:
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Appendix IX (6): ACCESSIBILITY MATRIX: HS MATRIX TRAVELLING TIME TO MAIN CITIES (MIN)

HS	POPULATION														ACC TOTAL	ACC INDICATOR
	1252020	27720	97428	84423	258020	1084885	128409	55600	35170	32606	55688	510491	98237	107005		
	Stockholm	Nyköping	Linköping	Jönköping	Malmö	Copenhagen	Uppsala	Västerås	Örebro	Göteborg	Växjö	Kalmar	Karlskrona	Halmstad		
Stockholm	0	40	59	83	147	171	40	60	96	201	150	211	225	170	1653	108
Södertälje	11	29	48	72	136	160	51	71	85	190	139	200	214	159	1565	105
Nyköping	40	0	19	43	107	131	80	100	105	161	110	171	187	130	1384	98
Norrköping	44	4	15	39	103	127	84	104	81	157	106	167	183	126	1340	97
Linköping	59	19	0	24	88	112	99	119	96	142	91	152	168	111	1280	94
Jönköping	83	43	24	0	64	88	123	143	120	118	67	128	144	87	1232	90
Värnamo	113	73	54	30	34	58	153	173	150	148	37	98	114	57	1292	87
Ljungby	129	89	70	46	18	42	169	189	166	164	53	114	130	41	1420	91
Helsingborg	134	94	75	51	13	37	174	194	171	169	58	119	135	46	1470	92
Lund	144	104	85	61	3	27	184	204	181	179	68	129	145	56	1570	95
Malmö	147	107	88	64	0	24	187	207	184	182	71	132	148	59	1600	96
Copenhagen	171	131	112	88	24	0	211	231	208	206	95	156	172	83	1888	106
Uppsala	40	80	99	123	187	211	0	100	136	241	190	251	265	210	2133	145
Västerås	60	100	119	143	151	175	100	0	51	261	167	228	215	193	1963	136
Örebro	96	114	102	126	100	124	136	51	0	244	116	177	164	142	1692	120
Göteborg	201	161	142	118	182	206	241	261	238	0	185	246	262	205	2648	206
Växjö	150	110	91	67	71	95	190	192	141	185	0	61	77	94	1524	110
Kalmar	211	171	152	128	132	156	251	253	202	246	61	0	74	155	2192	153
Karlskrona	227	187	168	144	148	172	267	269	218	262	77	74	0	171	2384	175
Halmstad	170	130	111	87	59	83	210	230	207	205	94	155	171	0	1912	129
Eskilstuna	49	67	86	110	147	171	89	54	47	228	163	224	211	189	1835	129
Mjölby	88	48	29	53	117	141	128	124	73	171	68	129	145	140	1454	113
Nässjö	115	75	56	34	92	116	155	151	100	152	41	102	118	115	1422	109
Alvesta	140	100	81	57	61	85	180	182	131	175	10	71	87	84	1444	104
Hässleholm	159	119	100	76	29	53	199	217	166	194	45	106	122	71	1656	107
Kristianstad	178	138	119	95	48	72	218	236	185	213	64	125	112	90	1893	125
Katrineholm	47	33	44	68	114	138	87	100	52	186	130	191	178	155	1523	108

Comparison of High-Speed train market between Spain and Sweden:
Madrid-Barcelona VS Stockholm-Copenhagen

Appendix IX (6): CHANGE OF ACCESIBILITY AND AVERAGE ACC BY LÄN

ACCESSIBILITY			
	CURRENT ACC INDICATOR	HS ACC INDICATOR	CHANGE
Stockholm	128	108	16,1%
Södertälje	124	105	15,3%
Nyköping	127	98	23,0%
Norrköping	117	97	17,3%
Linköping	134	94	30,1%
Jönköping	168	90	46,5%
Värnamo	158	87	45,2%
Ljungby		91	
Helsingborg	176	92	47,6%
Lund	149	95	36,3%
Malmö	153	96	37,3%
Copenhagen	167	106	36,3%
Uppsala	166	145	12,5%
Västerås	171	136	20,4%
Örebro	157	120	23,3%
Göteborg	284	206	27,5%
Växjö	140	110	21,3%
Kalmar	183	153	16,3%
Karlskrona	204	175	14,6%
Halmstad	212	129	39,1%
Eskilstuna	143	129	10,0%
Mjölby	141	113	20,0%
Nässjö	137	109	19,9%
Alvesta	133	104	22,4%
Hässleholm	143	107	25,1%
Kristianstad	160	125	21,8%
Katrineholm	115	108	6,4%

ACCESSIBILITY			
LÄN	CURRENT ACC INDICATOR	HS ACC INDICATOR	CHANGE
Örebro	157	120	23,30%
Västmanland	171	136	20,38%
Hallands	212	129	39,13%
Jönköpings	154	95	37,23%
Uppsala	166	145	12,46%
Södermanlands	129	111	13,16%
Östergötlands	131	101	22,44%
Kalmar	183	153	16,29%
Skåne	156	103	33,63%
Kronobergs	137	107	21,83%
Blekinge	204	175	14,59%
Stockholm	126	106	15,68%
Copenhagen	167	106	36,31%

