INTERNATIONAL UNION
OF RAILWAYS

High Speed Rail as a tool for regional development

In-depth Study





DB International GmbH
Passenger Transport Systems
Oskar-Sommer-Straße 15
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2011-08-08

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Cover Picture

Source: Own illustration referring to DB AG (Bartolomiej Banaszak, Ralf Louis, Axel Hartmann)

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List of Abbreviations

DB AG	Deutsche Bahn AG
EUR	Euro
FA	Factor Analysis
GDP	Gross Domestic Product
DESATIS	Statistisches Bundesamt Deutschland
HS	High Speed
HSL	High Speed Line
HSR	High Speed Rail
INSEE	Institut national de la statistique et des études économiques
ISTAT	Istituto nazionale di statistica
INE	Instituto Nacional de Estadīstica
OECD	Organisation for Economic Co-operation and Development
PCA	Principal Component Analysis
SNCF	Société National des Chemins de fer
UIC	Union Internationale des Chemins de fer, International Union of Railways
UK	United Kingdom
*	Correlation is significant at the level of 0.05
**	Correlation is significant at the level of 0.01

Executive Summary

Project Background

High Speed Rail (HSR) has become worldwide one of the most prominent transport modes in recent years. Several countries in Europe, America and in Asia are extending their networks and pushing these developments through the planning and construction of new lines. Apart from connections between two metropolitan areas the intervening regions must also be taken into consideration in more detail. Here, small or medium sized cities will benefit in a social or economic way from HSR and obtain HSR connections as a location advantage in comparison to cities or regions without such a link. Shorter travelling times and lower travel costs for users - brought about by HSR - are assumed to be an initial starting point for additional development in cities or regions.

The purpose of the present study is to evaluate the implications of HSR on regional and urban development in a scientific way. The study does not question impacts on mobility and modal choices because they are already well assessed. The positive effects on the regional and urban development are usually known in a qualitative way but have not yet been proved in a quantitative approach. Therefore, the study attempts to analyse and illustrate the non-traffic related impacts of HSR for the first time in a worldwide extensive sample. The overall analysis approach takes into consideration worldwide benchmarks comparing the situation of small and medium-sized cities and regions before and after being connected to HSR. Apart from the detailed quantitative investigation, the study serves as a basis for discussion including all pros and cons regarding the impacts when considering HSR examples. The general extensive and complicated questions include many different framework conditions and the answers depend on several conditions that need to be discussed in specific applications. The overall approach uses various tools such as for example comparison of similar cities with and without HSR as well as statistical methods.

The "Union Internationale des Chemins de fer" (UIC) has assigned the study on "High Speed and Territory Management" - to be considered within two batched studies - to research the questions concerning additional indirect effects of HSR, such as the social and economic development in cities and regions. Two further studies "High Speed Rail and the City" and "High Speed Rail contribution to sustainable development" complete the research on different aspects of this subject.

Approach

The study starts with a fundamental description and definition of the field of investigation. This includes the designated expected impacts in the chosen five countries Japan, France, Germany, Italy and Spain as well as the selected cities. The city selection itself is separated into the HSR cities selected and the corresponding non HSR cities (twin cities). In doing so, an important tool for showing impacts is used by choosing the comparable city pairs in the overall study. This comparison approach leads to a reduction of additional effects in the city or region that does not correlate with the HSR. For these cities, impacts such as changes in population, economy, tourism or especially changes in the surrounding areas have been investigated.

After defining the field of investigation, impacts are analysed in a qualitative way in greater or lesser detail. The general development is considered but the level of detail is dependent on the available information. Therefore, impacts without a useful data base are highlighted in this part and assessed per analysed city where possible. In doing so, this qualitative appraisal also serves as a brief description of the cities and their surrounding areas in order to understand the subsequent analytical steps. In other words, this qualitative assessment also helps to prepare as well as understand the quantitative analysis.

In contrast, the quantitative analysis as the main part of the study attempts to illustrate the impact of the HSR by using actual figures such as social or economic data. This kind of analysis deals with many various challenges regarding the verification of the impact of HSR, such as data acquisition and mostly highly aggregated data due to many other effects apart from the HSR in the considered investigation area. All in all, this illustrated analysis should be regarded as a first step and an attempt to solve this problem in order to obtain first quantitative indications regarding the impact of HSR. One important tool to reduce this complexity is once again the twin city issue, as already mentioned above. Quantitative analyses concentrate on the one hand on the comparison of the development of city pairs by using time series and correlation coefficients and on the other hand on providing reasons for having differences in the development, by using a Principal Component Analysis (PCA) as well as Regression Analysis.

Results of Qualitative Analysis

One detailed indicated impact here can cause a change in the image. HSR can influence the image of a city or change it in a positive way. Firstly, the image might change through the development of new economic structures stimulated by the HSR link. Examples are Puertollano in Spain or Fulda in Germany. Secondly, a city image is changed by values such as modernity or innovation, which are conferred by HS trains and advertisements with them. This point could be mentioned for most of the cities connected to HSR . For example, Nantes, Le Mans or Vendome in France, Segovia or Cordoba in Spain, as well as Montabaur or Fulda in Germany, are using their connection to the HSR intensively to present themselves as modern, innovative and open-minded places for tourists or enterprises.

Another impact of a city connection to a HSR which has been observed in several selected samples, is the change in land use in cities and especially in the surrounding area of the stations. However, this is not a general result of HSR, but depends on several different factors. In this study, two conditions have been considered: On the one hand the effects of completely newly built stations and the free area surrounding the stations: Here, a formerly agriculturally used area is generally utilised for industry, offices, services or retail. Examples of this are Le Creusot (France), Montabaur (Germany) or Segovia (Spain). On the other hand, land use has changed through the development or conversion of existing areas in a city after the connection of the station to the high-speed system. In Cordoba (Spain) for example, the construction of a railway tunnel provided space for a new quarter in the city centre. In Metz, Le Mans, Nantes (all in France), Puertollano, Ciudad Real (both in Spain), Korikama or Kitakami (both in Japan), unused freight yards, idle railway equipment or unused urban areas were made available for new use.

In the case of a change in the surrounding area as a special investigated impact, the qualitative results show a truly visible development in the case of HSR cities. In some isolated cases a development is also apparent for twin cities - without HSR. However, in these cases the cities are mostly foreseen to obtain a HSR connection in the future, or currently enjoy good long distance connections (e.g. Erfurt in Germany). In general, there is little or no development apparent before the linking up of the city and the opening of a new HSR station. One simple reason for this is the land area needed during the construction period. Already existing stations which obtain an HSR link also show no significant development before the final commissioning of HSR. One other result for an extension of a HSR station is the preparation of an intramodal transport hub including parking spaces and public transport.

A comparison of the results indicates differences in the cities in addition to differences between the countries. In fact, countries such as Spain, Japan or Germany focus on various kinds of new developments, whereas Germany consists mainly of hotel and congresses, Spain has focused on residential areas. In contrast, France creates completely new city districts including hotels, retail and residential areas etc.. In fact, Lyon and Lille are good examples of this. Moreover, hotels have mostly been developed in larger cities rather than in smaller ones. Also, where hotel development has taken place it usually included congress centres.

Although a generally improved development can be stated for the HSR cities in comparison to the twin cities, development differs between the HSR cities. Some cities have not changed yet as expected so that the questions regarding the reasons for this must be answered. Therefore, a qualitative assessment on the basis of this research leads to several preconditions as well as circumstances that need to be noted as reasons for the extension of the changes in the HSR cities. Here, positive supporting factors are for example direct access to motorways, commuter distances to the next metropolis, short distances to city centres, available areas for necessary development / new or old stations in city centres, fundamental basis in socio and economic facts, the periphery, or especially the political willingness including the cooperation of various institutions.

Results of Quantitative Analysis

The quantitative results provide in general a varying picture. The comparison of data time series for each considered impact up to eight years after commissioning of HSR leads to a better development in HSR cases than in non HSR cases in several analyses. However, this has not been confirmed as yet and also differs in countries and impacts, so that a valid impact of HSR has not yet been noted. In detail, data times series have not always led to the expected negative correlation coefficient to the greatest extent; referring to different developments between the city pairs as well as the positive correlation and referring to similar developments between the HSR cities. Nevertheless, examples in considered countries which have benefited can be highlighted - positives examples for HSR in comparison to twin cities. However, the results must be looked at whilst taking into consideration the difficulties in obtaining the needed data and mostly small sample sizes for all these analyses.

The analysis for Germany shows a better development for the HSR by comparing all the included impacts. Really good examples are Wolfsburg as well as Fulda. Whereas Wolfsburg has definitely benefited from the car manufacturing (Volkswagen), Fulda probably benefits due to its location within the network, with connections to different (HSR) cities, including a short travelling distance to the financial centre F

rankfurt / Main. In the case of Japan positive examples in development after commissioning of HSR can also be confirmed. However, the applied data were mostly interpolated, which needs to be considered when looking at the results. Here, Mishima or Koriyama can be highlighted as positive examples - comparison to the twin cities. In the case of France, Lille or Nantes should be mentioned due to several better developments in comparison to their twin cities. Perhaps, this can be explained for Lille by paying attention to the location in the overall transnational network, including connections to London, Brussels or Paris. The samples of Spain, as well as Italy, do not indicate significant overall differences between the pairs, whereas some results for individual effects have been registered.

Due to the differences in the results - also in the HSR case itself - the final step of this report has dealt with finding potential reasons for these differences. However, this has been done in a first comprehension by using a constrained number of quantitative measureable factors. The analyses, including PCA and regression, show separate results that also depend on the country. In summary, the size of the city including inhabitants per square kilometre and the distance as well as the travelling time to the next relevant city can be highlighted as a result of performing an analysis separated by country. However, these results are not significant on the designated level for each country and impact. In detail, Japan has shown mostly good results but interpolated data has been applied which leads to restricted statements. Moreover, there are several indications that not only one location precondition as for example the city size, describes the changes in the impact. Nonetheless, the transnational sample leads to similar indications in depending on the country but not in a statistically significant way as requested.

In fact, the interpretation of the quantitative results mainly depends on the restricted data base. However differences between HSR / non HSR are apparent and verifiable. These differences need to be discussed in a further approach in more detail since the success depends on several circumstances. For example HSR implementation needs a city / regional basis (socio-economic, infrastructure etc.). Moreover, HSR is not the only factor that effects city / regional development as has already been shown in the qualitative assessment. Nevertheless, HSR provides an opportunity to boost the development in the city / region. The stated results can be used for supporting qualitative statements and as an important framework / guide regarding this diverse subject. Furthermore, it enables a first estimation of the extent of impacts for potential future HSR linked cities. This forecast of the benefits of HSR could support decision makers of cities as well as regions by finding promising locations of an HSR station and achieving the designated effects.

1 Introduction and Scope of the Study

High Speed Rail (HSR) is gaining popularity worldwide. Several countries in Europe and in Asia are extending their networks and pushing these developments through the planning and construction of new lines. The study is to evaluate the implications of HSR on regional and urban development in a scientific way. The study does not question impacts on mobility and modal choices because they are already well assessed. In this context, the illustrations of market share versus journey time are often mentioned. Figure 1 illustrates such an example.

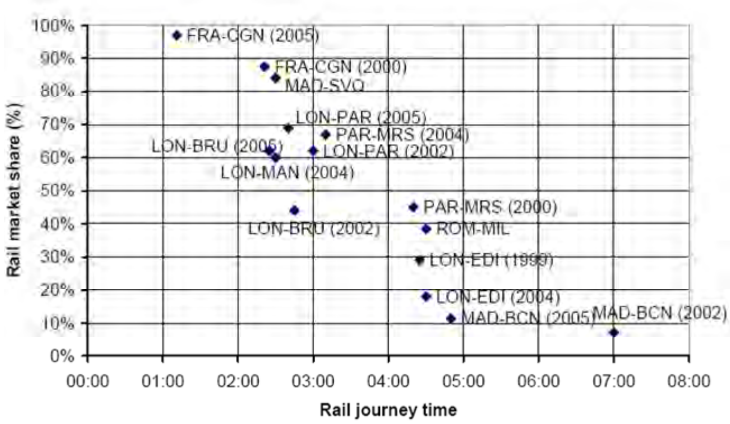

Figure 1: Market share as a function of rail journey time
[Source: Steer Davies Gleave (2006)]

The positive effects on the regional and urban development are usually known in a qualitative way but have not been proved yet in a quantitative approach. Therefore, the study attempts to analyse and illustrate the non-traffic related impact of HSR for the first time in a worldwide benchmark comparing the situation of cities and regions before and after the connection to HSR. As mentioned, the study focuses on the quantitative approach, nevertheless, the qualitative research is also carried out as it is considered important concerning for example the preparation of the final evidence in a quantitative way. Moreover, it is used here to describe impacts if a quantitative approach is not applicable because of missing quantitative information for a designated impact. In addition, the quantitative results shown could be compared to often made qualitative statements in existing documentation.

As a final result, the study shall lead to conclusions that mostly show quantitative evidence of the effects and enable in a first step the forecast of indirect impacts concerning cities as well regions with a potential connection to a High Speed Line (HSL) in the future. This attempt to forecast the benefits of HSR could support decision makers of cities as well as regions in finding promising locations for an HSR station. A further point is the provision of a guideline / discussion base for this overall diverse subject through this study.

In view of the complexity of this subject, due to the high number of potential effects and potential analysis approaches, the overall study was divided into two studies: preliminary and in-depth study.

1.1 Preliminary Study

The preliminary study mainly focused on a qualitative analysis of the impact of the HSR and served as a foundation for further investigation into the subject. This research included firstly a detailed review of available documentation and the definition of the field of impact. Moreover, country and city samples worldwide were illustrated and described for a first understanding. Apart from the description of the impact a methodology including the needed data base and useful statistical methods was indicated and applied in a first attempt, which was not detailed. The total consideration within this first view also used discussions with scientific bodies for adjusting the approach and interpreting results, as well as causes or consequences.

1.2 In-depth Study

In contrast to the preliminary study the ongoing follow-up research, in-depth study, serves to illustrate proven evidence between the implementation of the HSR and the quantitative urban and regional development. In order to show the evidence the in-depth study focuses on an application of several statistical methods. All in all, several countries and defined cities are analysed and tested as part of a worldwide example. The process of verification is accompanied by discussions with experts and scientific bodies to obtain an additional view.

1.3 General Definitions

For the general understanding and determination of the area of investigation the following definitions have to be taken into account within this study. Both definitions should be noted within the overall study but especially within the selection of the city sample.

For the definition of High Speed Rail; that is determined by UIC (2009) will be applied. This definition reads as follows “Railway lines specially built or upgraded and equipped for speeds higher than 200 km / h” [UIC (2009].

In the case of a HSR city or non HSR city, also called twin city, the connected infrastructure is used as a definition approach. Accordingly, a city is selected as HSR city if there is an infrastructure connection for running the above-mentioned speed requirements. This means that the city can be located on a line with two connections to the needed infrastructure or that the city is connected with at least one link of the required infrastructure. The definition mainly deals with the infrastructure because there are several cities that have a "connection to a HSR" but without the capacity to run at the speed needed for the use of HSR trains.

2 Analysis Approach

The first part of the overall analysis of the benefits will describe the main study base. In this context, the field of investigation will be defined. This includes a short introduction and description which will provide a first understanding and discussion regarding the designated impacts of HSR. In general, the detailed information and discussions regarding these impacts including documentation sources were considered in the preliminary study, which has already been presented. After describing and determining the countries, related cities will be selected. In both cases, the selection is based on different defined selection criteria. Accordingly, the countries will be selected for example by using the network length of HSR or the experience in operations. In a similar selection methodology the cities as well as the related twin cities will be defined by using for example the information regarding the number of inhabitants or the distance to the next important city. The selection of the cities as well as the following discussions are supported by international experts. In doing so, an internal view of the country considered is ensured. Apart from discussions and own definitions a questionnaire including requests for the final city definition was sent to various experts in cooperation with the UIC and supported the overall definition of the area of investigation. This questionnaire also served as a request for data sources and additional needed information regarding all included countries and cities.

After defining the area of investigation a first general qualitative analysis will be done for the selected countries including the selected cities. These first steps serve as a first overview on the one hand and as a final analysis in the case of impacts without available quantitative data on the other hand. Image, land use and surrounding area will be especially analysed in this way. The surrounding area will be shown on maps highlighting several kinds of development in a limited area, for example retail / shopping, industry or residential area. In this part general statements should be given and the development of the cities will be indicated in a first approximation. This overall qualitative comprehension and description also aims at preparing and understanding the data and analysis of the following quantitative considerations.

The objective of the next part - quantitative analysis - is to quantify the potential relation between the commissioning of the HSR and the potential change in one of the mentioned impacts. This part is seen as the main part of the study and shall also give indications regarding the reasons for differences in the development in comparison to the assumed benefits of HSR. All this should be attained by applying three statistical methods as a correlation coefficient in combination of times series, Principal Component Analysis as well as (Multivariate) Regression Analysis. Attention must be paid to the data needed for such detailed quantitative analysis because the availability and quality of the data mainly determines the success of the results. As a conclusion the results, the methodology and the data base shall be illustrated with regard to the various benefits as well as related cities.

Summarising the analysis methodology several different phases need to be carried out each time and in each part of the approach. This will not be illustrated in the report every time but is a really important background work. The overall steps were also described in the preliminary study. The first step, the identification of the potential effect, was also made there. Secondly, a specification of the impact is important for the understanding and discussion of the results. All in all, profiles need to be determined or kept in mind, including the determination and first descriptive analysis of the data as well as the definition of the analysis methodologies for the impacts. However, the analysis should generally be performed by applying the same approach and the same analysis methodology. The data therefore needs to be adapted and made comparable. This also includes consideration of the theoretical base and causal reasoning of the impacts in relation to the HSR. After defining all of the bases the analysis will be made and the results interpreted. An important point is here that the methodology is not a straight approach, which means several analysis results could also lead to a further definition of new data and a following new analysis (loop). This means, various investigation loops could be useful as well as necessary.

3 Determination of the Area of Investigation

This part serves as a base and defines the field of investigation. Firstly, the potential and in this study investigated impacts of HSR are shortly introduced and described for a common understanding. First assumptions and reflections with respect to the potential effects of HSR are contained in the descriptions of the impact. Secondly, the countries and the cities will be selected by using various predetermined criteria. Finally, the selected countries will be separated into groups to give a base for potential country related discussions if necessary.

3.1 Impact of High Speed Rail

The effects following the introduction of HSR will be considered in the study. The rough description is stated for each impact separately but the effects are also interdependent and also influence each other. Further information about the background of the impacts is given in the preliminary part of this overall subject.

Population

The population impact assumes an increase or decrease in the number of inhabitants per selected city as well as the extended area, as for example region or province. In relation to the HSR it is assumed for example that the number of inhabitants will increase after implementing HSR. In this context, reasons such as higher attractivity of the city, reduction in travelling time as well as travelling costs and increase in industry or the opportunity for new jobs can be mentioned amongst others. The change in population can general be appraised as a long term effect but short-term effects through relocations after commissioning of the station are possible.

In the case of changes in population, commuting needs also to be taken into account. The HSR reduces the travelling time to relevant cities and provides the opportunity to travel longer distances each day. This could also lead to a creation of "sleeping cities" on one hand and "working cities" on the other.

Commuter

In general, commuting could be interesting for people if the travelling time is improved or new centres of economic activity are on the increase. The impact regarding the commuting behaviour must also be seen in the framework of the development of population and industry. Potential effects are measurable through characteristics such as the share of HSR commuters or the absolute number of people commuting for cities, regions or special travelling connections.

Students

The number of students or especially the change in the number of students are mainly investigated in the cities or regions with universities. Students can be seen as commuters with a special purpose for the trip in contrast to, or in a similar way to, the consideration of the commuters making a business trip. This also implies that the HSR leads to a reduction of the travelling time and the universities extend their commuting area for students.

Gross Domestic Product (GDP)

Apart from the potential changes in the population as a social change, benefits in the economy could be possible and are even expected. Here, the GDP often applies as a measurement of the economic strength of a defined area such as a city, region or country. This global criteria includes the overall changes in the economy including several economic factors, so that the increase in industry - e.g. retail parks, new economy structures such as service industries - could lead to an increase in economic power measured by the GDP. Nevertheless, the GDP is a really extensive measurement, where it could be difficult to recognize smaller changes in economy.

Unemployment / Employment

Unemployment is a potential impact that also deals with the economic strength and depends on the potential changes in an economy. In this case the focus is on the measurement of unemployed or employed people without concentrating on special kinds of industry. However, changes in unemployment can also correlate to a change in commuting due the economic development of adjoining regions or cities. For finding correlation absolute figures (number of employees) as well as relations (unemployment rate) this could be used.

Surrounding area of a station

In many cases the changes in the surrounding area of a station is the most visible effect following implementation of HSR in a city / station. Therefore, the development and completion is defined as a short-term effect in many cases. However, the type and extent of the development depends on several conditions, as for example the station itself as well as the location of the station. This implies a new station on a greenfield site can probably enable more changes than a station in a city centre in an existing structure, which is mostly restricted in a historical city centre. The consideration here will not concentrate on special changes because it includes retail, shopping and also urban space for entertainment for example.

Real Estate / Land prices

Assumed effects relating to real estate or land prices were observed for example on the High Speed One Line between the Euro Chunnel and London, as discussed in the preliminary study. The prices rose after the announcement of the creation of the HSL and therefore before running the first train. Nevertheless, the changes can often be seen only as a short-term effect. Moreover, a potential self-fulfilling prophesy needs to be taken into account as this could also be observed within such infrastructure projects. In addition, providing new areas for industry etc., for instance in the surrounding area of a station, can reduce prices if there is no demand for all of the area provided. All in all, characteristics such as prices, prices per square kilometre or metre can be applied in time series to describe the potential changes as a consequence of the commissioning of HSR.

Land use

The consideration of land use relates to the particular use of different areas. Examples are residential, industry, retail as well as agriculture areas. In this study land use is included because in the implementation of a new HSR infrastructure potential new demands are created. These new demands can lead to changes in the general structure of the area. This implies for example that land so far used for agriculture would be changed for use as an industrial area due to a change in the demand for such areas. Moreover, existing industrial areas could be modified to meet new services demands - changes in the economic sector. The evidence is for example obtainable by comparing the split of several usages or the changes in square metres or kilometres separated by different types of space.

3.2 Definition of the Country Sample

The study aims at presenting a worldwide overview as well as analysis in respect to the potential impacts of HSR at a city and regional level. Therefore, the analysis requires an extended sample of countries that can be used for the investigation. The countries must fulfil various criteria that will be described in the following, since every country with HSR is not suitable currently because of framework conditions, such as for example operation period or data availability. The following part illustrates the preselected countries, the applied methodology and the designated countries for the study as a result. These final countries will be graded as a basis for a better understanding and interpretation of the final results.

3.2.1 Methodology

Due to the several viewpoints with respect to the impacts of HSR the selection approach of the countries includes different qualitative and quantitative criteria that should cover various perspectives such as for example technical and socio-economic issues. The applied decision and selection criteria are summarised as follows:

- History / future regarding the HSR development, time period of operation
- Experience in HSR operation
- High speed network (extension)
- Potential cities for investigation (city as well as twin city selection)
- Experience in investigation of the impacts of HSR (scientific bodies, literatures, studies)
- Data situation in respect to the data sources, data quality and general data availability
- Experiences from preliminary study
- Contact persons for discussions (e.g. scientific bodies, UIC members)

As illustrated, the selection of the potential countries is mainly based on the infrastructure criteria because the sample requires a good basis of experience in HSR operations and construction. However, the type of network etc gives a first indication depending on the city structure as well as the potential city itself.

In the next part various countries with HSR will be illustrated to find the final countries for the investigation. The sources for the following description are mainly the World Bank (2010) in the case of the socio-economic data and UIC (2010) for the presentation of data and facts for the HSR network per country.

China (Taiwan)

China is the biggest country with a high speed network. It has a population of 1.3 billion people who mainly live near the eastern coast of the country. Today, China is the second largest economy in the world. At the moment the HSR in China is expanding very rapidly. The first lines were commissioned in 2008, for example between Jianan and Quingdao or Beijing and Tianjing. At the end of 2010 the overall length of HSR was about 4,175 kilometres. In addition, more than 6,000 kilometres of HSL are under construction and will be commissioned in 2011 and 2012. In the case of Taiwan, as part of China, the existing line was commissioned in 2007 and the length amounts to approximately 345 kilometres. There are currently neither lines under construction nor lines in the planning stage.

In the case of China as a whole, short-term effects could only be considered in more detail in relation to the past operation time. In addition, few studies of the considered effects are available in comparison to other potential countries. Figure 2 illustrates the network and potential cities for the analyses.

Figure 2: HSR network China / Taiwan [Source: UIC (2011)]

France

France has much experience with HSR with regard to operations and research regarding the benefits of HSR. The first line, LGV Paris Sud Est, was commissioned in 1981 with a length of roughly 420 kilometres. The last line (LGV Est) was opened in 2007. The overall length of the HS network currently amounts to 1,896 kilometres. In addition, further projects are under construction. The population of France amounts to roughly 63 million people living evenly spread in the country (inhabitants per square kilometre: 92.8). Apart from Paris medium sized cities have also obtained HSR connections and more smaller cities will be connected to HSR in the future. Moreover, the city structures are more inhomogeneous as for example Germany due to the historical development. The lines connect different cities in different ways; as city centre stations, stations on the edge of towns as well as through and terminus stations. The city of Paris can be viewed as the centre of the HS network. Moreover, the preliminary study has already shown different sources of documentation and scientific bodies which deal with research regarding the benefits of HSR. This implies that several data as well as different approaches are available for the current investigation. In this context, the many years of operation as well as the experience in research provide a good basis for the analysis. Figure 3 shows the current HSR network of France.

Figure 3: HSR Network France [Source: UIC (2010)]

Germany

Germany also possesses experience regarding HS operations, because the first lines were opened in 1988 and in 1991 between Fulda and Wurzburg and Hanover and Fulda. The overall length of the whole line amounts to approximately 340 kilometres. Later, different sections such as for example Hanover – Berlin, Cologne – Frankfurt / M. as well as Berlin - Hamburg were commissioned in recent years. The extent of the network amounts to 1,285 kilometres as of today. In addition, new sections are in the planning stage as well as under construction

The population amounts to 82 million people in 2009 and approximately 229 inhabitants are living per square kilometre. This is high in contrast to other countries such as for example Spain or France. Germany consists of a balanced city structure where not all comparable cities are linked to HSR. As already shown in the preliminary study, Germany offers a good data situation and data quality concerning the impacting factors used, the various selected cities as well as the regions in comparison to other countries. Reports or studies are also available regarding this subject. Moreover, the time period for investigation offers a usable basis for quantitative research. The Figure 4 presents the lines of the German HS network.

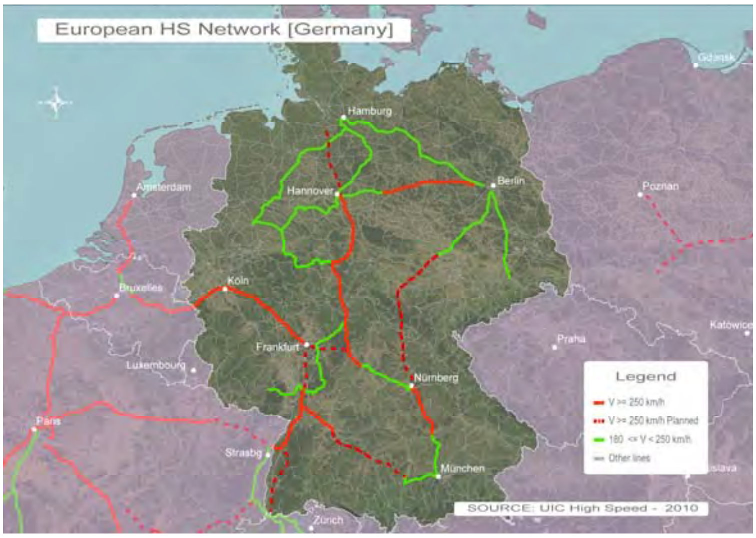

Figure 4: HSR Network Germany [Source: UIC (2011)]

Japan

With 128 million people Japan is a densely populated country situated on a series of islands in the pacific ocean. Japan is currently the third biggest economy in the world. The population density is very high and amounts to 337 inhabitants per square kilometre. Japan was the first to operate HS trains in comparison to the other countries mentioned and possesses the most experience in operations. The first line was opened between Tokyo and Osaka in 1964 and connects two of the biggest cities in Japan. The length amounts to 515 kilometres. All in all, Japan operates HSR on a HS network (Figure 5) with a length of 2,534 kilometres including the new line to Aomori. However, further lines are also under construction and in the planning stage.

The research activities regarding the benefits already shown for France or Germany can also be stated for Japan. Various available documentation with examples and investigations is on hand and helps in proving the impacting factors. In addition, due to the long operation period and the applied research, reasonable quantitative data and results may be expected. However, some of the available data are not on hand in every case and needs to be prepared if needed.

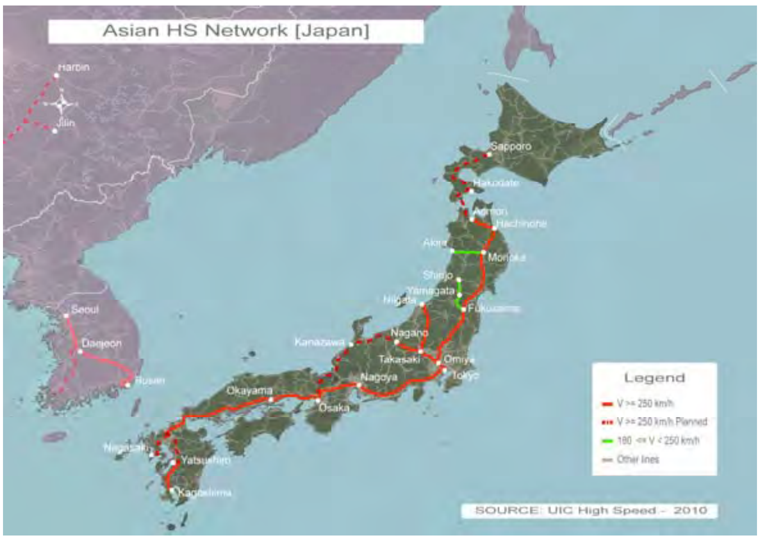

Figure 5: HSR Network Japan [Source: UIC (2011)]

Korea

Approximately 49 million people live in Korea; 81 % of them in cities. The population density is also high and amounts to 230 inhabitants per square kilometre. Korea has a small HSR "network" with only one line in operation; between Seoul and Daegu, which was opened in 2004. The length of the line amounts to approximately 330 kilometres. The section Daegu - Pusan is still under construction (length of roughly 82 kilometres). However, for an overall consideration of effects the involvement of Korea can be important for the selection of countries and the interpretation of the final results. Six years of operation will also provide the first quantitative results. Moreover, potential differences concerning networks and single lines will be taken into consideration if selected. Due to the short operation time short-term and middle-term impacts such as on the surrounding area can be analysed in more detail. The investigation of further impacts may be difficult due to the data situation and the period of operations. Here, the definition of reasonable twin cities for the current HSR cities could be difficult due to the current city structure in Korea.

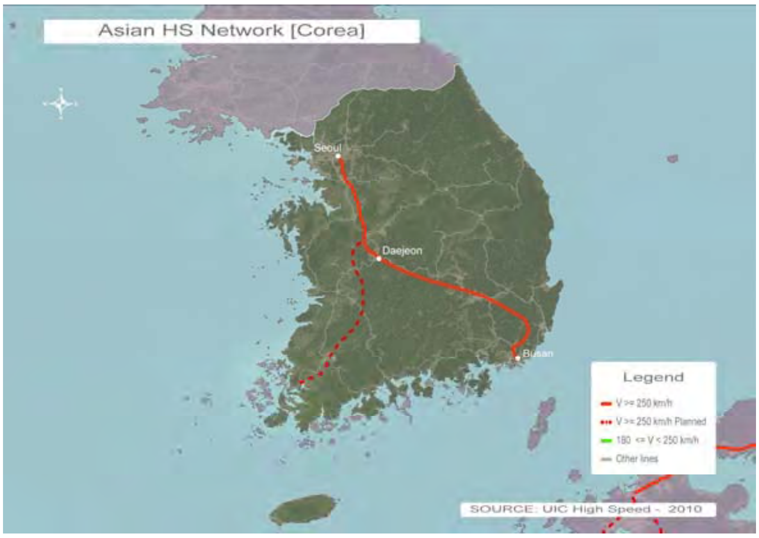

Figure 6: HSR Network Korea [Source: UIC (2011)]

Spain

The first line Seville - Madrid was commissioned in 1992 via Puertollano and Ciudad Real. The length amounts to 471 kilometres. The overall length of the network in operation amounts to 1,599 kilometres in 2009. In addition, many kilometres are under construction or in the planning process. Spain has about 46 million inhabitants and is situated on the Iberian peninsula. There are metropolises with more than 1 million inhabitants; Madrid and Barcelona. The number of inhabitants per square kilometre is similar to France and amounts to 91. This figure is also reflected in the city structure and the currently implemented HSR network.

Spanish research also provides several types of documentation respecting the HSR and additional effects (see also preliminary study). In the case of Spain different data as well as information for different potential impacting factors – short and long term - are available but often constrained in time series. Especially for the line Seville – Madrid with the cities Ciudad Real and Puertollano different information exists for analysing the potential impact of HSR. Figure 7 illustrates the current status of the network.

Figure 7: HSR Network Spain [Source: UIC (2011)]

United Kingdom (UK)

The UK mainly consists of the connection through the tunnel operated by the EUROSTAR with the main destination London. This implies that the overall "network" length amounts to 113 kilometres. The operation started in 2003. The UK, population of 62 million people, was also part of the preliminary study and includes first investigations regarding the city of Ashford and the station Ebbsfleet International. The data situation can be assumed to be mostly as useful as in other European countries. In general, available studies and documentation mainly focus on the future development and less on the past. However, this also mostly contains the discussion regarding the additional impact of HSR. The current situation is illustrated in Figure 8.

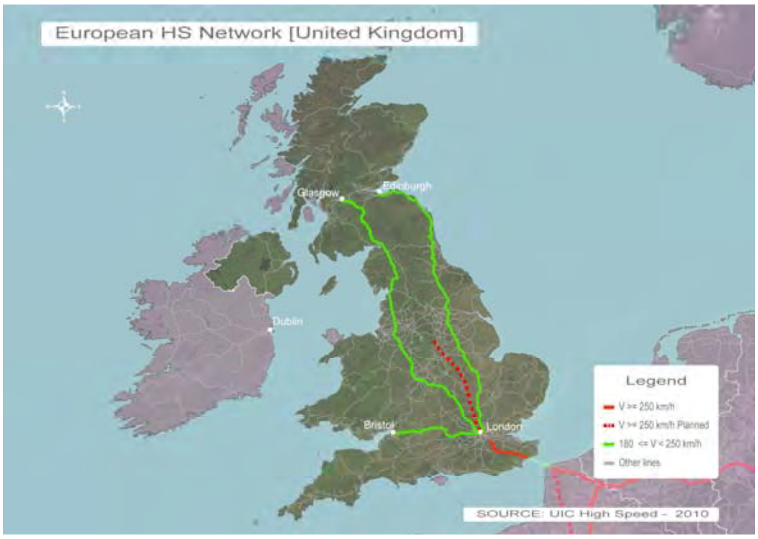

Figure 8: HSR Network United Kingdom [Source: UIC (2010)]

Italy

In the case of Italy different sections of the line between Rome and Florence were commissioned between 1981 and 1992. The overall length of the line is 148 kilometres. In addition, the lines Rome – Naples, Turin – Novara and Milan – Bologna were commissioned between 2006 and 2008. The overall current length in operation amounts to 923 kilometres. However, additional kilometres will be commissioned soon or are in the planning process. The population in Italy amounts to approximately 60 million people and the inhabitants per square kilometre are 198, which is similar to Germany for example. The country Italy was also part of the sample in the preliminary study and different data sources were pointed out on a good quality level. The Figure 9 highlights the current network of Italy.

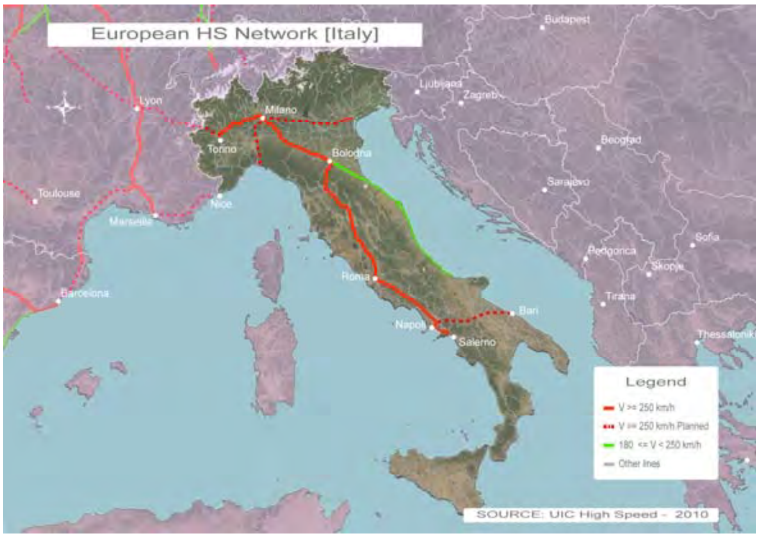

Figure 9: HSR Network Italy [Source: UIC (2011)]

Belgium

The first line in Belgium, which has a population of about 11 million inhabitants, was commissioned between Brussels and the French border in 1997. The length of the line amounts to 72 kilometres. Afterwards, two more lines were opened with a total length of 101 kilometres. The capital of Belgium, Brussels has an important function as a governmental centre in the European community. Brussels is therefore the destination of many business trips. All in all, the Belgium network consists of 209 kilometres of HS track and offers international traffic. In general, official data from national or local offices are available as already described for other countries. However, some several studies (case studies) are available. Figure 10 shows the current situation of HSR extensions in Belgium.

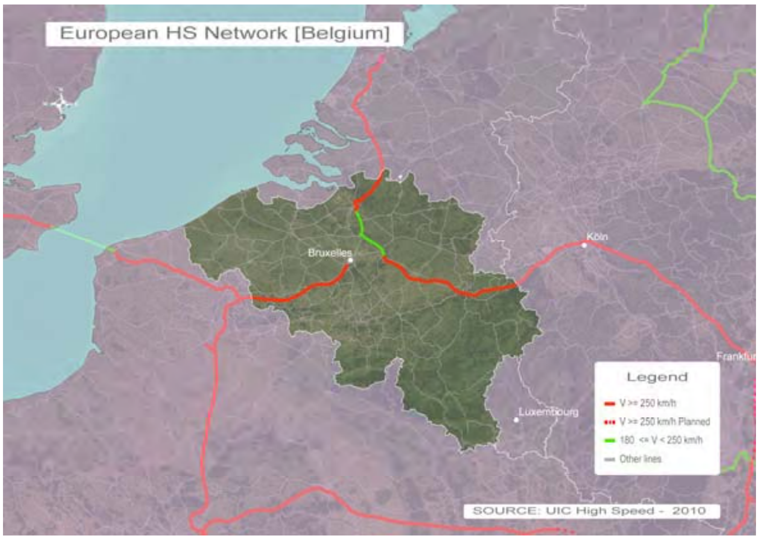

Figure 10: HSR Network Belgium [Source: UIC (2010)]

The Netherlands

The Netherlands consist of one HSL from Schiphol via Rotterdam to the Belgian Border. The line is 120 kilometres long and was commissioned in 2009. This line also offers international traffic as already described for Belgium. Considering its 17 million people, the Netherlands can be described as a densely populated country. Due to the lower operation time, short-term impacts can be discussed. Figure 11 presents the line in the Netherlands.

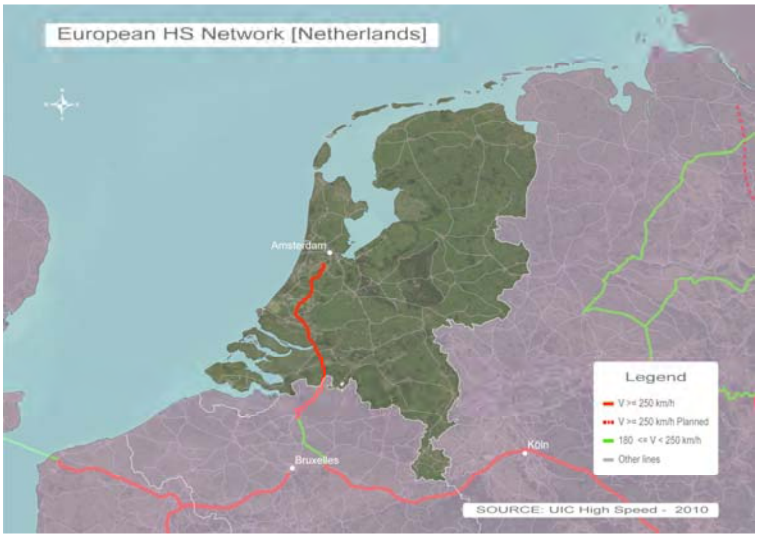

Figure 11: HSR Network The Netherlands [Source: UIC (2011)]

3.2.2 Sample

In general, the overall data situation for the countries is stated as sufficient for several years, especially for some impacts, as well as for data close to the current date. Constraints need to be made concerning some impacts, long time series up to today and the needed level of detail of the study; city or regional data. All in all, the data quality also differs between the designated countries. Moreover, studies and documentation are available in different depth and extent. As mentioned in the preliminary study such material is very important to find analysis methods and approaches as well as different detailed data sources and data descriptions. One additional point is also the experience with HSR. The network extension differs partly in high level, and the past operation time also differs in respect to the various countries. For the analysis past time periods regarding operations are very important because on the one hand the objective of the study mainly aims to quantify evidence out of the past by applying long time series and on the other hand the potential impacts differ in the time of development. Several of the considered impacts can be assumed as long-term impacts (e.g. population as well as economy).

Considering several criteria as mentioned, the countries France, Spain, Germany, Italy as well as Japan are designated for the analysis. In summary, the main facts of the country description and the final selection are summarised in the annex.

Grading

The grading of the selected countries is based on the description above and serves as an overall understanding of the approach and area of investigation. The country grading will also be applied for interpreting the results of the qualitative and quantitative analysis. In general, the characteristic classifications "infrastructure" and "socio-economic" are applied. This separation has been made for supporting the overall analysis. Accordingly, a concentration on the key figures has been made. As a summary, the chosen countries are graded in this study by applying the following key indicators:

- Commissioning year of the first HSL
- Network / line
- Network length
- Population density
- GDP per capita
- Network kilometres per square kilometre
- Inhabitants per network kilometre

Applying this information leads for example to the understanding as to why data is only partially available or effects have not yet taken place. A reason for this could be the late commissioning date and therefore the short time period up to the present. One more supporting information could be the city structure and the HSR network created for it. It can be assumed that the development of cities in France or Germany will be different because the structure and inhabitants per square kilometre are really different. This also affects the analysis; for example regarding the city and twin city definition. If variations are obtained in the development it can probably be explained when understanding differences in socio-economic or HSR structure among the considered countries.

According to the illustration of the main indicators the countries can be separated into three groups, that are summarised as follows (Figure 12):

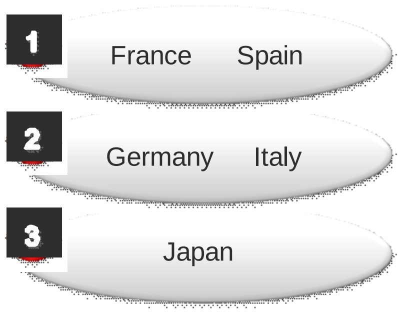

Figure 12: Classification of the selected countries

For this general separation of groups a rough hierarchical cluster analysis - the data base and the result is shown in annex - was consulted in a simple approach including transformed characteristics. Using this result France and Spain as well as Germany and Italy could be comparable. Japan is here clustered in an additional group and separated from the other countries on the basis of the presented data base.

3.3 Definition of the City Sample

Apart from the selection of the countries, cities need to be chosen for the final data sample as well. Here, several criteria will also be applied for the selection of the cities and mostly will depend on the previous country selection. Firstly, the HSR cities must be chosen followed by the twin city selection taking into account the HSR sample.

In addition to the cities, regions are also involved in the analysis. Here, some chosen cities will be especially considered and the analysis extended to the regions surrounding the city, depending on the data. In some cases, it is possible that regions can only be considered on a regional level due to the restricted data base that does not allow an analysis at a city level. The applied data base for selecting the HSR as well as the twin cities is illustrated in the Annex.

3.3.1 Methodology

HSR Cities

The general approach in finding the HSR cities is similar to the country selection already described. The final HSR sample needs to reflect several conditions considering for example operation period, city size or location of the station. All in all, the city selection should indicate the importance of the country with regard to current HSR operations and the HSR history but also needs to provide a mixed sample of currently existing conditions in the worldwide HSR network and fulfilling different kinds of features. Thus, the number of selected cities mainly differs amongst the countries due to their various existing framework conditions.

The choice of these HSR cities for the final sample is made in different steps and uses several approaches. On one hand, various data are collected with respect to technical as well as socio-economic descriptions at a qualitative together with a quantitative level and serve as decision making base. On the other hand, the particular selection is highly supported by the already mentioned questionnaire, requested from the international experts provided by UIC. Potential cities are recommended in connection with the analyses. Using this knowledge from the experts HSR cities are highlighted where changes / effects are to be expected or have been recognised in connection with the commissioning of HSR. The HSR city sample definition is based on data of the following key indicators:

- Selected countries
- Experience from preliminary study (city and region selection)
- HSR connection referring to UIC definition in an infrastructural understanding (speed greater or equal 200 kilometres per hour)
- Start of operations (elapsed time period of operation)
- Extension of the network
- Small and medium sized cities (no cities such as for example Madrid, Paris or Berlin as part of the city sample)
- Station category (primary or secondary, terminus or through station)
- Service level (e.g. number of HS trains per day)
- Domestic or international train connections
- Symmetry or dissymmetry (includes statements regarding link of cities to similar or different cities, e.g. connection of two small cities or connection of a small and a big city)

However, the selection of the samples and the data collection may be an alternative process through defining and adjusting with the experts. The selection does not only go directly in one direction because selected cities could be removed during the approach due to problems with the availability of information such as data for example.

<u>Twin Cities</u>

For the determination of twin cities the methodology as discussed in the preliminary study will be applied. This means, data collection regarding different information such as for example number of inhabitants, type of station, rate of employment or distance to relevant cities, importance of the cities themselves (e.g. capital cities of provinces or administrative areas, availability of universities, tourism, industry etc.) is carried out. In general, it is assumed that the more comparable twin cities are in comparison to the HSR city, the more the additional effects in the development of cities apart from the HSR connection can be excluded. Although, there are various additional possible effects that may differ among the cities. In line with the data base a selection approach applying qualitative as well as quantitative information will be used for determining the twin cities. The selection only considers national city pairs due to expected variations depending on the countries. The final twin city definition regarding the various countries was discussed with international experts again to obtain a qualitative internal statement concerning the considered countries as to whether the city selection is suitable in addition to the general comparison of key indicators.

The selection of the twin cities is a special and very important challenge in the study. The comparison should only point out changes that will arise because of HSR. So the choice of the respective city can influence achieving the purpose of the study. In some cases, it is difficult to define a city with the same framework conditions as a HSR city, except for the existence of the HSR. In fact, in several countries (e.g. Spain or France) it is extremely difficult to follow this path because the city structure as well as the level of expansion of HSR for instance does not provide a suitable choice of city pairs.

The following question appears sometimes here: "Why does the twin city not obtain a HSR connection despite the same framework conditions?". Therefore, in several cases the chosen twins will get HSR in future (planning or creation phase) but are here part of the twin city sample. In fact, this will be noted in the analysis if necessary because it was the only possibility to obtain suitable city pairs. However, the study mostly considers data in the past and an impact regarding current planning in some special cases can be excluded here. For instance, the gap and the available data between the opening of the HSR city and the potential opening of the twin city have to be taken into account. If there is a big gap, problems are not expected within the analysis. Actually, there are two possibilities, on the one hand the twin cities are not as comparable as required or on the other hand the city will get an HSR connection in the future which also can lead to an error in the analysis. In summary, in some cases the city does not appear to be as suitable as required but a better choice could not be made due to the city structure and the cities already connected to HSR. Therefore, the potential error must be accepted. Nevertheless, the choice of the countries seems to be suitable.

3.3.2 Sample

As shown and discussed the total city sample for the comparison consists of cities and twin cities. All in all, 49 cities in 5 countries are designated for the analysis. The reason for this number which does not relates to pairs is that Lyon (France) was selected without determining a suitable twin city owing to the framework conditions of Lyon in relation to France as a whole. The following cities described along with their twin cities were defined depending on the country for the analysis:

France

In the case of France six HSR cities and five twin cities were selected. As mentioned above, the number of cities and twin cities is unsymmetrical, the reason for this being Lyon. This city is selected for the analysis although it is difficult to determine a comparable city without HSR in France. In general, it is difficult to determine the twin cities here because of the general circumstances in France. The population density is not so high in the country as a whole and there are several major cities apart from Paris, most of which have already got a HSR connection. Figure 13 illustrates the city selection for France.

	City	Twin City
France	Lyon	no twin city
	Le Creusot	Moulins-sur-Allier
	Le Mans	Amiens
	Lille	Limoges
	Nantes	Clermont-Ferrand
	Metz	Caen

Figure 13: City sample France

Germany

In contrast to France, Germany has several cities of the same size and structure due to its historical development. All in all, six HSR cities and six twins are selected. The city sample (Figure 14) is summarised as follows:

	City	Twin City
Germany	Wolfsburg	Salzgitter
	Gottingen	Paderborn
	Limburg a. d. Lahn	Friedberg
	Kassel	Erfurt
	Fulda	Giessen
	Montabaur	Bad Ems

Figure 14: City sample Germany

Spain

Apart from the cities Ciudad Real and Puertollano as part of the preliminary study, cities such as Saragossa ,Valladolid, Cordoba and the relevant twin cities are defined here for the consideration of the HSR impact in Spain (Figure 15). All cities, except Puertollano and Villarreal are provincial capitals in Spain.

	City	Twin City
Spain	Ciudad Real	Caceres
	Puertollano	Villarreal
	Cordoba	Granade
	Valladolid	Murcia
	Segovia	Avila

Figure 15: City sample Spain

Japan

Taking into consideration the experience in HS operations as well as the network length, six HSR cities have also been identified for the analysis in Japan. A similar number was also chosen for France or Germany above. The sample of Japan considers the following cities as shown in Figure 16.

	City	Twin City
Japan	Kakegawa	Handa
	Saku	Shibata
	Mishima	Komatsu
	Karuizawa	Hakui
	Koriyama	Aomori
	Kitakami	Yokote

Figure 16: City sample Japan

Italy

In contrast to the larger samples of France, Germany or Japan the sample of Italy only includes four cities - two HSR cities and two non HSR cities - because of the late opening data as well as the network length and the potential number of cities for the sample. The cities are summarised in Figure 17.

	City	Twin City
Italy	Bologna	Bari
	Florence	Venice

Figure 17: City sample Italy

The information basis for each twin city selection is illustrated in the Annex. However, the choice was a single decision support besides special country information and discussion with international experts.

4 Impact of High Speed Rail - Qualitative Approach

In this part of the study the first section serves as a general overview and understanding of the potential benefits of HSR and their proof. An intensive consideration of the general understanding has already been made in the preliminary study. The second part deals with specific examples regarding the impact of HSR but in a qualitative manner. This implies that for different considered effects a general statement supported by examples will be given regarding the development and potential changes. However, in the case of surrounding areas a comparison of the HSR cities will be carried out by using maps including highlighted areas. The qualitative analysis mainly focuses on these analyses of the surrounding area. Moreover, the most and fastest changes can mainly be observed in the area around the station. The following detailed qualitative analysis of the surrounding areas also serves as a basis for understanding the quantitative results in the following parts of the study and to obtain an impression of the cities as well as the framework conditions in the countries and especially in the cities.

4.1 General

In available documentation several benefits of HSR are discussed on different levels of detail and from differing points of view. In most cases they are viewed from a qualitative level alone or only supported by quantitative statements. In principle, HSR as an improvement of infrastructure and accessibility leads to a change in city or regional development, as is often illustrated. However, the strength and the extent depend on several conditions, such as for example social and economic preconditions or support from the regional decision makers. The following part shows a general understanding of the impact of HSR as an infrastructure measurement. This also includes information concerning the opportunity to explain such effects or problems which one has to deal with during the analysis. Detailed information is shown in the preliminary study of the overall subject. This study provides several city examples in different countries regarding the benefit of HSR and an extensive review of available documentation.

In the following an impact chain illustrates a potential causal explanation of how the implementation of HSR - infrastructure in general - can lead to a change in social or economic issues. This impact chain can help to understand the effect of HSR in a qualitative way and can be proven with supporting quantitative information. Moreover, it assists by reducing the complex correlations between infrastructure (HSR) on the one hand and the impacts such as growth of GDP on the other hand. These chains take into account the variety of different influences which help in organising the causal description of the impacts. Within these deliberations the main factors for description of the impacts and reasons for the development can be indicated.

In general, the description of the chain starts with the new transport infrastructure and is mainly followed by the increase in accessibility. The change in accessibility is one of the important impacts and the starting point for the follow up impacts. Therefore, the subsequent changes in travelling time and costs as a first consequence leads to changes in the economy, as explained, as well as to changes in population or commuting. For example, households also make decisions on the basis of these costs and time considerations when thinking about a location for their home. Similar statements can be made for students, commuters or tourists. Moreover, the effects correlate with each other. This means, a more attractive area along with a strong economy attracts new inhabitants or commuters etc..

Bertenrath/Thöne/Walther (2006) present basic impact chains without focusing on a special transport mode – road, railway and ship, as a result of illustrated example chains (e.g. closing of gaps on motorways, new suburban train lines, creation and upgrading of freight railway lines) [Bertenrath/Thöne/Walther (2006)]. Figure 18 presents an example of a general impact chain with the focus on the labour market.

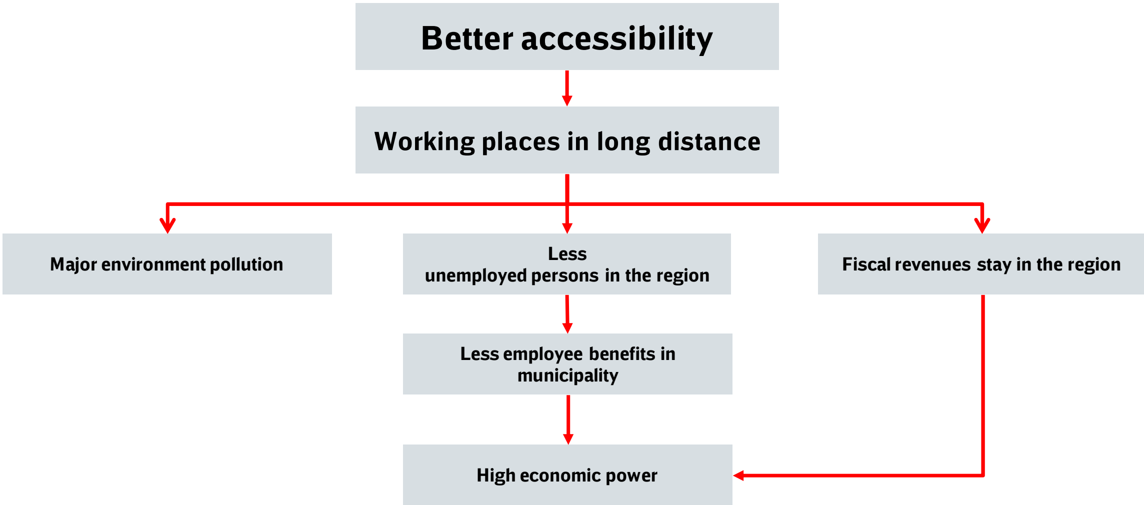

Figure 18: Impact chain with focus on the labour market
[Source: Own illustration with reference to Bertenrath/Thöne/Walther (2006)]

This approach can be highlighted for many considered effects. All this could be brought about by HSR as a consequence of improving the accessibility of the city or region under consideration. In the preliminary study it is also initially demonstrated that there are several effects such as changes in population, industrial growth, changes in tourism as well as an increase in commuting which have happened in the past on the one hand but there also exist differences as well as challenges on the other hand with respect to the implementation of HSR and their positive impact.

Nevertheless, it is not easy to carry out a quantitative proof of the qualitative assumed statements. The following statements were made in the preliminary study and need to be taken into account during analyses. The following statements can generally be highlighted here in a rough way. The review of documentation in the Preliminary Study (2010) presents the mentioned effects and certain framework conditions in more detail.

- The primary effect of the wider impact of HSR is the increase of accessibility.
- There are several but constrained impacts of HSR in the documentation.
- The investment in transport could be a cause as well as a consequence.
- Impacts of HSR can be created by "Self fulfilling prophesies".
- The impacts are rarely measurable in spite of intensive research efforts.
- The extent and the distribution of the impacts depend on different circumstances in the considered cases.
- The HSR can serve as an accelerator.
- The verification approach is described in studies in different ways.
- The impacting factors of HSR - can be separated into different groups.

In summary, qualitative statements regarding the impact of HSR have been made in most cases and the general theory regarding the correlations between the implementation of HSR and the subsequent changes is clear. However, it is really difficult to prove this correlation in a quantitative way and several framework conditions or restrictions need to be taken into account. The general aim of this study has been to show quantitative evidence for all of the designated effects of HSR. However, this is not possible all the time due to the unavailability of the required data level. Therefore, some of the effects will be considered in a qualitative way in the following parts: change in image, change in land use as well as change in surrounding area of the station.

4.2 Image

The connection to the HSR is able to have an impact on a city's image. On the one hand this image might change through the development of new economic structures stimulated by the connection to HSR. The city of Puertollano in Spain could be mentioned as one example, which had been dominated for centuries by coal mines and the resulting industry such as coal-fired power plants or chemical industry. Today, Puertollano's economy is characterised by green energy, high-tech power plants and the production of solar panels. Another example is the city of Fulda in Germany which was transformed from a city dependent on its textile industry to an important location for congresses – due to its situation in the centre of Germany and its excellent accessibility by train from all parts of the country. The same development could be observed in France (e.g. Le Mans) or Japan (e.g. Kakegawa), where industrial cities successfully managed the structural change towards the tertiary sector by gaining new opportunities through their connection to the high-speed system.

On the other hand, a city's image is changed through values such as modernity or innovation which are conveyed by high-speed trains and promotion through them. Cities like Nantes, Le Mans, Le Creusot or Vendôme in France, Valladolid, Segovia or Cordoba in Spain as well as Montabaur, Kassel or Fulda in Germany are intensively making use of their connection to the HSR of their country to present themselves as modern, innovative and open-minded places for tourists or enterprises.

[Sources: SNCF and Association, Calzada et al. (1998), Manonne (1995), Lacostes (1997), Chevalier (1997), Gutiérrez Puebla (2004), Menéndez Martinez et al. (2002), www.fulda.de, www.montabaur.de]

4.3 Land Use

An influence on the land use in the surrounding area of a station brought about by a city's connection to a HSR could be observed in several cities considered. However, this is not a general result of HSR but rather depends on several different factors. In this study, two conditions are identified.

Land use changed on the one hand, if a high-speed station was completely newly built on a free area. Here, a formerly agriculturally used area is now generally used for industry, offices, services or retail. Examples are Le Creusot (France), Montabaur, Limburg (both in Germany) or Segovia (Spain). In the case of the city of Saku (Japan), even a completely new quarter with apartments, shopping and offices developed around the newly built high-speed station in a former agricultural area.

The study showed on the other hand, that land use changed through the procuring or converting of existing areas in a city after the connection of the station to the high-speed system. In Cordoba (Spain) for example, the construction of a railway tunnel provided space for a new quarter in the city centre. In Metz, Le Mans, Nantes (all in France), Puertollano, Ciudad Real (both in Spain), Koriyama or Kitakami (both in Japan), unused freight yards, idle railway equipment or unused urban areas were converted to a new use. In doing so, entertainment played an important role, together with offices and shopping areas.

[Sources: SNCF and Association, Bazin/Beckerich/Delaplace (2006), Klein/Million (2005), Rabin (2003), Menéndez Martinez/Coronado Tordesillas/Rivas Alvarez (2002), Facchinetti-Mannone, Menéndez Martinezet al. (2006)]

4.4 Surrounding Area of the Stations

In the following, the surrounding area of stations is analysed. Due to missing quantitative data regarding the changes in the area of the stations a qualitative analysis is recommended and applied. The methodology includes an investigation of approximately the last ten years, which mainly will depend on the available documentation / sources. It is therefore generally not possible to determine exactly the development for stations which were opened at the very beginning. Nonetheless, it can be assumed that it does not matter in many cases for many stations due to the long life cycle of buildings. The oldest operating period was less than 30 years, except for Mishima in Japan. The qualitative assessment concentrates on the announcement of the projects. This implies, small and not announced changes - e.g. some changes in building / offices - are not evaluated. The sources are mainly the internet through the use of articles, homepages of cities and maps of the area. All stations of the cities will be analysed in a defined area of approximately two kilometres (diameter).

As mentioned, the analysis concentrates on the general development. For instance, small changes in offices cannot be ascertained. This leads to the focus on retail areas, new neighbourhoods etc.. Analysing the kind of development does not include the strength of the development, for example the area of the industrial estate or the number of offices. Therefore, the size of the city does not matter for this analysis. The analysis uses the following criteria and the respective illustration:

Figure 19: Surrounding area of the station - Criteria and illustration (key)

The analysis also includes some questions that should be kept in mind in finalising the results. Firstly, the definition of the twin cities was difficult in some cases especially for countries with less comparable cities and a small number of inhabitants per square kilometre. Examples are Murcia or Granada in Spain. Nevertheless, special developments were not recognised. One further point is the definition of HSR cities regarding the infrastructure approach which could lead to some difference in analysis. As said, the research was mainly based on the internet including articles, maps and several homepages. Actuality of the provided information could be a problem here. For example satellite pictures are not always current, so that some potential further developments are not highlighted or need to be added by using further documentation.

4.4.1 Germany

Montabaur[1]

The high-speed station of Montabaur has been built outside the city centre, at a short distance from the highway A3 Cologne – Frankfurt. The surrounding area of the station was developed both before and after commencement of operations, to be used for different purposes, e.g. business (service centre) and retail. Since the opening of the station, about 50 enterprises with 1,000 jobs took up residence in the so called "ICE Park"-quarter, a shopping mall is presently under construction. The station can be reached by car and additionally by bus. The surrounding area of the station provides 900 free parking places (Park&Ride). In addition, there are 130 parking spaces provided in an underground park. A bus station next to the station permits access to the region with 230 bus operations per day.

1 Source: www.montabaur.de, www.maps.google.de, de.wikipedia.org/wiki/Bahnhof_Montabaur, Effective : 31/03/2011.

Figure 20: Germany - Surrounding area of the station Montabaur

Twin city - Bad Ems[2]

The railway station of Bad Ems is embedded in the historic spa town of Bad Ems, between forests and the Lahn river. The surrounding area is characterised by one-family-houses and small-scale industry. No structural changes could be identified over recent decades.

Figure 21: Germany - Surrounding area of the station Bad Ems

2 Source: www.bad-ems.info, www.maps.google.de, de.wikipedia.org/wiki/Bad_Ems#Schiene, Effective : 31/03/2011.

Limburg[3]

The high speed station of Limburg (Limburg South) has been built outside the city centre, at a short distance to the highway Cologne – Frankfurt / M.. The City of Limburg plans to create here a new quarter for apartments and offices on 200,000 square metres (Limburg Railport). For this reason, the area around the station has been completely newly developed and is offered to investors, but since 2002 only four buildings for offices have been built. The station can be reached by car and bus, 900 free parking places are offered to commuters.

Figure 22: Germany - Surrounding area of the station Limburg

Twin city - Friedberg[4]

The railway station of Friedberg is situated in direct proximity to the city centre. It is surrounded by one-family-houses, retail and small-scale industry. The industrial quarter near the station has historically grown in this area because of the formerly needed freight-access to the railways. Over the recent decades, no structural changes could be identified.

3 Source: www.limburg.de, www.ice-limburg.de, www.maps.google.de, de.wikipedia.org/wiki/Bahnhof_Limburg_S%C3%BCd, Effective : 31/03/2011.

4 Source: www.friedberg-hessen.de, www.maps.google.de, de.wikipedia.org/wiki/Bahnhof_Friedberg_(Hessen) , Effective : 31/03/2011.

Figure 23: Germany - Surrounding area of the station Friedberg

Fulda[5]

The railway station is situated next to the historic city centre of Fulda. The old station, built in the 19th century is also used for the high speed line that serves Fulda since 1991. With the opening of the high speed line some reconstructions have been made: the main street which leads to the station is now a pedestrian zone with retailers. A central bus station in front of the railway station provides access to the public transport system of the city and the region. About 1000 parking places next to the station are available for commuters.

As the station is situated in an existing environment, the structure of the surrounding area did not change very intensively. However, a Congress and Culture Centre has been built directly next to the station on a former railway property. This centre and several other hotels and congress centres in Fulda define the city as "City of congresses".

5 Source: www.fulda.de, www.maps.google.de, de.wikipedia.org/wiki/Bahnhof_Fulda, Effective : 31/03/2011.

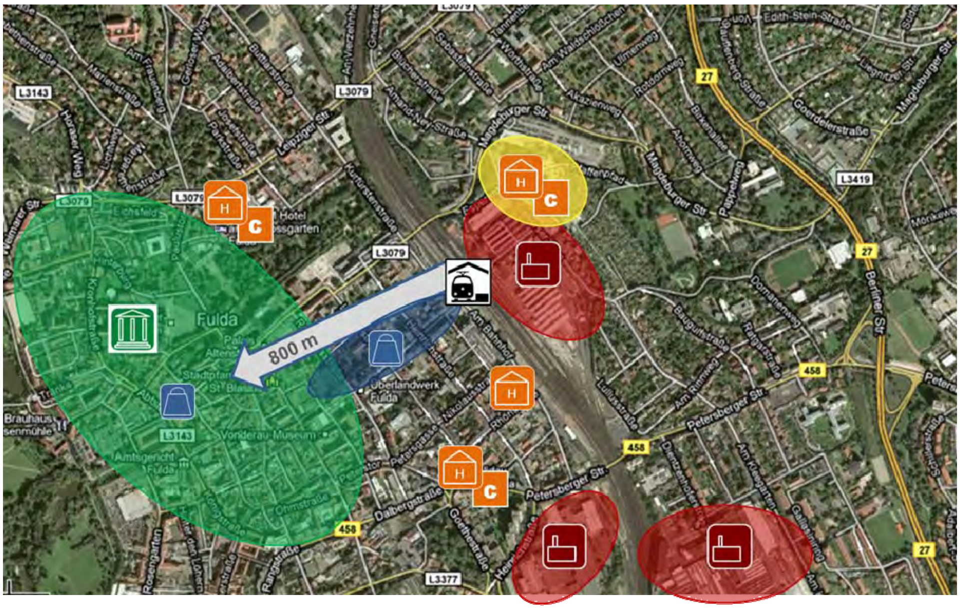

Figure 24: Germany - Surrounding area of the station Fulda

Twin city - Giessen[6]

The railway station is situated near the city centre. In the surrounding area can be found a lot of institutes of the Giessen University, especially hospitals of the medical faculty. Furthermore, historic houses and retailers dominate the surrounding area of the station. The central bus station of Giessen and parking places for about 100 cars are provided for commuters. No structural changes could be identified over recent decades.

Figure 25: Germany - Surrounding area of the station Giessen

6 Source: www.giessen.de, www.maps.google.de, de.wikipedia.org/wiki/Bahnhof_Gie%C3%9Fen, Effective : 31/03/2011.

Kassel[7]

In Kassel, the most important station is not Kassel Central Station but the newly built High speed station Kassel-Wilhelmshöhe. This station is located outside the city centre in the suburb of Bad Wilhelmshöhe. The structure of this part of Kassel changed after the opening of the high speed station from a silent suburban living quarter to a business quarter. Around the station can now be found several hotels and congress centres, a big shopping mall ("Atrium") and a high number of offices, amongst which the Kali+Salz AG (K+S) is the most important – this globally active enterprise moved its headquarters into the direct proximity of the high speed station.

In addition, in the surrounding area of Kassel-Wilhelmshöhe a high number of parking decks and the central bus station of Kassel, which permits access both to the city centre and the entire region, have been built.

Figure 26: Germany - Surrounding area of the station Kassel

Twin city - Erfurt[8]

Erfurt central station is a historic railway station dating from the 19th century directly near to the city centre of Erfurt. The surrounding area is characterised by the historic buildings of the old town with retail and touristic infrastructure on one side and housing areas with green zones on the other side of the station. Next to the station are two hotels with congress rooms. Erfurt central station has been modernised up to 2008. A parking deck, a tramway and a modern central bus station have been built. No further structural changes in the surrounding area could be identified.

7 Source: www.kassel.de, de.wikipedia.org/wiki/Bahnhof_Kassel-Wilhelmsh%C3%B6he, de.wikipedia.org/wiki/Bad_Wilhelmsh%C3%B6he, Effective : 31/03/2011.

8 Source: www.erfurt.de, www.maps.google.de, de.wikipedia.org/wiki/Erfurt_Hauptbahnhof, Effective : 31/03/2011.

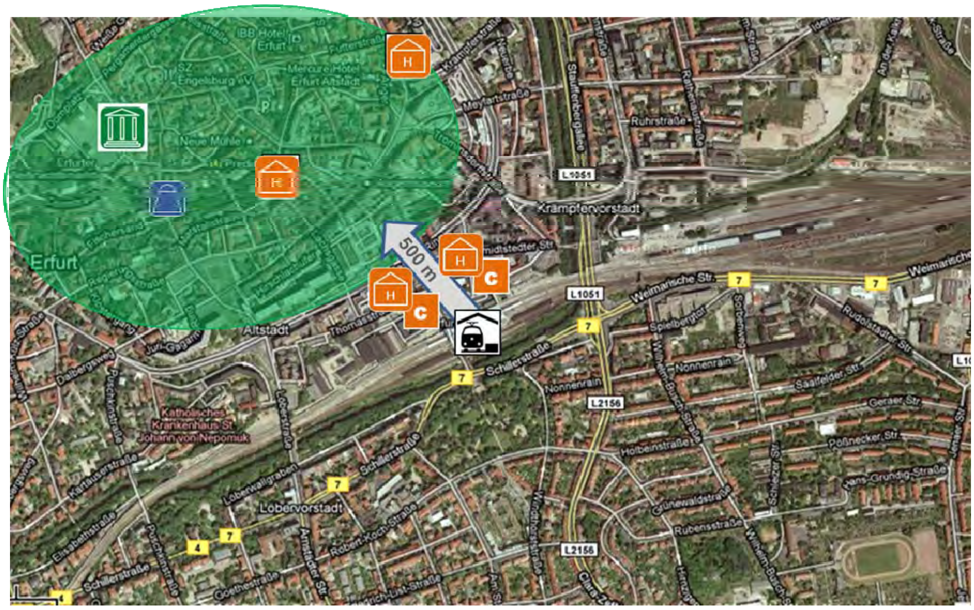

Figure 27: Germany - Surrounding area of the station Erfurt

Wolfsburg[9]

Wolfsburg central station is an old station dating from the 1950's that has been connected to the high speed line between Berlin and Hannover. Next to the station is situated the (historic) Volkswagen factory and the headquarters of Volkswagen. After the opening of the high speed line, a lot of projects have been developed at a short distance from the station which have extremely changed the appearance of the surrounding area. Among these are a shopping mall (designer outlet centre), an exhibition hall (phaeno), the Volkswagen Autostadt, the stadium of the Wolfsburg soccer team, a congress centre (Congress Park), a cinema and several hotels.

Next to the railway station, the central bus station of Wolfsburg and a high number of free parking places can be found.

9 Source: www.wolfsburg.de, www.maps.google.de, de.wikipedia.org/wiki/Wolfsburg_Hauptbahnhof, Effective : 31/03/2011.

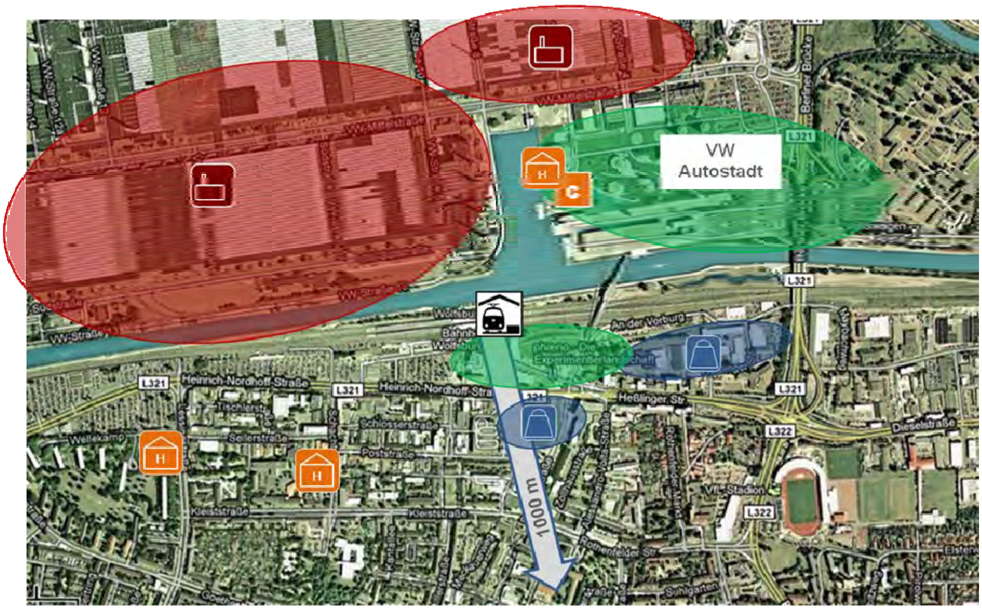

Figure 28: Germany - Surrounding area of the station Wolfsburg

Twin city - Salzgitter[10]

Salzgitter does not have a central station, but several smaller stations over the city's area. The most important station is Salzgitter-Ringelheim, 5 kilometres outside the city centre. The suburb of Ringelheim is of rural character with very little industry, one-family-houses and agricultural enterprises. A bus stop and about 100 parking places serve for commuters. No structural changes could be identified over recent decades.

Figure 29: Germany - Surrounding area of the station Salzgitter

10 Source: www.salzgitter.de, www.maps.google.de, de.wikipedia.org/wiki/Bahnhof_Salzgitter-Ringelheim, Effective : 31/03/2011.

Gottingen[11]

The station of Gottingen is a historic railway station dating from the 19th century, that has been connected to the high speed line in 1991. It is situated next to the city centre, so that there were no intensive changes made to the structure of the surrounding area. However, with the opening of the high speed line, the station has been completely modernised; a central bus station has been built and a parking deck for bicycles has been installed. Furthermore, the area of a former railway plant on the rear side of the railway station has been developed and modernised: an event hall (“Lokhalle”), a cinema and a hotel have been built and integrated into the city’s structure.

Figure 30: Germany - Surrounding area of the station Gottingen

Twin city - Paderborn[12]

Paderborn central station is situated near the historic city centre of Paderborn. Its surrounding area is dominated by retailers, industry and apartment houses. A central bus station in front of the railway station provides access to the public transport system of the city and the region. Approximately 200 parking places next to the station are available for commuters. Over recent decades, no structural changes could be identified.

11 Source: www.goettingen.de, www.maps.google.de, de.wikipedia.org/wiki/Bahnhof_G%C3%B6ttingen, Effective : 31/03/2011.

12 Source: www.paderborn.de, www.maps.google.de, de.wikipedia.org/wiki/Paderborn_Hauptbahnhof, Effective : 31/03/2011.

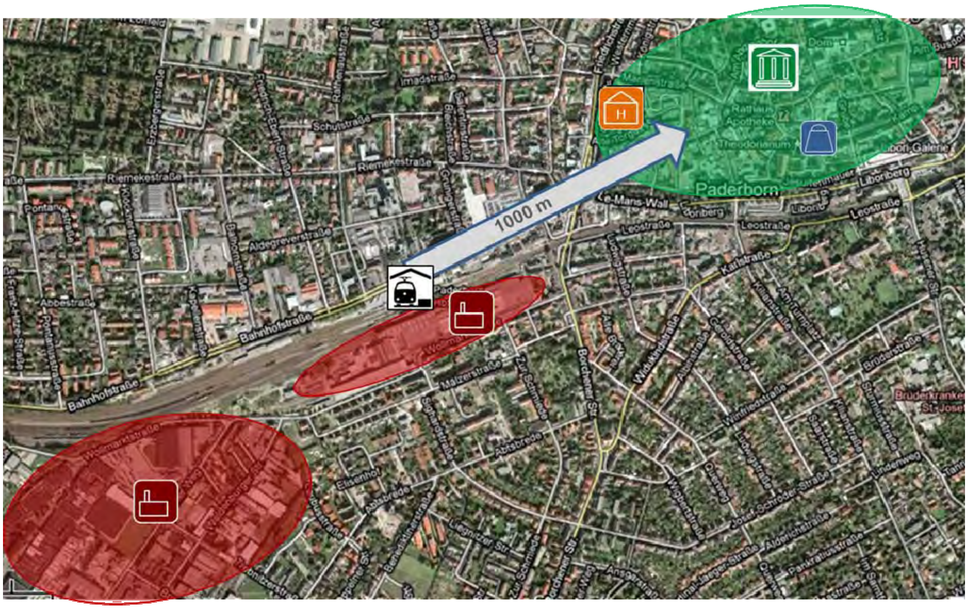

Figure 31: Germany - Surrounding area of the station Paderborn

4.4.2 France

Lyon[13]

Lyon possesses two railway stations; Lyon-Perrache and Lyon-Part-Dieu, both of which are important for the city's connection to the French high-speed system. Whilst Lyon-Perrache is a historic station from the 19th century and situated next to the historic city, Lyon-Part-Dieu is a newly built station for high-speed trains, opened in 1983. The two stations are approximately 3 kilometres apart.

Together with the construction of the station Lyon-Part-Dieu, a new business quarter was developed next to the railway. This quarter known as "La Part-Dieu" now contains an area of 1.6 million square metre with more than 800 enterprises and 40,000 employees. Several hotels with congress centres and a shopping mall with a surface of 120,000 m² complete this business quarter that forms something like a second city centre of Lyon.

Lyon-Part-Dieu is excellently embedded in the city's public transport system; it is served by a metro line, two tramway lines and several bus lines. Furthermore, a high number of parking places are provided for commuters next to the station.

13 Source: fr.wikipedia.org/wiki/Gare_de_Lyon-Part-Dieu, fr.wikipedia.org/wiki/Gare_de_Lyon-Perrache, fr.wikipedia.org/wiki/La_Part-Dieu, www.lyon.fr, www.centrecommercial-partdieu.com, www.maps.google.de, Effective : 31/03/2011.

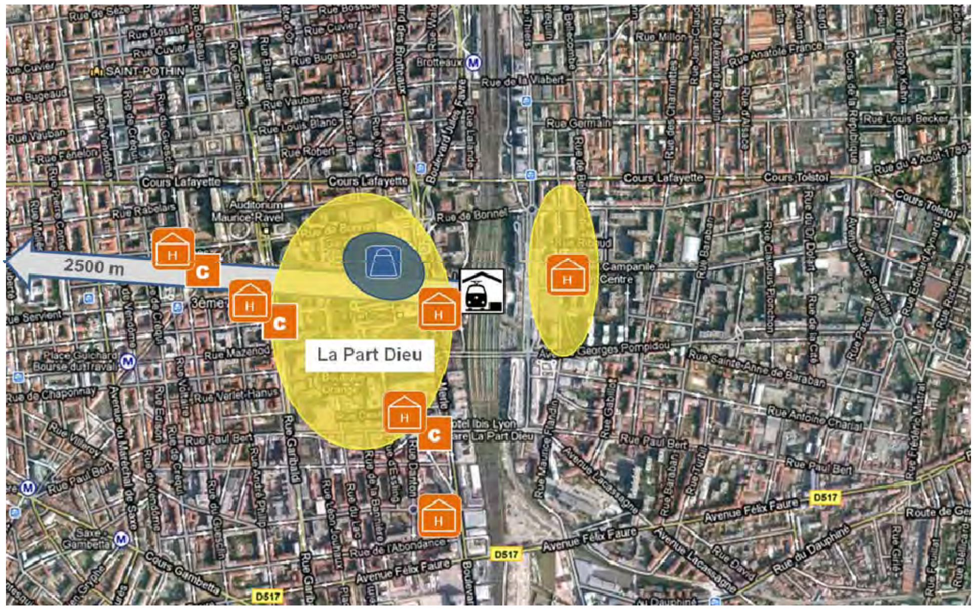

Figure 32: France - Surrounding area of the station Lyon-Part-Dieu

<u>Lille[14]</u>

Lille possesses two railway stations, which stand next door to one another: Lille-Europe station, a newly built station, which primarily serves high-speed trains and international services (Eurostar), and the historic Lille-Flandres station, which primarily serves for regional trains and ending high-speed trains. The stations are situated next to the historic city of Lille.

Both stations are linked by Euralille, a business and residential quarter of 70 ha with offices, apartments, hotels and a shopping mall. Euralille has been developed together with Lille Europe high-speed station. A similar project is the combined congress centre and event arena “Lille Grand Palais”, next to Lille-Flandres station. Moreover, Lille’s connection to the French high-speed system has attracted a high number of hotels with congress capacities, which have been established in the surrounding area of the stations.

The railway stations can be reached by public transport (tramway and bus service) and dispose of a high number of parking places in direct proximity.

14 Source: www.mairie-lille.fr, www.maps.google.de, fr.wikipedia.org/wiki/Gare_de_Lille-Europe, fr.wikipedia.org/wiki/Gare_de_Lille-Flandres, SNCF Effective : 31/03/2011. Les villes européennes de la grande vitesse (Ed.): Grande vitesse, mobilité, citoyenneté, p. 33.

Figure 33: France - Surrounding area of the station Lille

Twin city - Limoges[15]

The city's main railway station, Limoges-Bénédictins, is situated near the historic city. The surrounding area is characterised by residential quarters, retailers and offices especially for public administration. In the year 2000, a new central bus station and parking places were built next to the station to improve the connection between public transport and railway. Otherwise, no structural changes in the surrounding area could be identified over recent decades.

Figure 34: France - Surrounding area of the station Limoges

15 Source: www.ville-limoges.fr, www.maps.google.de, fr.wikipedia.org/wiki/Gare_de_Limoges-B%C3%A9n%C3%A9dictins, Effective : 31/03/2011.

Le Creusot[16]

Le Creusot TGV is a station that serves only for high-speed trains between Paris and Lyon. It is situated 3 kilometres away from Montchanin and 8 kilometres from the city of Le Creusot. Around the station, an area of 4 ha has been developed and reserved for hotels, congress centres, offices and other activities of the tertiary sector. Although the SNCF and regional politicians have made considerable efforts to attract enterprises, only a few investors could be observed. In contrast, the cities of Le Creusot and Montceau registered an increase in economic activities, which resulted in the conversion of former industrial areas.

The station is integrated into the regional public transport service and offers a very high number of parking places for commuters.

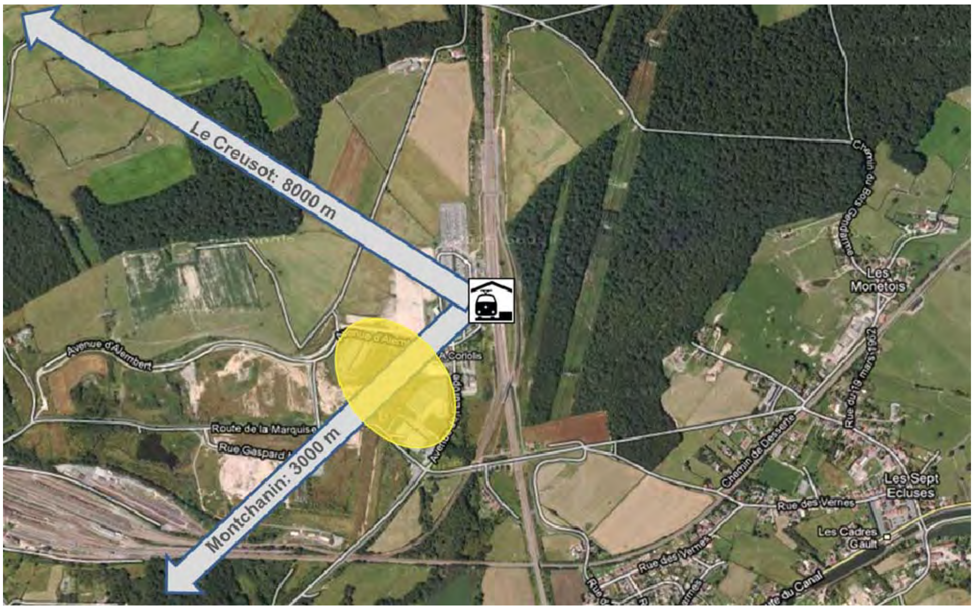

Figure 35: France - Surrounding area of the station Le Creusot

Twin city - Moulins-sur-Allier[17]

The railway station of Moulins-sur-Allier is situated near the historic city centre. Its surrounding area is dominated by retailers, apartment houses and public administration buildings. A bus station in front of the railway station provides access to the public transport system of the city and the region. Parking places next to the station are available for commuters. No structural changes could be identified over recent decades.

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16 Source: www.le-creusot.fr, www.maps.google.de, fr.wikipedia.org/wiki/Gare_du_Creusot_TGV, SNCF, Effective : 31/03/2011.
Les villes européennes de la grande vitesse (Ed.): Grande vitesse, mobilité, citoyenneté, p. 27.

17 Source: www.ville-moulins.fr, www.maps.google.de, fr.wikipedia.org/wiki/Gare_de_Moulins-sur-Allier, Effective : 31/03/2011.

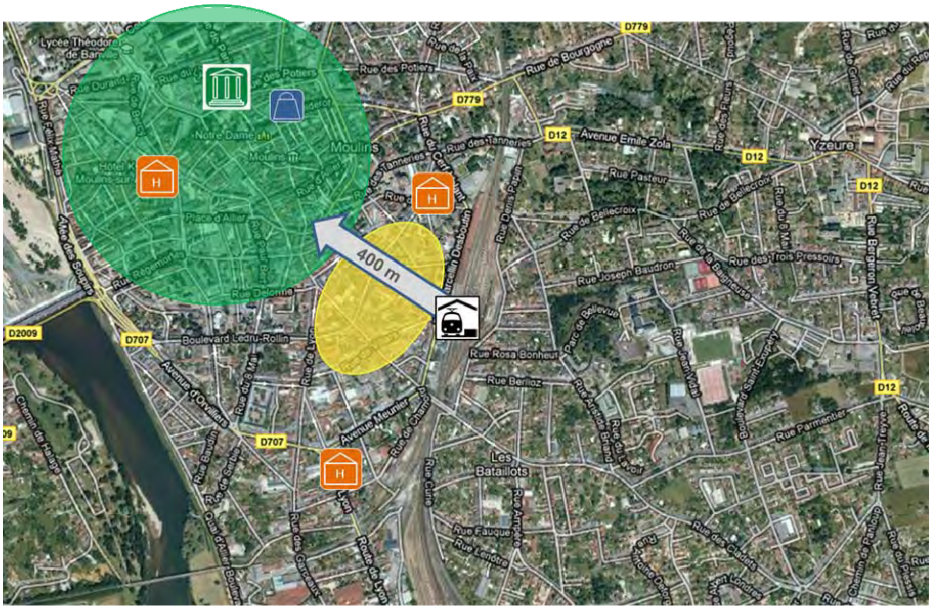


Figure 36: France - Surrounding area of the station Moulins-sur-Allier

Le Mans[18]

The railway station is situated near the historic city of Le Mans. The existing station, built in the 19th century has also been used since 1989 for the high-speed line to Paris that serves Le Mans. With the opening of the high-speed line, the surrounding area of the station changed enormously: in the northern part – in the direction towards the city centre – a high number of hotels with congress rooms have been built and parking places and a bus station for regional and local public bus service have been constructed. To the south of the station, a new quarter (Novaxis) with offices and apartments on 50,000 sq.m has developed. Other projects such as the “technopole université” or the shopping and business centre “Etoile Jacobins” in the city centre also followed as a result of the connection of Le Mans to the French high-speed system. The effects are clearly visible: more than 1,000 jobs have been created because of enterprises which moved their seat to Le Mans because of this new infrastructure.

18 Source: www.lemans.fr, www.maps.google.de, fr.wikipedia.org/wiki/Gare_du_Mans, SNCF, Effective : 31/03/2011.
Les villes européennes de la grande vitesse (Ed.): Grande vitesse, mobilité, citoyenneté, p. 11.

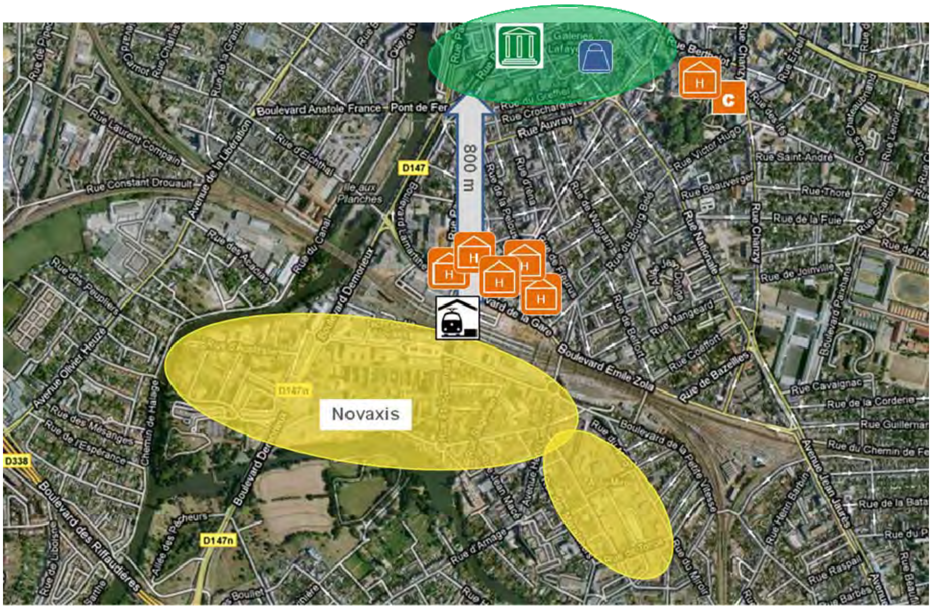


Figure 37: France - Surrounding area of the station Le Mans

Twin city - Amiens[19]

The Amiens railway station is situated near the city centre. The surrounding area is dominated by offices, retailers and apartments. Directly next to the station are a historic office and apartment tower (Tour Perret), a modern shopping centre and hotels. With a central bus station and a high number of parking places, the station is well integrated into the city's transport infrastructure. No structural changes could be identified over recent decades to the surrounding area.

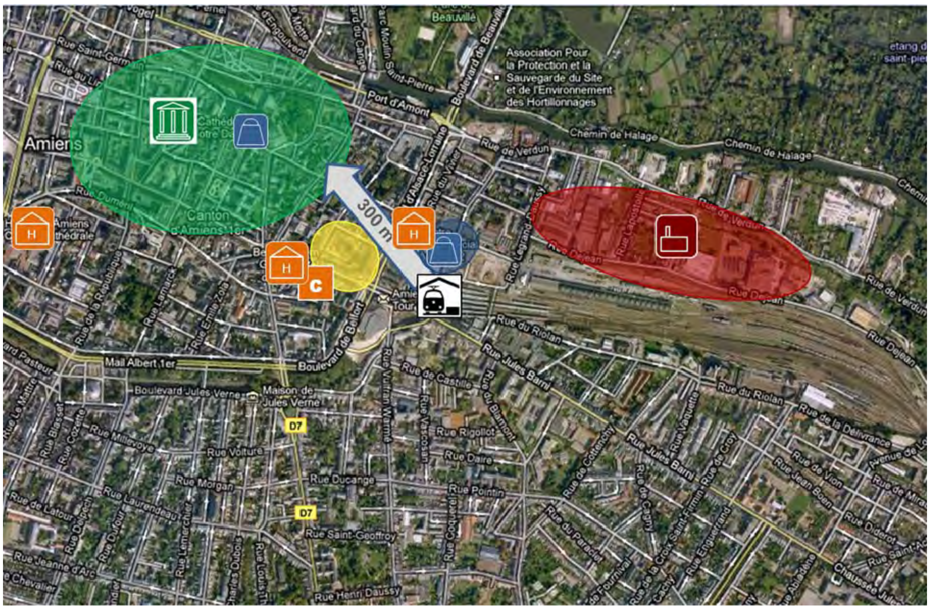


Figure 38: France - Surrounding area of the station Amiens

19 Source: www.amiens.fr, www.maps.google.de, fr.wikipedia.org/wiki/Gare_d'Amiens, Effective : 31/03/2011.

Metz[20]

The railway station of Metz is a historic railway station dating from the beginning of the 20th century, that has been connected to the French high-speed line LGV Est in 2007. It is situated next to the city centre, so that there were no intensive changes in the structure of the surrounding area. Nevertheless, since the opening of the high-speed line the organisation of traffic around the station has completely changed; new bus and taxi stations have been built and a parking deck over the rail tracks has been constructed. Furthermore, the area of a former railway plant on the south side of the railway station is planned to be developed into a new quarter with entertainment, offices and apartments (Quartier de l'Amphithéâtre). An event arena and an exhibition hall are the first buildings to have been opened in 2010.

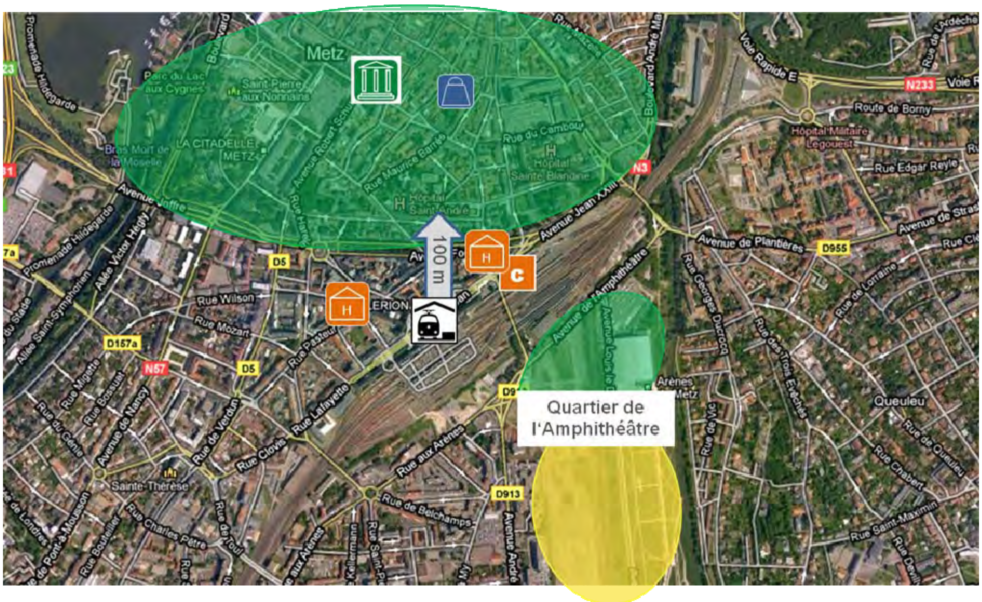


Figure 39: France - Surrounding area of the station Metz

Twin city - Caen[21]

The railway station is situated near the city centre and in direct proximity to the city harbour of Caen. The surrounding area is dominated by industry, the harbour and apartment houses. No structural changes to the surrounding area could be identified over recent decades.

20 Source: www.mairie-metz.fr, www.centrepompidou-metz.fr, www.maps.google.de, fr.wikipedia.org/wiki/Quartier_de_l'Amphith%C3%A9%C3%A2tre, fr.wikipedia.org/wiki/Gare_de_Metz-Ville, Effective : 31/03/2011.

21 Source: www.ville-caen.fr, www.maps.google.de, fr.wikipedia.org/wiki/Gare_de_caen, Effective : 31/03/2011.

Figure 40: France - Surrounding area of the station Caen

Nantes[22]

The railway station is situated next to the historic city of Nantes. The existing station which has developed since the 19th century, has also been used since 1989 for the high-speed line to Paris that serves Nantes. With the opening of the high-speed line, the surrounding area of the station changed enormously: In addition to the existing station building on the northern side, a second building on the southern side of the railway station has been constructed. This southern station building is the entrance to a new quarter ("Euronantes") with offices, apartments, retailers, hotels, a congress centre ("La Cité") and a soccer stadium covering a surface of 500,000 m². This quarter has been under construction since 2005 and will be finished in 2015. The effects are clearly visible: more than 10,000 jobs are expected to be provided because of enterprises moving their seat to Nantes as a result of this new infrastructure.

22 Source: www.nantes.fr, www.euronantes.com, www.maps.google.de, fr.wikipedia.org/wiki/Euronantes, fr.wikipedia.org/wiki/Gare_de_Nantes, Effective : 31/03/2011.

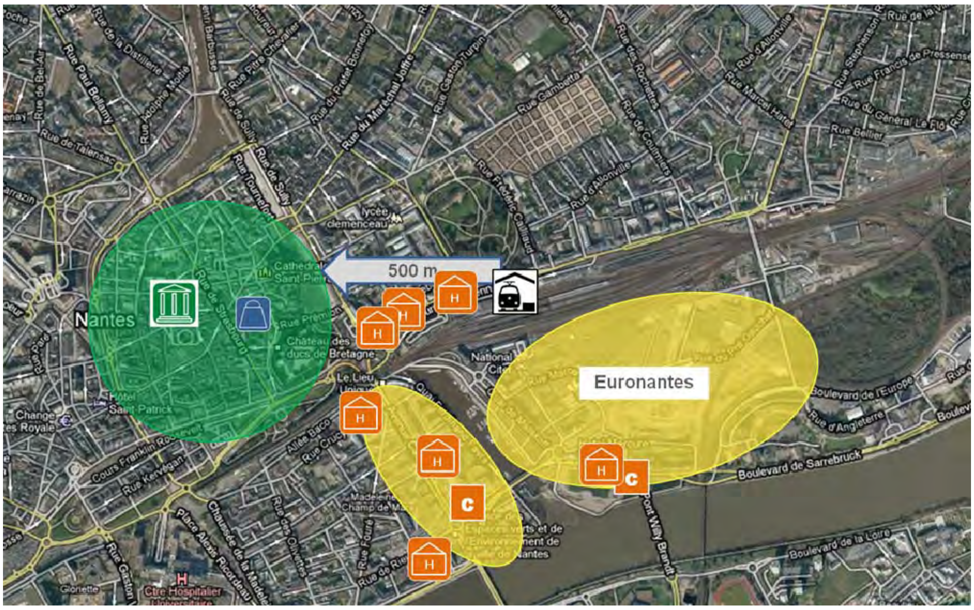


Figure 41: France - Surrounding area of the station Nantes

Twin City - Clermont-Ferrand[23]

The railway station of Clermont-Ferrand is situated near the historic city. Its surrounding area is dominated by retailers, apartment houses, public administration buildings and the campus of the university. A bus station in front of the railway station provides access to the public transport system of the city and the region. Parking places next to the station are available for commuters. No structural changes could be identified over recent decades.

Figure 42: France - Surrounding area of the station Clermont-Ferrand

23 Source: www.clermont-ferrand.fr, www.maps.google.de, fr.wikipedia.org/wiki/Gare_de_Clermont-Ferrand, Effective : 31/03/2011.

4.4.3 Spain

Ciudad Real[24]

The railway station is situated near the historic city of Ciudad Real. The existing station has also been used since 1992 for the high-speed line between Madrid and Seville that serves Ciudad Real. With the opening of the high-speed line, a new station building has been constructed and the surrounding area has changed its character: a modern university campus, a shopping mall, a high number of apartments and a business park has developed near the station since 1992.

The railway station can be reached by public transport and disposes of a high number of parking places for commuters to the rear side of the station.

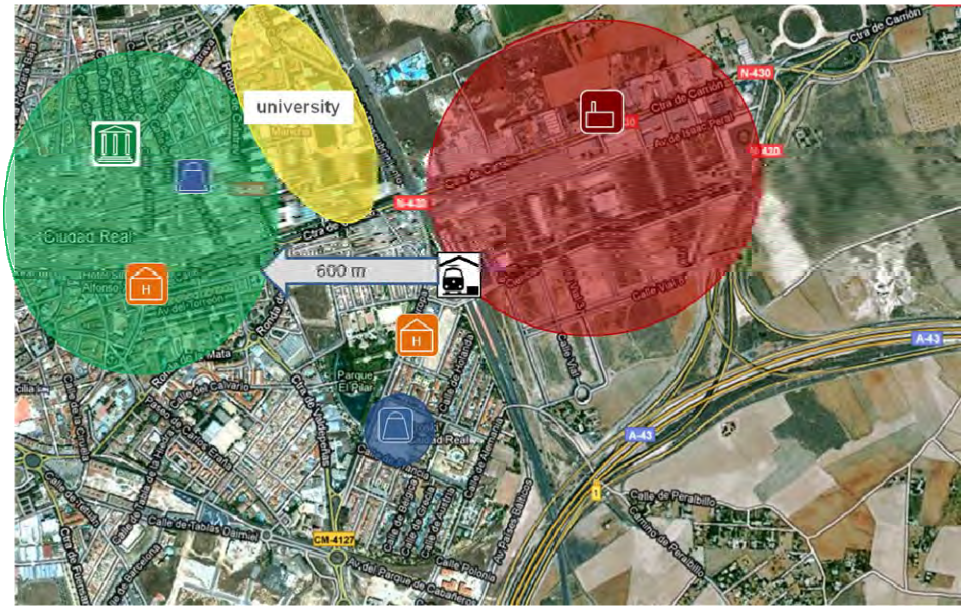


Figure 43: Spain - Surrounding area of the station Ciudad Real

Twin City - Caceres[25]

The city's railway station is situated on the periphery of Caceres. The surrounding area is dominated by residential quarters and retailers. A bus station in front of the railway station provides access to the public transport system of the city and the region. Parking places next to the station are available for commuters. No structural changes could be identified over recent decades.

24 Source: www.ciudadreal.es, www.maps.google.de, es.wikipedia.org/wiki/Estaci%C3%B3n_de_Ciudad_Real, Effective : 31/03/2011.

25 Source: www.ayto-caceres.es, www.maps.google.de, es.wikipedia.org/wiki/C%C3%A1ceres, Effective : 31/03/2011.

Figure 44: Spain - Surrounding area of the station Caceres

Puertollano[26]

The station of Puertollano is a railway station dating from the 19th century that has been connected to the high-speed line between Madrid and Seville in 1992. It is situated next to the historic city, intensive changes in the structure of the surrounding area could not be identified. However, with the opening of the high-speed line, new residential quarters near the station have been developed and the quarter around the station has been modernised and is presenting itself as a modern pedestrian zone and shopping area. The station is integrated into the regional public transport system and provides parking places for commuters.

26 Source: www.puertollano.es, www.maps.google.de, es.wikipedia.org/wiki/Puertollano, Effective : 31/03/2011.

Figure 45: Spain - Surrounding area of the station Puertollano

Twin City - Villarreal[27]

The railway station of Villarreal is situated next to the historic city. Its surrounding area is characterised by apartment houses, retailers and small-scale industry. As Villarreal's economy is dominated by the agricultural sector the location consists essentially of a broad agricultural area. A bus station in front of the railway station provides access to the public transport system of the city and the region. Parking places next to the station are available for commuters. No structural changes could be identified over recent decades.

27 Source: www.villarreal.es,de.wikipedia.org/wiki/Vila-real, www.maps.google.de, Effective : 31/03/2011.

Figure 46: Spain - Surrounding area of the station Villarreal

Cordoba[28]

Cordoba central station is situated next to the historic city and was opened in 1992 together with the commissioning of the high-speed line between Madrid and Seville. The construction of this high-speed line was accompanied by a completely new reorganisation of railway traffic in Cordoba. This included a new central station and the transferring of the railway tracks into a tunnel in the area of the city centre. This tunnel ended the separation of Cordoba's city centre into two parts and the space gained consisting of 42 ha led to the development of a new quarter with apartments, offices, hotels, parks and gastronomy near the central station and the city centre.

A bus station for local and regional buses and a parking deck at the rear side of the station serve for commuters.

28 Source: www.ayuncordoba.es, www.maps.google.de, es.wikipedia.org/wiki/C%C3%B3rdoba_(Espa%C3%B1a), es.wikipedia.org/wiki/Estaci%C3%B3n_de_C%C3%B3rdoba-Central, Effective : 31/03/2011.

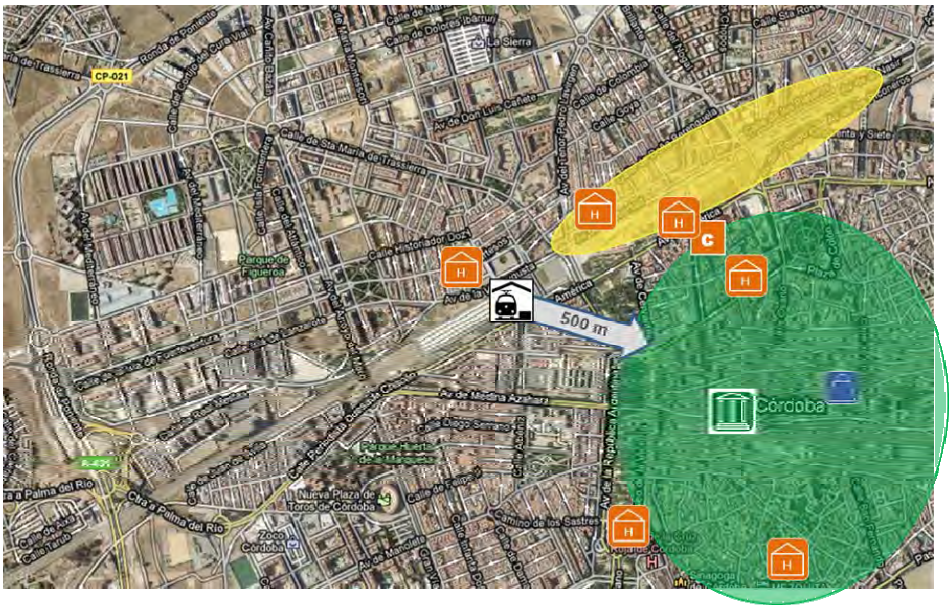


Figure 47: Spain - Surrounding area of the station Cordoba

Twin City - Granada[29]

The railway station of Granada is situated near the historic city. Its surrounding area is dominated by retailers, apartment houses, touristic infrastructure and the campus of the university. A bus station in front of the railway station provides access to the public transport system of the city and the region. Parking places next to the station are available for commuters. No structural changes could be identified over recent decades.

Figure 48: Spain - Surrounding area of the station Granada

29 Source: www.granada.org, www.maps.google.de, es.wikipedia.org/wiki/Granada, es.wikipedia.org/wiki/Estaci%C3%B3n_de_Granada

Valladolid[30]

Valladolid-Campo Grande is a historic railway station dating from the 19th century, which has been connected to the high-speed line to Madrid in 2007. It is situated next to the historic city centre on the one side and an industrial quarter on the other side of the station. Furthermore, the surrounding area is characterised by apartments and retailers. As this structure has grown historically no intensive changes were possible. However, with the opening of the high-speed line, the station has been completely modernised, a freight depot has been converted to a big car park for commuters and a modernised bus station in front of the railway station provides access to the public transport system of the city and the region.

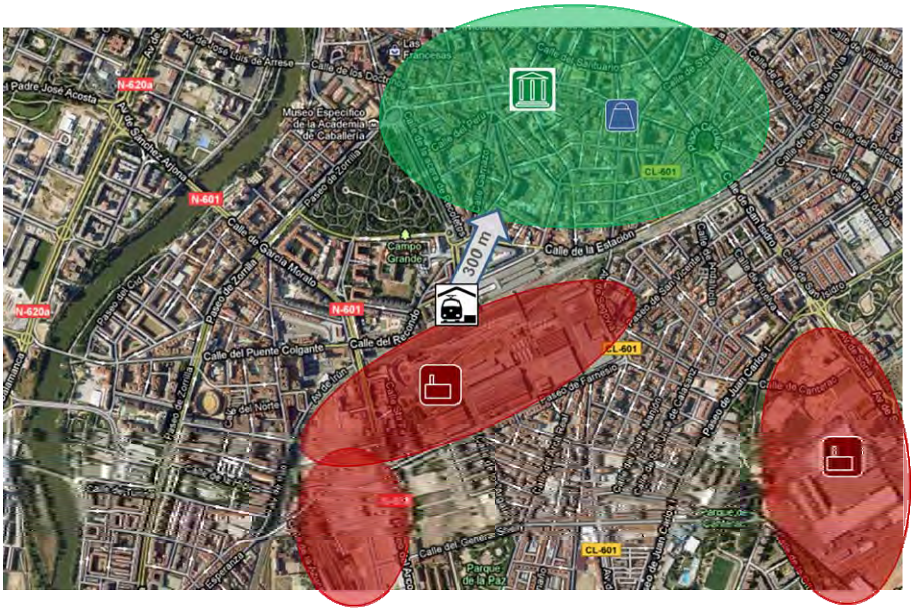


Figure 49: Spain - Surrounding area of the station Valladolid

Twin City - Murcia[31]

The railway station of Murcia del Carmen is situated near the historic city, in the "Quarter del Carmen". Its surrounding area is dominated by retailers, apartment houses, public administration buildings and industry. A bus station in front of the railway station provides access to the public transport system of the city and the region. Parking places next to the station are available for commuters. No structural changes could be identified over recent decades.

30 Source: www.ava.es, www.maps.google.de, es.wikipedia.org/wiki/Valladolid, es.wikipedia.org/wiki/Estaci%C3%B3n_de_Valladolid-Campo_Grande, Effective : 31/03/2011.

31 Source: www.murcia.es, www.maps.google.de, es.wikipedia.org/wiki/Murcia, es.wikipedia.org/wiki/Estaci%C3%B3n_de_Murcia_del_Carmen, Effective : 31/03/2011.

Figure 50: Spain - Surrounding area of the station Murcia

Segovia[32]

The high-speed station of Segovia (Segovia-Guiomar) has been built 7 kilometres outside the city centre, at a short distance to the highway AP61 and was opened in 2007. It is situated between an industrial quarter and the mountains of the Sierra de Guadarrama, where the 28.4 kilometres long Guadarrama Tunnel begins. The industrial quarter – which existed already before the opening of Segovia-Guiomar – saw a rapid development after the construction of the station.

The station can be reached by car (highway) and additionally by bus. The surrounding area of the station provides a high number of free parking places (Park&Ride) and a bus station next to the station permits access to the region and to the city centre of Segovia.

32 Source: www.segovia.es, www.maps.google.de, es.wikipedia.org/wiki/Segovia, es.wikipedia.org/wiki/Estaci%C3%B3n_de_Segovia-Guiomar, Effective : 31/03/2011.

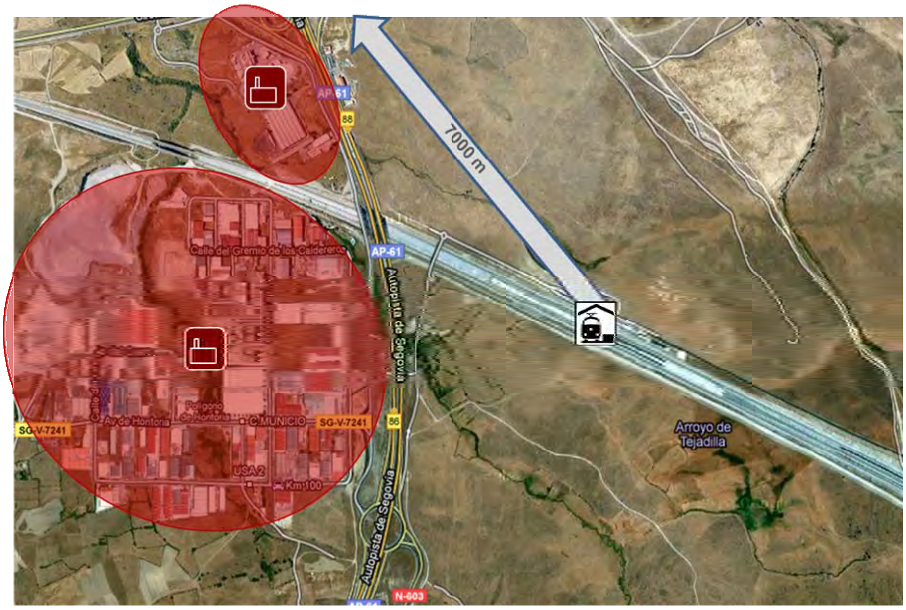


Figure 51: Spain - Surrounding area of the station Segovia

Twin City - Avila[33]

The railway station is situated next to the historic city of Avila. It had been an important hub in the Spanish railway system but lost its importance to Segovia with the commissioning of the high-speed line between Madrid and Valladolid in 2007. The surrounding area is characterised by residential quarters with retailers and an industrial quarter next to the railway tracks. The residential quarter on the western side (next to the industrial area) has been developed during the last decade and is still under construction. The station is integrated into the regional public bus service and provides parking places for commuters.

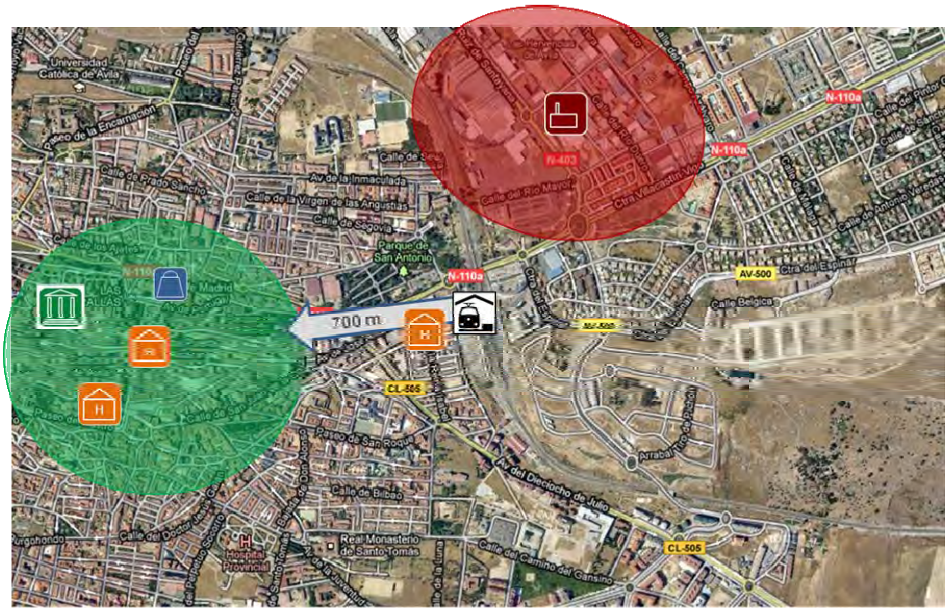


Figure 52: Spain - Surrounding area of the station Avila

33 Source: www.avila.es, www.maps.google.de, es.wikipedia.org/wiki/Estaci%C3%B3n_de_%3%81vila, es.wikipedia.org/wiki/%C3%81vila, Effective : 31/03/2011.

4.4.4 Japan

Kakegawa[34]

The railway station is situated next to the city centre of Kakegawa. It is part of the Shinkansen high-speed line between Tokyo and Osaka, which was opened in 1964. The high-speed station opened only in 1988 – before this date, the Shinkansen trains passed Kakegawa without stopping. The costs for constructing the station were paid by the city of Kakegawa and the region. Their expectations have been completely fulfilled: three business hotels and several city hotels have been opened around the station: as Kakegawa is situated exactly at the middle distance between Tokyo and Osaka, the city developed into a very attractive location for conferences. The city centre – underdeveloped because of a big shopping mall outside the city – has been revitalised. The Shinkansen railway station is integrated into public transport services and offers a high number of parking places for commuters.

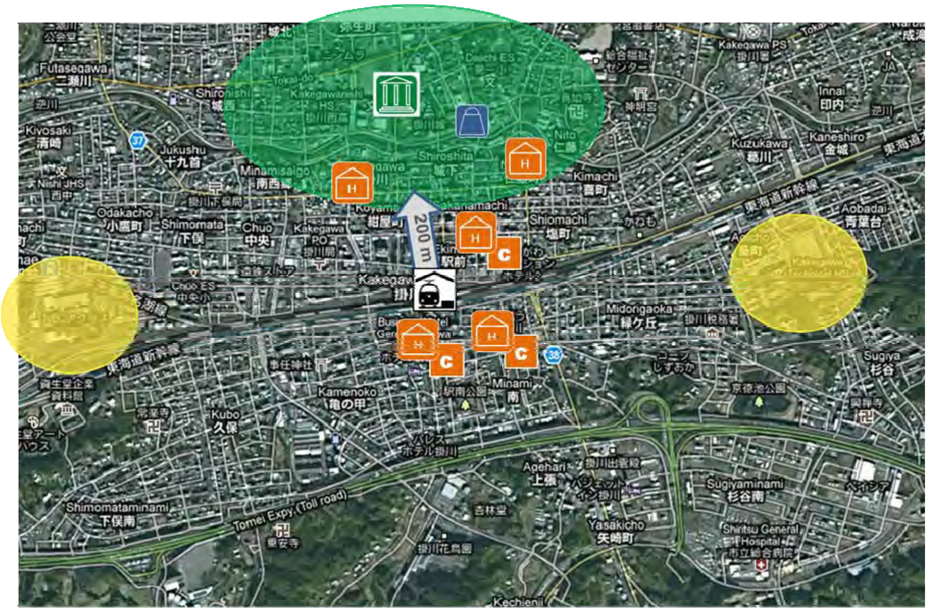


Figure 53: Japan - Surrounding area of the station Kakegawa

Twin City - Handa[35]

The railway station of Handa is situated near the city centre. Its surrounding area is dominated by retailers, apartment houses and – as Handa is traditionally a city of industry – industrial areas. The railway station is integrated into the public transport system of the city and the region. Parking places next to the station are available for commuters. No structural changes could be identified over recent decades.

34 Source: ja.wikipedia.org/wiki/%E6%8E%9B%E5%B7%9D%E9%A7%85, www.maps.google.de, Okada, , Effective : 30/04/2011. Hiroshi: Features and Economic and Social Effects of The Shinkansen. In: Japan Railway & Transport Review. October 1994.

35 Source: www.city.handa.lg.jp, www.maps.google.de, de.wikipedia.org/wiki/Handa Effective : 30/04/2011.

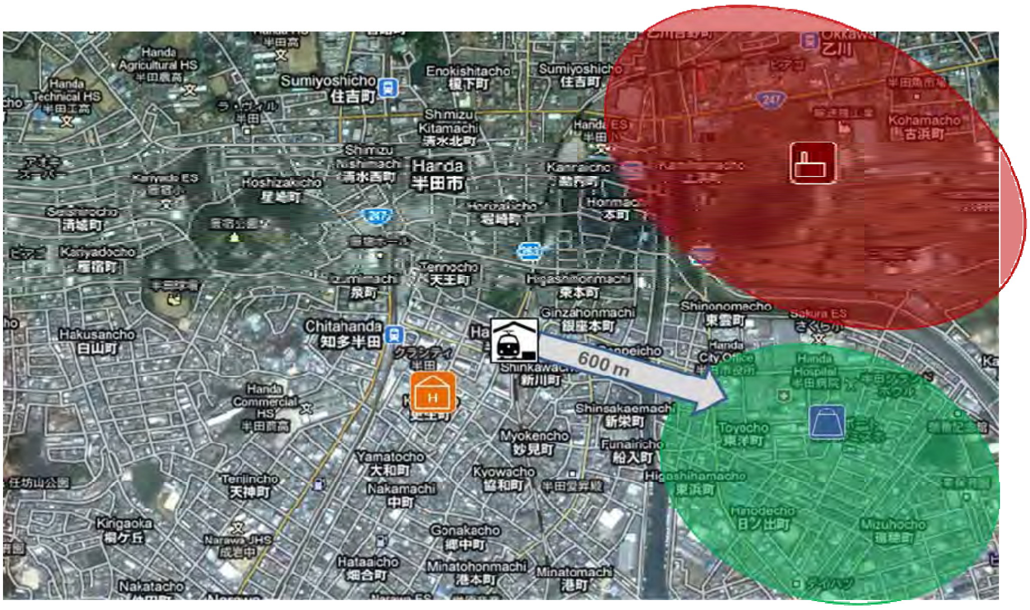


Figure 54: Japan - Surrounding area of the station Handa

<u>Saku[36]</u>

The Shinkansen station of Saku, Sakudaira, has been constructed on a free area outside the city centre. It is situated on the high-speed line between Tokyo and Nagano and was opened in 1997. Within a few years, a new quarter with retailers, offices and amusement establishments developed on the free area around the Sakudaira railway station which is now completely integrated into the city's structure. The station is served by public transport and provides a high number of parking places for commuters.

36 Source: www.city.saku.nagano.jp, en.wikipedia.org/wiki/Sakudaira_Station, www.maps.google.de, Effective : 30/04/2011. Hiraishi, Masashi: Japan Railways, Successful Financing Models. Presentation from March 26, 2009.

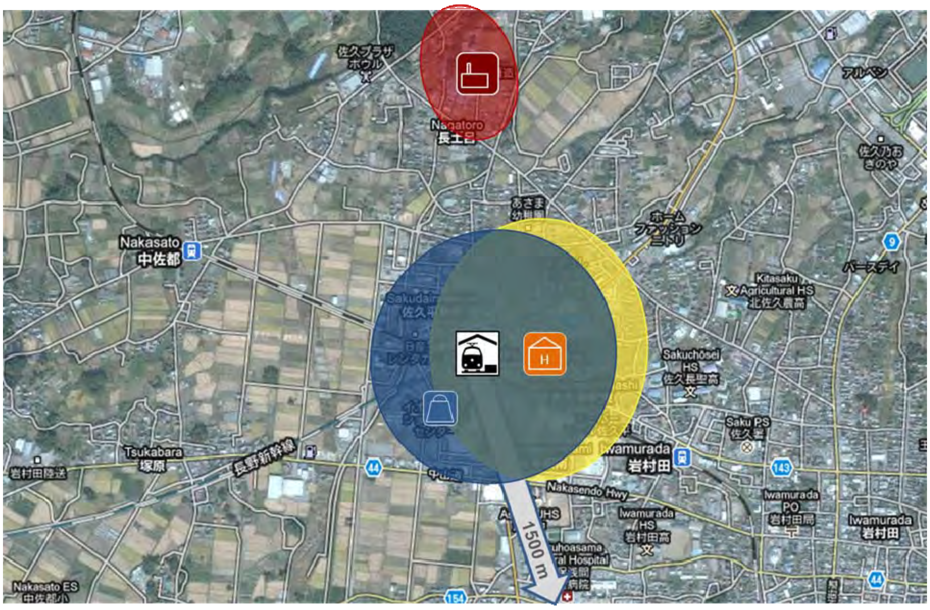
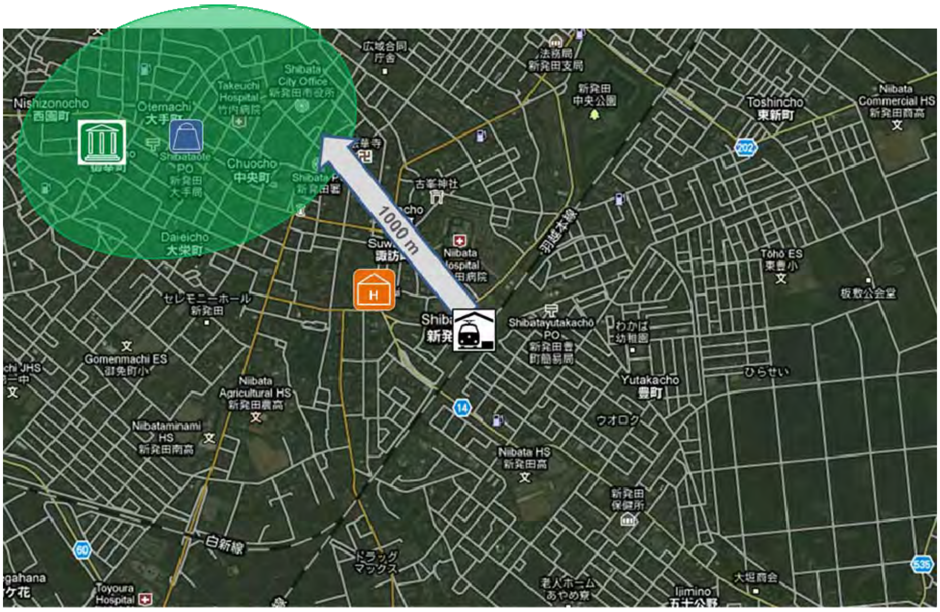


Figure 55: Japan - Surrounding area of the station Saku

Twin City - Shibata[37]

The railway station is situated near the historic city of Shibata. Its surrounding area is dominated by apartment houses and public administration buildings. After the opening of shopping malls at the city's periphery the city centre and the area around the station experienced structural problems, which have to be solved by local politics. A bus station in front of the railway station provides access to the public transport system of the city and the region. Parking places next to the station are available for commuters. No structural changes over recent decades could be identified.



37 Source: www.city.shibata.niigata.jp, www.maps.google.de, ja.wikipedia.org/wiki/%E6%96%B0%E7%99%BA%E7%94%B0%E9%A7%85, Effective : 30/04/2011.

Figure 56: Japan - Surrounding area of the station Shibata

Mishima[38]

The Shinkansen station of Mishima is part of the high-speed line between Tokyo and Osaka. It is situated next to the city centre and was opened in 1969. The surrounding area is characterised by offices, retailers, business hotels and apartments. The Shinkansen railway station is integrated into regional public transport services and offers a high number of parking places for commuters.

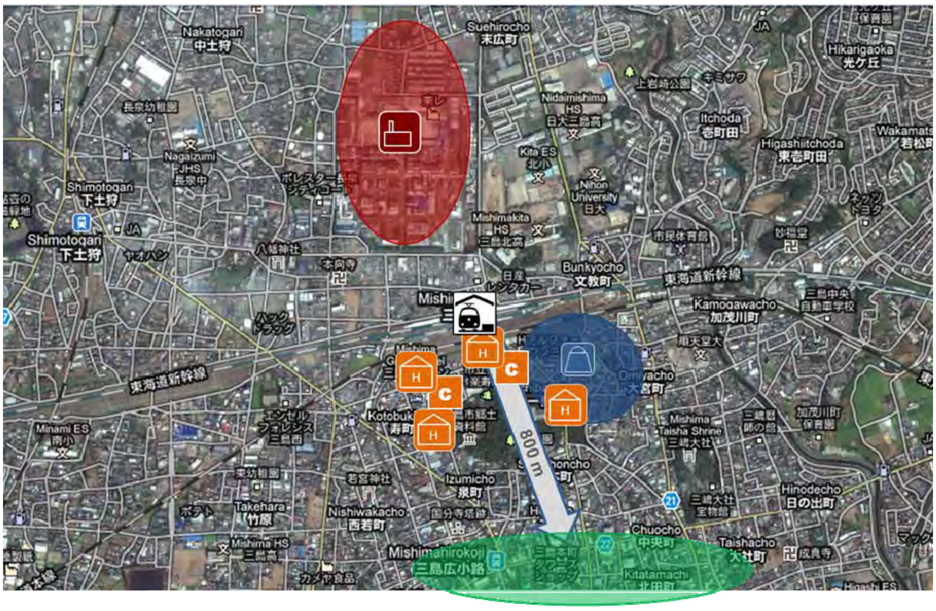


Figure 57: Japan - Surrounding area of the station Mishima

Twin City - Komatsu[39]

The railway station of Komatsu is situated near the city centre. Its surrounding area is dominated by offices, retailers and apartment houses. The railway station is integrated into the public transport system of the city and the region. Parking places next to the station are available for commuters. No structural changes over recent decades could be identified.

38 Source: www.city.mishima.shizuoka.jp, www.maps.google.de, en.wikipedia.org/wiki/Mishima_Station, Effective : 30/04/2011.
Sands, Brian: The development effects of high-speed rail stations and implications for California. Berkeley, April 1993
39 Source: www.city.komatsu.ishikawa.jp, www.maps.google.de, ja.wikipedia.org/wiki/%E5%B0%8F%E6%9D%BE%E9%A7%85, Effective : 30/04/2011.

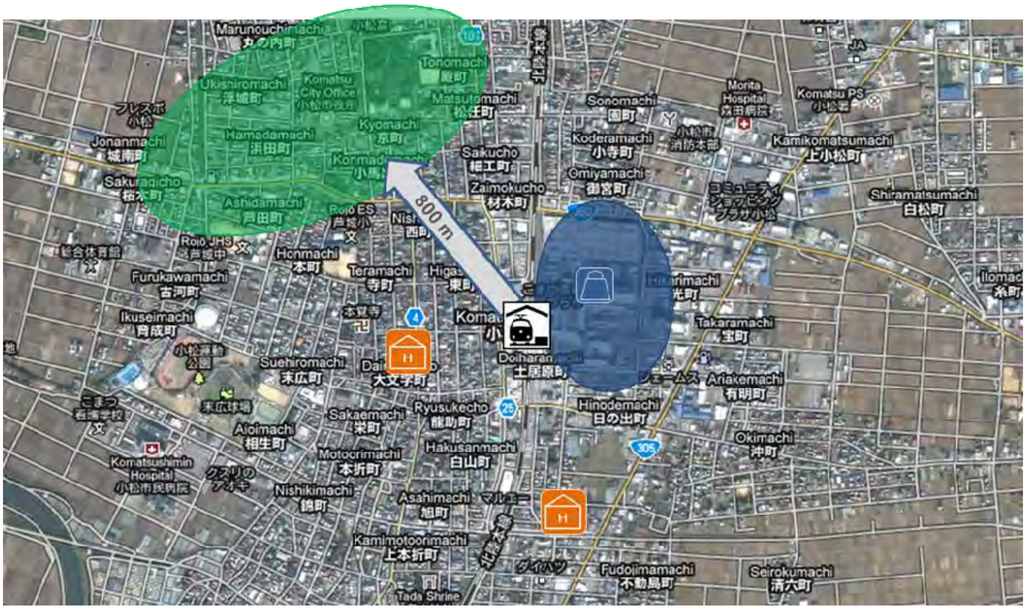
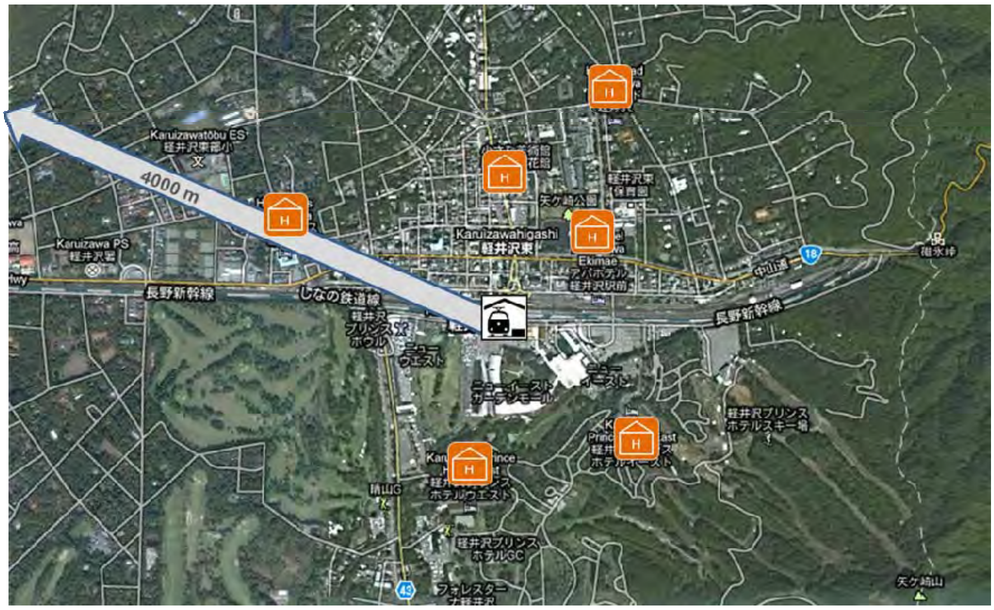


Figure 58: Japan - Surrounding area of the station Komatsu

Karuizawa[40]

The Shinkansen high-speed station of Karuizawa has been built about 4 kilometres outside the city centre. It is part of the Shinkansen line between Tokyo and Nagano and was opened in 1997. As Karuizawa is a very popular tourist city in the mountains near Tokyo, the surrounding area is strongly dominated by touristic infrastructure, especially hotels and retailers. Because of its situation between high mountains, the area around the station does not have space for further development. The station is integrated into the regional public transport services and offers parking places for visitors and commuters.



40 Source: www.town.karuizawa.nagano.jp/html/English/index.html, en.wikipedia.org/wiki/Karuizawa_Station, www.maps.google.de , Effective : 30/04/2011.

Figure 59: Japan - Surrounding area of the station Karuizawa

Twin City - Hakui[41]

The railway station is situated next to the historic city of Hakui, on the coast of the Sea of Japan. The surrounding area of the station is characterised by apartment houses, offices and touristic infrastructure on the one side and agriculture on the other side. The railway station is integrated into the public transport system of the city and the region. Parking places next to the station are available for commuters. No structural changes over recent decades could be identified.

Figure 60: Japan - Surrounding area of the station Hakui

Koriyama[42]

The railway station is situated outside the city centre of Kakegawa. It is part of the Shinkansen high-speed line between Tokyo and Aomori and is served by Shinkansen trains since 1982. The surrounding area is characterised by retailers, offices, apartment houses and business hotels. The Shinkansen railway station is integrated into the public transport services and offers a high number of parking places for commuters.

41 Source: www.city.hakui.ishikawa.jp, www.maps.google.de, ja.wikipedia.org/wiki/%E7%BE%BD%E5%92%8B%E9%A7%85 Effective : 30/04/2011.

42 Source: www.city.koriyama.fukushima.jp/international/index.html, www.maps.google.de, de.wikipedia.org/wiki/Bahnhof_K%C5%8 Driyama, Effective : 30/04/2011.

Smith, Roderick: The Japanese Shinkansen. Catalyst for the renaissance of rail. In: The Journal of Transport History 24/2. Pages 222 – 234.

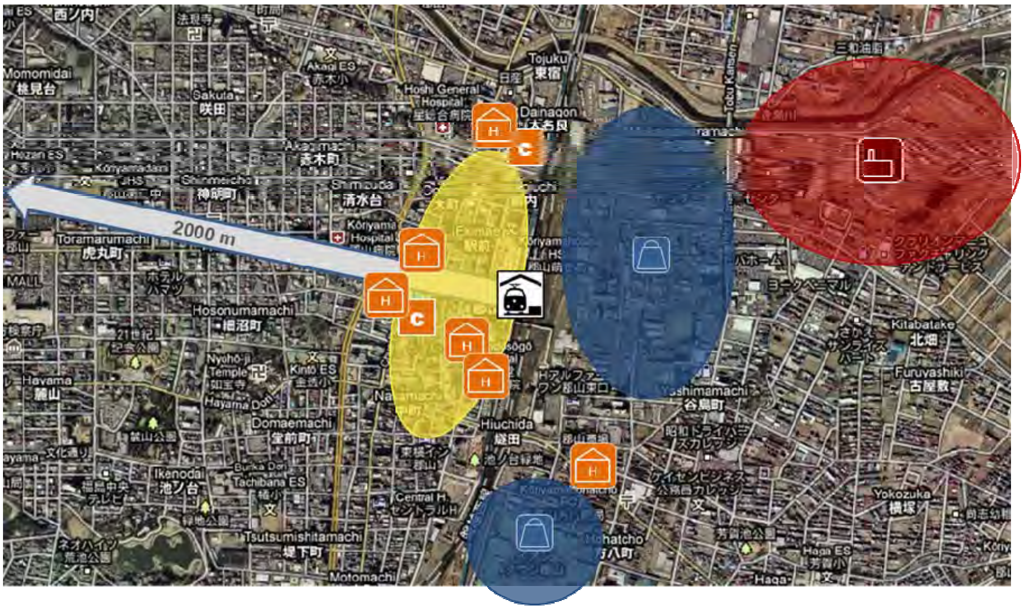


Figure 61: Japan - Surrounding area of the station Koriyama

Twin City - Aomori[43]

The historic railway station of Aomori was opened in 1891 and is situated near the city centre. Its surrounding area is dominated by industry, retailers, apartment houses and public administration buildings. The central bus station next to the railway station provides access to the public transport system of the city and the region. Parking places next to the station are available for commuters. Over the last decades, no structural changes could be identified – in 2010 a new high-speed station (Shin-Aomori) opened outside the city centre and reduced the importance of the historic station in long-distance railway transport.

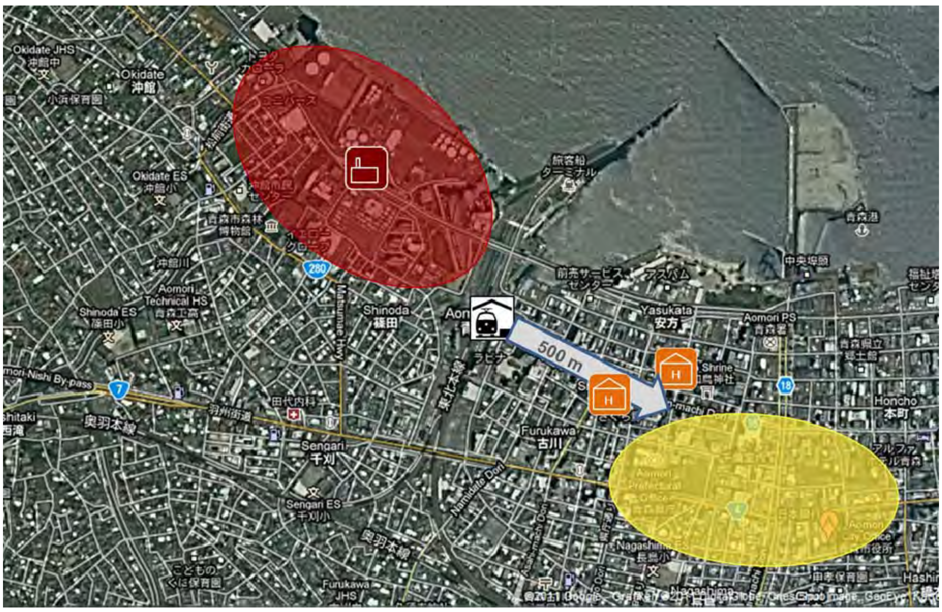


Figure 62: Japan - Surrounding area of the station Aomori

43 Source: www.city.aomori.aomori.jp, www.maps.google.de, en.wikipedia.org/wiki/Aomori_Station, Effective : 30/04/2011.

Kitakami[44]

The station is part of the high-speed line between Tokyo and Aomori. It is situated next to the city centre and was opened for Shinkansen trains in 1982. The surrounding area is characterised by retailers, offices and apartment houses. The station is integrated into the public transport services and offers a high number of parking places for commuters.

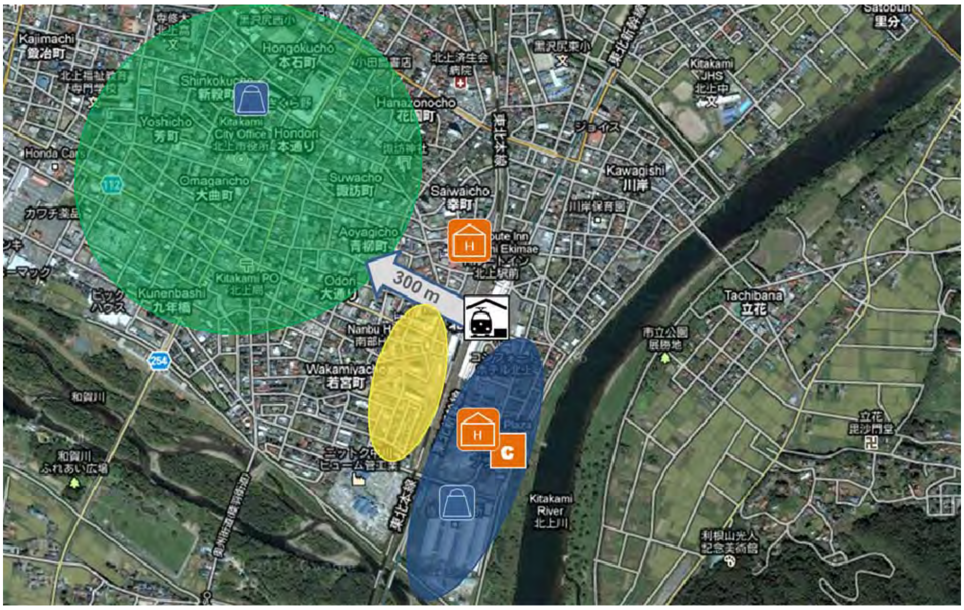


Figure 63: Japan - Surrounding area of the station Kitakami

Twin City - Yokote[45]

The railway station of Yokote is situated near the city centre. Its surrounding area is dominated by retailers, apartment houses and public administration buildings. A bus station in front of the railway station provides access to the public transport system of the city and the region. Parking places next to the station are available for commuters. No structural changes over recent decades could be identified.

44 Source: www.city.kitakami.iwate.jp, www.maps.google.de, ja.wikipedia.org/wiki/%E5%8C%97%E4%B8%8A%E9%A7%85, Effective : 30/04/2011.
45 Source: www.city.yokote.akita.jp, www.maps.google.de, en.wikipedia.org/wiki/Yokote_Station, Effective : 30/04/2011.

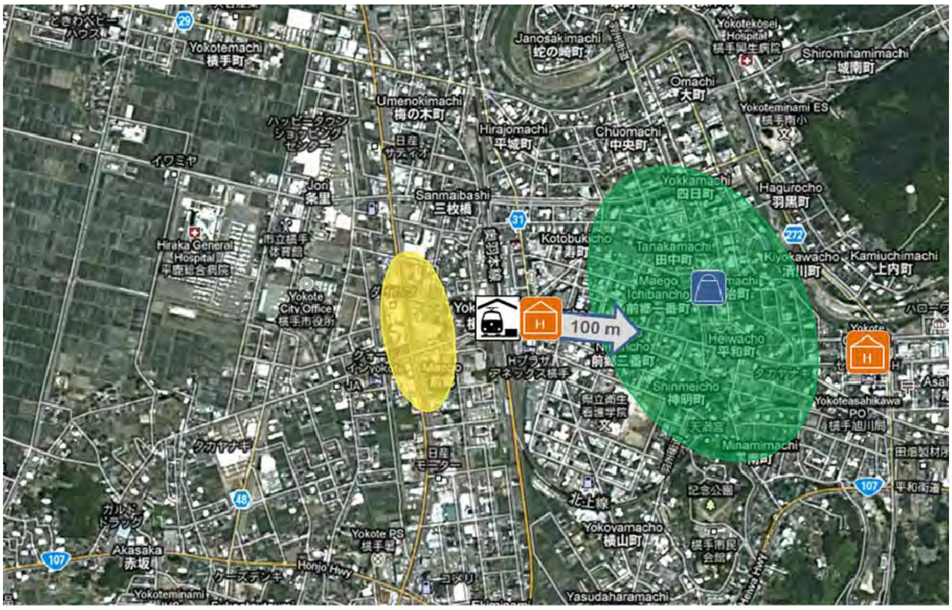


Figure 64: Japan - Surrounding area of the station Yokote

4.4.5 Italy

Florence[46]

Florence Santa Maria Novella (Firenze SMN) is the central station of Florence and is frequented by more than 160,000 passengers per day. The railway station is integrated into the historic city of Florence. For this reason, the surrounding area is characterised by touristic infrastructure, especially hotels. The central tramway and bus station of Florence is situated next to the railway station. No structural changes over recent decades could be identified.

46 Source: www.comune.fi.it, www.grandistazioni.it/grandistazioni.html, www.maps.google.de, it.wikipedia.org/wiki/Stazione_di_Firenze_Santa_Maria_Novella, Effective : 31/03/2011.

Figure 65: Italy - Surrounding area of the station Firenze

Twin city - Venice[47]

Venice possesses two big railway stations that can be seen as central stations: the junction station Venice Mestre on the mainland with about 85,000 passengers and 500 trains per day and the terminal station Venice Santa Lucia on the island of Venice in the historic city centre with about 82,000 passengers and 450 trains per day. Both stations are linked by the Ponte della libertà (Liberty Bridge) between the historic city and the mainland.

The Venice Mestre railway station is situated between the venetian quarters of Mestre and Marghera, that are both dominated by industry, the harbour and apartments for workers. An important bus station and several parking places are provided for commuters.

47 Source: www.comune.venezia.it, www.grandistazioni.it/grandistazioni.html, www.maps.google.de, it.wikipedia.org/wiki/Stazione_di_Venezia_Santa_Lucia, it.wikipedia.org/wiki/Stazione_di_Venezia_Mestre, Effective : 31/03/2011.

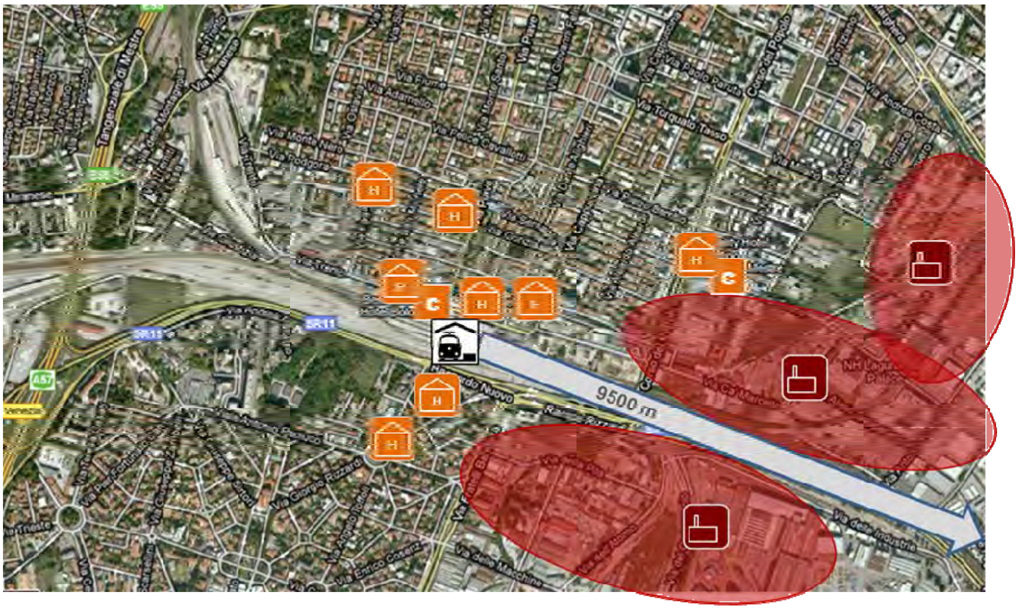


Figure 66: Italy - Surrounding area of the station Venice I

Venice Santa Lucia is rooted in the historic city of Venice and surrounded by an enormous number of hotels and other touristic infrastructure. Moreover, the passenger terminal of the harbour, the central bus station of Venice and a high number of parking places can be found next to the station.

Figure 67: Italy - Surrounding area of the station Venice II

Bologna[48]

Bologna central station is a historic railway station dating from the 19th century, near the city centre of Bologna. It has been connected to the high speed lines to Milan (2008) and Florence (2009) and serves 160,000 passengers per day. Currently, a new three-level railway station for high speed trains is being built under the historic station.

Residential quarters, historically grown industrial areas and the historic city centre with its touristic infrastructure and retailers are characteristic of the station's environment. Furthermore, the construction works for the new underground high speed station are influencing an essential part of the surrounding area. The touristic infrastructure is completed by congress hotels directly next to the station, which are benefiting from Bologna's connection to the Italian high speed system. Moreover, together with the construction of the new underground station, a shopping mall and a parking deck will be built.

Figure 68: Italy - Surrounding area of the station Bologna

Twin city - Bari[49]

Bari central station is situated in the historic city centre of Bari and serves 38,000 passengers per day. The surrounding area is dominated by residential quarters, offices and retailers. A bus stop and about 100 parking places serve commuters. No structural changes over recent decades could be identified.

48 Source: www.comune.bologna.it, www.grandistazioni.it/grandistazioni.html, www.maps.google.de, it.wikipedia.org/wiki/Stazione_di_Bologna_Centrale, Effective : 31/03/2011.

49 Source: www.comune.bari.it, www.grandistazioni.it/grandistazioni.html, www.maps.google.de, it.wikipedia.org/wiki/Stazione_di_Bari_Centrale, Effective : 31/03/2011.

Figure 69: Italy - Surrounding area of the station Bari

4.5 Summary

In general, there exists a theoretical approach that deals with measurements of the impact of infrastructures, especially the impact of HSR. An approach could be highlighted in an impact chain. In this case, the creation of a new infrastructure, including a reduction of travelling time and costs, is the starting point. This reduction can lead to further impacts such as considered in this study. A detailed description can be found in the Preliminary Study (2010) of the overall investigation into the field of "HSR and Territory Management".

The general issue of the study was to show quantitative evidence of the impact of HSR. Nevertheless, it also includes several changes; for example with respect to the unavailability of data or the aggregation level of the data. Considering such framework conditions all the designated impacts could not be analysed on a quantitative level. Therefore, the considered impacts of image, land use as well as surrounding area were analysed in the mentioned qualitative process, although quantitative information is used as a basis for discussion and support of the analysis. This first summary shows the first indicated results of the qualitative assessment.

The analysis of the impact in image leads to the conclusion that HSR could influence the image of a city and change it in a positive way. Here can be mentioned the development of new economic structures stimulated by the connection to HSR. Puertollano for example has changed to green energy, high-tech power plants and the production of solar panels. Fulda in Germany or Kakegawa in Japan are further examples of a changing image through modifications to the economy. In addition, cities with HSR benefit from the image of HSR itself because this transport mode conveys modernity and innovation. Here, cities such as Nantes, Le Mans, Le Creusot or Vendome in France, Valladolid, Segovia or Cordoba in Spain as well as Montabaur, Kassel or Fulda in Germany are using their connection to the HSR network to present themselves as modern, innovative and open-minded places for tourists or enterprises. Apart from the image, HSR implementation also leads to changes in land use in two different ways as have been noted in this study. Firstly, land use has changed where a HS station was completely newly built on a free area. Here, a formerly agriculturally used area is broadly used for industry, offices, services or retailers. Examples are Le Creusot, Montabaur or Segovia. In addition, the study has shown that land use has changed by acquiring or converting existing areas in a city centre after connecting the station to the HSR. In Cordoba for example, the construction of a railway tunnel brought space for a new quarter in the city centre. Metz, Ciudad Real or Koriyama are examples for changes to existing spaces such as for example unused freight yards, idle railway equipment or unused urban areas, which were converted to new uses. This has been observed for all the countries except for Italy, where there is generally not enough space to make great changes in the historical city centres of the investigated cities.

Finally, the changes in the surrounding areas have been analysed in detail. Figure 70 summarises the development in the surroundings of the stations, separated according to cities as well as countries. As explained above, this analysis concentrated on the main changes in the areas and is based on internet research (maps, homepages of the cities etc.). In general a time period of the last ten years was used. This implies that this research does not relate to the commissioning date in every case.

Figure 70: Qualitative results – Summary

All in all, the results show a development in the case of HSR cities. In some cases, a development is also visible for twin cities. But in these cases the cities will mostly get a HSR connection in the future (e.g. Erfurt) or / and are well connected to long distance traffic. In general, there is no apparent development before the linking up of the city and opening of the HSR station, especially in the case of newly created stations. This observation is mainly based on the fact that the creation of the station and the line needs space and so the development of the surroundings takes place later. However, the developments in the surroundings mostly concentrate on preparations for hotels for example together with congresses, offices and residential areas.

Apart from the general development in HSR cases, analyses have also shown differences between the countries. In fact, the countries Spain, Japan, Germany focus on separate areas of development. For example, Germany consists of more hotel and congresses and Spain on residential areas. Although hotels have mostly been developed in bigger cities and not in smaller ones. Where hotel developments have taken place they mostly include congress centres. Meanwhile, the cities in France create completely new city districts including hotels, retail centres, residential areas etc.. In Italy, developments could mostly not be implemented to a great extent due to the locations in historical city centres. One more and important aspect for all stations and especially for the HSR stations is the establishment of an intramodal transport hub including parking spaces and public transport.

The development of a station area can also been seen in comparison to the development of the related city or region or appears as a definite indicator. However, there are differences in development between the surrounding areas as well as the city and region with regard to the time periods and the type of development.

Finally, changes in the surrounding areas occur mostly in the case of HSR stations but here differences in extent and time period of implementation can also be observed. In fact, the analysis has determined that the level of differences in the development depends on various framework conditions. In summary, following conditions have been identified:

- Direct access to motorway
- Commuter distance to next metropolis
- Short distance to city centre
  (mostly smaller development outside but this kind of station is visible in small cities)
- Available areas for development necessary / new or old station in city centre or in the periphery
- Existing basis for development in the surrounding area is necessary
  (city size, economic power etc.)
- Service level - number of trains per day
  (e.g. "more than one train in the morning and one in the evening")
- Station as hub / commuter hub including connection to other transport modes
- Political willingness, cooperation of various institutions

The changes to the surrounding areas are the first to be seen in many cases. This could be an indicator or not of the acceptation of the station and the HSR and so for the potential changes in a wider area than the city or region. In general, the changes in the surrounding area are mostly the easiest in - available area as condition - the field of impacts and it also considers a lot of the other effects as for example land use or changes in industry. Nevertheless, the changes of surrounding areas are generally the first and most seen impact of a HSR link.

5 Impact of High Speed Rail – Quantitative Approach

In contrast to the qualitative approach the quantitative analysis attempts to illustrate the impact of the HSR by using detailed socio and economic information. Moreover, this kind of analysis deals with many various questions regarding the verification of the HSR impact. On the one hand there is the data acquisition: A good and detailed data base serves as a fundamental condition for analysing the changes in cities as well as regions. In fact, the analysis needs long times series at a city level due to the partly long needed development times of the effects. Therefore, a certain operation period is a necessary condition. Apart from the need for time series, data is mostly highly aggregated and it is difficult to refer the development of a city / region to the commissioning of HSR. Possible additional potential effects in the cities for example other infrastructural or economic measures - are not taken into consideration and could not be extracted from the data. However, this illustrated analysis should be a first step or attempt to solve this problem and to obtain first quantitative indications regarding the consequence of HSR. The main tool to reduce this complexity should be here the comparison of HSR cities with their twin cities, as already mentioned.

This part of the report is separated into a first introduction to the applied statistical methods, including the approaches, as well as a first general description of the available data base, together with the methodology how to deal with this data in order to get comparable results and reach a good data quality. Therefore, the data will be adjusted to the methodology and not vice versa. The final analyses are defined and will be made similarly in each country separated analysis. After comparing the time series including correlations in a first step, potential responsible location factors (framework conditions of the city) for explaining differences in the development will be introduced and roughly described and later applied in this report. In general, this part attempts to explain or provide a first understanding in respect to expected variations in the development following HSR implementation. This result could be used as a first indication when forecasting the impact. The part will be closed by considering a transnational sample to explain differences and show advantages of HSR following the commissioning.

5.1 Data Base

This part illustrates a rough first view of the data base for the following analysis as well as how to deal with this. A detailed description will be made in the analysis carried out later. Firstly, the general data bases and potential problems will be presented depending on the countries. After that, solutions in case of data with bad quality will be highlighted. Missing values or not useful inconsistent data could be mentioned here. All in all, the methodology must be adjusted to the data base the inverse method is not possible .

5.1.1 Assessment of the Data Base

Due to the quantitative purpose of the study a complete and useful data base is one of the most important points. The data must be available at city level according to all considered effects as well as all selected cities. The collection approach firstly and mainly used the well known internet sources to get the needed data. This main working step takes into consideration the supply of data from the official statistical offices in the considered country. Secondly, the lack of data was discussed with officials of the statistical offices as well as contact persons in the different countries mainly provided by UIC. Therefore, some data deficiencies could be eliminated. Finally, potential methods are indicated and applied for improving and getting an applicable data base. An example is the interpolation for closing data gaps.

As a result, the data base is not completed as requested in the purpose of the study. The time series do not contain all the needed data especially in respect of the commissioning date of HSR stations. Here, cities with a long operation time are mostly affected, as data is only available for recent years. However, the existing data is applied und serves as the basis for the investigations. The quality of the data base generally varies in respect to the selected countries as well as considered effects of HSR. Especially the data needed in the case of population is broadly available. In contrast, the data for land use as well as real estate on the country are exceedingly difficult to obtain independently and as time series. Finally, the study could not provide data and analyses for all designated impacts in all countries. However, where data is available for one impact in one country then it is also available for several years for all designated cities.

5.1.2 Approaches for comparable Results

As already mentioned the quality of the data base differs in respect to the selected countries as well as the considered impact. However, the time series must be comparable in the total sample despite the different opening dates of the High Speed stations and the availability of data. Therefore, one more task is to prepare a complete comparable sample per country depending on the framework conditions and to get the best possible data base, resulting finally in a transnational sample from well prepared national samples. In this case, the collection aims to get a completed data set to avoid the single comparison of only one city and its related twin city, as this is mostly possible each time but not for the expected time period.

All these further mentioned approaches include a detailed data preparation every time. Firstly, a general consideration regarding a check of missing values or inconsistencies has been made. In a second step the data will be prepared specially according to the designated approach as described below. All in all, time series considering growth rates will be used. The data preparation for the location factors does not consider the following detailed approach because this data only refers to some dates today and in the past and does not need comparable times series. Nevertheless, the data for one detailed date must also be comparable.

- **First best approach and second best approach**

The commonly used desirable approach is illustrated in Figure 71 that includes an illustrative example. First of all, the time series needs to be comparable in the case of the commissioning date. The commissioning date is here identified as best reference date for getting comparable results and reaching the objective of the study. Secondly, the available data set has to be defined for the analysis before and after the opening of the station and the HSL. The size of the useful data for the verification depends on the difference between the several opening dates and on the overall available data (length of the time series). The first best approach indicates that the data needed, especially concerning the commissioning, is available for the total city sample despite differences in the commissioning of stations. This implies that years before and after the commissioning date are considered. The same years will always be compared.

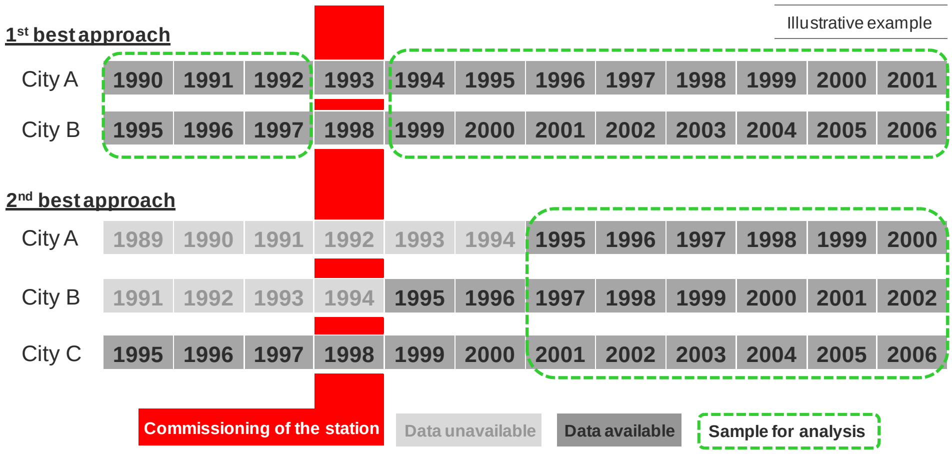


Figure 71: Data preparation, first and second best approach

- **Second best approach**

The 2nd best approach illustrates a potential problem concerning the extent of the time series in the considered case. This implies, that the analysis could only be carried out by applying data after the implementation of the HSL by paying attention to a data gap after opening in the case of city A. However, the data are comparable after preparation because all data of the cities have the same time separation to the commissioning year and are therefore comparable. In many cases, the data samples are reduced very much here because of large time lapses between the opening of the stations in one case and the first year with available data in another case. Therefore, the overall city sample must be adapted to obtain a useful sample for applying the statistical methods.

The sample usually consists of the same number of cities and twin cities because of the same starting date in the form of the commissioning (independent of the data availability).

- **Third best approach**

In contrast to the second best approach the third best approach does not include an overall analysis for all the designated cities in the country. This means, the different commissioning dates and the problem with the availability of data leads to several constraints in the analysis, especially regarding the number of comparable cities. The analysis must be separated and could only be done for comparing several city pairs of the overall country sample (mostly with the same opening date).

- **Fourth best approach**

The last possibility includes very different incomplete data. In this context, the individual analysis per city in comparison to the twin city is the only way to investigate the impact. However, the only comparison of the city also refers to the main objective of the study and can fulfil it. Nevertheless, comparison among the HSR or non HSR groups are not possible and limited the overall analysis.

5.1.3 Potential Conditions for Differences in the Amount of Impact

In the further analysis a separated picture is expected. On one side potential benefits can be indicated in the analysis and on the other side benefits cannot be assumed. Therefore, additional analyses need to clarify why there are differences in the development. In other words, why there is a change after implementing HSR and why there is no change or not as expected in the development. In doing so, the analysis shall highlight potential key factors that describe the city or the region that could be responsible for the development after commissioning. These results will be used for decision makers to support discussions regarding the opening of a new line or especially a new station in their region.

The following factors - called location factors in the further approach - will be applied with respect to a potential influence in the development of the city as well as the region. The factors are separated into technical and socio-economic aspects. Equal or similar aspects were used during the qualitative analysis explained above and shall be kept in mind for the next verifications. In this study a general first rough approach will be provided. Therefore, a first choice of potential influences is highlighted and applied.

International trains

Depending on the mentioned number of trains per day, the international trains will also be evaluated if available. The characteristic is defined binary - one relates to "international trains available" and zero to "international trains are not available". In general, it is assumed that this is also an important factor for higher attractiveness of a city. Moreover, this kind of condition will be evaluated for the HSR cities only. In some countries, as for example Japan, this characteristic will not play a role due to the none-existence of international trains. This selection does not consider the previously applied UIC HSR definition of "equal to or higher than 200 km / h" at all.

Travelling time to a reference city

The travelling time can be seen in a similar correlation to the number of the trains, since the potential passengers want to have many trains per day and a short travelling time to their destination. In this assumption the connections between cities of different sizes is also included. For instance, a small city could be connected to a big city and the traffic resembles suburban traffic and is attractive for commuting.

In general, a reference city is chosen to determine the travelling time to this city. Accordingly, the most important city near to the HSR city is selected. Attention should be paid to the country considered because of the different structures and distribution of city populations in the country. For example, in France a different city structure exists to that in Germany. This implies that in France the next important city is always Paris as the HSR network is so aligned. In contrast, Germany consists of several potentially important cities in the surrounding areas of the HSR cities. Similar reflections need to be made for the other countries and selected cities. The travelling time is indicated in minutes.

Airline distance to a reference city

The airline distance is used for the analysis because of the potential correlation between the distance to an important city and its development in a similar way to that previously described travelling time. Therefore, there is a correlation between distance and travelling time expected. However, both should be evaluated and discussed during the detailed analysis. The airline distance is established as the reference to the next important city. The value is defined in kilometres.

Station location

The location of a station takes into account if the station is situated close to the city centre or in the periphery. A peripheral location here is considered as a location at the edge of the city as well as far away from the city centre but within the city. In general, it can be assumed that a location in the city centre is more attractive and more efficient for the general development, especially for the surrounding area of the station, than the location outside the city centre or at the edge of the city. However, a location in the city centre can also constrain the development of the surrounding area of the station due to existing structures. A historic city centre is such an example. This point also needs to be considered concerning new stations or renewal of existing stations. In this case some assumptions have already been made within the chapter analysing the surrounding areas and shall be applied in this verification.

The location will include the mentioned distances to the city centre (see above surrounding area of the station) but the characteristic will be reduced to a binary characteristic - one means city centre and zero implies outside of the city (at the edge). A special distance is not defined because it is a subjective assessment dependant on the overall situation in the sample per country but the airline distance is considered for decision making. The determination only includes the HSR cities.

Station development

Considering the previous aspect, a general criteria development of the station area is used. The background is the assumption that the development of a city firstly needs a good development of the surrounding area of the station. The city must adapt the station. Adapting the station leads to the distribution of the development. Using the results from the analysis above, the city will be scored in a binary system. One means "development" and zero "no development". The assessment will be done for each city regardless of whether it is a HS city or not.

Network position

This discussion point includes the questions regarding the strength of the development depending on the location of the city or the station in the network. This means, the city could be located on the line or on a node connecting several lines. Here, HSR lines are only considered. The point could be possibly correlated with the number of trains per day. The consideration will be reduced to a binary characteristic including the declaration "line" and "node". "Node" includes one turnout at least. The network position will only be considered for the HSR cities sample.

Population (city size) / population density

The population / population density in the year of commissioning can also play an important role regarding the development of the area following the new HSR. A higher number of inhabitants can be attractive for the city / region and also attract industry due to the availability of employees. As a general statement it is assumed that a larger city has generally more opportunities for growth. The values are defined for the year of commissioning of the HSR.

The area of the city is considered to be the current size used for calculating the density of population. Where data is unavailable the potential error is accepted although some changes are expected for example in changes in land use after commissioning in the case of HSR. Therefore, the density is also related to the commissioning date. Nevertheless, the data will be tested and if the results are not reasonable the characteristic will be excluded.

Service level (number of trains)

Here, it is assumed that the number of trains, e.g. per day, influences the extent of the expected impact of HSR. This assumption includes for example the idea that the higher the number of trains per day the higher the attractiveness of the station itself with regard to commuters as well as for economic interests, e.g. service sector or industry. Finally, a higher attractiveness will lead to higher changes in the impact and vice versa.

In general, an average value per day is used due to a variation of trains per day depending on the day of the week. In addition to the number of trains, existing international connections will also be evaluated and discussed during the analysis.

GDP / GDP per capita

Apart from technical criteria, economic reasons can also be responsible for the strength of the development. This implies an assumption such as the higher the economic strength before creating HSL, the higher is the probability that the city / region will grow after the commissioning of the station. In this way, the GDP is appropriated in this first approach for the description of the existing economic power of the considered area. In this case, the GDP as well as the GDP per capita can be designated. Both the GDP and GDP per capita are ascertained for the year of commissioning depending on the available data. Nevertheless, the GDP and the GDP per capita cannot be applied as an economic measurement in all cases because of the unavailability of data. This means the data is firstly not on hand per city and secondly not on hand for the year of commissioning as needed. It could however be used within the interpretation of the results as additional information.

5.2 Applied Statistical Methods

Within the quantitative approach the statistical methods correlation analysis along with time series comparison, Principal Component Analysis and Regression (multivariate) will be carried out. These methods are mostly based on metric data and are separated from the process of the qualitative analysis as generally focused in the preliminary study. Applying the mentioned method serves to obtain indications on the one hand and final results concerning the correlation between HSR and urban and regional development in a quantitative way on the other hand, together with potential explanations concerning the reason for obtaining or forecasting a development. In principal, both the Regression and the PCA serves as an explanation tool for the differences but with different approaches and illustration possibilities, whereas the PCA includes redundant or similar data in one factor and the Regression excludes this. However, the Regression can handle several data whereas the PCA is constrained in the case of illustration to three factors. One further problem is often the interpretation of the factors after including several mathematically similar information. Therefore, both methods will be used to highlight the advantages and reduce the disadvantages for the overall analysis.

5.2.1 Correlation Coefficient

The correlation coefficient will provide results in a first step of the total analysis comparing especially time series. In fact, the Bravais-Pearson-Coefficient is applied here which ranges between minus one and plus one. Minus one signifies that there is a contrasting correlation assumed and plus one that there is a similar correlation assumed considering in every case two characteristics. The general aim is not the comparison of the times series and their changes year by year in a very detailed level exact comparison. A general comparison is designated in consideration of the trend of the series. This means that the trend which is expected in the series here has not to be excluded by using for example differences or partial correlation analysis (third characteristic the time). Therefore, a standard bivariate analysis is taken into account.

The following understanding and expectation is applied for testing the potential dependencies: Comparing prepared time series and applying the coefficient an effect could be assumed if the coefficient is negative and close to one, comparing HSR cities and non HSR cities. This is the general and main objective for the analysis. In contrast, the two groups HSR and non HSR can be tested separately. Therefore, the coefficient must be positive and close to one in order to comment on a similar development within these groups. Attention should be paid to the statement plus one and minus one because these figures only give a measure for the strength of the correlation without indicating the direction of the development. This implies, minus one only indicates a different development between two selected cities and plus one the same direction. Apart from this general explanation, coefficients indicating no correlations, i.e. the region of zero, could also indicate a higher development of HSR in comparison. As an example is mentioned here a constant development (HSR) against a decrease of values (non HSR). In summary, the correlation coefficients give indications which must also be compared finally in comparison to the times series to get the direction and detailed development. All these reflections need to be taken into consideration that the different effects may vary in the time to materialise. It is also possible that an effect after appearing will disappear after several years. For instance, the number of inhabitants increases within three years after commissioning. However, following these changes in population the positive development will not continue as before. Therefore, this point including correlation for different basic years should also be taken into consideration (e.g. three or six years after implementing HSR).

The data base for the correlation estimation is based on the time series that have ascertained growth rates in relation to the commissioning year. In fact, it is important to have the same data base for this consideration, otherwise the data unavailability could reduce the data set and constrain the analysis. The preparation of the data is explained below in more detail.

In line with the objective of finding a negative relation or no relation (positive understanding for HSR) between HSR cities and twin cities in this first assessment, not useful or unreasonable results will not be considered in further steps. Where no indications exist in the case of an impact of HSR, the further analyses - PCA and regression - will not deal with these effects due to this first result. One further point will be considered if there is not enough data available for testing in a suitable way. In other words, the first appraisal also serves as a selection criterion for the following investigations. This means, if there are differences / no differences in some cases the question in respect to the reason why have to be asked. If there is a generally similar development for all cities the further analysis is not useful and will not be carried out.

5.2.2 Principal Component Analysis

The PCA is used for indicating potential correlations between HSR and also regional development. However, the identification of potential reasons for expected differences in the development (location factors) is in the centre of this consideration. Both the overall city sample as well as a limited sample with respect to the HSR cities is separately applied. In doing so, various defined location factors as for example the service level of trains could be tested in a separate way because the number of HSR trains could not be evaluated for the twin city for instance. Moreover, the PCA aims to structure and to simplify data bases by reducing the number of characteristics that describe the overall situation and connected circumstances. The characteristics are reduced to factors that can be applied for illustrating in a two or three dimensional chart.

However, the composition of characteristics within one factor needs to be reasonable and capable of interpretation. Therefore, the aggregation of characteristics appears to be useful in the case of similar statements (redundant data) on one hand and for the illustration in charts - depends on the number of identified factors - on the other hand. Therefore, the results are mainly to be applied to reduce the abundance of information and to accomplish easy-view illustration, including various differing or similar information. These illustrations, or generally the analyses, are also used mainly for obtaining indications that can be tested within the regression analysis in more detail. This means that the PCA will support the choice of characteristics for the multivariate regression analysis avoiding co-linearity (dependent characteristics).

In general, the approach of PCA is made in the same way for each investigated country. First of all, different metric scaled characteristics will be evaluated and prepared for application. In principal, these are the same per country but depend on the data availability. The characteristics include on one hand location factors which serve as framework conditions and on the other hand the changes in the considered effect, e.g. the change in population (growth rates). Examples for location factors are city size, economic strength of a city or the service level explained by the number of trains per day. These location factors should describe the general situation in and around the city following HSR by explaining the differences in development between the cities if any have been identified. A detailed description of these potential influences is shown in part 5.1.3.The final values of the data base are transformed by using the logarithmic function mainly due to reducing all the various characteristic to one comparable level (transformed characteristic).

The characteristics for the PCA will be preselected and also tested by applying the correlation analysis (Pearson). On the one hand the correlations between the impacts and the location factors as well as the correlations between the location factors itself on the other hand, will be taken into account. The results of the correlations also show indications as to how reasonable the data is for the PCA. If there is a heterogeneous data structure correlations are generally small and an application should be questioned [Backhaus et al. (2006): p. 273]. This preselection also includes the quality of these coefficients by using the significance measurements. Nevertheless, this is one potential quality measure in addition to those mentioned below. On this basis the PCA will be carried out per country and as an overall analysis, including the data of all countries, in one transnational sample. In the end, two factors - at best two interpretable factors - are used for illustrating a chart. A general expectation is that one factor will include the changes in the considered impact and one or more factors consider a selected composition of the analysed location factors.

Attention should be paid to additional or final quality measures of the PCA and therefore regard to the significance of the results. Therefore, the correlation analysis is used as a tool to obtain indications for potential factors as well as a first proof but the choice will finally be applied within the complete running of the PCA. A quality measure known as MSA ("Measure of Sampling

Adequacy") is used in the analysis as it provides indications as to how good the initial characteristics are compatible. This is a well known and applied criterion for evaluating the basic characteristics with respect to the correlation of the characteristics as well as if a PCA is useful by using this data base [Backhaus et al. (2006): pp. 276]. The MSA evaluates the quality besides the correlation analysis which is also a quality measurement as mentioned. Therefore, this quality should be applied within the following analyses and will support the decision if a PCA is performed and also how useful the final results will be. In documentation, it is recommend to have a MSA > 0.8. In contrast, the PCA should not be used if the MSA is less than 0.5 [Backhaus et al. (2006): pp. 276]. In this report, analyses and illustrations of PCA results are not designated for a MSA lower than 0.6, also considering the statements in Table 1. Finally, if there are similar MSA results using various compositions of characteristics the factors with the best interpretation opportunity will finally be selected as best result.

Criteria (value)	Evaluation
MSA ≥ 0.9	marvelous
MSA ≥ 0.8	meritorious
MSA ≥ 0.7	middling
MSA ≥ 0.6	mediocre
MSA ≥ 0.5	miserable
MSA < 0.5	unacceptable

Table 1: Quality measure PCA (MSA criteria)
[Source: Backhaus et al. (2006) pp. 276]

The MSA can also be applied separately per characteristic. Hence, step by step characteristics with a bad MSA will be excluded because they are not helpful for reaching the aim of the analysis. Further quality measurements besides the correlation, including significance and the MSA are possible but will not be used in this analysis.

Some specific frame conditions need to be taken into account and will be considered during the analysis. Firstly, the PCA only includes metric defined characteristics, at least interval scaled could be used. This implies, nominal scaled characteristics (location factors) will not be tested by applying the PCA but will be included in the regression analysis. Moreover, the sample size should be at least equal to the number of applied characteristics [Backhaus et al. (2006): p. 331].

As a final result of the PCA, factor values are determined and illustrated in a chart as mentioned. Here a short introduction with respect to the interpretation should be given. The factor values are standardised values consisting of a mean value zero and a variance of one. Therefore, the interpretation needs to recognise these conditions. A factor value of zero illustrated in a final chart means that a city has an average value in comparison to the applied factor considering the whole city sample. A positive factor value means the city consists of a value higher than the average in comparison to the other cities. A negative factor value is interpreted in a similar way but means a value lower than the average [Backhaus et al. (2006) p. 323].

5.2.3 Regression Analysis

The Regression should also clear up the question as to which location factors or criteria does influence or enable changes in the city / region in relation to the impact of the HSR. All in all, the approach conduces to find conditions to reach the positive indirect effects of the HSR. This also includes the general question regarding the implementation of HSR. However, the potential correlation will mainly be determined separately per city, location factor and effect. Especially by using multivariate analysis a potential linear correlation between several location factors and the change in the city / region is assumed, since it is expected and also stated in documentation that not only one source of information can explain the differences in the development of cities / regions. The proof needs to be made in a statistically significant way. In fact, the variance of the development should be explained using various location factors aimed at estimating the developments in future projects.

The characteristics and location factors are considered in the same way as before for PCA. For example, explanatory characteristics are location of the station, economic power of the city / region, accessibility, service level, availability of domestic connections together with the distance to the next city. A detailed description of these potential influences is shown in part 5.1.3. In contrast, the explained characteristics are certain growth rates in determined intervals to the commissioning, e.g. three or six years after HSR implementation. The PCA could also support here by providing potential factors containing some of the mentioned characteristics. In addition, the data set is used including all cities as well as applying only HSR cities.

In contrast to the PCA, nominally scaled characteristics will be contained in this approach. Here, the "dummy methodology" is applied. This means, nominally scaled characteristics will be transformed into different binary characteristics - zero and one. This information can contribute to a better final estimation result but will not be used as stand alone criteria without adding metric data.

The approach (same way for each country as well as transnational sample) in doing this regression includes following data collection a logarithm transformation of all data in order to have a same level for all data, since the data is gathered in different measures. Subsequently, a pre-selection of reasonable characteristics can be done using the correlation coefficient once again. Here, it is necessary to check the dependencies between the location factors themselves as well as to the changes in rate of the considered impact. Testing the location factors amongst each other should give indications for co-linearity (redundant data) due to one condition of the regression model. All in all, the conditions for applying the regression will be proved and finally the significance (requested level of 0.1) and R square of the results need to be taken into consideration for the total model as well as the single predicted coefficients and their standard errors.

5.3 Impact of High Speed Rail - Quantitative Approach

This part of the report shows a detailed quantitative analysis and results separated by countries on the one hand together with a final transnational consideration on the other hand. Attention should be paid to the level of detail per country that mainly depends on the available data which highly differs between the countries, as mentioned. The analysis considers each of the impacts separately where possible.

Firstly, the general available data base will briefly be described and prepared for each country. A detailed explanation and preparation of the final data basis per impact used will be made within the specific investigation, as the methodology also depends on the data basis. As a result, impacts that can only be used per country will be separated out. For each designated effect a time series will be prepared. In fact, growth rates in relation to the commissioning year are shown for each city, depending on the data level. Here, three years before and eight years after implementation of HSR are the constraints of the analysis. However, depending on the data on hand, the considered years after and before opening varies. This implies a consideration of between three and eleven years is also possible for example. Therefore, a gap between the commissioning and the first facts available needs to be accepted. Nonetheless, the data is comparable in this way. The comparison of exact data after implementation and data including a gap is difficult as for example a single effect of HSR is also imaginable very close after commissioning without any further changes. Moreover, the most changes are expected close to the opening date but this also depends more or less on the impacts. In other words, the population for example will need more time to change but it is also possible that the first significant effects could be seen directly after the commissioning.

Secondly, the statistical tools as already described are used. Here, the correlation analysis starts this investigation and is followed by the regression analysis as well as the PCA for a detailed further step. All the relevant detailed statistical outputs for the PCA as well as regression analysis are presented in the Annex.

5.3.1 France

Data Base and applied Impact

In general, the data base of France is not as complete as requested for all the foreseen cities and impacts. In total, eleven cities were selected as described. Due to the city structure in France the analysis uses six HSR cities and five non HSR cities. Lyon will be illustrated in a separate way and will not be included in the city pair analysis but is part of the investigation within the HSR group in general. The main data was found in the internet by using the official website of the national statistic office; INSEE. However, the data base is not completely as requested and the basis cannot be rated as completely useful for the allowed analysis. On one hand the data includes gaps in the available time series and on the other hand the data is only available for recent years. All in all, the main indicated data only allows an analysis regarding the following effects:

- Population
- Unemployment
- GDP
- Students
- Tourism

This implies that the analysis concentrates on these mentioned impacts of HSR. However, the analyses detail differs between the considered effects depending on the available data basis. For the remaining impacts , data has not been available or only in a really constrained way (e.g. only one year). Therefore, an analysis cannot be carried out.

Time Series and Correlation Analyses

- **Population**

The data for the number of inhabitants is only available for several years in the time period 1968 to 2007. The years available are 1968, 1975, 1982, 1990, 1999, 2006 and 2007. Accordingly, the data gaps have been closed by using the linear interpolation. However, this assumption needs to be taken into account within the performance of the methods and interpretation of the results. Figure 72 summarises the development of the population before and after the implementation of the station (year zero). Due to the late opening date Metz and the related twin city are considered separately. The remaining cities are analysed as one data set and as a comparison of city pairs. Nevertheless, all the illustrated growth rates above are comparable because of the same reference date; commissioning.

				Commissioning								
	Year											
	-3	-2	-1	0	1	2	3	4	5	6	7	8
Lyon	1.045	1.030	1.015	1.000	0.985	0.986	0.987	0.987	0.988	0.989	0.989	0.990
Le Creusot	1.016	1.011	1.005	1.000	0.995	0.982	0.970	0.957	0.945	0.932	0.919	0.907
Le Mans	1.006	1.004	1.002	1.000	0.998	0.999	0.999	0.999	1.000	1.000	1.001	1.001
Nantes	0.993	0.995	0.998	1.000	1.002	1.014	1.025	1.037	1.048	1.060	1.071	1.083
Lille	0.977	0.985	0.992	1.000	1.008	1.015	1.023	1.030	1.038	1.045	1.055	1.064
Metz	1.005	1.006	1.007	1.000								
Twin city (n/a)												
Moulins-sur-Allier	1.015	1.010	1.005	1.000	0.995	0.983	0.972	0.960	0.948	0.937	0.925	0.913
Amiens	0.998	0.999	0.999	1.000	1.001	1.004	1.007	1.010	1.013	1.016	1.019	1.022
Clermont-Ferrand	1.030	1.020	1.010	1.000	0.990	0.991	0.992	0.992	0.993	0.994	0.995	0.995
Limoges	0.999	0.999	1.000	1.000	1.000	1.001	1.001	1.001	1.002	1.002	1.005	1.008
Caen	1.016	1.012	1.007	1.000								

* The calculated growth factors are based on interpolated data.

Figure 72: France - Changes in population - Number of inhabitants at city level (growth rates)
[Source: Own preparation and illustration using data from INSEE (2010)]

The first step of the analysis deals with the preparation of the correlation coefficients for each twin city pair and the comparison within the HSR group and the twin city group. Due to the linear interpolation of the missing data the correlation coefficients are very high. Therefore, the analysis focuses mainly on the direction of the development.

When comparing the first the eight years after starting HSR various statements are possible. Within the group of HSR the number of inhabitants in cities increased, in some cases, during the eight years after commissioning. However, the development in the case of Lyon, Le Creusot and Le Mans differs. On the one hand Lyon and Le Mans stopped the decrease in population and developed constantly, whilst in the case of Le Creusot the decrease continued during these eight years. This can also be seen in the correlation coefficients, which are all positive except for Le Creusot where the contrary development took place. Within the twin cities, the results also differ. On the one hand there is an increase in population (Amiens, Limoges and Clermont-Ferrand) and on the other hand the number of inhabitants decreased between the commissioning and the eight years (Moulins-sur-Allier). This confirms the negative as well as positive coefficients in the analysis.

The detailed consideration of the pairs with respect to the correlation coefficients continues with different results. A comparison leads to the following correlation coefficients: Lille / Limoges 0.9**, Le Creusot / Moulins-sur-Allier 1.0**, Le Mans / Amiens 0.8**, Nantes / Clermont-Ferrand 0.1. This implies that Nantes and Clermont-Ferrand only behave differently. Both cities increased in general, but Clermont-Ferrand decreased first and then increased slower or behaved constantly when compared with Nantes. In contrast, Lille and Limoges increased over the whole period but on different level. The population increase in Lille was much higher than in Limoges. Comparing Le Mans and Amiens the twin city had a higher increase in comparison to the HSR city who's development was almost constant. All in all, HSR cities stopped the decrease in population or boosted the population.

In comparing the data before the commissioning of HSR various statements are possible. On the one hand the number of inhabitants increased and on the other hand the inhabitants decreased regardless of whether the cities were with or without HSR.

- **Unemployment**

In the case of unemployment, the data is available at the regional level (departement) as well as at the city level as needed. However, varying data is provided for each city because every city is located in another department. The data exists for the time period 1982 to 1998 at the regional level and between 1999 and 2009 at city level. Therefore, the analysis will be divided into two approaches with respect to the data situation. Due to the late opening date Metz will completely be excluded from the analysis using the regional data.

Figure 73 serves as the basis for the regional analysis and Figure 74 as basis for the analysis at city level. Due to the availability of data starting in 1982 (one year later than needed), all the illustrations of the growth rate start two years after the commissioning and without the cities Metz and Caen. So that all the data is comparable in respect to the cities as well as twin cities.

				Commissioning								
	Year											
	-3	-2	-1	0 (1)	2	3	4	5	6	7	8	9
Lyon				1.000	1.000	1.056	1.241	1.278	1.333	1.333	1.241	1.204
Le Creusot				1.000	1.016	1.032	1.079	1.143	1.206	1.238	1.222	1.302
Le Mans	1.167	1.189	1.122	1.000	0.988	1.082	1.141	1.282	1.176	1.153	1.176	1.106
Nantes	1.216	1.186	1.072	1.000	0.979	1.052	1.134	1.227	1.134	1.144	1.186	1.113
Lille				1.000	0.952	0.979	1.034	0.979	0.793	0.690	0.648	0.655
Metz				n/a								
Twin city (n/a)				n/a								
Moulins-sur-Allier				1.000	0.982	1.193	1.368	1.439	1.456	1.404	1.298	1.263
Amiens	1.050	1.109	1.069	1.000	1.010	1.050	1.139	1.248	1.168	1.178	1.238	1.218
Clermont-Ferrand	0.971	0.957	0.957	1.000	1.101	1.159	1.130	1.101	1.116	1.203	1.246	1.203
Limoges				1.000	0.964	0.988	1.012	0.964	0.976	0.807	0.723	0.747
Caen				n/a								

Figure 73: France - Changes in unemployment - Rate at regional level (growth rates) [Source: Own preparation and illustration using data from INSEE (2010)]

The illustration in the table above mainly shows a decrease of the rate before opening and an increase of the rate after implementing HSR. An exception here is Lille with a high decrease in the last considered years. Nevertheless, there are also differences in the level of increase between the cities that must be analysed in detail afterwards. However, the small sample size has to be noted. In general almost all the rates developed in the same direction and are more or less strong. This is valid for the comparison within the HSR group, the twin city group, as well as the comparison of the city pairs. The analysis shows a correlation coefficient for Lille / Limoges of 0.9**, Le Creusot / Moulins-sur-Allier of 0.7, Le Mans / Amiens of 0.9**and for Nantes / Clermont-Ferrand of 0.5 in respect to the year after starting HSR. This result shows a higher increase in unemployment in Clermont-Ferrand than in the HSR associate Nantes when considering the regional data. Moreover, Lille shows a lower unemployment in comparison to the twin city at the end.

Nevertheless, the different decades of opening must be taken into consideration here. In other words, the economy fluctuates over the years and this could also be the case for the employment. The late opening date of Lille falls within a general decreasing period of unemployment. This consideration only concentrates on eight years after commissioning which could possibly handicap other cities. However, the comparison of the city and their respective pair finally counts because this comparison helps to exclude, as mentioned, additional effects.

Figure 74 illustrates the changes in unemployment at city level. As shown, the data was not available as needed, so that the analysis starts at various intervals to the commissioning date. This means that the cities with the same interval to the commissioning date can be compared and therefore, the comparison will be concentrated on the city pairs.

				Commissioning								
	Year											
	-3	-2	-1	0 (18,11,6)	1 (19,12,7)	2 (20,13,8)	3 (21,14,9)	4 (22,15,10)	5 (23,16,11)	6 (24,17,12)	7 (25,18,13)	8 (26,19,14)
Lyon*				1.000	0.798	0.681	0.734	0.840	0.872	0.862	0.840	0.766
Le Creusot*				1.000	0.870	0.789	0.854	0.919	0.927	0.919	0.902	0.789
Le Mans*				1.000	0.813	0.719	0.729	0.740	0.802	0.833	0.885	0.792
Nantes*				1.000	0.847	0.765	0.765	0.806	0.816	0.806	0.806	0.714
Lille*				1.000	0.870	0.817	0.826	0.870	0.913	0.939	0.948	0.861
Metz	1.026	1.064	1.090	1.000	0.923	1.205						
Twin city (n/a)				n/a								
Moulins-sur-Allier*				1.000	0.824	0.769	0.692	0.725	0.769	0.780	0.802	0.725
Amiens*				1.000	0.866	0.803	0.780	0.780	0.811	0.819	0.843	0.787
Clermont-Ferrand*				1.000	0.884	0.837	0.802	0.826	0.872	0.860	0.872	0.826
Limoges*				1.000	0.827	0.741	0.765	0.827	0.877	0.901	0.963	0.877
Caen	1.110	1.122	1.134	1.000	0.902	1.134						

* The comparison starts 18 years after commissioning for Lyon and Le Creusot, 11 years for Le Mans and Nantes and 6 years for Lille.

Figure 74: France - Changes in unemployment - Rate at city level (growth rates)
[Source: Own preparation and illustration using data from INSEE (2010)]

A first quick look does not indicate a detailed result with respect to one city group, which also depends on the different reference dates. Therefore, the correlation is determined for the pairs as follows: Lille / Limoges 0.9**, Le Creusot / Moulins-sur-Allier 0.6, Le Mans / Amiens 0.9**and for Nantes / Clermont-Ferrand 0.9**. As previously, Metz and Caen are excluded due to the short time period after commissioning. All in all, the first indications are confirmed and no significant differences can be stated.

In summary, some statements could be made pro HSR here. However, these results concentrate on the regional level which includes more effects as desired and needed. The main data on city levels does not lead to significant results comparing HSR cities and non HSR cities.

- **Gross Domestic Product (GDP)**

In general, the data for GDP is provided between 1990 and 2007 for all the cities considered without any data gaps. Due to the analysis objective of comparable results (commissioning dates of the station) the applied data base is reduced and the first year for analysis refers to the 9th year after commissioning which is applied for all cities. Due to the late opening date data needed for Metz and Caen does not exist. Consequently, the analysis is separated. The results by applying the growth rate, Figure 75, can be summarised as follows:

				Commissioning								
	Year											
	-3	-2	-1	0 (9)	10	11	12	13	14	15	16	17
Lyon				1.000	1.034	1.068	1.068	1.105	1.165	1.211	1.271	1.332
Le Creusot				1.000	1.022	1.041	1.017	1.044	1.078	1.093	1.123	1.161
Le Mans				1.000	1.029	1.085	1.127	1.153	1.175	1.213	1.244	1.279
Nantes				1.000	1.040	1.105	1.159	1.195	1.228	1.278	1.322	1.371
Lille				1.000	1.039	1.087	1.138	1.207	1.265			
Metz				1.000								
Twin city (n/a)				n/a								
Moulins-sur-Allier				1.000	1.009	1.021	1.017	1.052	1.094	1.115	1.159	1.226
Amiens				1.000	1.018	1.040	1.070	1.095	1.114	1.146	1.174	1.204
Clermont-Ferrand				1.000	1.015	1.050	1.077	1.112	1.140	1.189	1.226	1.273
Limoges				1.000	1.013	1.040	1.082	1.128	1.184			
Caen				1.000								

Figure 75: France - Changes in GDP at city level (growth rates)
[Source: Own preparation and illustration using data from INSEE (2010)]

Having analysed the potential changes in GDP one overall result can be shown by comparing the years as illustrated above. However, these do not relate to the first years after starting HSR. As a result, all the cities developed in the same direction and more or less strong. The correlation coefficients are higher than 0.9** regardless of whether only HSR, twins or the city pairs. This is also valid for years that are not illustrated above.

- **Students**

To analyse the changes in number of students the city sample needs to be reduced due to the presence of universities. Accordingly, data for ten years is used (2000 and 2009). Taking into account the existing data for 2000 and the different early opening dates all the data is generally related to the years 2000, except Metz and Caen (2007). Therefore, the growth rates of each city considered can only be compared with cities that have the same commissioning date. However, several cities have the same date which enables a comparison of small city groups.

				Commissioning								
	Year											
	-3	-2	-1	0	1	2	3	4	5	6	7	8
Lyon*				1.000	0.999	1.017	1.058	1.082	1.106	1.108	1.096	1.133
Le Creusot*				n/a								
Le Mans*				1.000	0.949	0.950	0.987	1.029	1.060	1.060	1.071	1.092
Nantes*				1.000	0.970	0.966	0.976	0.966	0.993	0.975	0.944	1.026
Lille*				1.000	0.969	0.983	1.009	1.029	1.025	1.023	1.017	1.000
Metz	1.098	1.098	1.043	1.000	0.905							
Twin city (n/a)				n/a								
Moulins-sur-Allier*				n/a								
Amiens*				1.000	0.970	0.982	1.030	1.025	1.038	1.039	1.010	1.085
Clermont-Ferrand*				1.000	0.976	0.995	1.036	1.033	1.021	1.011	1.008	1.040
Limoges*				1.000	0.980	1.010	1.027	1.028	1.059	1.047	1.022	1.025
Caen	1.040	1.044	1.036	1.000	1.005							

* The comparison starts 19 years after commissioning for Lyon and Le Creusot, 12 years for Le Mans and Nantes and 7 years for Lille.

Figure 76: France - Development of students - Number of students at city level (growth rates)
[Source: Own preparation and illustration using data from Ministère de l'éducation nationale France (2010)]

The development of the number of students after starting HSR differs but on the whole increased. As mentioned, a comparison of the city pairs is only reasonable if there is the same commissioning date, due to the data base. So the following correlation coefficients can be shown: Lille / Limoges 0.8**, Le Mans / Amiens 0.8** and Nantes / Clermont-Ferrand 0.4. This means that there is an increase for all the cities but in a different way. The most differences are in the case of Nantes and Clermont-Ferrand because of the differences in development. Here, a higher increase in the case of non HSR city in comparison to HSR city is illustrated. A comparison between the cities Metz and Caen shows an increase in Caen and a decrease in Metz.

- **Tourism**

The analysis of potential changes in the tourism could be carried out with several characteristics. On the one hand the number of overnight stays and on the other hand the number of arrivals are potential measurements. With the availability of these characteristics the average stays in the city could be ascertained. However, in this case data only exists for the number of overnight stays between 2003 and 2008 at a regional level (departement). Due to the level of availability of the data a comparison of the city pairs (or the city with the same opening date) only is recommended and each city, except Metz and Caen, is related to 2003 as the applied year zero (see table below). Figure 77 presents the growth rates in respect of the number of overnight stays per year.

				Commissioning								
	Year											
	-3	-2	-1	0 (14, 22)	1 (15,23)	2 (16,24)	3 (17,25)	4 (18,26)	5(19,26)	6(14,27)	7 (14,28)	8 (14,29)
Lyon*				1.000	0.996	1.046	1.058	1.159	1.138			
Le Creusot*				1.000	0.963	0.991	0.982	1.009	1.010			
Le Mans*				1.000	1.141	1.146	1.144	1.164	1.188			
Nantes*				1.000	1.083	1.027	1.080	1.086	1.105			
Lille*				1.000	1.083	0.999	1.035	1.035	1.072			
Metz	0.912	0.887	0.904	1.000	0.964							
Twin City (n/a)				n/a								
Moulins-sur-Allier*				1.000	1.101	1.094	1.102	1.060	1.072			
Amiens*				1.000	1.028	1.057	1.054	1.057	1.030			
Clermont-Ferrand*				1.000	0.965	1.007	0.966	0.939	0.948			
Limoges*				1.000	1.008	0.995	1.030	1.058	1.081			
Caen	1.053	1.005	0.967	1.000	0.970							

* The comparison starts 22 years after commissioning for Lyon and Le Creusot, 14 years for Le Mans and Nantes and 10 years for Lille.

Figure 77: France - Development of tourism - Number of overnight stays at regional level (growth rates)
[Source: Own preparation and illustration using data from INSEE (2010)]

As in the previous cases, this analysis is only possible by comparing the city pairs as well as the cities with the same opening of HSR, because of the data situation. A first look at this data base does not lead to a general result. There are increases as well as decreases in the number of overnight stays. The comparison of the pairs by using the correlation brings the following results: Lille / Limoges 0.5, Le Creusot / Moulins-sur-Allier -0.6, Le Mans / Amiens 0.7 and Nantes / Clermont-Ferrand -0.9*. This means that differences as well as a better development could be stated for the HSR cities Lille and Nantes. Although Le Mans also had a string increase one year after commissioning, this is not valid for the following years. A comparison between Le Creusot and its twin shows a better development in the case of the twin city.

In addition to these mentioned values a statistic regarding the share of business travellers is available and used for France, although only at regional level. This data needs to be analysed by paying attention to the assumption of a correlation between the service industry and the HS service. In general, the analysis uses the same assumptions as discussed with the number of arrivals because of the same framework conditions.

				Commissioning								
	Year											
	-3	-2	-1	0 (14, 22)	1 (15,23)	2 (16,24)	3 (17,25)	4 (18,26)	5(19,26)	6(14,27)	7 (14,28)	8 (14,29)
Lyon*				1.000	0.975	0.995	1.078	1.060	1.039			
Le Creusot*				1.000	1.021	1.088	1.088	1.090	1.149			
Le Mans*				1.000	1.055	1.058	1.068	1.097	1.066			
Nantes*				1.000	0.965	0.983	0.942	1.002	1.019			
Lille*				1.000	1.014	1.028	1.063	1.068	1.068			
Metz	1.021	1.011	0.994	1.000	0.998							
Twin City (n/a)				n/a								
Moulins-sur-Allier*				1.000	1.011	1.056	1.090	1.093	1.120			
Amiens*				1.000	1.033	1.039	1.041	1.022	1.091			
Clermont-Ferrand*				1.000	1.011	1.017	1.160	1.182	1.140			
Limoges*				1.000	0.971	0.979	0.997	1.003	0.993			
Caen	0.824	0.924	1.031	1.000	0.929							

* The comparison starts 22 years after commissioning for Lyon and Le Creusot, 14 years for Le Mans and Nantes and 10 years for Lille.

Figure 78: France - Development of tourism - Percentage of business travellers at regional level (growth rates)
[Source: Own preparation and illustration using data from INSEE (2010)]

Comparing the city pairs using the available data is also valid for the analysis of the service sector. The comparison of the pairs by using the correlation leads to the following coefficients: Lille / Limoges 0.4, Le Creusot / Moulins-sur-Allier 0.9**, Le Mans / Amiens 0.4 and Nantes / Clermont-Ferrand 0.1. In general, these results show differences between the cities but sometimes as an advantage for the HSR cities and sometimes for the non HSR cities. Lille could be highlighted in this comparison to the twin city as a definite positive example.

Principal Component Analysis and Regression Analysis

After obtaining first indications by using the growth rates and the resulting specific correlation coefficients above, an additional analyses will be done. The objective of this study is also to detail the question as to why there are differences in the development between city pairs on the one hand and within the HSR group on the other hand. Due to the first experiences according to the results and the available data base the impact population will be considered for France in the following. All the other data sets are not useful for the analysis because of the mainly too small sample size after preparing comparable results. In addition, this investigation needs to exclude Metz and the defined twin city Caen because of the late opening date in comparison to the available data. Lyon is also not part of the investigation of the overall sample including twin cities, but will be integrated into the analysis of the HSR sample only.

Due to the often mentioned unavailability of data depending on the countries all of the considered location factors could not be used as mentioned here. However, the following characteristics are part of the investigation in the case of France: travelling time and distance to reference city, number of inhabitants per city, inhabitants per square kilometre, development in surrounding areas of the stations and especially for HSR investigation number of trains per day, station location, availability of international trains as well as the consideration of the network position. Therefore, the economic strength by using the GDP could not be determined. But as mentioned, the binary characteristics (international trains, station location, development in the surrounding area of the station) are used only for the regressions analysis in combination with the metric scaled ones.

Having done the correlation analysis for the total sample some correlations as well as causal findings can be pointed out. Firstly, a relation is assumed between the distance and the travelling time (0.8*) in general. Moreover, it is stated that the number of inhabitants and the inhabitants per square kilometre also correlates (0.5). In considering the HSR cities - sample size of four - similar results are obtained plus correlation in respect to the number of trains per day. These values are summarised as follows:

Sample including HSR only

- Distance and travel time to the next relevant city (0.9**)
- Number of trains per day and number of inhabitants per square kilometres (0.9**)
- Number of trains per day and number of inhabitants of the city (0.8)
- Number of inhabitants per square kilometres and number of inhabitants of the city (0.9*)

The specific correlations with respect to population will be shown within the detailed analysis of the HSR impact.

- **Population**

As mentioned above, the data set of population includes an interpolation of the data which leads to restrictions in the interpretation after testing several indications. In general, growth rates three and six years after commissioning and the potential influences mentioned in 5.1.3 will be opposed and tested according to the designated location factors. In addition to the correlation above, the correlation especially relating to the population can be tested. There is therefore a correlation between the growth rates three and six years (1.0**) as expected and between the rates itself and the number of inhabitants per city 0.9** three years after opening, 0.9** six years after opening. The total sample including HSR cities only shows a correlation of 0.9** between the two mentioned growth rates of population too.

Principal Component Analysis

In respect to the analysed correlations above; the changes in population, the travelling time and distance as well as the number of inhabitants are mainly designated for the PCA in the case of considering all the cities and twin cities. Different compositions of the factors have been tested. Applying all these characteristics, the MSA amounts to 0.7 in the best case. Here, the changes in population are designated as one factor and the city size as another. This implies, that the second only considers one characteristic as being a reasonable and interpretable case. Using this for the PCA, the following charts are presented.

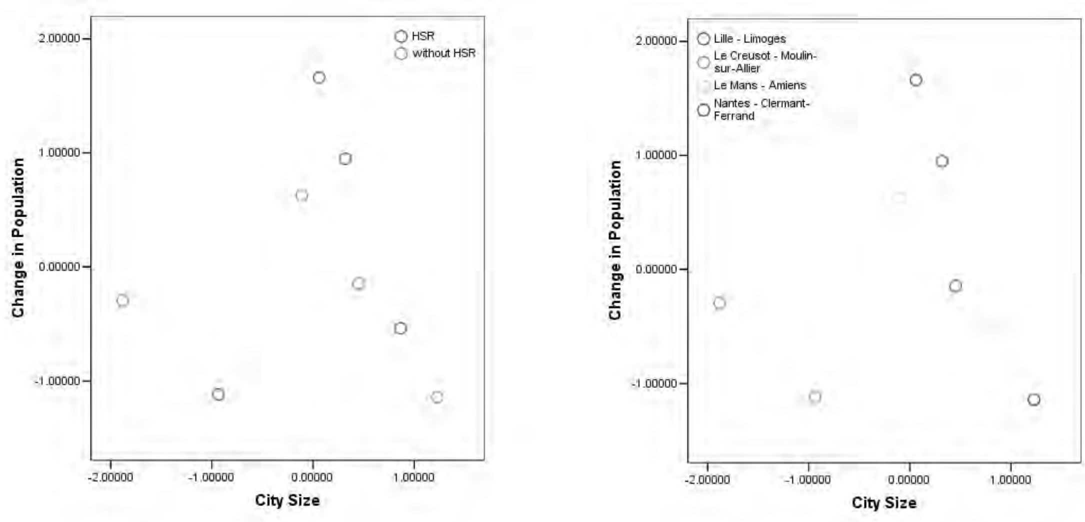


Figure 79: France - PCA - Changes in population
[Source: Own preparation and illustration using data from INSEE (2010)]

As can be seen in the charts, it is difficult to extract a general result. Although, there could be an advance to HSR considering a certain size of the city. In detail, there is a concentration on the right in the diagrams, due to the chosen city structure and considering the city size. However, there is one city pair extracted in the left corner with a small city size in comparison to the other cities, Le Creusot / Moulins-sur-Allier. The concentration on the right does not lead to general statements concerning an above or below average development in population separated into HSR or non HSR cities. Although an advancement towards HSR is possible. Moreover, the positive change in population is generally higher for the HSR cities when only comparing city pairs in the right figure. In contrast, there is the pair Le Creusot / Moulins-sur-Allier which general had a negative development in comparison to the other cities and the twin city development was higher than the HSR city. Furthermore, there are three out of five twin cities under the average for changes in population.

In a next step the HSR cities are considered separately, including Lyon. Several compositions including the mentioned location characteristics lead to the maximum MSA of 0.5 which could not be applied for a further illustrations and useful analyses.

Regression Analysis

As mentioned, the regression analysis serves for finding the same indications as within the PCA but uses another approach. In addition, binary characteristics as for example the presence of international trains are used and therefore the framework condition of cities can be described in more detail. However, the application of this kind of characteristics is in addition to the metric scaled but never as stand alone criteria. One further point is that individual criteria could be analysed separately by using more than one criterion for the description. In the case of PCA various criteria are merged into one factor which makes for a harder identification of results and dependences. The regression will be checked for the explained characteristic change in population three as well as six years after commissioning. By doing this, all the information that has been so far obtained from PCA and correlation analysis will be involved. Therefore, it is also useful to include the factor population from above as a tested separate explained characteristic.

In the case of the overall sample including HSR and non HSR cities, the result relates to that of PCA. Nevertheless, there is no useful final regression result when using the different changes in population (plus three years, plus six years, factor of both) as well as the designated explanatory characteristics. Indications for dependencies come from the city size but not in the needed and designated quality level (statistics). Furthermore, all the other potential description characteristics have not lead to any significant results.

Finally, the sample is reduced to the HSR cities and additional and explanatory characteristics will be enlarged using binary characteristics such as presence of international trains and network position. All in all, statistically reasonable results could also not be indicated. However, there are indications for influences of city size but the sample size appears to be too small for significant results, which is also valid for the analysis using HSR and non HSR cities.

5.3.2 Germany

Data Base and applied Impact

The overall consideration of Germany deals with 12 cities, 6 HSR and 6 non HSR cities. Due to the availability of the data not all of the assumed potential benefits can be analysed as foreseen. However, the data situation can be rated as good in comparison to other considered countries in this investigation. All the data is collected from the statistical office in Germany (2010). However, the data are mostly available at a city level depending on the cities and impacts. In some cases constraints regarding the data availability before opening of the station had to be taken into account. All in all, the following potential impacts can be analysed in more or less detail for Germany:

- Population
- GDP
- Economy
- Tourism
- Land Price
- Commuter

Time Series and Correlation Analyses

- **Population**

In the case of population the data base fulfils the needed conditions completely because data before and after commissioning is available at city level. Figure 80 illustrates the first indications in the form of growth rates for calculating the correlation coefficients and obtaining first indications. The gaps at the end of the table for Montabaur and Limburg are created due to the late opening date of both stations. The analysis is therefore separated into two groups Montabaur and Limburg in one group and the rest in the other group, due to the framework conditions. This separation relates to the determination of the correlation coefficient.

	Commissioning											
	Year											
	-3	-2	-1	0	1	2	3	4	5	6	7	8
Gottingen	0.950	0.967	0.980	1.000	1.023	1.033	1.026	1.023	1.017	1.024	1.013	1.004
Kassel	0.986	0.999	1.013	1.000	1.042	1.054	1.052	1.051	1.047	1.040	1.033	1.023
Fulda	0.950	0.969	0.984	1.000	1.013	1.027	1.044	1.064	1.080	1.090	1.090	1.089
Wolfsburg	1.034	1.020	1.005	1.000	0.998	0.997	0.998	1.001	1.004	1.000	0.992	0.986
Limburg a. d. Lahn	0.997	0.998	0.996	1.000	1.003	1.006	1.010	1.006	1.003	0.996	0.994	
Montabaur		0.911	0.925	1.000	0.995	1.003	1.015	1.013	1.006	1.007	1.004	
Paderborn	0.908	0.927	0.960	1.000	1.022	1.035	1.046	1.064	1.077	1.082	1.085	1.095
Erfurt	1.074	1.059	1.020	1.000	0.991	0.980	1.042	1.030	1.016	1.002	0.990	0.982
Giessen	0.988	1.010	1.010	1.000	1.004	0.999	0.999	1.002	0.996	0.990	0.982	0.987
Salzgitter	1.032	1.024	1.012	1.000	0.990	0.984	0.979	0.971	0.963	0.953	0.944	0.935
Friedberg	0.969	0.972	0.988	1.000	0.999	1.003	1.002	1.008	1.012	1.014	1.015	
Bad Ems	1.010	1.010	1.008	1.000	1.007	0.998	0.976	0.968	0.958	0.960	0.956	

Figure 80: Germany - Changes in population - Number of inhabitants at city level (growth rates)
[Source: Own preparation and illustration using data from DESTATIS (2010)]

The general first view indicates various developments within the groups of HSR cities as well as within the group of non HSR cities without Montabaur and Limburg and their twin cities. On one hand the number of inhabitants increased and on the other decreased during the three years before and eight years after implementing HSR. Moreover, in several cases an approximately constant development can be assumed including variations. A detailed analysis within this HSR group leads to the assumption that the only really increasing city is Fulda. Accordingly, all correlation coefficients are positive in different amounts except Fulda which is negative correlated with each HSR city. However, Kassel and Wolfsburg could also be mentioned in respect to a better development in comparison to the twin cities. A special comparison of the twin cities for this group shows all cities are positively correlated except Paderborn, which has developed in another direction in comparison to the other twin cities. In summary, the following coefficients are calculated for the pairs considering eight years following the commissioning date: Gottingen / Paderborn -0.3, Kassel / Erfurt 0.4, Fulda / Giessen -0.8* and Wolfsburg / Salzgitter 0.6.

In the case of Montabaur and Limburg as well as the respective twin cities, similar statements can be made. Firstly, the development comparing HSR cities is absolutely similar, illustrated by a high positive coefficient. Looking at the twin cities there could be assumed an increase for Friedberg and a decrease for Bad Ems. This difference could be described in a significant way including a correlation of -0.9**. Finally, analysing the correlations show an amount of -0.6 for Limburg / Friedberg and -0.6 for Montabaur / Bad Ems. This means, the development differs in both cases. However, on one hand it could be stated that Montabaur benefited from HSR and on the other hand Limburg not. As in other analyses the question "Why are there differences?" should be answered. Extending times series for the analysis confirms the illustrated results in both cases of the investigation.

- **Gross Domestic Product**

In the case of GDP the data is generally on hand at regional level except for Kassel / Erfurt and Wolfsburg / Salzgitter. The main problem is the early data before opening the first stations in

1991. Figure 81 presents the first results regarding the growth rates in the form of time series. The mixed data set is accepted because of the main objective to have data at city level. The main objective, the city pair comparison, is possible because the data is at the same level in each case.

	Year			Commissioning								
	-3	-2	-1	0	1	2	3	4	5	6	7	8
Gottingen	0.789	0.832	0.875	1.000	1.000	1.018	1.035	1.047	1.049	1.037	1.058	1.111
Kassel*				1.000	1.000	1.008	1.016	1.018	1.021	1.047	1.044	1.072
Fulda				1.000	1.000	1.036	1.072	1.101	1.113	1.159	1.195	1.233
Wolfsburg*	0.713	0.674	0.756	1.000	1.084	1.078	1.173	1.046	1.072	0.976	1.153	1.125
Limburg a. d. Lahn	0.909	0.952	0.983	1.000	1.016	1.048	1.059	1.091	1.147	1.187		
Montabaur	0.928	0.962	0.966	1.000	1.000	1.016	1.030	1.098	1.160	1.202		
Paderborn				1.000	1.000	1.033	1.066	1.095	1.141	1.154	1.224	1.291
Erfurt*				1.000	1.000	1.247	1.493	1.501	1.509	1.526	1.564	1.594
Giessen				1.000	1.000	1.021	1.043	1.059	1.066	1.069	1.091	1.115
Salzgitter*	0.893	0.882	0.902	1.000	0.936	1.030	1.019	1.020	1.028	1.187	1.135	1.147
Friedberg	0.887	0.919	0.974	1.000	1.047	1.077	1.110	1.129	1.183	1.224		
Bad Ems	0.902	0.938	0.944	1.000	0.983	0.996	0.986	1.031	1.055	1.061		

*This data is available on city level.

Figure 81: Germany - Changes in GDP - Regional and city level (growth rates)
[Source: Own preparation and illustration using data from DESTATIS (2010)]

Due to the constraint data availability, depending on area and time period, the analysis will focus on the comparison of the city pairs after the opening of HSR. A general first view leads to the assumption that there is an overall increase whether HSR city or non HSR city. This also applies for the year before the commissioning. The coefficients can be shown as follows: Gottingen / Paderborn 0.9**, Kassel / Erfurt 0.8*, Fulda / Giessen 1.0**, Wolfsburg / Salzgitter -0.4, Limburg / Friedberg 1.0**, Montabaur / Bad Ems 1.0**. Analysing the correlation confirms this impression except for Wolfsburg / Salzgitter. This pair differs in development for the considered years but a better development for HSR could not be indicated. Some decreases in some years are responsible for this result.

- **Unemployment**

The data for analysing the unemployment is also used both on regional as well as city level depending on the data availability. The characteristic unemployment rate is used. The data is generally on hand between 2001 and 2009. In the case of Bad Ems, there is no data available, also not at regional level. Due to the overall short availability of data, several relation years are applied and lead to the only analysis of the city pairs. Figure 82 shows the data used in the form of growth rates.

				Commisioning								
	Year											
	-3	-2	-1	0 (10, 4)	1 (11,5)	2 (12,6)	3 (13,7)	4 (14,8)	5 (15,9)	6 (16,10)	7 (17,11)	8(18,12)
Gottingen*				1.000	1.000	1.000	1.000	1.171	1.126	1.045	0.874	0.775
Kassel*				1.000	0.993	1.036	1.064	1.371	1.193	0.986	0.886	0.886
Fulda*				1.000	1.045	1.119	1.119	1.269	1.030	0.881	0.791	0.866
Wolfsburg**				1.000	0.955	0.943	0.932	1.227	1.182	1.011	0.795	0.750
Limburg a. d. Lahn			0.921	1.000	1.159	1.254	1.587	1.413	1.143	1.000	0.984	
Montabaur			1.017	1.000	1.119	1.119	1.339	1.203	0.966	0.814	0.932	
Paderborn*				1.000	1.061	1.073	1.122	1.317	1.256	1.037	0.866	0.927
Erfurt*				1.000	1.050	1.138	1.138	1.200	1.006	0.906	0.819	0.756
Giessen*				1.000	1.064	1.205	1.231	1.526	1.462	1.308	1.141	1.051
Salzgitter**				1.000	0.967	1.000	1.008	1.171	1.146	0.927	0.780	0.846
Friedberg			0.919	1.000	1.145	1.194	1.435	1.339	1.048	0.903	0.919	
Bad Ems				n/a								

* The comparison of Gottingen, Kassel and Fulda starts 10 years after commissioning.
** The comparison of Wolfsburg and Salzgitter starts 4 years after commissioning and data is on hand at city level.

Figure 82: Germany - Changes in unemployment - Rate at regional as well as city level (growth rates)
[Source: Own preparation and illustration using data from DESTATIS (2010)]

As already mentioned, the analysis deals with the comparison of the city pairs because of the data situation. The outcomes of the analysis can be shown as follows: Gottingen / Paderborn 0.9**, Kassel / Erfurt 0.8*, Fulda / Giessen 0.5, Wolfsburg / Salzgitter 0.9**, Limburg / Friedberg 0.9**. In summary, a similar development of the city pairs can be assumed by using these figures. However, there are recognisably potential differences. For instance, Fulda had a strong decrease after several years following the opening of HSR in comparison to Giessen. The region including Montabaur shows a decrease in unemployment as well but the statement regarding the twin city is missing. Nevertheless, there are also increasing values for the twin cities, so that a general statement is difficult to establish.

- **Economy**

Considering the potential economic effects the changes in business registration are investigated. The data is mainly available after commissioning of the station. After opening, the data is available depending on the commissioning data respecting the current year 2010. All in all, the data is available per city with the constraints regarding Gottingen and the corresponding twin city. Figure 83 illustrates the growth rates for the available data.

				Commissioning								
	Year											
	-3	-2	-1	0 (1,7)	1(2,8)	2(3,9)	3(4,10)	4(5,11)	5(6,12)	6(7,13)	7(8,14)	8(15)
Gottingen*				1.000	1.153	1.119	1.056	1.052	0.999	1.034	1.237	1.147
Kassel*				1.000	1.059	1.006	1.027	0.959	0.986	1.033	1.206	1.221
Fulda*				1.000	0.977	1.049	0.973	1.023	0.797	1.024	1.194	1.076
Wolfsburg*				1.000	1.172	1.058	0.978	1.059				
Limburg a. d. Lahn	1.022	0.927	1.008	1.000	0.992	1.165	1.055	1.151	1.157	1.057		
Montabaur	1.116	1.019	1.053	1.000	1.094	1.217	1.195	1.130	1.032	1.067		
Paderborn*				1.000	1.044	0.984	0.972	0.906	0.949	1.047	1.337	1.245
Erfurt*				1.000	1.011	0.894	0.933	0.848	0.843	0.901	1.131	0.971
Giessen*				1.000	0.979	0.927	0.912	0.836	0.787	0.672	0.921	1.062
Salzgitter*				1.000	0.944	0.903	0.867	0.906				
Friedberg	1.250	1.094	1.087	1.000	1.275	1.395	1.366	1.514	1.431	1.236		
Bad Ems	1.093	1.009	1.031	1.000	1.040	1.238	1.228	1.169	1.082	1.077		

* The comparison of the cities starts 7 years after commissioning, except for Montabaur and Limburg (1 year).
* The data for Gottingen and the respective twin city is used at regional level.

Figure 83: Germany - Changes in economy - Number of business registrations at regional and city level (growth rates)
[Source: Own preparation and illustration using data from DESTATIS (2010)]

The data availability leads to a comparison of different groups with respect to the commissioning year. A complete analysis is not useful due to the data on hand. Therefore, a comparison of the cities respecting the twin cities is recommended but it is also possible to compare the cities having the same commissioning year by paying attention to the data level. Applying the correlation analysis the following values can be presented for the pairs: Gottingen / Paderborn 0.8*, Kassel / Erfurt 0.7*, Fulda / Giessen 0.3, Wolfsburg / Salzgitter 0.2, Limburg / Friedberg 0.8*, Montabaur / Bad Ems 0.9**. Comparing these results, a general contrasting correlation cannot be noted. But the outcomes shows for instance a different development in the case of Fulda and Wolfsburg. Here, a better development is assumed for the mentioned HSR cities.

- **Tourism**

The investigation of tourism generally considers several characteristics such as number of overnight stays as well as number of arrivals. Figure 84 shows the growth rates with respect to overnight stays. The data is generally well available at city level with the exception of Kassel and Erfurt where there is no data before commissioning of the station and another reference has to be chosen (+ 4 years). In addition, the data for Montabaur is only available at regional level (county). Therefore, the data is adapted for the twin city as well. Some data is missing at the end of the consideration due to the relationship between the opening of the station and the current date 2010.

				Commissioning								
	Year											
	-3	-2	-1	0 (4)	1 (5)	2 (6)	3 (7)	4 (8)	5 (9)	6 (10)	7 (11)	8 (12)
Gottingen	0.841	0.919	0.952	1.000	0.981	0.890	0.840	0.910	0.969	1.042	1.134	1.113
Kassel*				1.000	1.088	1.318	1.194	1.334	1.393	1.386	1.575	1.332
Fulda	0.766	0.727	0.877	1.000	0.974	1.006	1.023	0.961	0.921	0.930	0.962	1.015
Wolfsburg	0.643	0.781	0.914	1.000	1.048	1.328	1.236	1.509	1.834	1.628	1.426	1.535
Limburg a. d. Lahn	1.006	0.993	1.016	1.000	0.966	1.126	1.186	1.114	1.176	1.295	1.412	
Montabaur**	1.002	1.055	0.975	1.000	1.048	1.031	1.001	0.975	0.973	0.993		
Paderborn	0.835	0.948	0.923	1.000	0.988	0.975	1.009	1.028	1.008	1.016	1.177	1.279
Erfurt*				1.000	1.135	1.173	1.153	1.357	1.340	1.276	1.287	1.318
Giessen	0.774	0.841	0.997	1.000	0.924	0.839	0.705	0.710	0.675	0.703	0.699	0.770
Salzgitter	1.033	1.051	1.268	1.000	0.949	1.006	1.227	0.763	0.644	0.695	0.758	0.676
Friedberg	1.094	1.133	1.074	1.000	0.896	0.995	0.975	0.944	0.939	0.933	0.863	
Bad Ems**	1.008	1.079	1.078	1.000	0.974	0.977	0.966	0.969	1.009	1.013		

* The comparison of Kassel and Erfurt starts 4 years after commissioning.

** The data of Montabaur is used on regional level, the twin city correspondingly.

Figure 84: Germany - Changes in tourism - Number of overnight stays at city level (growth rates)
[Source: Own preparation and illustration using data from DESTATIS (2010)]

Due to some differences in the data base the analysis only focuses on the analysis of the city pairs. However, some other comparisons are useful considering the framework conditions of the data as well as the commissioning. Applying the correlation analysis the following values can be presented for the pairs: Gottingen / Paderborn 0.8*, Kassel / Erfurt 0.8**, Fulda / Giessen 0.4, Wolfsburg / Salzgitter -0.8*. As a result various differences can be determined. A different positive development in comparison to their twin cities can be noted for Fulda and especially for Wolfsburg. Here, a view of the development of the surrounding areas of the stations can help for understanding. In the case of Wolfsburg, a special entertainment area was built close to the station. Moreover, the customers can get their new car from the factory and mostly come one day beforehand by train.

Considering both Montabaur and Limburg on the line Frankfurt - Cologne the following correlations can be established concerning the years after implementing HSR: Montabaur / Bad Ems -0.4 and Limburg / Friedberg -0.5. As a result, negative coefficients in both cases are seen. The data for Montabaur is on hand at regional level but does not give a clear picture with respect to the twin region and for the whole period under consideration. Nevertheless, Limburg had a high increase in tourism after the opening of the station; also in contrast to the twin city.

Having analysed the overnight stays the same considerations are made for the number of arrivals. This implies that the absolute numbers of tourists arrived are analysed. Figure 85 shows the data in form of the growth rates in respect to the commissioning year. The restrictions are similar to the analysis of the number of overnight stays.

				Comissioning								
	Year											
	-3	-2	-1	0 (4)	1 (5)	2 (6)	3 (7)	4 (8)	5 (9)	6 (10)	7 (11)	8 (12)
Gottingen	0.792	0.873	0.971	1.000	0.921	0.852	0.791	0.843	0.885	0.965	1.051	1.012
Kassel*				1.000	1.058	1.351	1.175	1.308	1.399	1.365	1.557	1.343
Fulda	0.747	0.710	0.860	1.000	0.962	0.987	1.059	1.006	0.988	0.970	0.998	1.020
Wolfsburg	0.660	0.848	0.934	1.000	1.090	1.391	1.329	1.627	1.690	1.691	1.606	1.735
Limburg a. d. Lahn	1.004	1.007	0.991	1.000	0.962	1.166	1.189	1.151	1.197	1.288	1.268	
Montabaur**	0.980	1.030	0.938	1.000	1.061	1.111	1.139	1.141	1.153	1.174		
Paderborn	0.891	0.983	0.962	1.000	1.012	1.001	1.047	1.066	1.074	1.063	1.194	1.410
Erfurt*				1.000	1.163	1.209	1.199	1.423	1.396	1.333	1.346	1.376
Giessen	1.004	1.024	0.994	1.000	0.946	0.895	0.793	0.868	0.886	0.941	0.960	1.078
Salzgitter	1.136	1.089	1.109	1.000	0.923	1.078	1.202	1.041	0.991	1.040	1.106	0.989
Friedberg	0.912	0.993	1.074	1.000	0.889	0.955	0.981	0.928	0.890	0.802	0.772	
Bad Ems**	1.056	1.157	1.105	1.000	0.985	0.976	1.000	1.025	1.137	1.157		

* The comparison of Kassel and Erfurt starts 4 years after commissioning.

** The data of Montabaur is used on regional level, the twin city correspondingly.

Figure 85: Germany - Development of tourism - Number of arrivals at city level (growth rates)
[Source: Own preparation and illustration using data from DESTATIS (2010)]

The analysis of the arrivals deals with the same approach as for the number of overnight stays. Moreover, the data constraints are the same. Therefore, considering the first pairs the outcomes as demonstrated are as follows: Gottingen / Paderborn 0.5, Kassel / Erfurt 0.8*, Fulda / Giessen -0.3, Wolfsburg / Salzgitter 0.1. Here, Wolfsburg can be highlighted due to the big increase in comparison to the twin city once again. However, the changes in Wolfsburg as already explained are a reason in this case. In the case of Fulda a better development could be an explanation, although not the complete one. Moreover, the development in the case of Gottingen / Paderborn is not relevant for the HSR city. The coefficient for Montabaur / Bad Ems amounts to 0.6 and for Limburg / Friedberg -0.6. These figures show the strong increase of Limburg once again. But, this development was already ongoing before the HSR was introduced. This could be an indication that the area has a generally highly attractive touristic value without the influence of HSR. Montabaur also shows a higher development in comparison to the non HSR city.

- **Land Price**

The data for considering the change in land prices is available for different years and mostly on a regional level. So, the data can only be considered comparable for the city pairs as well as for the cities with the same commissioning date. Figure 86 presents the various developments with respect to the several reference points. In general, the data set shows more or less different changes in the data. In some cases, high differences between two cities are noted. Therefore, the data quality needs to be questioned in some cases.

				Commissioning								
	Year											
	-3	-2	-1	0 (4)	1 (5)	2 (6)	3 (7)	4 (8)	5(9)	6 (10)	7(11)	8 (12)
Gottingen*				1.000	0.993	1.037	1.208	1.307	1.122	1.072	1.447	1.405
Kassel*				1.000	1.995	2.223	2.451	2.110	1.692	1.481	1.415	1.466
Fulda*				1.000	0.918	0.979	1.284	1.370	1.347	1.484	1.609	1.570
Wolfsburg	1.509	1.035	1.122	1.000	1.351	0.896	1.172	1.198	1.043	1.433	1.558	1.471
Limburg a. d. Lahn	0.881	1.092	0.898	1.000	1.331	1.444	1.570	1.549	1.635	1.754		
Montabaur	0.760	0.771	0.967	1.000	0.930	0.943	1.183	1.224	1.134	0.970		
Paderborn*				1.000	1.575	0.660	1.556	1.610	1.663	2.457	3.511	4.565
Erfurt*				1.000	1.218	1.090	1.268	1.149	1.271	1.263	1.073	1.441
Giessen*				1.000	0.929	0.887	0.910	0.886	1.085	0.964	1.296	1.203
Salzgitter	0.888	0.834	0.726	1.000	0.723	1.343	1.499	1.509	1.234	1.119	1.246	0.468
Friedberg	0.793	1.047	1.222	1.000	0.883	1.514	0.894	1.133	1.177	1.429		
Bad Ems	0.843	0.842	0.764	1.000	0.902	1.041	0.991	1.162	1.149	1.097		

* The comparison starts 4 years after commissioning.
The data is available on regional level except for Kassel, Wolfsburg and the corresponding twin cities.

Figure 86: Germany - Changes in land prices - EUR / square meter at city and regional level (growth rates)
[Source: Own preparation and illustration using data from DESTATIS (2010)]

The following correlations can be mentioned for the cities illustrated above: Gottingen / Paderborn 0.7*, Kassel / Erfurt 0.2, Fulda / Giessen 0.7, Wolfsburg / Salzgitter -0.4. These results indicate a potential correlation for the available city data because an effect is assumed in the HSR city, especially in the surrounding area of the station. In the case of Wolfsburg the data shows an increase immediately following the implementation whereas for Kassel there is a difference extending over several years. In the case of HSR it can be assumed that an increase after implementation and a decrease or stabilisation several years later takes place. However, there are no obvious results.

The coefficients for Limburg and Montabaur (regional level) regarding a time series of six years after opening leads to the following results: Montabaur / Bad Ems 0.5 and Limburg / Friedberg 0.4. The decrease in Montabaur after opening could also be explained due to the release of new areas that were for instance previously for agricultural use. However, the data is only available at a regional level. For Limburg it could also be stated that prices are on a higher level but the results are not obvious.

- **Commuter**

As illustrated in Figure 87, the data for commuter traffic (inbound as well as outbound) in all cases is not available for the years before commissioning of the station. In addition, the data after the opening of the HSR stations is only available within the statistics after 1994, with the exception of Erfurt. This implies that the intervals between the first analyses and the opening date differ. Montabaur, Limburg as well as Wolfsburg and the respective twin cities are viewed in the general way after and before opening. The analysis approach is used equally for inbound and outbound commuting. The data is used at city level but is also available at regional level. Attention should be paid to the aggregation level because these values include all commuter independently from transport mode.

Commissioning

	Year											
	-3	-2	-1	0 (3, 6)	1(4, 7)	2(5, 8)	3(6, 9)	4(7, 10)	5(8, 11)	6(9, 12)	7(10, 13)	8(11, 14)
Gottingen*				1.000	1.008	1.040	1.019	1.021	1.041	1.052	1.074	1.062
Kassel*				1.000	0.997	1.003	1.010	1.021	1.029	1.018	0.999	0.986
Fulda*				1.000	0.977	1.001	0.975	0.971	0.978	0.997	1.015	1.021
Wolfsburg	0.910	0.908	0.925	1.000	1.089	1.198	1.255	1.237	1.348	1.394	1.338	1.338
Limburg a. d. Lahn	1.017	1.027	1.029	1.000	1.001	1.013	1.017	1.053	1.093	1.133	1.124	
Montabaur	0.858	0.897	0.956	1.000	1.009	1.029	1.036	1.069	1.131	1.193	1.193	
Paderborn*				1.000	1.010	1.024	1.059	1.114	1.183	1.240	1.295	1.281
Erfurt*				1.000	1.030	1.039	1.052	1.042	1.042	1.020	1.013	0.966
Giessen*				1.000	0.985	0.994	0.988	0.974	0.976	0.994	1.020	0.983
Salzgitter	0.934	0.889	0.897	1.000	0.988	1.015	1.014	1.029	1.035	1.013	1.016	1.031
Friedberg	0.941	1.195	1.009	1.000	0.984	0.976	0.965	1.032	1.115	1.199	1.265	
Bad Ems	0.913	0.915	0.966	1.000	0.978	0.971	0.979	1.028	1.053	1.079	1.130	

* The comparison starts 3 years after commissioning for Gottingen and Fulda as well as 6 years after commissioning for Kassel.

Figure 87: Germany - Development of the commuter traffic - Number of commuters inbound at city level (growth rates)
[Source: Own preparation and illustration using data from DESTATIS (2010)]

A first quick review of the data leads to the assumption that all the numbers increased more or less (approximately constant) within these time periods, city groups and city pairs. However, the extent of the growth rates differ although there is no visible difference with regard to the distance to the opening year . This impression can be confirmed by analysing the correlations as follows: Gottingen / Paderborn 0.9**, Kassel / Erfurt 0.7*, Fulda / Giessen 0.6, Wolfsburg / Salzgitter 0.7* including separate reference in comparison to the cities before. In the case of the cities on the line Cologne - Frankfurt the values are ascertained as follows: Montabaur / Bad Ems 0.9**, Limburg / Friedberg 0.9**. All in all, a general development in the same direction can be stated and no obvious pro's for HSR are highlighted. Nonetheless, Fulda could be mentioned as one potential example for a better development in comparison to the twin city. Similar results are expected in the next part analysing the outbound commuter traffic.

In the case of outbound commuters the same approach is used as before. Figure 88 shows the development of the (outbound) commuter traffic.

Commissioning

	Year											
	-3	-2	-1	0 (3, 6)	1(4, 7)	2(5, 8)	3(6, 9)	4(7, 10)	5(8, 11)	6(9, 12)	7(10, 13)	8(11, 14)
Gottingen*				1.000	1.056	1.048	1.084	1.102	1.229	1.328	1.284	1.265
Kassel*				1.000	1.012	1.084	1.141	1.152	1.117	1.087	1.082	1.073
Fulda*				1.000	1.058	1.095	1.136	1.207	1.304	1.376	1.420	1.388
Wolfsburg	0.977	0.955	0.963	1.000	0.965	1.021	1.066	1.106	1.127	1.083	1.100	1.075
Limburg a. d. Lahn	0.937	0.978	0.977	1.000	0.993	0.982	0.979	0.989	0.997	1.006	1.021	
Montabaur	0.986	1.022	1.003	1.000	0.977	0.978	0.978	0.978	1.000	1.022	1.031	
Paderborn*				1.000	1.077	1.116	1.121	1.162	1.234	1.302	1.317	1.295
Erfurt*				1.000	1.097	1.135	1.180	1.214	1.188	1.186	1.214	1.232
Giessen*				1.000	1.046	1.055	1.117	1.163	1.291	1.374	1.406	1.420
Salzgitter	0.998	1.008	1.008	1.000	1.038	1.079	1.074	1.068	1.062	1.055	1.047	1.036
Friedberg	0.974	0.912	0.998	1.000	0.988	0.976	0.985	0.998	0.996	0.994	0.997	
Bad Ems	0.972	1.010	1.006	1.000	0.994	0.988	0.980	0.970	0.998	1.026	1.015	

* The comparison starts 3 years after commissioning for Gottingen and Fulda as well as 6 years after commissioning for Kassel.

Figure 88: Germany - Development of the commuter traffic - Number of commuters outbound at city level (growth rates)
[Source: Own preparation and illustration using data from DESTATIS (2010)]

The results in the case of outbound commuters are provided as follows: Gottingen / Paderborn 0.9**, Kassel / Erfurt 0.8*, Fulda / Giessen 1.0**, Wolfsburg / Salzgitter 0.4, Montabaur / Bad Ems 0.9**, Limburg / Friedberg 0.7. In general, a similar development can be indicated with the exception of Wolfsburg / Salzgitter. However, an obvious statement could not be made.

Principal Component Analysis and Regression Analysis

In the case of Germany, mainly all the designated cities will be used for the further investigation in this part. Some changes will be made depending on the investigated impacts. However, the considered impacts need to be reduced based on the framework conditions and results during the first part of the study. All in all, the following potential impacts are involved in this investigation:

- **Population**
- **Tourism**

Due to the often mentioned unavailability of data depending on the countries, the considered location factors could not be used as mentioned. However, the following characteristics are part of the investigation in the case of Germany: travelling time and distance to reference city, number of inhabitants, inhabitants per square kilometre, development in surrounding areas and especially for HSR, number of trains per day, station location, availability of international connections as well as the consideration of the network position. The binary characteristics are used only for the regression analysis in combination with the metric scaled ones as mentioned above. Nevertheless, the economic strength through the use of GDP is not considered here because of the data situation.

Because of the different data bases (e.g. number of applicable cities) in the case of both population and tourism, the general correlations between for example distance and travelling time give varying values. In detail, the sample sizes differ. This will also be considered in the first comparison using dependencies between the location factors which also seem to be a cause. The following overview shows the results for both the population and the tourism.

Sample including HSR and non HSR

- Travelling time and distance to a reference city (0.7** (population), 0.6 (tourism))
- Number of inhabitants per city and number of inhabitants per square kilometre (0.5 (population))
- Number of inhabitants per city and distance to a reference city (0.7* (tourism))

Sample including HSR only

- Distance to a reference city and the number of inhabitants per city (0.8 (tourism))
- Distance to a reference city and the number of trains per day (0.8 (population) 0.8 (tourism))
- Number of inhabitants and inhabitants per square kilometre (0.8 (population))
- Number of trains per day in comparison to the number of inhabitants and inhabitants per square kilometre (0.6, 0.6)

- **Population**

The data base for the population could be rated as suitable and all cities will be included in the analysis. After analysing the correlation between the location factors themselves, the correlations will be determined in comparison with the considered impacts for preparing the analysis methods. The comparison using correlations shows the following general potential dependencies which seem to be causal as well:

Sample including HSR and non HSR

- Growth rates in population three and six years after commissioning (0.8**)
- Growth rates in population three years after commissioning and distance to the next reference city (0.6*)
- Growth rates in population three years after commissioning and number of inhabitants per city (0.5)

Sample including HSR

- Growth rates in population three and six years after commissioning (0.8)
- Growth rates in population three years after commissioning and travelling time as well as number of trains per day (0.8*, 0.9*)
- Growth rates in population six years after commissioning and travelling time as well as number of trains per day (0.7, 0.8)

It is quite interesting in this case, that the most dependencies exist for the change three years after implementing HSR and not later. Therefore, a HSR implementation would only bring a short-term effect due to an innovation for example but also without remaining at this new level for the following years. However, the sample is too small for a detailed statement.

Principal Component Analysis

After discussing the correlations between the location factors described, the relevant characteristics are applied. On one hand a factor including the changes of population as determined thus far for each consideration and on the other hand a factor containing number of inhabitants with inhabitants per square kilometre as well as travelling time and distance is conceivable. When applying these assumptions the “best” interpretation of the PCA is attained by using the factor 1 including changes in population plus 3 and plus 6 years and factor 2 including the number of inhabitants per city once again. Here, the MSA only amounts to 0.5. Nevertheless, this result should be illustrated as presented in the following charts (Figure 89) because results for further discussions should be illustrated.

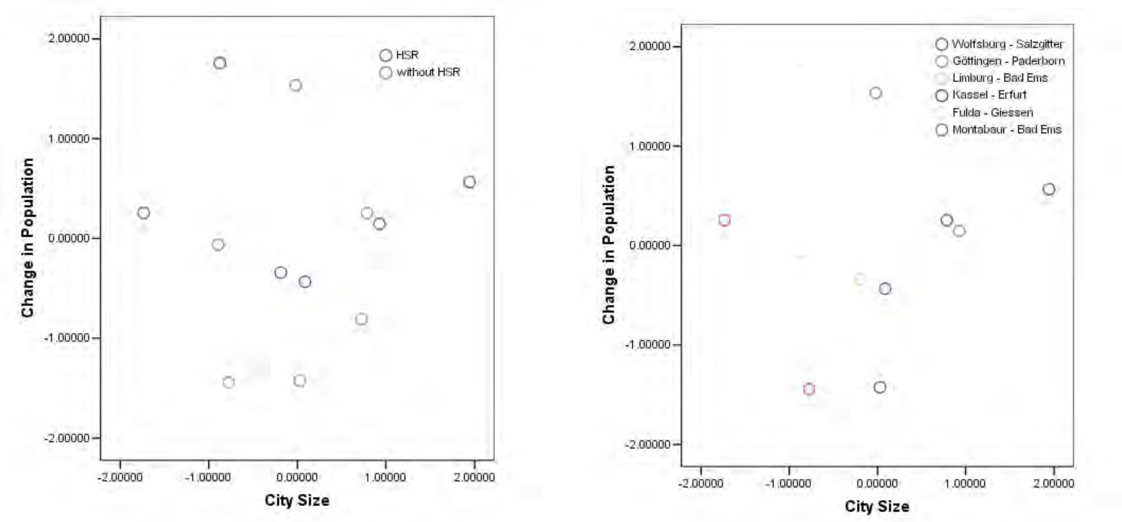


Figure 89: Germany - PCA - Changes in population
[Source: Own illustration and preparation using data from DESTATIS (2010)]

As a first description of the result it can be noted that most of cities are located around the average changes in population with a higher number of HSR cities than non HSR cities. At the bottom of the scale of changes in population are mostly situated twin cities. The comparison of the city pairs confirms this assumption because mostly a higher increase in population is indicated for the HSR cities. Finally, a special general pattern taking into account the city size is not apparent using this sample size and the available data. All this could also be explained by the really small MSA which does not lead to a better interpretation. This could also be stated considering the MSA of approximately 0.5.

When applying the sample for HSR only, the most suitable and interpretable result can be obtained by using factor 1 changes in population as before and factor 2 including the distance to a reference city. The MSA amounts to 0.7 in this case which implies a middling result. The following Figure 90 illustrates this result. Most of the HSR cities are located below the average change in population except for Kassel and Fulda. Whereby, Fulda must be pointed out as here the change in population is highly over the average. This must be taken into consideration here, because it influences the illustration. In contrast, there is Wolfsburg at the bottom of the change in population (under the average). Nevertheless, a responsibility of the distance influencing the changes in population cannot be identified in the diagram.

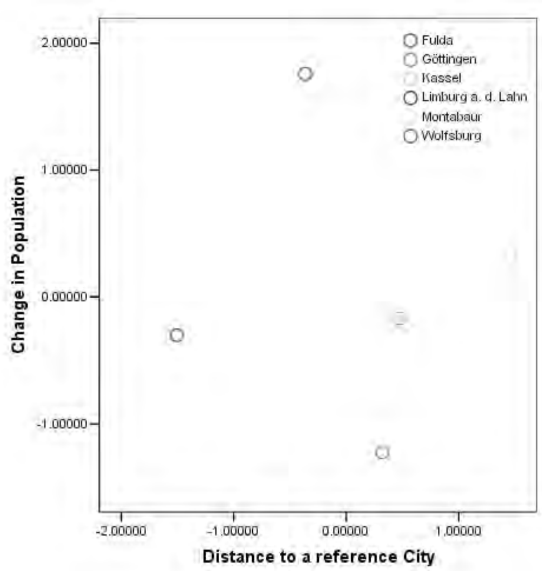


Figure 90: Germany - PCA - Changes in population
[Source: Own illustration and preparation using data from DESTATIS (2010) and www.google.de]

Regression Analysis

The application of the regression analysis in the case of overall sample leads to several possibilities for performing a multivariate analysis with the preselected location factors. In the case of changes in population three years after commissioning the only significant result (on a 0.05 level) for the explanation of the changes concerns the distance to a reference city. However, the standard error of the coefficient is approximately 30 %, which does not seem to be acceptable. Altogether, only 40 % (R square) of the variance could be explained by using this result. In general, the predicted coefficient is positive and so the same development direction is assumed for both of the characteristics used.

In seeking to explain the changes six years after implementation other results are obtained because the distance to a reference city here is not significant on a level of 0.05. However, further compositions of location factors in the regression analysis do not lead to any useful results. Nevertheless, there are indications for the development in the surrounding areas of the stations as well as the travelling time to a reference city.

In a next analysis the factor population, which was previously prepared in the PCA, is used. Here, three variables - travelling time, inhabitants per square kilometre and distance to a reference city - could be chosen for preparing a regression equation with three variables from the indications. However, the results are not significant and not useful on a requested quality level.

Considering the HSR only, significant characteristics could not be stated at all. However, there are significant results on a 0.05 level in the case of the number of trains per day for explaining separately the changes in population three and six years after implementing HSR. Here, approximately 70 % of the variances in changes in population could be explained by the number of trains per day in the case of plus three years (significance level of 0.05) and 60 % in the case of plus six years (significance level of 0.1) after commissioning. The coefficients are predicted as being positive. Attention should be paid to the fact that the current number of trains is applied and the changes are in the past in respective to the opening. One more point is that the relationship is the same over the years independent of the absolute number of trains per day.

- **Tourism**

In the case of tourism, both the number of arrivals as well the number of overnight stays are applied as explained above. The two types of characteristics - overnight stays and arrivals will be analysed in a comparison and in a separate way. The HSR cities Kassel and Montabaur as well as their respective twin cities will be removed for the overall analysis because the data is not comparable to the other cities. All in all, eight cities are used for the investigation; cities and twin cities. The sample size is the same for the whole analysis - no special consideration is made depending on the characteristic. The first comparison based on correlations indicates general potential dependencies as follows, separated by the two measurements of the impact tourism:

Sample including HSR and non HSR

Overnight Stays

- Growth rates in tourism three years after commissioning and number of inhabitants per square kilometre (-0.7*)

Arrivals

- Growth rates in tourism three years after commissioning and number of inhabitants per square kilometre (-0.8*)

In addition, it is stated that there is a correlation between the changes in arrivals and the number of overnight stays, as expected. Therefore, a mixed factor for analyses could be reasonable. The coefficient is higher than 0.8.

Sample including HSR only

Overnight Stays

- Growth rates in tourism three years after commissioning and number of inhabitants per square kilometre (-0.7)
- Growth rates in tourism three years after commissioning and distance to a reference city (-0.6)
- Growth rates in tourism six years after commissioning and travelling time (-0.7-0.8)
- Growth rates three and six years after commissioning and the number of trains per day (-0.9, -0.9)

Arrivals

- Growth rates in tourism three years after commissioning and number of inhabitants per square kilometre (-0.7)
- Growth rates in tourism three as well as six years after commissioning and distance to a reference city (-0.7, -0.9)
- Growth rates three and six years after commissioning and the number of trains per day (-0.8, -0.9)

In addition it is also pointed out that there is a correlation between the changes in arrivals and the number of overnight stays, as expected. A mixed factor for analyses is useful. The coefficient is higher than 0.8.

The illustrated correlation overview leads to the result that some dependencies can be expected but there is mainly not a significant correlation on requested levels. Therefore, this should be kept in mind for the next analyses. Nevertheless, the focus on HSR will not be continued here due to the small sample size and the first, mostly not significant, results.

Principal Component Analysis

Firstly, the number of overnight stays for tourists is tested for the overall sample. However, there is not a final reasonable and interpretable result in this case. Nevertheless, indications with respect to a separation by using for example population density could be identified. This analysis however, does not reach the defined and applied quality measurements. A similar consideration can be made by applying the arrivals instead of overnight stays. Here, a result with respect to the set quality measurements could likewise not be attained.

A further separation is made for the total consideration of the tourism (overnight and arrivals). However, the MSA also denotes less than 0.5 or slightly higher. An interpretation of the factors does not lead to reasonable results. Therefore, useful results for the changes in tourism could not be prepared using the PCA and the overall data sample including HSR and non HSR.

Regression Analysis

In running the regression analysis for tourism, all the considered location factors are included as previously. The regression will be estimated for the changes in overnight stays (plus three and six years) and the number of arrivals (plus three and six years). A consideration of a factor using the several characteristics of arrivals and overnight stays is not indicated due to the results within the PCA above. In running the regression analysis for tourism, all the considered location factors are included as previously.

Firstly, the regression is applied for the overnight stays, especially three years after commissioning. Here, a reasonable result is determined by using the inhabitants per square kilometre. The result is significant on a level of 0.05. The coefficient is negatively predicted, which implies for example that a small population density leads to a higher increase in the number of overnight stays. R square amounts to 0.6. This overall result needs to be considered whilst taking into account the small sample size. Hence, cities such as Limburg or Wolfsburg could influence the results more than expected due to the high changes in tourism and the relatively small population density. Focussing on the change in overnight stays six years after implementing of HSR does not lead to similar results. Moreover, significant coefficients could not be determined for describing the variances of the change in overnight stays six years after commissioning of the HSR.

In a last step analysing the tourism the number of arrivals are taken into account. Firstly, the changes three years after implementation are considered. Here, the population density is significant on a level of 0.05 once again as already applied for the changes in overnight stays three years after commissioning. The dependency is likewise negative. R square amounts to 0.6. In this case an influence is also assumed from the cities Limburg and Wolfsburg as mentioned above. Finally, the changes in arrivals six years later is tested. In doing so, a similar result to the changes in overnight stays is obtained here. This means, there are no significant estimations for explaining the variances in the change in arrivals six years after commissioning.

5.3.3 Italy

Data Base and applied Impact

The data availability as well as quality is good in the case of Italy but the data is not available for all needed potential benefits of HSR. Nevertheless, where the data is available for an investigated impact it covers nearly all the needed years in the considered time series. The data presented is based on information from the national statistic office (ISTAT) as well as the regional offices, in respect to the provinces responsible. Moreover, some additional sources have been taken into consideration. In summary, the following impacts will be included in the quantitative analysis:

- Population
- GDP
- Unemployment
- Students
- Tourism

The analysis of Italy consists of four cities (two HSR cities and two non HSR cities). Due to the relevant gap of the commissioning dates for both HSR cities and some data gaps in the past the overall data sample cannot be used for a total analysis. Therefore, the cities must mainly be analysed separately in comparison to their twin cities (fourth best approach), although a small part of the data is comparable in some cases. In the analysis of Italy it should also be taken into consideration that the HSL has been opened in several steps. Hence, cities could have a connection to HSR before the commissioning of the complete line. In this context, the commissioning date refers to the assumed date with regard to the finalisation of the total planned HSL.

Time Series and Correlation Analysis

- **Population**

In the case of population, the number of inhabitants is generally available for the years between 1982 and 2009 on a city level, so that in this case a small range regarding comparable data could be applied as seen in the Figure 91 (one year after opening). Nevertheless, the current analysis concentrates on the comparison of the cities and their twin cities, due to the huge gap between the opening dates and the small number of selected cities for the total analysis.

	Commisioning Year											
	-3	-2	-1	0	1	2	3	4	5	6	7	8
Florence	1.033	1.023	1.012	1.000	0.978	0.972	0.957	0.939	0.933	0.920	0.916	0.900
Bologna	1.006	1.004	1.002	1.000	1.007							
Venice	1.034	1.022	1.010	1.000	0.985	0.971	0.958	0.946	0.939	0.932	0.923	0.917
Bari	1.018	1.014	1.008	1.000	0.994							

Figure 91: Italy - Changes in population - Number of inhabitants at city level (growth rates) [Source: Own preparation and illustration using data from ISTAT (2010)]

The data shows a general decrease of the population before and after commissioning of the station. One exception which must be mentioned is the case of Bologna where the population increased in 2009. In addition, the decrease of inhabitants in Florence is higher than in Venice (twin city), except in year eight. The correlation coefficient amounts to 0.9** (zero to eight years after commissioning) for this city pair. This implies that both cities generally developed in the same way between 1991 and 1999. For Bologna a better development is assumed when considering only one year after opening. Furthermore, this development is also against the trend up to opening the station. Nevertheless, further data needs to be collected and analysed.

- **Gross Domestic Product (GDP)**

In general, the data for the GDP - here especially the GDP per capita - is available between 1995 and 2009 for all the considered cities without data gaps. As mentioned for all cities in Italy, a comparison is only applied for the cities as well as the twin cities. The Figure 92 presents the final data basis and the growth rates for the GDP per capita at city level. However, the comparison of Florence and Venice starts four years after the commissioning due to the data availability.

				Commissioning								
	Year											
	-3	-2	-1	0 (4)	1 (5)	2 (6)	3 (7)	4 (8)	5 (9)	6 (10)	7 (11)	8 (12)
Florence*				1.000	1.064	1.112	1.155	1.196	1.280	1.378	1.416	1.500
Bologna	0.858	0.884	0.898	1.000	0.964							
Venice*				1.000	1.067	1.110	1.154	1.182	1.237	1.347	1.411	1.385
Bari	0.872	0.958	0.993	1.000	0.931							

* The comparison starts 4 years after commissioning in the case of Florence and Venice.

Figure 92: Italy - Changes in GDP - GDP per capita at city level (growth rates)
[Source: Own preparation and illustration using data from Italian Chamber of Commerce (2010)]

The illustration above shows that the city pairs developed in the same direction before and after the opening of the HSR. The decrease after implementation in the case of the city pair Bologna / Bari could be considered as an outcome of the economic crisis. The correlation coefficient for Florence and Venice is indicated as 0.9** (4 to 12 years after commissioning). In summary, no obvious statements can be made in this analysis.

- **Unemployment**

The values for unemployment are also available at a city level. However, the data is available between 1993 and 2009 as a percentage rate only. Figure 93 shows the growth rates for the considered cities depending on the available data base. In the case of Florence and Venice a gap between the opening year and the first year with available data is used again.

				Commissioning								
	Year											
	-3	-2	-1	0 (2)	1 (3)	2 (4)	3 (5)	4 (6)	5 (7)	6 (8)	7 (9)	8 (10)
Florence*				1.000	1.085	1.070	1.014	1.028	0.986	0.915	0.761	0.606
Bologna	0.844	0.906	0.906	1.000	1.500							
Venice*				1.000	1.156	1.047	1.031	0.984	0.953	0.891	0.750	0.719
Bari	1.164	1.147	0.966	1.000	1.086							

* The comparison starts 2 years after commissioning in the case of Florence and Venice.

Figure 93: Italy - Changes in unemployment - Rate at city level (growth rates)
[Source: Own preparation and illustration using data from ISTAT (2010)]

With regard to the table illustrating the growth rates, a similar and different development is shown by comparing the city pairs. In the case of Bologna, the rate increased before and after the commissioning date. In contrast, Bari had a decrease in unemployment as well as an increase after opening. On the whole, Bari has a higher unemployment rate than Bologna. Comparing Florence and Venice the unemployment generally decreased in the considered time period after opening the complete HSL. The correlation coefficient for Florence and Venice can be denoted as 0.9** which indicates the same development. A further comparison up to 2009 showed a similar development for both cities.

- **Students**

The data considering the impact in the number of students has been collected for the years 1998 to 2009. The data includes the number of students per city. The sample, including the growth rates, is summarised in Figure 94. Due to the data availability Florence and Venice must be considered by applying a gap in the years after opening.

				Commissioning								
	Year											
	-3	-2	-1	0 (7)	1 (8)	2 (9)	3 (10)	4 (11)	5 (12)	6 (13)	7 (14)	8 (15)
Florence*				1.000	0.999	0.977	1.024	1.035	1.072	1.073	1.044	1.046
Bologna	1.112	1.071	1.041	1.000	0.986							
Venice*				1.000	0.952	0.925	0.919	0.859	0.869	0.846	0.827	0.832
Bari	0.969	0.878	0.964	1.000	0.977							

* The comparison starts 7 years after commissioning in the case of Florence and Venice.

Figure 94: Italy - Development of students - Number of students at city level (growth rates)
[Source: Own preparation and illustration using data from Italian Ministry of Education, Universities and Research (2010)]

Analysing the first city pair - Bologna / Bari - a similar decreasing development is noted, although the figures for Bari show more fluctuation. The times series of the second pair differs in increasing and decreasing. On one hand the number of students increased for Florence and on the other hand decreased for Venice in the considered time period (15 year after commissioning). The respective correlation coefficient is negative and amounts to -0.7* considering seven up to fourteen years after commissioning. The means a contrary development could be assumed.

- **Tourism**

The data for tourism - especially the number of overnight stays - is available between 1996 and 2008 but only at a regional level (province) which also leads to adaptations comparing Florence and Venice. The Figure 95 shows the modified data base.

				Commissioning								
	Year											
	-3	-2	-1	0 (5)	1 (6)	2 (7)	3 (8)	4 (9)	5 (10)	6 (11)	7 (12)	8 (13)
Florence*				1.000	0.968	1.030	1.089	1.187	1.197	1.143	1.080	1.119
Bologna	1.052	1.030	0.974	1.000								
Venice*				1.000	0.983	1.006	1.021	1.037	1.087	1.049	1.039	1.037
Bari	1.003	0.956	0.961	1.000								

* The comparison starts 5 years after commissioning in the case of Florence and Venice.

Figure 95: Italy - Development of the overnight stays - Number of stays at a regional level (growth rates)
[Source: Own preparation and illustration using data from ISTAT, regional office (2010)]

Having illustrated the growth rates for the overnight stays, the changes are very similar with regard to the pair Bologna / Bari. As can be seen, the number of overnight stays decreased between 2005 and 2008, except for a small decrease in 2008 for both. The comparison of Florence and Venice shows a similar development. This is also evident in the correlation coefficient that is calculated as 0.9**. The comparison has also taken into account the special role of Venice as a tourist city.

Principal Component and Regression Analysis

Due to the small sample and the big gap between the commissioning dates of the cities a further detailed analysis is neither reasonable nor feasible. In detail, the sample size is too small for the applied statistical methods. Moreover, the development is equal in the cities except for the number of students in one case. Nonetheless, one city pair Florence / Venice is selected for the transnational data sample below concerning the effects on population.

5.3.4 Japan

Data Base and applied Impacts

In comparison to other countries, Japan has a good data basis for the quantitative approach but various data is also missing. The data for the six HSR cities and the six twin cities is provided by the national statistical office and is available in the internet. However, some data is not available for each year and sometimes there is no complete time series on hand. Moreover, some data, e. g. GDP is only available for the prefecture and therefore not at a city level as needed. Here, solutions for the individual cases will be explained later. All in all, the following six potential impacts of HSR can be taken into account:

- Population
- GDP
- Unemployment
- Students
- Economy
- Commuter

In many investigated cases overall comparable data bases can be prepared. This means that a comparison of the data between the cities can be made - e.g. the growth rates have the same distance to the commissioning dates. Therefore, analyses besides the city pair comparison are also possible. However, Mishima and the twin city have to be mostly considered separately due to the very early opening date.

Time Series and Correlation Analyses

Population

The data set for population is one that has not data for each year in this part but for every five years starting in 1980 although at city level as required. Therefore, the data for the interim gap is interpolated. Nevertheless, this assumption needs to be noted within the final interpretation of the results, because this has an impact on the correlation coefficient due to similar developments between the given years. Therefore, high correlation coefficients are expected. Using this interpolation, the time series from 1980 to 2010 is completely at hand. Figure 96 illustrates the main part of the data base for analysing the impact of population.

				Commissioning								
	Year											
	-3	-2	-1	0 (11)	1 (12)	2 (13)	3 (14)	4 (15)	5 (16)	6 (17)	7 (18)	8 (19)
Mishima*				1.000	1.011	1.021	1.032	1.042	1.053	1.065	1.077	1.090
Koriyama		0.983	0.992	1.000	1.008	1.017	1.025	1.034	1.043	1.051	1.060	1.069
Kitakami		0.981	0.991	1.000	1.009	1.019	1.028	1.035	1.041	1.048	1.055	1.062
Kakegawa	0.971	0.980	0.990	1.000	1.010	1.020	1.029	1.039	1.048	1.058	1.068	1.076
Karuizawa	0.980	0.979	0.989	1.000	1.011	1.021	1.032	1.044	1.057	1.069	1.081	1.093
Saku	0.987	0.991	0.996	1.000	1.004	1.009	1.013	1.014	1.015	1.016	1.017	1.018
Komatsu*				1.000	1.003	1.007	1.010	1.013	1.016	1.016	1.017	1.017
Aomori		0.992	0.996	1.000	1.004	1.008	1.012	1.007	1.003	0.998	0.993	0.989
Yokote		1.005	1.002	1.000	0.998	0.995	0.993	0.987	0.982	0.976	0.971	0.965
Handa	0.959	0.972	0.986	1.000	1.014	1.028	1.042	1.056	1.070	1.085	1.099	1.108
Hakui	1.022	1.015	1.007	1.000	0.993	0.985	0.978	0.970	0.962	0.954	0.947	0.939
Shibata	0.998	1.002	1.001	1.000	0.999	0.998	0.997	0.994	0.992	0.989	0.987	0.984

* The comparison of Mishima and Komatsu starts 11 years after commissioning.
The data between the available years is interpolated.

Figure 96: Japan - Changes in population - Number of inhabitants at city level (growth rates)
[Source: Own preparation and illustration using data from Japan Statistical Office (2010)]

A comparison of the growth rates after starting HSR leads to different results. On one hand differences in the development are visible and on the other hand the same development for the city pairs concerning the eight years after HSR is observed. Having analysed the group of HSR cities, a general positive development for all cities can be mentioned. This implies, the correlation coefficient is higher than 0.9* and overall positive. The same consideration regarding the non HSR cities does not lead to similar results. In fact, the analysis mainly shows a decrease in population but there are also cities with an increase in population within the considered time period. An analysis including further years of the time period leads to similar results. These analyses do not include the cities of Mishima and Komatsu because of the variances in reference years.

Comparing the city pairs the following correlation coefficients can be presented: Kakegawa / Handa 1.0**, Saku / Shibata -0.9**, Karuizawa / Hakui -1.0**, Koriyama / Aomori -0.7** and Kitakami / Yokote -0.9. The figures show that three out of four pairs had a separate development within eight years after starting HSR. Therefore, the HSR cities developed better than the non HSR cities. Comparing Mishima and Komatsu leads to the correlation coefficient of 0.9** keeping the varying time period in mind. Both Mishima and Komatsu had an increase in population and therefore no differences are assumed.

An analysis of the years before starting HSR mainly leads to the statement that the HSR cities also increased before the start-up. However, the development of the non HSR cities is not at all equivalent. A general pattern is not verifiable.

- **Gross Domestic Product (GDP)**

In general, the data for proving the changes in GDP is available for the years between 1996 and 2006 for all the considered cities without data gaps but only on a regional level (Prefecture). Due to the objective of comparable results (commissioning dates of the stations) the applied data base is reduced. Moreover, the illustration Figure 97 only accepts a comparison of the cities / twin cities with the same opening date, which is illustrated by the different distances to the commissioning date. The regional data of some cities is applied with the same data because they are located in the same Prefecture.

				Commissioning								
	Year											
	-3	-2	-1	0 (27, 14, 8)	1 (28, 15, 9)	2 (29,16,10)	3 (30, 17,11)	4 (31,18,12)	5 (32,19,13)	6 (33,20,14)	7 (34,21,15)	8 (35, 22,16)
Mishima*				1.000	1.005	1.001	0.989	1.041	0.989	1.012	1.007	1.011
Koriyama*				1.000	1.002	0.988	0.983	0.995	0.955	0.939	0.920	0.946
Kitakami*				1.000	0.998	1.000	1.007	1.028	0.961	0.956	0.949	0.954
Kakegawa*				1.000	1.005	1.001	0.989	1.041	0.989	1.012	1.007	1.011
Karuizawa			0.999	1.000	0.987	0.992	1.027	0.969	0.937	0.933	0.931	0.954
Saku			0.999	1.000	0.987	0.992	1.027	0.969	0.937	0.933	0.931	0.954
Komatsu*				1.000	0.996	1.003	1.009	1.012	0.987	0.973	0.961	0.961
Aomori*				1.000	0.983	0.983	0.985	0.998	0.974	0.953	0.945	0.929
Yokote*				1.000	0.992	0.988	0.978	0.969	0.954	0.934	0.926	0.921
Handa*				1.000	0.983	0.979	0.970	0.965	0.965	0.982	0.979	1.002
Hakui			1.004	1.000	1.007	1.013	1.016	0.991	0.978	0.965	0.966	0.978
Shibata			1.003	1.000	1.005	0.979	0.982	0.959	0.941	0.937	0.944	0.954

* The comparison of Mishima and Komatsu starts 27 years after commissioning, Koriyama, Kitakami, Aomoiri and Yokote 14 years, Kakegawa and Handa 8 years.

Figure 97: Japan - Changes in GDP - Regional level (growth rates)
[Source: Own preparation and illustration using data from Japan Statistical Office (2010)]

In general, the table above shows increasing and decreasing values in the considered time periods. Due to the late availability of data and the different opening dates, the following analysis only focuses on the comparison of the city pairs only because of the same data base. The following correlation coefficients can be presented for the development of GDP: Kakegawa / Handa 1.0**, Saku / Shibata 0.9**, Mishima / Komatsu 0.1 ,Karuizawa / Hakui 0.9**, Koriyama

/ Aomori 0.7, Kitakami / Yokote 0.8* and Mishima / Komatsu -0.2. As a result of the mainly positive coefficients a similar development is assumed for both the HSR and non HSR cities, although, some results are not significant and longer time series need to be used, for example in the case of Mishima / Komatsu. An extension of the years under consideration, where possible, leads to a similar result. The only difference in a positive way for HSR cities is indicated for Mishima. However, the data are on a regional level, which could be a problem for obtaining final statements.

- **Unemployment**

The unemployment in the considered cities and regions is investigated by using the number of unemployed persons. Here, the data is available for the years between 1980 and 2005 at the requested city level. However, the data is not available for each year and therefore the gaps are closed by applying interpolations. This needs to be taken into account during the analysis, especially regarding the correlation coefficient which attempts to determine a linear correlation. Moreover, the issues in interpreting the results due to the absolute figures for unemployment have also to be considered. Figure 98 presents the data base for the next investigation steps.

				Commissioning								
	Year											
	-3	-2	-1	0 (11)	1 (12)	2 (13)	3 (14)	4 (15)	5 (16)	6 (17)	7 (18)	8 (19)
Mishima*				1.000	1.044	1.089	1.133	1.178	1.545	1.589	1.634	1.678
Koriyama		0.974	0.987	1.000	1.013	1.026	1.394	1.407	1.420	1.433	1.446	1.207
Kitakami		0.899	0.949	1.000	1.051	1.101	1.431	1.482	1.532	1.583	1.633	1.202
Kakegawa	0.877	0.918	0.959	1.000	1.041	0.920	0.961	1.002	1.043	1.084	1.471	1.512
Karuizawa	1.018	0.715	0.858	1.000	1.142	1.285	0.814	0.956	1.099	1.241	1.383	1.310
Saku	0.725	0.940	0.970	1.000	1.030	1.060	1.300	1.330	1.360	1.390	1.420	1.923
Komatsu*				1.000	1.052	1.103	1.155	1.207	1.349	1.401	1.453	1.504
Aomori		0.983	0.992	1.000	1.008	1.017	1.611	1.620	1.628	1.636	1.645	1.371
Yokote		0.912	0.956	1.000	1.044	1.088	1.305	1.349	1.393	1.437	1.481	1.153
Handa	0.900	0.934	0.967	1.000	1.033	1.049	1.082	1.115	1.148	1.181	1.679	1.712
Hakui	0.869	0.842	0.921	1.000	1.079	1.158	0.951	1.030	1.109	1.188	1.267	1.347
Shibata	0.833	0.948	0.974	1.000	1.026	1.052	1.314	1.340	1.366	1.392	1.419	1.652

* The comparison of Mishima and Komatsu starts 11 years after commissioning.
The data between the available years is interpolated.

Figure 98: Japan - Changes in unemployment - Number of unemployed persons at city level (growth rates)
[Source: Own preparation and illustration using data from Japan Statistical Office (2010)]

The analysis is generally based on the same data structure and period to the opening year, except in the case of Mishima and its twin city. Therefore, the analysis deals with two parts, Mishima / Komatsu and the remainder. A comparison of the HSR cities eight years after the commissioning leads to more or less similar results, since the number of unemployed persons increased except for some occasional variances. In summary, the pairs developed in the same positive way based on the year 0 (11) to 8 (19). However, there are differences within the HSR group as well as the non HSR group.

All in all, the detailed comparison of the city pairs confirms the first impression: Koriyama / Aomori 1.0**, Kitakami / Yokote 1.0**, Kakegawa / Handa 1.0**, Karuizawa / Hakui 0.9**, Saku / Shibata 1.0**. The coefficient for Mishima / Komatsu amounts to 1.0**. Comparing all the results a difference between the cities and twin cities cannot be assumed. Actually, the results for the city / twin city correlation amounts to highly positive significant results, also due to the interpolation. Similar results will be generated by using an extended time series if available. For example a comparison of the growth rates over 19 years leads to a coefficient of 1.0** taking into account the interpolated data.

- **Economy**

The potential changes in the economy will be proven by using the number of companies especially wholesale and retail. The data exists from 1982 to 2007 but only for every three years at a city level. The data is therefore once again interpolated to obtain a complete time series from 1982 to 2007. All the cities except Mishima and the twin city Komatsu are directly related to the opening date. Moreover, there is no data available for Handa, so that an analysis of this city pair cannot be carried out in this illustration. Figure 99 presents the growth rates that will be used for the following analysis.

				Commissioning								
	Year											
	-3	-2	-1	0 (13)	1 (14)	2 (15)	3 (16)	4 (17)	5 (18)	6 (19)	7 (20)	8 (21)
Mishima*				1.000	0.994	0.988	0.947	0.956	0.965	0.976	0.976	0.976
Koriyama				1.000	0.998	0.995	0.977	0.980	0.984	1.023	1.023	1.024
Kitakami				1.000	0.991	0.983	0.948	0.961	0.973	0.946	0.946	0.947
Kakegawa	0.944	0.955	0.966	1.000	1.000	1.000	1.001	0.993	0.985	0.961	0.955	0.950
Karuizawa	0.923	0.897	0.872	1.000	1.005	1.223	1.190	1.157	1.287	1.288	1.407	1.312
Saku	1.051	1.045	1.039	1.000	1.001	1.039	1.031	1.023	0.965	0.965	0.939	0.916
Komatsu*				1.000	0.994	0.989	0.943	0.951	0.959	0.877	0.877	0.877
Aomori				1.000	0.998	0.996	0.952	0.955	0.958	0.874	0.874	0.874
Yokote				1.000	0.996	0.992	0.933	0.939	0.945	0.913	0.913	0.913
Handa				n/a								
Hakui	1.091	1.072	1.054	1.000	1.003	1.014	0.991	0.967	0.934	0.935	0.877	0.808
Shibata	1.055	1.050	1.044	1.000	1.001	0.996	0.989	0.982	0.923	0.923	0.889	0.870

* The comparison of Mishima and Komatsu starts 13 years after commissioning.
The data between the available years is interpolated.

Figure 99: Japan - Changes in economy - Number of companies at city level (growth rates)
[Source: Own preparation and illustration using data from Statistical Office (2010)]

When concentrating on the years after commissioning for the HSR cities, an increase as well as a decrease of the number of companies is generally evident. In detail, the development of several cities is subject to variations. For example, the city of Saku shows an increase with the opening of HSR, but, the number of companies decreased four years later. This first impression can be counteracted by using the correlation coefficient. The results vary between significant negative values and significant positive values so that a general statement with respect to the development is not possible. In contrast, the non HSR cities show a general decrease both after the commissioning as well as before. This is confirmed by the correlation coefficients, which show positive values.

Finally, the comparison of the city pairs results in the following coefficients: Koriyama / Aomori 0.7**, Kitakami / Yokote 1.0**, Karuizawa / Hakui -0.7*, Saku / Shibata 0.9**. In addition, the coefficient for Mishima / Komatsu amounts to 0.4, whereas both decreased within the considered time period. Taking all the results into consideration, several HSR cities, but not all cities, increased in different positive ways. However, the difference is not as high as for the non HSR cities, e.g. Mishima / Komatsu. All in all, a better development for HSR could be indicated, but this analysis is concentrating on special parts of the economy (wholesale as well as retail).

- **Students**

For the analysis of the potential impact regarding this special group, the number of students is available from 1984 to 2008. Each of the selected cities has a university and is therefore the source for the number of students. The data is not directly related to the opening date for each city and to get a comparable data set further steps are also required. Therefore, each growth rate starts two years after commissioning, except for Mishima / Komatsu. The interval is used because of the second opening date 1982 and the data availability from 1984. The overall data set is therefore comparable except for the mentioned city pair. Figure 100 illustrates the growth rates for the number of students.

				Commissioning								
	Year											
	-3	-2	-1	0 (15)	2 (16)	3 (17)	4 (18)	5 (19)	6 (20)	7 (21)	8 (22)	9 (23)
Mishima*				1.000	1.012	1.032	1.022	1.054	1.028	0.997	0.949	0.918
Koriyama				1.000	1.023	1.041	1.063	1.063	1.064	1.057	1.053	1.049
Kitakami				1.000	1.032	1.055	1.082	1.128	1.152	1.156	1.143	1.112
Kakegawa	0.961	0.988	1.003	1.000	0.999	0.990	0.982	0.969	0.949	0.932	0.923	0.912
Karuizawa	1.058	1.027	1.006	1.000	0.975	0.937	0.879	0.860	0.851	0.875	0.860	0.802
Saku	1.057	1.042	1.011	1.000	1.002	0.989	0.963	0.935	0.915	0.898	0.874	0.853
Komatsu*				1.000	1.057	1.085	1.104	1.123	1.108	1.087	1.044	0.990
Aomori				1.000	1.027	1.031	1.023	1.013	1.007	0.990	0.962	0.933
Yokote				1.000	1.025	1.021	1.009	0.994	0.994	0.995	0.990	0.988
Handa	1.148	1.107	1.052	1.000	0.979	0.941	0.916	0.866	0.857	0.873	0.887	0.894
Hakui	1.074	1.031	1.028	1.000	0.981	0.956	0.909	0.894	0.878	0.849	0.827	0.822
Shibata	1.035	1.022	1.005	1.000	0.987	0.975	0.972	0.946	0.929	0.887	0.853	0.817

* The comparison of Mishima and Komatsu starts 15 years after commissioning.

Figure 100: Japan - Changes in students - Number of students at city level (growth rates)
[Source: Own preparation and illustration using data from Japan Statistical Office (2010)]

On comparing the HSR cities and the years after commissioning a different development can be seen. On one hand the number of students increased for example for Koriyama or Kitakami and on the other hand the number decreased for example in the case of Saku, Karuizawa and Kakegawa. Therefore, the correlation coefficient is not positive at all and a different development between the HSR cities must be noted. In contrast, the number of students decreased in the case of non HSR cities overall. The coefficient ranges between 0.4 and 0.9**, which implies that all cities developed more or less in the same direction.

In summary, different results are expected when comparing the city pairs. The correlation coefficient confirms this as follows: Koriyama / Aomori -0.1, Kitakami / Yokote -0.7**, Kakegawa / Handa 0.7*, Karuizawa / Hakui 1.0**, Saku / Shibata 1.0**. In the case of the Mishima / Komatsu - different time period - the coefficient amounts to 0.9**. As a result, the only differences showing an advantage for the HSR cities could here be determined for the city Kitakami, Koriyama as well as to a lesser degree also Kakegawa.

- **Commuter**

The potential change in commuting is proven by the number of commuters, especially inbound. The data at city level is available between 1980 and 2005. The data, however, needs to be interpolated due to the constrained availability every five years. Accordingly, all these cities are comparable except for Mishima / Komatsu due to the early opening year. Figure 101 presents the time series for the analysis. In fact, this includes the number of commuters for all transport modes and not only HSR which constrains the value of the result.

				Commissioning								
	Year											
	-3	-2	-1	0 (11)	1 (12)	2 (13)	3 (14)	4 (15)	5 (16)	6 (17)	7 (18)	8 (19)
Mishima*				1.000	1.024	1.047	1.071	1.095	1.118	1.146	1.173	1.201
Koriyama		0.944	0.972	1.000	1.028	1.056	1.085	1.150	1.215	1.281	1.346	1.411
Kitakami		0.921	0.960	1.000	1.040	1.079	1.119	1.173	1.227	1.280	1.334	1.388
Kakegawa	0.861	0.907	0.954	1.000	1.046	1.093	1.155	1.217	1.279	1.341	1.403	1.461
Karuizawa	0.917	0.954	0.977	1.000	1.023	1.046	1.069	1.137	1.206	1.275	1.343	1.412
Saku	0.919	0.947	0.973	1.000	1.027	1.053	1.080	1.003	0.925	0.848	0.770	0.693
Komatsu*				1.000	1.050	1.101	1.151	1.201	1.252	1.290	1.328	1.366
Aomori		1.007	1.003	1.000	0.997	0.993	0.990	1.008	1.027	1.046	1.064	1.083
Yokote		0.926	0.963	1.000	1.037	1.074	1.110	1.160	1.209	1.258	1.307	1.356
Handa	0.907	0.938	0.969	1.000	1.031	1.062	1.095	1.128	1.161	1.194	1.227	1.242
Hakui	0.968	0.983	0.992	1.000	1.008	1.017	1.025	1.028	1.031	1.034	1.037	1.040
Shibata	0.923	0.951	0.976	1.000	1.024	1.049	1.073	1.015	0.957	0.899	0.840	0.782

* The comparison of Mishima and Komatsu starts 11 years after commissioning.
The data between the available years is interpolated.

Figure 101: Japan - Development of commuter - Number of commuter inbound at city level (growth rates)
[Source: Own preparation and illustration using data from Japan Statistical Office (2010)]

In comparing the HSR cities except for Mishima a general increase can be noted. However, Saku had a strong decease in commuters in comparison to other HSR cities. This first picture can be confirmed with the correlation coefficients. These coefficients show high positive values because of the same direction of development and the interpolation for closing the data gaps. However, in the case of Saku there is a strong contrast illustrated by high negative values. The analysis of the twin cities shows a similar picture including increase of all cities except Shibata the twin city of Saku. The correlation analysis confirms these assumptions and first findings.

All in all, this first reflection determines the comparisons of the cities with or without HSR. The following values have been established: Koriyama / Aomori 1.0**, Kitakami / Yokote 1.0**, Kakegawa / Handa 1.0**, Karuizawa / Hakui 0.9**, Saku / Shibata 1.0**. All these values are significant and strongly positive. All cities had an increase in commuters with the exception of Saku and Shibata which had decreases. These results are confirmed by using extended times series where available. A similar result can be mentioned for Mishima / Komatsu (1.0**). So that no differences between HSR cities and non HSR cities can be confirmed by applying this data.

<u>Principal Component and Regression Analysis</u>

Considering the analyses above and the data bases the three following impacts are designated for PCA and regression analysis as follows:

- **Population**
- **Economy**
- **Students**

The city of Mishima and the respective twin city is not included in the following as a comparable data set cannot be established. As mentioned above, data for this city is not available due to the very early opening date. Accordingly, the sample size will be reduced to ten cities for each part of the investigation whether PCA or regression. Moreover, Handa and the twin city will not be considered in the case of applying economic data as there is no data available as needed. Once again it must be taken into account that the data used for Japan are interpolated and this must be considered in the interpretation of the results.

Due to the often mentioned unavailability of data, depending on the countries, the considered location factors could also not be used as mentioned. Therefore, the following characteristics are part of the investigation in the case of Japan: travelling time and distance to reference city, number of inhabitants, inhabitants per square kilometre, development in surrounding area and especially for HSR, the number of trains per day together with station location.

This implies that the economic strength indicated by GDP could also not be taken into account here. Moreover, the presence of international trains is not relevant for Japan. Finally, the network is also not relevant for the investigation as every station considered is located on a line with only two directions.

As for each country, the following overview shows first results in respect to the correlations between each other, separated into a total sample as well as HSR only.

Sample including HSR and non HSR

- Travelling time and distance to a reference city (0.9** (population, economic as well as students))
- Number of inhabitants and the number of inhabitants per square kilometre (0.7 (Economy))

Sample including HSR only

- Travelling time and distance to a reference city 0.9 (population, Economy as well as students)
- Number of inhabitants and the number of inhabitants per square kilometre (0.9*)
- Number of inhabitants per city and inhabitants per square kilometre in comparison to the number of trains per day (0.6, 0.7)

- **Population**

The special and detailed consideration of the first impact on population leads to the correlation presented below, especially for the change in population three, six and nine years after implementation of HSR.

Sample including HSR and non HSR

- Growth rates in population among each other (three, six and nine years after commissioning) (1.0**)
- Growth rates in population three, six and nine years after commissioning and travelling time
  (-0.6, -0.7*, -0.7*)
- Growth rates in population three, six and nine years after commissioning and distance to a reference city (-0.5, -0.6, -0.6)

Sample including HSR only

- Growth rates in population among each other (three, six and nine years after commissioning) (1.0**)

Principal Component Analysis

In the case of population one composition of the characteristics leads to the best result and a MSA of 0.7. This includes two factors, one in the detail on determining the change in population three and nine years after commissioning and one including the distance and the travelling time to the next relevant city. Applying these factors the following charts can be established.

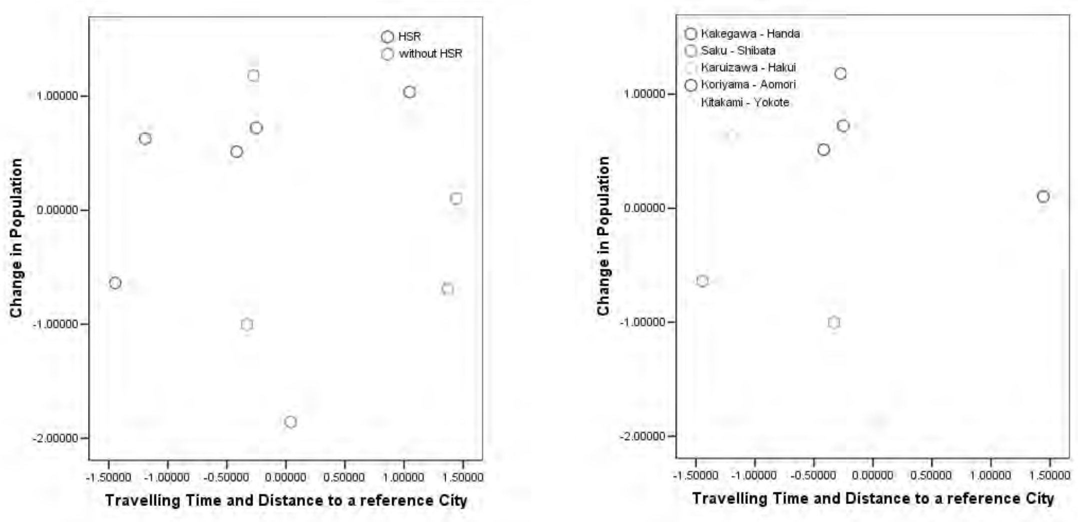


Figure 102: Japan - PCA - Changes in population
[Source: Own illustration and preparation using data from Japan Statistical Office (2010) and www.google.de, www.hyperdia.com]

In general, the results mostly show an above average change in population of the HSR cities in comparison to the other cities. All in all, five cities developed higher than the average and five cities are below the average. Whereas, the below average developed cities are dominated by non HSR cities. Taking into consideration the travelling time and the distance it could be stated that the cities where the travelling times and distances are below average in comparison to the other cities had a higher change in population. However, this does not count for each considered city as mentioned. An influence of the HSR could be assumed here due to the better accessibility provided by HSR. The comparison of the city pairs could confirm these first results. Nevertheless, one factor includes both the travelling time and the distance. Therefore, further detailed analysis needs to be done, e.g. by using the regression analysis.

When applying the HSR only several compositions are possible. However, the first factor always consists of the three characteristics of changes in population (three, six and nine years). The second factor can include for example the travelling time or the number of inhabitants per square kilometre as well as the number of trains per day but in a separated form. Nevertheless, the best result is reached by using city size in the form of the number of inhabitants (Figure 103). The MSA amounts to 0.7 in this case.

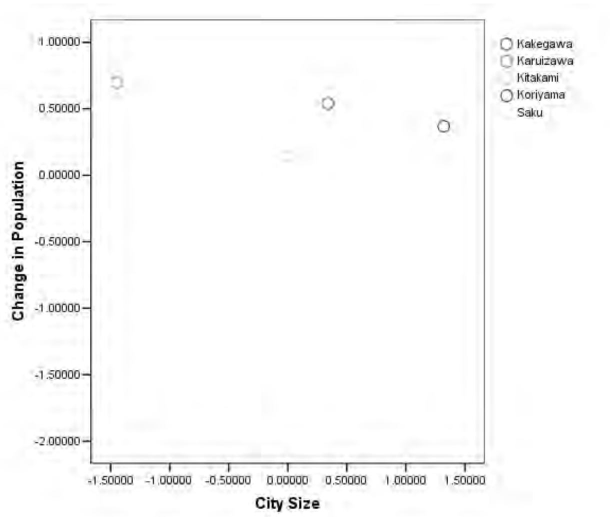


Figure 103: Japan - PCA - Changes in population
[Source: Own illustration and preparation using data from Japan Statistical Office (2010) and www.google.de]

Considering the illustration, the results generally show one city Saku that mainly developed under the average in comparison to the other cities. So, an outlier is assumed here which needs to be taken into account during an interpretation of the results. However, an overall dependency of the development in comparison to the city size could not be determined because of the distribution in the figure.

Regression Analysis

The regression analysis contains on one hand the total sample, including HSR and non HSR, and on the other hand the HSR only as previously done. Moreover, the changes in population for the defined years will be tested separately as well as using the previously determined factors in PCA. In making the regression the changes in population over three years are firstly taken into account. In this case the travelling time could be used as a characteristic for explaining the change in population (significance level of 0.05). However, R square only amounts to 0.4. The coefficient is estimated in a negatively way, which assumes a contrary relationship between the change in population and the travelling time as is also indicated by illustrating the correlation coefficients. Similar statements could be made for the change in population six and nine years after implementing. Similar results are provided using the distance to a reference city for explaining the changes in population. However, significant results are not reached applying the changes in population three years after the opening of the station. Both the travelling time and the distance are only applied separately in two simple regressions and not within one multivariate analysis. However, in some cases the standard error is approximately 50 % and therefore not acceptable. The travelling time leads to better results including a R square of up to 0.5. All the coefficient for the travelling time and the distance to a reference city are predicted negatively which seems to be reasonable here. In the case of applying the factor of population, significant results are not determined. Detailed results are illustrated in the Annex.

In the case of considering HSR only, significant as well as reasonable results could not be indicated. However, there are indications as also described within the correlation analysis. Here, the number of trains per day as well as the number of inhabitants could be mentioned in describing the variances in changes in population. The result does not depend on the change used (three, six or nine years) nor on the applied factor.

- **Economy**

As mentioned, the consideration of the economic changes will be done without Handa and its twin city due to unavailability of data. However, the twin city Kakegawa will be applied within the sample including the HSR only. Altogether, the total sample is reduced to eight cities which indicates the following dependencies for the economic impact.

Sample including HSR and non HSR

- Growth rates in economy three and six years after commissioning (0.9**)
- Growth rates in economy three as well as six years after commissioning and number of inhabitants per city (-0.7*, -0.6)
- Growth rates in economy three as well as six years after commissioning and distance to a reference city (-0.8**, -0.7*)

Sample including HSR only

- Growth rates in economy three and six years after commissioning (0.9*)
- Growth rates in economy three as well as six years after commissioning and number of inhabitants per city (-0.8, -0.7)
- Growth rates in economy three as well as six years after commissioning and distance to a reference city (-0.8, -0.6)
- Growth rates in economy three as well as six years after commissioning and travelling time (-0.7, -0.6)
- Growth rates in economy three as well as six years after commissioning and number of inhabitants per square kilometre (-0.7, -0.7)

Principal Component Analysis

The PCA "economy" leads to a MSA of 0.7 which is considered as a good result. The first factor is determined by including changes in economy within three and six years and the second factor only includes travelling time. Applying the number of inhabitants per square kilometre is also possible, but will not be considered here due to some interpretation problems which can be caused by the available data. Figure 104 illustrates the result of the PCA using the change in economy and travelling time as described.

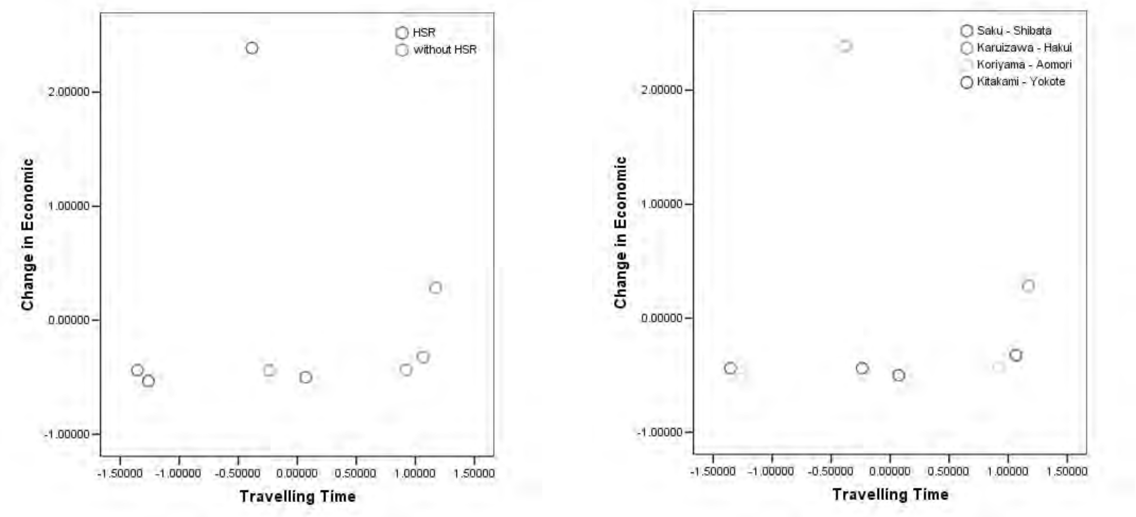


Figure 104: Japan - PCA - Changes in economy
[Source: Own illustration and preparation using data from Japan Statistical Office (2010) and www.google.de]

These charts above show first of all Saku as an over average developed city in comparison to the rest of the sample. Excluding this outlier an advantage for the changes in population in respective to travelling could not be noted. Neither a short travelling time (mostly HSR) nor a long travelling can affect the changes in population here. So, an influence could not be stated using the available sample and data. Similar reflections appear comparing the HSR and non HSR cities in the illustrated city pairs.

In a next step HSR is only considered. In this analysis, PCA applies on the one hand the changes in economy once again. On the other hand the factor including the number of inhabitants per square kilometre leads to the best results. The MSA amounts to 0.7.

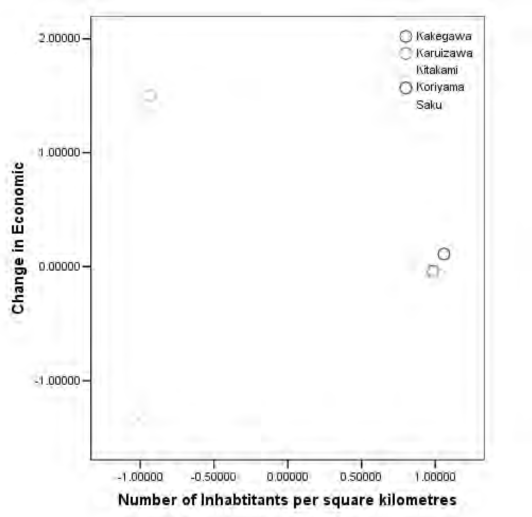


Figure 105: Japan - PCA - Changes in Economy
[Source: Own illustration and preparation using data from Japan Statistical Office (2010)]

Finally, the Figure 105 presents the results in the case where the changes in Economy for the HSR only are considered. Here, one could assume that cities with a higher density population than the average have obtained a higher positive economical change. Some cities are opposed to this assumption. A final result is difficult to give due to the small sample which needs to be extended to verify this first impression.

Regression Analysis

The regression analysis tries to explain the changes in the economy per city. Firstly, the change in the economy during three and six years after commissioning is considered separately in comparison to the designated location factors. Taking into account the changes three years after opening, the travelling time and the distance can be seen here as significant and reasonable. However, both need to be considered in a separated way to explain the variance in the economic change. In other words, both coefficients must be used in two separated equations. Both coefficients were estimated in a negative way, which implies a contrary correlation between the change in Economy and the location factor. R square amounts to 0.7 for the distance to a reference city and 0.5 in the case of travelling time. The coefficients are significant on a level of 0.05 and negative predicted.

A similar statement is made when analysing the Economy changes six years after commissioning. Here, the significance is also on a level of 0.05 and R square amounts to 0.5 analysing the distance to a reference city and 0.6 in the case of travelling time to a reference city. Both coefficients are estimated as being negative which also indicates a reasonable result. Here, the number of inhabitants additionally shows a significant coefficient estimation but the results are not as good as for the travelling time or distance to a reference city. The number of inhabitants is predicted in a positive way in comparison to the changes in the economy.

The second analysis only focuses on the HSR. In summary, reasonable and significant results are not designated for a separate consideration of changes in economy for three and six years after commissioning. However, when applying the factor including the changes plus three and plus six years the travelling time is a predicted coefficient but not on a designated level of significance.

- **Students**

The determination of the correlation between the impact and the location factor that was made for all the cases above, can also be made for the potential changes in students. The following summary shows the results.

Sample including HSR and non HSR

- Growth rates in students among each other (three, years and six and nine years after commissioning) (0.9**)
- Growth rates in students three, six and nine years after commissioning and number of inhabitants per city (0.7*, 0.6, 0.6)
- Growth rates in students three, six and nine years after commissioning and distance to a reference city (0.7*, 0.6, 0.5)

Sample including HSR

- Growth rates in students among each other (three, six and nine years after commissioning) (0.9**)
- Growth rates in students three, six and nine years after commissioning and number of inhabitants per city (0.8, 0.6, 0.6)
- Growth rates in students three, six and nine years after commissioning and distance to a reference city (0.8, 0.9*, 0.9*)
- Growth rates in students three, six and nine years after commissioning and travelling time (0.8, 0.9, 0.8)

Principal Component Analysis

The PCA using students leads to a MSA of 0.8 in the indicated case applying suitable location factors. Therefore, a factor 1 is applied including change rates in students for three, six as well as nine years after implementing HSR and the distance to a reference city. The charts below show the results separated by HSR and non HSR (on the left) respectively city pairs (on the right).

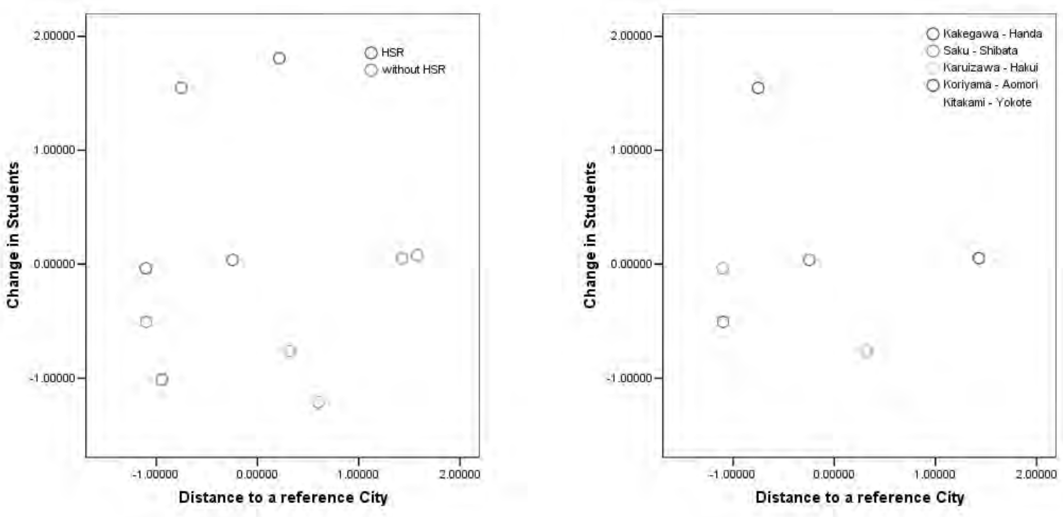


Figure 106: Japan - PCA - Changes in students
[Source: Own illustration and preparation using data from Japan Statistical Office (2010) and www.google.de]

Considering the changes in students on a whole most of the HSR cities had a higher positive change in students in comparison to their twin cities. There is no twin city with an above average development of all cities; mostly below. However, it could be assumed that a smaller distance to an important reference city leads to higher increases in the number of students especially in the case of HSR. Nevertheless, the sample should be excluded when verifying single assumption as also mentioned before.

In a next step the HSR is investigated separately. In this case the best result leads to a first factor including the changes in the number of students three, six and nine years after commissioning. Whereas the second factor includes the distance to a reference city only. Here, the MSA amounts to 0.8. However, the result (Figure 110) does not lead to a general conclusion. Several kinds of distances show a positive over average result in the changes in students independently from the city.

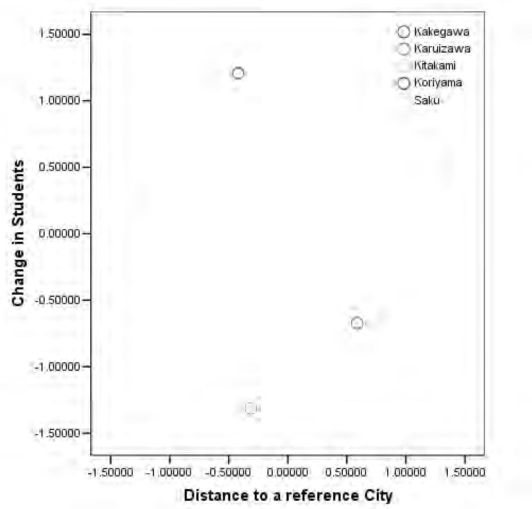


Figure 107: Japan - PCA - Changes in students
[Source: Own illustration and preparation using data from Japan Statistical Office (2010) and www.google.de]

Regression Analysis

Here, the regression analysis could be made in different steps once again. The change in the years after commissioning is used separately or as one factor. Moreover, the sample includes either the HSR and the non HSR cities or the HSR only. Using the factor of changes in students (three, six and nine years) significant and reasonable results are not reached. Nevertheless, indications in respect to the travelling time, distance as well as inhabitants could be made.

Concentrating on plus three years after commissioning the best results in respective to the R square is reached by using the travelling time as well as the distance to a reference city in one equation. R square amounts to 0.7 and both coefficients are significant on level 0.05. The travelling time is predicted as negative whereas the distance is estimated as being positive.

Similar results are possible applying the change in students six years after commissioning. Applying travelling time as well as distance leads to an amount of R square of 0.7. The reached significance level here is 0.05 once again. So, travelling time as well as distance are useful location factors to describe these changes.

The final application of the changes nine years after commissioning does not lead to useful results. This is due to for example the needed missing significant results, or the high unacceptable standard errors.

The analysis considering HSR only indicated several results. In the case of analysing the changes in students plus three, six and nine years as stand alone criteria the location factor distance to a reference city leads to significant results including positive predicted coefficients. R square amounts to a value higher than 0.7 and the significance level ranges between 0.05 and 0.1. The annex illustrated extracts of these results. Using the change in students as factor (three, six and nine years after HSR commissioning) the number of inhabitants is highlighted as a best prediction with an amount of R square of 0.7. The coefficient is predicted in a positive way.

5.3.5 Spain

Data Base and applied Impact

The analysis of Spain is based on an acceptable data base. However, the data set is not completely fulfilled as requested. In general, data in the past is missing for the three HSR cities with 1992 as the year of implementation. The main data sources were the national statistical office (INE) and the regional department in part. The final data base enables a more or less constrained analysis of the following potential effects of HSR:

- Population
- GDP
- Unemployment
- Economy
- Tourism

The data availability regarding the mentioned impacts differs concerning the level - on city or regional level. In addition, the distance between the commissioning date 1992 (three cities) and 2007 (two cities) has to be taken into account by preparing the total comparable data basis. Due to this interval between opening dates the analysis will be concentrated on two parts of HSR cities - commissioning in 1992 on one hand and commissioning in 2007 on the other.

Time Series and Correlation Analyses

- **Population**

The data for population is prepared for the years 1986 to 2009 at city level. The sample does not include data gaps and a total comparable data basis for additional evaluation is possible - besides the twin city approach. An exception is noted due to the constrained times series for Valladolid as well as Segovia which results from the late opening date. Figure 108 illustrates the changes in growth rates before and after commissioning.

				Commissioning								
	Year											
	-3	-2	-1	0	1	2	3	4	5	6	7	8
Ciudad Real	0.992	1.006	0.987	1.000	1.042	1.074	1.090	1.027	1.043	1.058	1.058	1.042
Puertollano	1.016	1.013	0.989	1.000	1.019	1.027	1.032	0.986	0.986	0.986	0.978	0.975
Cordoba	0.999	1.007	0.990	1.000	1.021	1.036	1.042	1.004	1.010	1.016	1.022	1.027
Valladolid	1.016	1.014	1.011	1.000	1.006	1.004						
Segovia	0.992	0.998	0.990	1.000	1.014	1.011						
Caceres	0.962	0.979	0.988	1.000	1.036	1.063	1.073	1.030	1.035	1.041	1.041	1.089
Villarreal	0.997	1.012	0.993	1.000	1.025	1.040	1.045	1.035	1.043	1.050	1.071	1.087
Granada	1.021	1.035	0.983	1.000	1.022	1.044	1.050	0.946	0.938	0.930	0.942	0.941
Murcia	0.943	0.969	0.986	1.000	1.018	1.033						
Avila	0.974	0.978	0.990	1.000	1.044	1.057						

Figure 108: Spain - Changes in population - Number of inhabitants at city level (growth rates) [Source: Own preparation and illustration using data from INE (2010)]

Firstly, the cities that were connected to HSR in 1992 - Ciudad Real, Puertollano - increased their number of inhabitants over the eight years after start-up of HSR, with the exception of Puertollano. In fact, this can also be observed for the respective twin cities except Granada. In particular, the increase is high within three years after commissioning of HSR, but this is also the case for the non HSR cities. The evaluation by applying the correlation coefficient produces a similar picture. In comparing the HSR cities, the coefficients are generally positive in several calculations. This means, they have the same development direction when comparing the first eight years with HSR. In the cases of the cities themselves a positive correlation is only seen for Granada and Caceres because Villarreal has a negative correlation and develops in a different way (increase of population).

The analysis of the pairs arrives at the following results for the correlation coefficient: Ciudad Real / Caceres 0.7*, Puertollano / Villarreal -0.5 and Cordoba / Granada 0.6. It appears that there is no difference in the development of population with or without HSR. Therefore, the sample can be extended from 8 to 17 years after implementation of HSR. In doing so, the coefficients confirm the results mentioned for the cities before.

Due to the short times series for Segovia and Valladolid a short assessment only is reasonable. After implementing the HSR in 2007 all cities had an increase within the following two years. This increase also existed for all cities, except Valladolid, before the HSR started. The number of inhabitants in Valladolid firstly decreased and then increased after finishing the HSL. All in all, there are likewise no differences in development.

- **Gross Domestic Product (GDP)**

In the case of GDP, the data is available between 1980 and 2007 at a provincial level. Up to 1989 the data is available in Pesetas. The values were therefore converted to Euro by using the exchange rate of the Euro in force. Therefore, the conversion must be taken into account within the interpretation and evaluation of the results if problems should appear. Due to the extended data basis and the same basis of all the growth rates that are described in Figure 109 an overall analysis can be made in the next steps. This means that more than a simple comparison of a city and twin city is possible. However, the two groups with the opening dates of 1992 and 2007 will be used as before. Attention should also be paid to Ciudad Real and Puertollano because the same data are used, since they are located in the same province.

	Commissioning											
	Year											
	-3	-2	-1	0	1	2	3	4	5	6	7	8
Ciudad Real	0.776	0.873	0.932	1.000	1.025	1.065	1.188	1.269	1.355	1.435	1.540	1.684
Puertollano	0.776	0.873	0.932	1.000	1.025	1.065	1.188	1.269	1.355	1.435	1.540	1.684
Cordoba	0.714	0.834	0.958	1.000	1.053	1.106	1.253	1.310	1.381	1.471	1.548	1.628
Valladolid	0.790	0.862	0.931	1.000	1.018							
Segovia	0.791	0.863	0.931	1.000	1.000							
Caceres	0.774	0.823	0.906	1.000	1.050	1.129	1.022	1.093	1.104	1.157	1.285	1.260
Villarreal	0.769	0.863	0.945	1.000	1.044	1.104	1.198	1.278	1.389	1.528	1.622	1.833
Granada	0.757	0.841	0.928	1.000	1.058	1.151	1.248	1.318	1.381	1.448	1.547	1.688
Murcia	0.782	0.858	0.930	1.000	1.039							
Avila	0.773	0.813	0.893	1.000	1.035							

Figure 109: Spain - Changes in GDP - Regional level (growth rates)
[Source: Own preparation and illustration using data from INE (2010)]

The illustrated times series in the case of GDP shows a general growth whether it is considered for the years before or after the commissioning as well as the kind of city with or without HSR. In the case of the cities on the line Madrid - Seville the following correlation could be ascertained by considering up to eight years after commissioning: Ciudad Real / Caceres 0.9**, Puertollano / Villarreal 1.0**, Cordoba / Granada 1.0**. An extension of the time series leads to similar results. In the case of Valladolid as well as Segovia similar results are visible in comparison to their twin cities. In summary similarities are determined overall. However, the data is only available at a regional level which extends the area of additional effects apart from the HSR. Therefore, an analysis is more difficult due to more influences.

- **Unemployment**

To investigate the changes in unemployment in the case of Spain the number of unemployed persons are considered since unemployment rates are not available. This should be noted within the analysis. The data used is generally available and applied here between 1989 and 2007 although at provincial level only. Therefore, the data of Ciudad Real and Puertollano is the same, as they are located in the same province. This needs to be taken into account during the analysis. For example, a more intensive impact in the region could be possible due to two HSR cities being considered in one province. The analysis is mainly divided into two groups of cities as applied before; those opening 1992 as well as 2007. Figure 110 presents the data base for three years before and eight years after commissioning.

				Commissioning								
	Year											
	-3	-2	-1	0	1	2	3	4	5	6	7	8
Ciudad Real	1.021	0.852	0.819	1.000	1.284	1.407	1.383	1.354	1.374	1.440	1.280	1.008
Puertollano	1.021	0.852	0.819	1.000	1.284	1.407	1.383	1.354	1.374	1.440	1.280	1.008
Cordoba	0.962	0.887	0.852	1.000	1.101	1.083	1.123	1.252	1.183	1.233	1.224	1.041
Valladolid	1.668	1.163	1.102	1.000								
Segovia	1.550	1.275	1.375	1.000								
Caceres	1.017	1.024	0.945	1.000	1.229	1.247	1.178	1.425	1.445	1.380	1.243	1.257
Villareal	0.596	0.661	0.861	1.000	1.278	1.216	1.094	0.931	0.759	0.678	0.702	0.559
Granada	0.991	0.944	0.883	1.000	1.147	1.170	1.336	1.377	1.417	1.345	1.175	1.007
Murcia	1.249	0.958	0.983	1.000								
Avila	1.294	1.216	0.961	1.000								

Figure 110: Spain - Changes in unemployment - Number of unemployed persons at regional level (growth rates)
[Source: Own preparation and illustration using data from INE (2010)]

A first analysis of the growth rates as before (year zero to eight) shows a mixed picture for all cities on the line Madrid - Seville. The comparison of the HSR cities leads to positive correlation coefficients, higher than 0.7* (Ciudad Real and Puertollano are located in the same province). The comparison of the non HSR cities amongst each other shows a different result with positive as well as negative correlations. In fact, the development differs within these cities, especially for Villarreal which has a strong decrease. This implies that all the HSR and non HSR cities did not develop in the same direction amongst each other after the reference date i.e. starting the HSR. However, there is often an increase at the beginning and a decrease in the 7th and 8th year (1999) which can correlate with general economic developments.

The comparison of the HSR and the non HSR cities comes to the first result that the city and the twin city have a positive correlation coefficient as well. The coefficient amounts to 0.6 for Ciudad

Real/ Caceres, 0.2 for Puertollano / Villarreal and 0.8* in the case of Cordoba / Granada. All in all, the assumption can be taken that the development does not differ between the cities and the twin cities in the case of employment except Villarreal. In addition, an extension of the time series - more than 8 years - does not lead to any significant change in the results and in respect of the main objectives of the study.

Comparing the data before starting HSR - including Segovia and Valladolid - decreases can be observed in the direction of the commissioning year. This counts for all the other cities considered on the line Madrid - Seville. In the case of twin cities the number of unemployed persons mostly decreased. This difference in comparison could be explained perhaps by the construction work before opening the HSR station.

- **Economy**

A potential impact on the economy shall be investigated by analysing the number of companies. The data is generally available between 1999 and 2009 but only at a regional (province) level. Therefore, the cities of Ciudad Real and Puertollano have the same results because they are located in the same province, as already mentioned. This framework condition has to be taken into consideration in performing the analysis. The analysis starts seven years after the opening of the line for the three cities on the line of Madrid - Seville. Figure 111 summarises growth rates that are based on the changes in the number of companies. In this illustration attention must be paid to the varying basic years due to the reduced data availability and the restricted comparability.

				Commissioning								
	Year											
	-3	-2	-1	0 (7)	1 (8)	2 (9)	3 (10)	4 (11)	5 (12)	6 (13)	7 (14)	8 (15)
Ciudad Real*				1.000	0.979	1.013	1.019	1.066	1.155	1.175	1.212	1.269
Puertollano*				1.000	0.979	1.013	1.019	1.066	1.155	1.175	1.212	1.269
Cordoba*				1.000	1.228	1.199	1.232	1.277	1.321	1.382	1.435	1.501
Valladolid	0.882	0.906	0.953	1.000	1.026	1.018						
Segovia	0.892	0.910	0.949	1.000	1.024	1.006						
Caceres*				1.000	0.969	0.977	1.580	1.585	1.392	1.680	1.693	1.762
Villarreal*				1.000	1.007	1.007	1.039	1.083	1.186	1.202	1.261	1.350
Granada*				1.000	1.014	1.023	1.080	1.075	1.132	1.215	1.283	1.371
Murcia	0.847	0.874	0.931	1.000	1.028	0.982						
Avila	0.893	0.913	0.947	1.000	1.031	1.022						

* The comparison starts 7 years after commisioning for Ciudad Real, Puertollano and Cordoba.

Figure 111: Spain - Changes in economy - Number of companies at regional level (growth rates)
[Source: Own preparation and illustration using data from INE (2010)]

On the basis of the existing data a general increase can be noted for the city group with the starting year of 1992 (Ciudad Real, Puertollano, Cordoba and the respective twins). The second group, starting HSR in 2007 shows an increase before the commissioning and one year afterwards. However, there is a decrease in the number of companies in 2009 in relation to 2007, but this point can also be seen for the other cities in 2009 and could be related to the general economic crisis. A potential reason for the differences between these two groups can be seen in the different distances to the opening dates and hence different time periods with different framework conditions apart from the HSR.

These mentioned first impressions of the data set can be verified for the group starting HSR in 1992 by determining the correlation coefficients (0 to 8 years and 15). In general, all the correlations are positive and higher than 0.8*. This implies that the development within the HSR cities as well as twin cities and the city pairs is in the same positive direction. There are no recognisably significant differences. For example, the coefficient for Cordoba / Granada amounts to 0.9**. An enlargement does not show further differing results to those which have been already mentioned.

In the case of Segovia and Valladolid and the respective twin cities a meaningful detailed investigation of the time around the commissioning cannot be made, as mentioned. Comparing the year after starting HSR a positive correlation confirms the first assumptions but not on a significant level. Both the HSR cities and the twin cities raised the number of companies in 2008 but lowered the number in 2009. The values before opening the HSR are also highly correlated and do not allow for determining the differences between the cities in respect to their development.

- **Tourism**

The impact of tourism is analysed by applying the changes in the number of overnight stays as a first step and secondly the number of arrivals. The data exist for the years between 1999 and 2009 on a provincial level. The analysis groups will be used as before in accordance with the framework conditions such as for example the data availability. Ciudad Real and Puertollano have the same data base because they are located in the same province, which could reinforce the impact in the region. Figure 112 illustrates the changes in overnight stays and Figure 113 deals with the changes in the number of arrivals.

				Commissioning								
	Year											
	-3	-2	-1	0 (7)	1 (8)	2 (9)	3 (10)	4 (11)	5 (12)	6 (13)	7 (14)	8 (15)
Ciudad Real*				1.000	1.029	1.129	1.143	1.226	1.217	1.409	1.389	1.579
Puertollano*				1.000	1.029	1.129	1.143	1.226	1.217	1.409	1.389	1.579
Cordoba*				1.000	1.027	1.095	1.068	1.066	1.183	1.275	1.327	1.404
Valladolid	0.854	0.883	0.935	1.000	1.021	0.958						
Segovia	0.750	0.755	0.835	1.000	0.997	0.930						
Caceres*				1.000	1.184	1.293	1.174	1.233	1.279	1.313	1.475	1.540
Villarreal*				1.000	1.030	1.089	1.224	1.340	1.425	1.473	1.581	1.539
Granada*				1.000	1.009	1.060	1.111	1.127	1.173	1.331	1.410	1.424
Murcia	0.836	0.851	0.870	1.000	0.949	0.850						
Avila	0.867	0.912	0.983	1.000	0.971	0.878						

*The comparison starts 7 years after commisioning of Ciudad Real, Puertollano and Cordoba - one year of Valladolid and Segovia.

Figure 112: Spain - Changes in tourism - Number of overnight stays at a regional level (growth rates)
[Source: Own preparation and illustration using data from INE (2010)]

A first look at the cities of Ciudad Real, Puertollano, Cordoba and their respective twins comes to the assumption that there is no visible difference between the cities and the twins. However, this is only the data for the provinces with a lot of other potential effects apart from the HSR. A parallel analysis of the correlation coefficients supports the impression because all the cities are highly positively correlated, 0.9, with a significance level of 0.05 at least. It does not matter if HSR or twins are analysed separately or together in the assumed constellation. Although there are some variances in the times series they are for both with and without HSR. A comparison of the cities starting HSR in 2007; Segovia and Valladolid, shows the same results. This means that all the cities are highly correlated and increase or develop in the same way, regardless of whether with or without HSR. The decrease in 2009, two years after starting HSR, could be related to the economic crisis once again.

Having analysed the number of overnight stays, more or less similar statements are presentable for the following number of arrivals. All in all, the cities are correlated highly in the same direction except for Puertollano / Villarreal, where a higher development could be stated for the province of Puertollano in comparison to the province of Villarreal. However, the data for Puertollano also includes information from Ciudad Real in the same province. Therefore, the results need to be questioned. In comparing the results for Valladolid and Segovia plus their twin cities more or less the same developments can be noted.

				Commissioning								
	Year											
	-3	-2	-1	0 (7)	1 (8)	2 (9)	3 (10)	4 (11)	5 (12)	6 (13)	7 (14)	8 (15)
Ciudad Real*				1.000	1.017	1.013	0.972	0.965	1.002	1.131	1.094	1.194
Puertollano*				1.000	1.017	1.013	0.972	0.965	1.002	1.131	1.094	1.194
Cordoba*				1.000	1.021	1.047	0.957	0.935	1.024	1.084	1.124	1.176
Valladolid	0.779	0.823	0.896	1.000	0.991	0.928						
Segovia	0.746	0.747	0.846	1.000	0.994	0.938						
Caceres*				1.000	1.119	1.161	1.018	1.056	1.076	1.085	1.163	1.196
Villarreal*				1.000	1.032	1.098	1.169	1.278	1.401	1.516	1.759	1.739
Granada*				1.000	0.996	1.042	1.058	1.068	1.097	1.282	1.351	1.314
Murcia	0.740	0.806	0.934	1.000	0.936	0.814						
Avila	0.928	0.959	0.990	1.000	0.951	0.849						

* The comparison starts 7 years after commisioning of Ciudad Real, Puertollano and Cordoba.

Figure 113: Spain - Changes in tourism - Number of arrivals at regional level (growth rates)
[Source: Own preparation and illustration using data from INE (2010)]

All these results concerning the number of arrivals as well as the number of overnight stays lead to the statement that there will also be no change in the mean duration of stay where a region with HSR is compared to a region without HSR.

Principal Component and Regression Analysis

As pointed out above, population is the only characteristic within this detailed analysis. This impact was on one hand the only one with differences in comparison to the twin cities or amongst the HSR cities themselves as well as providing the most suitable data base on the other hand. In the case of Spain, three cities were connected to HSR in 1992 and two in 2007. Due to the requirements for comparable data in this and the other analyses, Valladolid and Segovia together with their twin cities are not part of the following analysis because of the limited availability of data; considered time periods too short. Therefore, six cities remain for the analysis. In addition, the number of designated location factors needs to be reduced because of the unavailability and less comparability of the data. The following characteristics are therefore part of the analysis: travelling time and distance to the reference city, number of inhabitants, inhabitants per square kilometre, development in surrounding areas and especially for HSR, number of trains per day, station location as well as the consideration of the network position. The location of the station is here mostly on the edge of the city but nonetheless close to the city centre. Therefore, the stations are defined as being close to city centre rather than outside of the city. The GDP as a measurement of the economic strength is also excluded due to the availability of data only at a regional level, which is not useful for the following analyses. The presence of international trains is also excluded in the case of Spain. The changes in population itself will be stated for three, six and nine years after commissioning which underlines the useful data availability for population.

Considering the correlations, especially in this first step, for the location factor a relationship between the number of inhabitants per square kilometre and the distance to the next relevant city; here Madrid in each case (0.6) can be highlighted. The value for number of inhabitants in comparison to distance amounts to 0.6. The correlation focussing on distance and travelling time amounts to 0.8*. In view of the sample concentrating on HSR cities (only three cities in the sample) mostly high correlations are indicated for the distance and the travelling time (1.0*), population density and inhabitants per city (0.6) as well as number of trains per day in comparison to the city size (0.9), the distance (0.8) and travelling time (0.7). In contrast to other analyses, a separated analysis for HSR only will not be done because of the small sample size, but these data will nonetheless be used in the transnational considerations.

- **Population**

The first step, including the correlation analysis, has not provided a reasonable approach for discussing potential influence factors on the development, although the development was not the same in each case. The conclusion to be drawn is that either there are no special circumstances for the development, or the data quality is not good enough to illustrate such factors - more characteristics or / and a bigger city sample could lead to other assumptions.

Nevertheless, the following correlations have been determined concerning the comparison of the impact on population and the location factors - separated into the overall sample and a sample including HSR only.

Sample including HSR and non HSR

- Growth rates in population six and nine years after commissioning (0.9**)
- Growth rates in population three years after opening in comparison to six years and nine years (0.5, 0.5)
- Growth rates in population six years after commissioning and inhabitants per square kilometre (-0.7)
- Growth rates six as well as nine years after commissioning and the number of inhabitants per city (-0.6, -0.5)
- Growth rates in population nine years after commissioning and inhabitants per square kilometre (-0.6)
- Growth rates in population three years after HSR commissioning and distance to a reference city (-0.5)

Sample including HSR only

- Growth rates in population three years after commissioning in comparison to six and nine years after commissioning (0.9, 0.8)
- Growth rates in population six years after commissioning in comparison to nine years after commissioning (0.9)
- Growth rates in population three years after opening and travelling time, distance to a reference city and inhabitants per square kilometre (-0.7, -0.7, -0.9)

- Growth rates in population six and nine years after opening and inhabitants per square kilometre (-0.8, -0.6)
- Growth rates in population nine years after opening and number of trains per day (0.5)

Due to the especially small sample size in the HSR case and the respective associated uncertainty PCA analysis as well as regression is excluded here, as already mentioned. The not significant results of the correlation analysis support such an approach. Nevertheless, a negative correlation is indicated between the changes in population and the city size as well as the population density, in contrast to France for example.

Principal Component Analysis

As a first step the total sample including all six cities is determined. The varying composition of the characteristics leads to variously more or less suitable results. However, the MSA reaches approximately same level independently of the considerations of some characteristics. Taking into consideration criteria such as for example opportunity of interpretation of the results, the first factor is defined including the population changes for six and nine years. The second factor finally includes the city size only in form of the number of inhabitants. This results in a MSA amounting to 0.6. The following charts (Figure 114) illustrate the results comparing city pairs (on the right) as well as HSR and non HSR cities on the left.

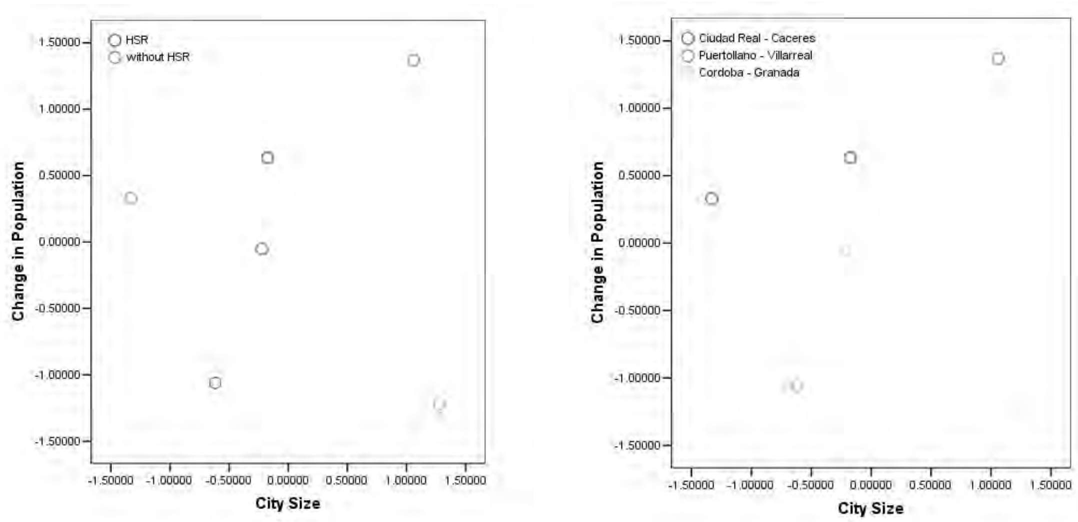


Figure 114: Spain - PCA - Changes in population
[Source: Own preparation and illustration using data from INE (2010)]

Here, the interpretation is hard due to the diverse picture and the small sample size. There are changes in population which are higher or lower than the average without focussing on a kind of city size. Although in two out of three cases the HSR cities have shown a higher increase in comparison to their non HSR city. So, these indications can be kept in mind for the transnational sample in the following chapter.

Regression Analysis

As mentioned before in the report, the regression analysis only concentrates on the overall sample including the six cities (HSR and non HSR). However, the main problem is to find explanations for the changes in population by using the mentioned location factors. Now, the binary facts will be added as before in order to describe also the uncertainties by further facts. However, various compositions for estimating the several changes in population separately or as one factor as used before, do not lead to statistically significant as well as reasonable results in the assessment. However, there are indications regarding dependencies between changes in population and city size or population density, as well as development of the surrounding area of the station. In further steps and considering the development in Spain, the sample size needs to be extended.

5.4 Analyses and Results - Transnational Sample

In this part, the overall analysis deals with a transnational data sample. For this, the sample will be extended on one hand but potential differences in the countries are included and could influence the results. In the first part the differences as well as the difficulty of the data quality has already been mentioned. Therefore, selected characteristics are involved in this analysis. Moreover, several data samples per country and city will be reduced to obtain a comparable total sample regarding the growth rates with respect to the commissioning date of the station. One more problem within this additional analyses is the data base and especially the data for the location factors which should explain potential differences in the development. Therefore, this data cannot be provided in an overall comparable standard and the data base is reduced or broadly changed in comparison to the analyses made above.

In summary, the transnational sample intends to discuss, by extending the sample, the questions regarding the influences of location factors as made above. It is assumed that an extended sample brings more certainty with regard to the results. However, this analysis also consists of potential results with respect to the differences in the countries and their different development after implementing HSR as mentioned. In consideration of the various criteria, population is the only impact that can be analysed in a transnational sample. In other cases, data was not available for the impact, the years after commissioning, or on the same required city level. The overall analysis approach remains the same as shown previously.

- **Population**

Firstly, the correlations between all the considered characteristics are analysed and highlighted more than ever before for the main important links between several characteristics. Taking into account the data available, changes in population (growth rates) are applied for three and six years after implementing HSR. Nevertheless, this general sample does not include all the cities of the original country sample due to several mentioned restrictions of data. The overall sample consists of 38 cities, including the twins.

Considering the prepared data base and location factors the following reasonable correlations can be highlighted in a first step.

Sample including HSR and non HSR

- Growth rates in population three and six years after commissioning (0.7**)
- Growth rates in population three years after commissioning and inhabitants per square kilometre (-0.4*)
- Distance to a reference city and travelling time (0.8**)
- Number of inhabitants per city and inhabitants per square kilometre (0.4*)
- Number of inhabitants per city and distance to a reference city (0.4**)

These correlations show reasonable as well as partly expected results. Accordingly, the correlation between the growth rates plus three and plus six in comparison to the commissioning are developing in the same direction. However, in the case of growth rate plus three and the city size a negative correlation is noted. This implies that the higher is the number of inhabitants per square kilometre the lower are the changes in population or vice versa. These first considerations lead to the conclusion that PCA factors including population changes on the one hand and distance or number of inhabitants on the other hand could be used.

Principal Component Analysis

An application of the array of the identified characteristics leads to the result that a preparation of a PCA is useful in a limited way. The relevant criteria of MSA is approximately 0.6 in the case of applying the population density - number of inhabitants per square kilometre. The following charts (Figure 115) show the cases including population density as a result. On the left the results are presented depending on the HSR / non HSR and on the right depending on the country.

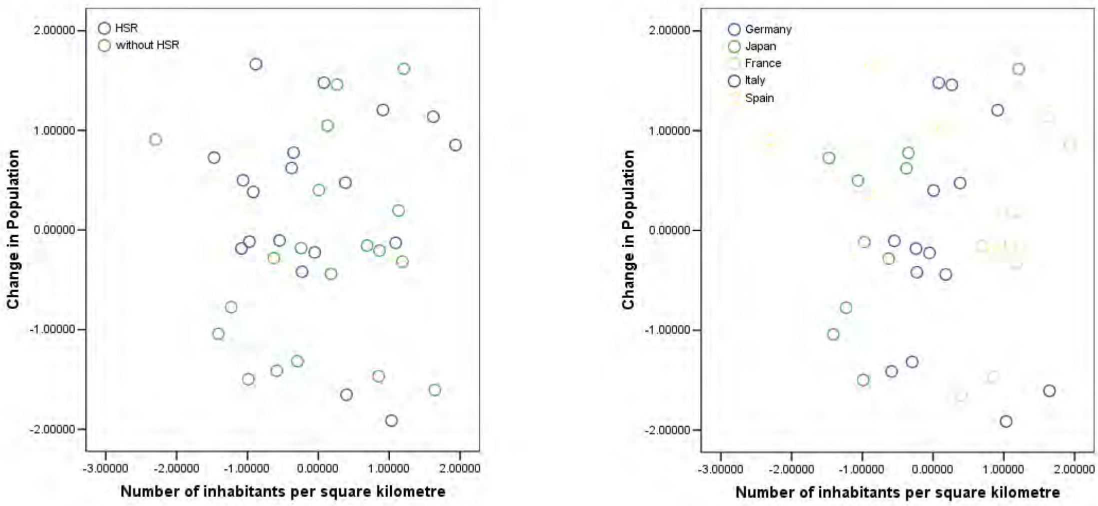


Figure 115: Transnational - PCA - Changes in population
[Source: Own preparation and illustration using data from the national statistical offices per country (2010)]

As the MSA has indicated, the results are not as clear as desired. However, indications could be seen. For example mostly twin cities developed in the case of population below average or equal to average in comparison to HSR cities. Nevertheless, a detailed answer regarding the influence of the population density could not be given here because different kinds of changes in population are also related to different kinds of population density. A statement concerning a country could also not be given although general differences exist between countries.

Apart from the application of a sample including both HSR and non HSR only cities with a link to High Speed can be viewed. The following determined correlation can support this analysis.

Sample including HSR only

- Growth rates in population three and six years after commissioning (0.8**)
- Distance to a reference city and travelling time (0.9**)
- Number of inhabitants per city and inhabitants per square kilometre (0.5*)
- Number of inhabitants per city and distance to a reference city (0.5*)
- Number of inhabitants per city and the number of trains per day (0.6**)

Considering the HSR cities separately, the MSA amounts to 0.6 as also in the case of the overall sample. One factor includes the changes in population as before and the other factor only includes the population density. The result is illustrated in Figure 116.

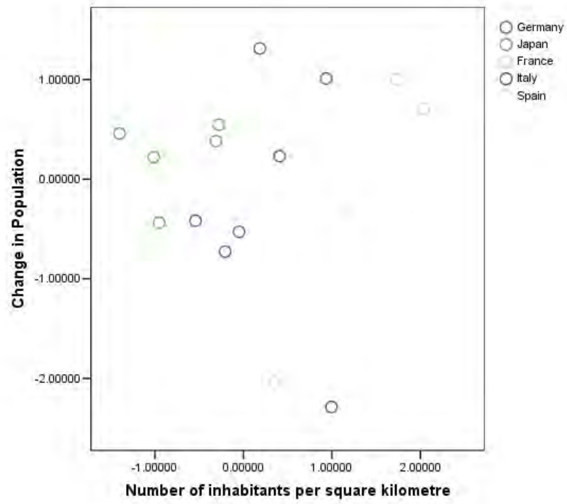


Figure 116: Transnational - PCA - Changes in population - HSR only
[Source: Own preparation and illustration using data from the national statistical office per country (2010)]

The result mainly shows a separation by country with respect to the population density. But a significant result regarding the question of whether the changes in population differ for different population densities cannot finally be stated here. There are changes in population over and below average of the factors independent of the population density.

Regression Analysis

The information and characteristics used within this regression analysis are based upon the shown correlation analysis and the previous applied standard procedure. Therefore, any possible useful information is extracted and potential co-linearity's are highlighted. Three calculations have been completed. The difference is only the explained characteristics changes in population, first of all three years and secondly six years after commissioning as well as a factor including both (determined factor from the PCA). Therefore, various compositions of the explanatory characteristics including the binaries are carried out to explain the variances of the developments. All in all, useful significant results could not be illustrated in the case of regression. Some indications with respect to the influence of population density or development of the surrounding areas of the station can be mentioned but with standard errors of the coefficients of approximately 50 % which is not acceptable here. Nevertheless, there are indications for a higher correlation within the first three years than within six years or more. This indicates a higher influence of HSR in the first years after the commissioning.

5.5 Summary

The last part of the study shows the detailed attempt to find quantitative evidence for the impact of HSR regarding several predefined impacts. Therefore, the data base was defined and prepared depending on the country under consideration and the considered effect. One main challenge within this important step was the difficulty regarding data availability. In detail, the data was mostly not available at the requested city level as well as for the years needed (time series). These problems lead to adjustments in the approaches to the analyses which include reduced data bases followed by limited applications of the designated statistical tools. Therefore, the data and the tools are mainly used for showing the approach for the evidence of impacts. As a result it can be stated that the tools have worked but some results are not those desired due to the restricted availability of data.

Nevertheless, the results also provide several good reasonable indications for the effect of HSR depending on the data and cities, as well as countries. In consideration of the first analysis - time series and correlation coefficients - Figure 114 summarises the results. Here, the comparison of the city and the respective twin city is made. Where a city had a better development against the twin city in one of the impacts, the field is highlighted in the table. If there is no apparent difference the general grey background is shown. The decision as to yes or no was made by using the correlation coefficients as well as considering the time series itself. These results refer to the analysis performed considering the limited data base together with the restricted time period. The data sources are also presented because it is assumed that a result at city level is more realistic than at regional level. One reason for this is for example the probability of more additional effects and conditions in the region in comparison to the cities. In other words, the wider the area - extension of the investigation area - the higher are the various influences from other aspects outside of the HSR and the more difficult it is to find evidence in this field.

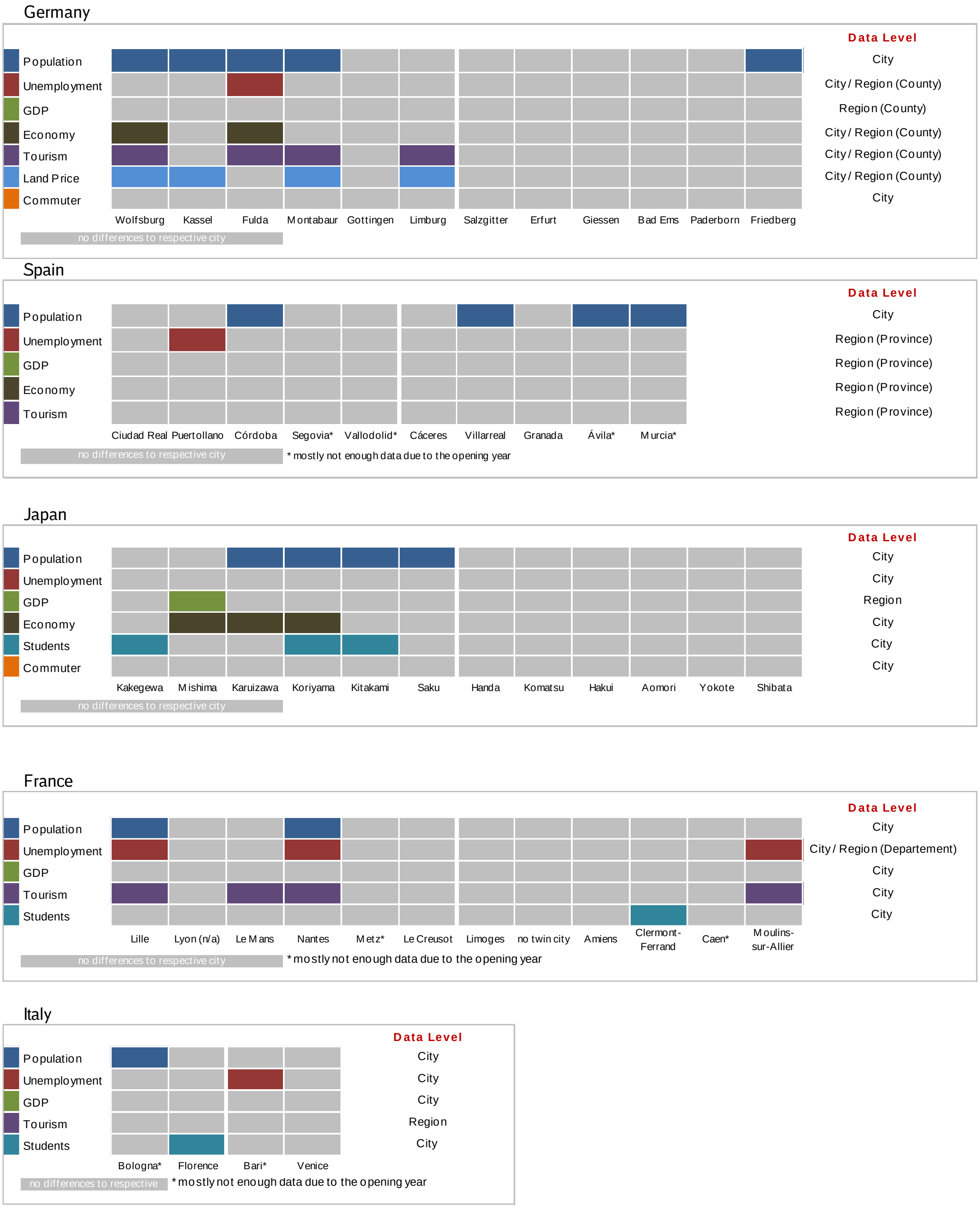


Figure 117: Quantitative results – Summary

In the case of Germany a good development for the HSR is ascertained by comparing all included impacts. Examples that could be highlighted are Wolfsburg as well as Fulda. Potential explanations for this can be certainly the car manufacture (Volkswagen) in Wolfsburg and for Fulda its location in the network with connections to different HSR cities, including a short travelling distance to the financial centre Frankfurt / Main. Japan also shows positive examples in its development after the commissioning of HSR, mostly in the case of changes in population. All in all, Mishima or Koriyama can be highlighted as positive examples - in comparison to the twin cities. However, the applied data were mostly interpolated which needs to be considered when looking at the results. Lille or Nantes could be highlighted due to better development in comparison to twin cities as well as among the HSR itself when considering France. However, the twin city choice must also be taken into account here. Due to the city structure as well as the population density it was difficult to determine comparable cities in some cases. Cities which have a special structure as well as importance already have HSR connections. In addition, some of the chosen twin cities will obtain a HSR connection in the future, which affected the current analysis directly due to the comparison of data out of the past, which needs to be recognised here. In regard to this, a same understanding of defining the twin cities needs to be taken into account, for example in the case of Spain. Nevertheless, Spain does not indicate significant overall differences between the pairs whereas some results for individual effects have been noted. A similar statement is made for Italy. However, the sample size only includes four cities and especially only two cities with a long operating period.

Due to the differences in the results - also in the HSR case it's self - the next part of the study has focussed on finding potential reasons for these differences as well as general influences in the development. However, this has been done in a first understanding by using a constrained number of quantitative measureable factors. In general, it could be stated that the results differ amongst and within the countries, which can also be explained by the difference in the sample size, but may even be a reason for the described differences amongst the countries. In summary, the size of the city including inhabitants per square kilometre and the distance as well as the travelling time to the next relevant city can be highlighted as a result of doing an analysis separated by country. However, these results are not significant on a designated level for each country or investigated impact and the transnational sample leads to similar results but not in a requested statistically significant way at all. Although, Japan has indicated good results but using mostly interpolated data. Moreover, it can be assumed that the explanation for the extent of changes in impacts cannot be made by applying only one factor. Therefore, the changes need to be described by using for example the city size as well as the travelling and not only one of them. Nevertheless, the share of each location may differ for each impact and country and have not yet been detailed.

In fact, the interpretation of the quantitative results mainly depend on the restricted data base. However, there are apparent differences between HSR / non HSR which are verifiable. These differences need to be discussed in more detail in a further approach because the success depends on several circumstances. For example HSR implementation needs a city / regional basis (socio-economic, infrastructure, tourism etc.). Moreover, HSR is not the only factor that effects city / regional development as has already been shown in the qualitative assessment. Nevertheless, HSR provides an opportunity to boost the development in the city / region and the stated results can be used to support qualitative statements and as an important framework / guide with regard to this diverse subject.

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Annex

List of Content

Definition of the field of investigation

Country selection

Country	Part of the world	Start of HSR operation	Network length [km]	Data available (impact)	Cities available (impact)	Preliminary study	Contact persons	Documentations available
Belgium	Europe	1997	209	✓✗	✓✗	✗	✓✗	✓✗
China (Taiwan)	Asia	2008	4,520	✗	✓✗	✗	✓✗	✗
France	Europe	1981	1,896	✓✗	✓	✓	✓	✓
Germany	Europe	8	1,285	✓✗	✓	✓	✓	✓
Italy	Europe	1981	923	✓✗	✓	✓	✓✗	✗
Japan	Asia	1964	2,534	✓✗	✓	✓	✓✗	✓
Korea	Asia	2004	330	✗	✓✗	✗	✓✗	✗
Spain	Europe	1992	2,056	✓✗	✓	✓	✓	✓
The Netherlands	Europe	2009	120	✓✗	✓✗	✗	✓✗	✓✗
United Kingdom	Europe	2003	113	✓✗	✓✗	✗	✓✗	✓

selected countries

Network data Source: UIC (2011)

Figure 118: Country selection - decision basis

City / twin city selection

Spain

	City	Population 2008 [inhabitants]	> Category	Population commissioning [inhabitants]	University	Seat of Administration Region	Seat of Administration Province	Airline distance Madrid [km]	> Category	Station location	Highway	Airport	Population density in province [inhabitants/sqkm]	Commissioning
HSR	Ciudad Real	74,345	B	57,807	x	-	x	160	B	City centre	x	-	27	1992
HSR	Puertollano	52,300	C	51,501	-	-	-	195	B	City centre	x	x	27	1992
HSR	Córdoba	328,547	A	305,086	x	-	x	295	A	City centre	x	x	58	1992
HSR	Valladolid	315,522	A	316,564	x	x	x	162	B	City centre	x	x	65	2007
HSR	Segovia	55,748	C	56,047	-	-	x	69	D	Outside	x	-	24	2007
Non HSR	Cáceres	94,179	B	75,512	x	-	x	252	B	City centre	x	x	21	-
Non HSR	Villarreal	51,205	C	49,045	-	-	-	309	A	City centre	x	-	90	-
Non HSR	Granada	239,154	A	38,207	x	-	x	360	A	City centre	x	x	72	-
Non HSR	Murcia	441,345	A	422,861	x	x	x	350	A	City centre	x	x	123	-
Non HSR	Ávila	58,245	C	259,702	x	-	x	88	D	City centre	x	-	21	-

Sources:

Time table	Deutsche Bahn (2010), www.bahn.de
GDP, inhabitans	Statistical office Spain (2010), www.ine.es
Distances	www.google.de
Homepages of the cities for additional informationen	

Figure 119: City / twin city selection Spain - data basis

Italy

	City	Population [inhabitants]	> Category	Population commissioning [inhabitants]	University	Seat of Administration Region	Seat of Administration Province	Airline distance Rome [km]	> Category	Station location	Highway	Airport	Population density in departement [inhabitants/sqkm]	Commissioning
HSR	Florence	368,901	A	407,723	x	x	x	231	B	City centre	x	x	282	1991
HSR	Bologna	377,220	A	372,256	x	x	x	303	A	City centre	x	x	266	2008
Non HSR	Venice	270,801	A	313,486	x	x	x	394	A	City centre	x	x	349	-
Non HSR	Bari	320,150	A	322,511	x	x	x	375	A	City centre	x	x	328	-

Sources:

Time table	Deutsche Bahn (2010), www.bahn.de
GDP, inhabitans	Statistical office Italy (2010), www.istat.it
Distances	www.google.de
Homepages of the cities for additional informationen	

Figure 120: City / twin city selection Italy - data basis

Germany

	City	Population 2009 [inhabitants]	> Category	Population commissioning [inhabitants]	University	Regional centre	Reference city	Airline distance to a reference city [km]	> Category	Station location	Highway	Airport	Population density in county [inhabitants/sqkm]	Commissioning
HSR	Gottingen	121,455	B	124,331	x	x	Hanover	94	C	City centre	x	-	1,036	1991
HSR	Kassel	194,168	B	191,828	x	x	Frankfurt / Main	118	B	City centre	x	x	1,824	1991
HSR	Fulda	64,129	C	57,180	x	x	Frankfurt / Main	86	C	City centre	x	-	158	1991
HSR	Wolfsburg	120,538	B	122,185	-	x	Hanover	71	C	City centre	x	x	594	1998
HSR	Montabaur	12,486	C	13,510	-	-	Frankfurt / Main	54	C	City centre	x	-	202	2002
HSR	Limburg	33,504	C	33,635	-	-	Frankfurt / Main	70	C	City centre	x	-	232	2002
Non HSR	Paderborn	145,320	B	125,730	x	x	Hanover	100	B	City centre	x	x	810	-
Non HSR	Erfurt	203,333	B	204,912	x	x	Hanover	180	B	City centre	x	x	757	-
Non HSR	Giessen	75,140	C	73,763	x	x	Frankfurt / Main	53	C	City centre	x	-	299	-
Non HSR	Salzgitter	104,423	B	114,104	-	x	Hanover	47	C	Outside	x	x	462	-
Non HSR	Bad Ems	9,179	C	27,508	-	-	Frankfurt / Main	25	C	City centre	-	-	159	-
Non HSR	Friedberg	27,922	C	10,325	-	-	Frankfurt / Main	73	C	City centre	-	-	271	-

Sources:
Time table — Deutsche Bahn (2010), www.bahn.de
GDP, inhabitans — Statistical office Germany (2010), www.destatis.de
Distances — www.google.de
Homepages of the cities for additional informationen

Figure 121: City / twin city selection Germany - data basis

France

	City	Population [inhabitants]	> Category	University	Seat of Administration Region	Seat of Administration Departement	Airline distance Paris [km]	> Category	Station location	Highway	Airport	Population density in departement [inhabitants/sqkm]	Commissioning
HSR	Lyon	472,330	A	x	x	x	391	A	City centre	x	x	516	1981
HSR	Le Creusot	23,793	C	-	-	-	277	B	Outside	-	-	64	1981
HSR	Le Mans	144,164	B	x	-	x	184	C	City centre	x	x	90	1989
HSR	Nantes	283,025	A	x	x	x	344	A	City centre	x	x	183	1989
HSR	Lille	225,789	A	x	x	x	205	C	City centre	x	x	447	1993
HSR	Metz	123,580	B	x	x	x	281	B	Outside	x	x	167	2007
Non HSR	Lyon (no twin city)	-	-	-	-	-	-	-	-	-	-	-	-
Non HSR	Moulins-sur-Allier	23,200	C	-	-	x	266	B	City centre	-	-	47	-
Non HSR	Amiens	134,737	B	x	x	x	116	D	City centre	x	x	92	-
Non HSR	Clermont-Ferrand	139,501	B	x	x	x	347	A	City centre	x	x	79	-
Non HSR	Limoges	138,882	B	x	x	x	347	A	City centre	x	x	67	-
Non HSR	Caen	109,630	B	x	x	x	202	C	Outside	x	x	121	-

Sources:

Time table	Deutsche Bahn (2010), www.bahn.de
GDP, inhabitans	Statistical office France (2010), www.insee.fr
Distances	www.google.de

Homepages of the cities for additional informationen

Figure 122: City / twin city selection France - data basis

Japan

	City	Population [inhabitants] 2009	> Category	Population commissioning [inhabitants]	University	Reference city	Airline distance to a reference city [km]	> Category	Station location	Highway	Airport	Commissioning
HSR	Mishima	111,612	C	94,612	x	Tokyo	95	D	City centre	x	x	1969
	Koriyama	338,518	C	289,451	x	Tokyo	220	B	Outside	x	x	1982
	Kitakami	93,967	C	76,633	-	Tokyo	420	A	City centre	x	-	1982
	Kakegawa	117,621	B	105,030	x	Tokyo	224	B	City centre	x	x	1988
	Saku	17,990	B	97,813	x	Tokyo	125	C	Outside	x	-	1997
	Karuizawa	99,944	B	15,345	-	Tokyo	122	C	Outside	x	x	1997
Non HSR	Komatsu	108,840	C	104,329	x	Osaka	209	B	City centre	x	x	-
	Aomori	304,016	C	309,768	x	Tokyo	578	A	City centre	x	x	-
	Yokote	100,016	C	120,479	x	Tokyo	682	A	City centre	x	x	-
	Handa	118,012	B	99,550	x	Osaka	133	C	City centre	x	x	-
	Shibata	23,692	B	106,563	x	Tokyo	255	B	City centre	x	x	-
	Hakui	102,688	B	26,502	x	Osaka	293	B	City centre	x	x	-

Sources:
Time table www.hyperdia.com/en/
GDP, inhabitans Statistical office Germany (2010), www.destatis.de
Distances www.google.de
Homepages of the cities for additional informationen

Figure 123: City / twin city selection Japan - data basis

Country grading

Data base

Country	Frist commissioning	Population (2009) [thsd. inhabitants]	Population density [inhabitants/sqkm]	Employment [employees]	Employment rate [%]	GDP [billion US-$]	GDP / capita [mio EUR]	Area [sqkm]	Network extension [HSR-km/sqkm]	HSR distribution [inhabitans/ HSR-km]	Network length [km]	Network
China (Taiwan)	2008	1,324,655	138	n/a	n/a	4,327	3,267	9,571,302	0.00047	293	4,520	Network
France	1981	62,599	93	25,456,000	40665.2	2,857	45,633	674,843	0.00281	33	1,896	Network
Germany	1991	82,025	230	40,236,000	49053.3	3,649	44,492	357,112	0.00360	64	1,285	Network
Italy	1992*	59,779	198	23,038,000	38538.6	2118	35,435	301,338	0.00306	65	923	Network
Japan	1964	127,559	338	62,819,000	49247.0	4,911	38,499	377,835	0.00671	50	2,534	Line
Korea	2004	48,751	230	23,506,000	48216.4	929	19,059	211,762	0.00156	148	330	Line
Spain	1992	45,828	91	19,134,000	41751.8	1,604	35,006	504,645	0.00407	22	2,056	Network

* First section was opened in 1992.

Sources:

Population	Worldbank (2011)	http://data.worldbank.org/indicator/SP.POP.TOTL
GDP	Worldbank (2011)	http://data.worldbank.org/indicator/NY.GDP.MKTP.CD
Area	Worldbank (2011)	http://data.worldbank.org/indicator/AG.LND.TOTL.K2
Employment	Worldbank (2011)	http://data.worldbank.org/indicator/SL.EMP.TOTL.SP.ZS
HS-Network	UIC (2011)	www.uic.org

Figure 124: Country grading - data base

Result cluster analysis

Proximity Matrix

Case	Squared Euclidean Distance				
	1:France	2:Germany	3:Italy	4:Japan	5:Spain
1:France	.000	6.325	11.215	22.637	6.401
2:Germany	6.325	.000	3.835	20.830	11.862
3:Italy	11.215	3.835	.000	24.996	9.772
4:Japan	22.637	20.830	24.996	.000	22.126
5:Spain	6.401	11.862	9.772	22.126	.000

This is a dissimilarity matrix

Vertical Icicle

Number of clusters	Case								
	4:Japan		3:Italy		2:Germany		5:Spain		1:France
1	X	X	X	X	X	X	X	X	X
2	X		X	X	X	X	X	X	X
3	X		X	X	X		X	X	X
4	X		X	X	X		X		X

Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	2	3	1.918	0	0	3
2	1	5	5.118	0	0	3
3	1	2	12.353	2	1	4
4	1	4	28.000	3	0	0

Figure 125: Country grading – detailed results

Principal Component Analysis, Regression

France

Data base

	City	Commissioning	Population 3 years after commissioning [rate]	Population 6 years after commissioning [rate]	Reference city	Shortest travel time [min]	Airline distance to reference city [km]	Trains 2010 [number/ day]	Population, commissioning [inhabitants]	Area, city 2010 [sqkm]	Population density city [number / sqkm]	GDP, city commissioning [thsd. EUR]	HSR-Network postion	Station developement	Station location	HSR-international trains
HSR	Lyon	1981	0.987	0.989	Paris	117	391	119	419,327	48	8,760	-	Line	Yes	City centre	Yes
HSR	Le Creusot	1981	0.970	0.932	Paris	77	277	18	32,323	18	1,785	-	Line	No	Outside	No
HSR	Le Mans	1989	0.999	1.000	Paris	55	184	34	145,502	53	2,755	-	Line	Yes	City centre	No
HSR	Nantes	1989	1.025	1.060	Paris	125	344	40	244,995	65	3,758	-	Line	Yes	City centre	No
HSR	Lille	1993	1.015	1.045	Paris	60	205	124	203,316	35	5,839	-	Node	Yes	City centre	Yes
HSR	Metz	2007	-	-	Paris	83	281	26	123,580	42	2,947	3,004,724	Line	Yes	City centre	Yes
Non HSR	Twin city (n/a)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non HSR	Moulins-sur-Allier	-	0.972	0.937	Paris	143	266	-	25,289	9	2,937	-	-	No	City centre	-
Non HSR	Amiens	-	1.007	1.016	Paris	67	116	-	131,872	49	2,666	-	-	Yes	City centre	-
Non HSR	Clermont-Ferrand	-	0.992	0.994	Paris	180	347	-	136,181	43	3,191	-	-	No	Outside	-
Non HSR	Limoges	-	1.001	1.002	Paris	240	347	-	133,632	78	1,713	-	-	Yes	City centre	-
Non HSR	Caen	-	-	-	Paris	107	202	-	109,630	26	4,266	2,652,168	-	No	Outside	-

Sources:
Time table — Deutsche Bahn (2010), www.bahn.de
GDP, inhabitans — Statistical office France (2010), www.insee.fr
Distances — www.google.de

Figure 126: France - Data base PCA and Regression

PCA – Results

HSR and non HSR - Population

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.659
Bartlett's Test of Sphericity	Approx. Chi-Square	36.583
	df	3
	Sig.	.000

Anti-image Matrices

		Popplus3	Popplus6	Inhabitants
Anti-image Covariance	Popplus3	.011	-.008	.010
	Popplus6	-.008	.007	-.014
	Inhabitants	.010	-.014	.068
Anti-image Correlation	Popplus3	.641[a]	-.952	.378
	Popplus6	-.952	.594[a]	-.631
	Inhabitants	.378	-.631	.770[a]

a. Measures of Sampling Adequacy(MSA)

Rotated Component Matrix[a]

	Component	
	1	2
Popplus3	.822	.568
Popplus6	.785	.618
Inhabitants	.584	.811

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Figure 127: France - Statistical results of the PCA (Population - HSR and non HSR)

Germany

Data base

	City	Commissioning	Population 3 years after commissioning [rate]	Population 6 years after commissioning [rate]	Tourism (overnight stays) 3 years after commissioing [rate]	Tourism (overnight stays) 6 years after commissioning [rate]	Tourism (arrivals) 6 years after commissioning [rate]	Tourism (arrivals) 6 years after commissioning [rate]	Reference city	Shortest travel time to reference city [min]	Airline distance to reference city [km]	Trains 2010 [number / day]	City Population, commissioning [inhabitants]	Area, city 2010 [sqkm]	Population density city [number / sqkm]	GDP region, commissioning [thsd. EUR]	HSR-Network postion	Station developement	Station location	HSR-international trains
HSR	Gottingen	1991	1.026	1.024	0.840	1.042	0.791	0.965	Hanover	34	94	101	124,331	117	1,063	5,636,000	Line	Yes	City centre	Yes
HSR	Kassel*	1991	1.052	1.040	-	-	-	-	Hanover	55	118	106	191,828	107	1,793	6,645,000	Node	Yes	Outside	Yes
HSR	Fulda	1991	1.044	1.090	1.023	0.930	1.059	0.970	Frankfurt / Main	53	92	95	57,180	105	545	4,397,000	Node	Yes	City centre	Yes
HSR	Wolfsburg	1998	0.998	1.000	1.236	1.628	1.329	1.691	Hanover	32	87	38	122,185	204	599	7,677,021	Node	Yes	City centre	Yes
HSR	Montabaur	2002	1.015	1.007	-	-	-	-	Frankfurt / Main	46	76	36	13,510	34	397	4,383,304	Line	Yes	Outside	No
HSR	Limburg	2002	1.010	0.996	1.186	1.295	1.189	1.288	Frankfurt / Main	34	59	33	33,635	45	747	3,432,774	Line	No	Outside	No
Non HSR	Paderborn	-	1.046	1.082	1.009	1.016	1.047	1.063	Hanover	108	104	-	125,730	180	699	5,092,000	-	No	-	-
Non HSR	Erfurt*	-	1.042	1.002	-	-	-	-	Hanover	135	185	-	204,912	269	762	3,354,000	-	Yes	-	-
Non HSR	Giessen	-	0.999	0.990	0.705	0.703	0.793	0.941	Frankfurt / Main	40	51	-	73,763	73	1,010	5,678,000	-	No	-	-
Non HSR	Salzgitter*	-	0.979	0.953	1.227	0.695	1.202	1.040	Hanover	49	57	-	114,104	224	509	3,295,212	-	No	-	-
Non HSR	Friedberg	-	1.002	1.014	0.975	0.933	0.981	0.802	Frankfurt / Main	24	25	-	27,508	50	550	-	-	NO	-	-
Non HSR	Bad Ems	-	0.976	0.960	-	-	-	-	Frankfurt / Main	83	81	-	10,325	15	688	2,312,028	-	No	-	-

* GDP: independent city

Sources:
Time table — Deutsche Bahn (2010), www.bahn.de
GDP, inhabitans — Statistical office Germany (2010), www.destatis.de
Distances — www.google.de

Figure 128: Germany - Data base PCA and Regression

PCA – Results

HSR and non HSR - Population

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.494
Bartlett's Test of Sphericity	Approx. Chi-Square	15.111
	df	3
	Sig.	.002

Anti-image Matrices

		Popplus3	Popplus6	Inhabitants
Anti-image Covariance	Popplus3	.210	-.198	-.194
	Popplus6	-.198	.260	.128
	Inhabitants	-.194	.128	.670
Anti-image Correlation	Popplus3	.497[a]	-.847	-.518
	Popplus6	-.847	.495[a]	.308
	Inhabitants	-.518	.308	.485[a]

a. Measures of Sampling Adequacy(MSA)

Rotated Component Matrix[a]

	Component	
	1	2
Popplus3	.895	.365
Popplus6	.971	.087
Inhabitants	.192	.978

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Figure 129: Germany - Statistical results of the PCA (Population - HSR and non HSR)

HSR only - Population

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.653
Bartlett's Test of Sphericity	Approx. Chi-Square	5.360
	df	3
	Sig.	.147

Rotated Component Matrix[a]

	Component	
	1	2
Popplus3	.816	.487
Popplus6	.942	.239
Distance	.312	.945

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Anti-image Matrices

		Popplus3	Popplus6	Distance
Anti-image Covariance	Popplus3	.261	-.214	-.184
	Popplus6	-.214	.344	.009
	Distance	-.184	.009	.534
Anti-image Correlation	Popplus3	.598[a]	-.715	-.492
	Popplus6	-.715	.650[a]	.021
	Distance	-.492	.021	.758[a]

a. Measures of Sampling Adequacy(MSA)

Figure 130: Germany - Statistical results of the PCA (Population – HSR only)

Regression - Results

HSR and non HSR - Population

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.591[a]	.349	.284	.0218726

a. Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.118	.058		-2.038	.069
	Distance	.031	.013	.591	2.317	.043

a. Dependent Variable: Popplus3

Figure 131: Germany – Statistical results of the regression, population three years after commissioning (HSR and non HSR)

HSR only - Population

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.863[a]	.745	.681	.0113961

a. Predictors: (Constant), Trains

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.101	.037		-2.744	.052
	Trains	.030	.009	.863	3.416	.027

a. Dependent Variable: Popplus3

Figure 132: Germany – Statistical results of the regression, population three years after commissioning (HSR only)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.759[a]	.577	.471	.0246392

a. Predictors: (Constant), Trains

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.159	.080		-1.997	.116
	Trains	.045	.019	.759	2.335	.080

a. Dependent Variable: Popplus6

Figure 133: Statistical results of the regression, population six years after commissioning (HSR only)

HSR and non HSR – Tourism, overnight stays

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.740[a]	.547	.472	.1425264

a. Predictors: (Constant), Inhabitantssq

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.366	1.248		2.697	.036
	Inhabitantssq	-.514	.191	-.740	-2.692	.036

a. Dependent Variable: Tourismplus3overnight

Figure 134: Germany – Statistical results of the regression, overnight stays three years after commissioning (HSR and non HSR)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.750[a]	.562	.489	.1352757

a. Predictors: (Constant), Inhabitantssq

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.319	1.185		2.801	.031
	Inhabitantssq	-.503	.181	-.750	-2.776	.032

a. Dependent Variable: Tourismplus3arrivals

Figure 135: Germany - Statistical results of the regression, arrivals three years after commissioning (HSR and non HSR)

Japan

Data base

	City	Commissioning	Population 3 years after commissioning [rate]	Population 6 years after commissioning [rate]	Population 9 years after commissioning [rate]	Economy 3 years after commissioning [rate]	Economy 6 years after commissioning [rate]	Students 3 years after commissioning [rate]	Students 6 years after commissioning [rate]	Students 9 years after commissioning [rate]	Reference city	Shortest travel time to reference city [min]	Airline distance to reference city [km]	Trains 2010 [number / day]	Population, commissioning [inhabitants]**	Area, city 2010 [sqkm]	Population density city, commissioning [number / sqkm]**	GDP region, commissioning [Mio. Yen]	HSR-Network postion	Station developement	Station Location	HSR-international trains
HSR	Mishima*	1969	-	-	-	-	-	-	-	-	Tokyo	51	95	87	94,612	62	1,523	15,901,659	Line	Yes	City centre	No
HSR	Koriyama*	1982	1.025	1.051	1.077	0.977	1.023	1.041	1.064	1.049	Tokyo	84	220	97	294,340	757	389	8,192,258	Line	Yes	Outside	No
HSR	Kitakami*	1982	1.028	1.048	1.075	0.948	0.946	1.055	1.152	1.112	Tokyo	156	420	39	78,079	438	178	4,821,952	Line	Yes	City centre	No
HSR	Kakegawa*	1988	1.029	1.058	1.085	1.001	0.961	0.990	0.949	0.912	Tokyo	90	224	66	103,008	266	388	15,901,659	Line	Yes	City centre	No
HSR	Saku	1997	1.013	1.016	1.017	1.031	0.965	0.989	0.915	0.853	Tokyo	77	125	51	98,694	424	233	8,568,732	Line	Yes	Outside	No
HSR	Karuizawa	1997	1.032	1.069	1.107	1.190	1.288	0.937	0.851	0.802	Tokyo	67	122	52	15,679	156	100	8,568,732	Line	Yes	Outside	No
Non HSR	Komatsu*	-	-	-	-	-	-	-	-	-	Osaka	138	209	-	104,329	371	281	4,663,638	-	No	-	-
Non HSR	Aomori*	-	1.012	0.998	0.993	0.952	0.874	1.031	1.007	0.933	Tokyo	227	578	-	312,280	825	379	4,652,977	-	No	-	-
Non HSR	Yokote*	-	0.993	0.976	0.960	0.933	0.913	1.021	0.994	0.988	Tokyo	240	682	-	119923	693	173	3,987,868	-	Yes	-	-
Non HSR	Handa*	-	1.042	1.085	1.117	-	-	0.941	0.857	0.894	Osaka	122	133	-	96,883	47	2,051	34,395,600	-	No	-	-
Non HSR	Shibata	-	0.997	0.989	0.979	0.989	0.923	0.975	0.929	0.817	Tokyo	131	255	-	106,344	533	200	9,695,620	-	No	-	-
Non HSR	Hakui	-	0.978	0.954	0.931	0.991	0.935	0.956	0.878	0.822	Osaka	219	293	-	26,118	82	319	4,643,626	-	No	-	-

* GDP: 1996

** In the case of population, the commissioning date for Mishima and Komatsu is set to 1980 due to the data availability.

Sources:
Time table www.hyperdia.com
GDP, inhabitans Statistical office Japan (2010), www.stat.go.jp
Distances www.google.de

Figure 136: Japan - Data base PCA and Regression

PCA - Results

HSR and non HSR – Population

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.656
Bartlett's Test of Sphericity	Approx. Chi-Square	36.105
	df	6
	Sig.	.000

Anti-image Matrices

		Popplus3	Popplus9	TravelTime	Distance
Anti-image Covariance	Popplus3	.036	-.032	-.017	-.011
	Popplus9	-.032	.030	.025	.008
	TravelTime	-.017	.025	.198	-.169
	Distance	-.011	.008	-.169	.273
Anti-image Correlation	Popplus3	.614[a]	-.970	-.204	-.108
	Popplus9	-.970	.627[a]	.319	.086
	TravelTime	-.204	.319	.704[a]	-.728
	Distance	-.108	.086	-.728	.699[a]

a. Measures of Sampling Adequacy(MSA)

Rotated Component Matrix[a]

	Component	
	1	2
Popplus3	.958	-.268
Popplus9	.925	-.367
TravelTime	-.421	.864
Distance	-.231	.945

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Figure 137: Japan - Statistical results of the PCA (Population - HSR and non HSR)

HSR only - Population

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.720
Bartlett's Test of Sphericity	Approx. Chi-Square	16.266
	df	6
	Sig.	.012

Rotated Component Matrix[a]

	Component	
	1	2
Popplus3	.967	-.218
Popplus6	.975	-.206
Popplus9	.977	-.206
Inhabitants	-.211	.977

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Anti-image Matrices

		Popplus3	Popplus6	Popplus9	Inhabitants
Anti-image Covariance	Popplus3	.031	.004	-.006	.016
	Popplus6	.004	.005	-.004	.002
	Popplus9	-.006	-.004	.004	-.002
	Inhabitants	.016	.002	-.002	.826
Anti-image Correlation	Popplus3	.828[a]	.292	-.582	.098
	Popplus6	.292	.683[a]	-.945	.028
	Popplus9	-.582	-.945	.633[a]	-.029
	Inhabitants	.098	.028	-.029	.978[a]

a. Measures of Sampling Adequacy(MSA)

Figure 138: Japan - Statistical results of the PCA (Population - HSR only)

Regression

HSR and non HSR – Population

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.623[a]	.388	.311	.0166035

a. Predictors: (Constant), TravelTime

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.142	.057		2.499	.037
	TravelTime	-.026	.012	-.623	-2.251	.054

a. Dependent Variable: Popplus3

Figure 139: Japan - Statistical results of the regression, population plus three years (HSR and non HSR)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.696[a]	.484	.419	.0328502

a. Predictors: (Constant), TravelTime

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.329	.112		2.934	.019
	TravelTime	-.063	.023	-.696	-2.739	.025

a. Dependent Variable: Popplus6

Figure 140: Japan - Statistical results of the regression, population plus six years (HSR and non HSR) - travelling time

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.579[a]	.335	.252	.0372960

a. Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.248	.113		2.202	.059
	Distance	-.040	.020	-.579	-2.006	.080

a. Dependent Variable: Popplus6

Figure 141: Japan - Statistical results of the regression population plus six years (HSR and non HSR) - distance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.700[a]	.491	.427	.048863

a. Predictors: (Constant), TravelTime

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.493	.167		2.954	.018
	TravelTime	-.095	.034	-.700	-2.776	.024

a. Dependent Variable: Popplus9

Figure 142: Japan - Statistical results of the regression, population plus nine years (HSR and non HSR) – travelling time

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.565[a]	.319	.234	.056503

a. Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.360	.170		2.110	.068
	Distance	-.059	.031	-.565	-1.935	.089

a. Dependent Variable: Popplus9

Figure 143: Japan - Statistical results of the regression, population plus nine years (HSR and non HSR) - distance

PCA - Results

HSR and non HSR - Economy

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.715
Bartlett's Test of Sphericity	Approx. Chi-Square	13.563
	df	3
	Sig.	.004

Rotated Component Matrix[a]

	Component	
	1	2
Economyplus3	.899	-.387
Economyplus6	.877	-.430
TravelTime	-.415	.910

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Anti-image Matrices

		Economy plus3	Economy plus6	TravelTime
Anti-image Covariance	Economyplus3	.167	-.129	.043
	Economyplus6	-.129	.155	.080
	TravelTime	.043	.080	.423
Anti-image Correlation	Economyplus3	.670[a]	-.803	.163
	Economyplus6	-.803	.653[a]	.311
	TravelTime	.163	.311	.899[a]

a. Measures of Sampling Adequacy(MSA)

Figure 144: Japan - Statistical results of the PCA (Population - HSR only)

PCA - Results

HSR only – Economy

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.699
Bartlett's Test of Sphericity	Approx. Chi-Square	5.445
	df	3
	Sig.	.142

Anti-image Matrices

		Economy plus3	Economy plus6	Inhabitantssq
Anti-image Covariance	Economyplus3	.157	-.131	.062
	Economyplus6	-.131	.159	.053
	Inhabitantssq	.062	.053	.490
Anti-image Correlation	Economyplus3	.641[a]	-.832	.224
	Economyplus6	-.832	.644[a]	.190
	Inhabitantssq	.224	.190	.919[a]

a. Measures of Sampling Adequacy(MSA)

Rotated Component Matrix[a]

	Component	
	1	2
Economyplus3	.900	-.383
Economyplus6	.904	-.374
Inhabitantssq	-.387	.922

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Figure 145: Japan - Statistical results of the PCA (Economy - HSR only)

Regression - Results

HSR and non HSR - Economy

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.729[a]	.531	.453	.0572830

a. Predictors: (Constant), TravelTime

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.531	.205		2.588	.041
	TravelTime	-.109	.042	-.729	-2.608	.040

a. Dependent Variable: Economyplus3

Figure 146: Japan - Statistical results of the regression economy plus three years (HSR and non HSR) – travelling time

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.809[a]	.654	.596	.0492085

a. Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.549	.164		3.341	.016
	Distance	-.097	.029	-.809	-3.368	.015

a. Dependent Variable: Economyplus3

Figure 147: Japan - Statistical results of the regression economy plus three years (HSR and non HSR) - distance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.703[a]	.494	.410	.0926448

a. Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.722	.309		2.332	.058
	Distance	-.132	.054	-.703	-2.422	.052

a. Dependent Variable: Economyplus6

Figure 148: Japan - Statistical results of the regression, economy plus six years (HSR and non HSR) - distance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.752[a]	.565	.492	.0859311

a. Predictors: (Constant), TravelTime

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.832	.308		2.701	.036
	TravelTime	-.175	.063	-.752	-2.792	.032

a. Dependent Variable: Economyplus6

Figure 149: Japan - Statistical results of the regression, economy plus six years (HSR and non HSR) – travelling time

PCA - Results

HSR and non HSR – Students

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.764
Bartlett's Test of Sphericity	Approx. Chi-Square	34.609
	df	6
	Sig.	.000

Rotated Component Matrix[a]

	Component	
	1	2
Studentsplus6	.918	.359
Studentsplus9	.939	.217
Studentsplus3	.873	.435
Distance	.311	.948

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Anti-image Matrices

		Students plus6	Students plus9	Students plus3	Distance
Anti-image Covariance	Studentsplus6	.047	-.049	-.043	.009
	Studentsplus9	-.049	.172	.006	.033
	Studentsplus3	-.043	.006	.059	-.061
	Distance	.009	.033	-.061	.535
Anti-image Correlation	Studentsplus6	.686[a]	-.547	-.824	.057
	Studentsplus9	-.547	.854[a]	.063	.109
	Studentsplus3	-.824	.063	.727[a]	-.340
	Distance	.057	.109	-.340	.894[a]

a. Measures of Sampling Adequacy(MSA)

Figure 150: Japan - Statistical results of the PCA (Students - HSR and non HSR)

PCA - Results

HSR only – Students

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.750
Bartlett's Test of Sphericity	Approx. Chi-Square	17.916
	df	6
	Sig.	.006

Component Matrix[a]

	Component	
	1	2
Studentsplus6	.997	-.046
Studentsplus9	.994	-.048
Studentsplus3	.967	-.238
Distance	.938	.345

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

Anti-image Matrices

		Studentsplus6	Studentsplus9	Studentsplus3	Distance
Anti-image Covariance	Studentsplus6	.007	-.007	-.009	-.014
	Studentsplus9	-.007	.012	.000	.000
	Studentsplus3	-.009	.000	.031	.035
	Distance	-.014	.000	.035	.087
Anti-image Correlation	Studentsplus6	.682[a]	-.756	-.635	-.565
	Studentsplus9	-.756	.828[a]	.018	.013
	Studentsplus3	-.635	.018	.751[a]	.670
	Distance	-.565	.013	.670	.755[a]

a. Measures of Sampling Adequacy(MSA)

Figure 151: Japan - Statistical results of the PCA (Students - HSR only)

Regression

HSR and non HSR - Students

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.845[a]	.714	.632	.0256806

a. Predictors: (Constant), TravelTime, Distance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.156	.088		-1.775	.119
	Distance	.103	.026	1.500	3.917	.006
	TravelTime	-.087	.034	-.979	-2.555	.038

a. Dependent Variable: Studentsplus3

Figure 152: Japan - Statistical results of the regression, students plus three years (HSR and non HSR)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.808[a]	.652	.553	.0653332

a. Predictors: (Constant), TravelTime, Distance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.343	.224		-1.536	.168
	Distance	.231	.067	1.455	3.445	.011
	TravelTime	-.202	.087	-.984	-2.331	.053

a. Dependent Variable: Studentsplus6

Figure 153: Japan - Statistical results of the regression, students plus six years (HSR and non HSR)

HSR only - Students

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.829[a]	.687	.583	.0304981

a. Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.406	.159		-2.550	.084
	Distance	.077	.030	.829	2.569	.083

a. Dependent Variable: Studentsplus3

Figure 154: Japan - Statistical results of the regression, students plus three years (HSR only)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.918[a]	.842	.789	.0555677

a. Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.174	.290		-4.050	.027
	Distance	.218	.055	.918	3.996	.028

a. Dependent Variable: Studentsplus6

Figure 155: Japan - Statistical results of the regression, students plus six years (HSR only)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.912[a]	.832	.776	.0651876

a. Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.369	.340		-4.025	.028
	Distance	.247	.064	.912	3.852	.031

a. Dependent Variable: Studentsplus9

Figure 156: Japan - Statistical results of the regression, students plus nine years (HSR only)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.847[a]	.717	.623	.61385325

a. Predictors: (Constant), Inhabitants

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-9.075	3.300		-2.750	.071
	Inhabitants	.802	.291	.847	2.760	.070

a. Dependent Variable: Change in Students

Figure 157: Japan - Statistical results of the regression, students factor PCA
(HSR only)

Italy

Data base

	City	Commissioning	Population 3 years after commissioning [rate]	Population 6 years after commissioning [rate]	Reference city	Shortest travel time to reference city [min]	Airline distance to reference city [km]	Trains 2010 [number/ day]	Population, commissioning [inhabitants]	Area, city 2010 [sqkm]	Population density city [number/sqkm]	GDP/ capita, city, commissioning [EUR]	HSR-network postion	Station developement	Location Station	HSR-international trains
HSR	Florence*	1991	0.957	0.920	Rome	82	231	116	407,723	102	3,997	17,936	Line	No	City centre	No
HSR	Bologna	2008	-	-	Rome	122	303	186	372,256	140	2,659	34,511	Line	Yes	City centre	No
Non HSR	Venice*	-	0.958	0.932	Rome	193	394	-	313,486	41	7,609	17,021	-	No	-	-
Non HSR	Bari	-	-	-	Rome	243	375	-	322,511	116	2,780	18,606	-	No	-	-

*GDP per capita: 1995

Sources:

Sources:	Time table	Deutsche Bahn (2010), www.bahn.de
	GDP, inhabitans	Statistical office Italy (2010), www.istat.it
	Distances	www.google.de

Figure 158: Italy - Data base PCA and Regression

Spain

Data base

	City	Commissioning	Population 3 years after commissioning [rate]	Population 6 years after commissioning [rate]	Population 9 years after commissioning [rate]	Reference city	Shortest travel time to reference city [min]	Airline distance to reference city [km]	Trains 2010 [number/ day]	Population city, commissioning [inhabitants]	Area, city 2010 [sqkm]	Population density city [number/sqkm]	GDP, region, commissioning [thsd. EUR]	HSR-Network postion	Station developement	Station location	HSR-international trains
HSR	Ciudad Real*	1992	1.090	1.058	1.060	Madrid	52	160	58	57,807	285	203	3,588,794	Line	Yes	City centre	No
HSR	Puertollano*	1992	1.032	0.986	0.963	Madrid	67	195	43	51,501	219	235	3,588,794	Line	Yes	City centre	No
HSR	Córdoba	1992	1.042	1.016	1.029	Madrid	103	295	93	305,086	1,252	244	4,975,671	Node	Yes	City centre	No
HSR	Valladolid	2007	-	-	-	Madrid	56	162	12	316,564	198	1,600	13,039,366	Line	No	City centre	No
HSR	Segovia	2007	-	-	-	Madrid	28	69	10	56,047	164	343	3,800,228	Line	Yes	Outside	No
Non HSR	Cáceres	-	1.073	1.041	1.095	Madrid	235	252	-	75,512	1,750	43	3,178,819	-	Yes	-	-
Non HSR	Villareal	-	1.045	1.050	1.108	Madrid	167	309	-	38,207	55	695	778,501	-	No	-	-
Non HSR	Granada	-	1.050	0.930	0.937	Madrid	310	360	-	259,702	88	2,951	4,975,671	-	No	-	-
Non HSR	Murcia	-	-	-	-	Madrid	250	350	-	422,861	882	479	27,100,446	-	No	-	-
Non HSR	Ávila	-	-	-	-	Madrid	85	88	-	53,794	231	233	3,331,452	-	Yes	-	-

*GDP: Ciudad Real and Puertollano are located in the same province.

Sources:

Sources:	Time table	Deutsche Bahn (2010), www.bahn.de
	GDP, inhabitans	Statistical office Spain (2010), www.ine.es
	Distances	www.google.de

Figure 159: Spain - Data base PCA and Regression

PCA – Results

HSR and non HSR - Population

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.597
Bartlett's Test of Sphericity	Approx. Chi-Square	7.461
	df	3
	Sig.	.059

Rotated Component Matrix[a]

	Component	
	1	2
Popplus6	.918	-.346
Popplus9	.957	-.231
Inhabitants	-.284	.958

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Anti-image Matrices

		Popplus6	Popplus9	Inhabitants
Anti-image Covariance	Popplus6	.126	-.121	.109
	Popplus9	-.121	.145	-.044
	Inhabitants	.109	-.044	.641
Anti-image Correlation	Popplus6	.556[a]	-.899	.384
	Popplus9	-.899	.571[a]	-.143
	Inhabitants	.384	-.143	.780[a]

a. Measures of Sampling Adequacy(MSA)

Figure 160: Spain - Statistical results of the PCA (HSR and non HSR)

Transnational sample

PCA - Results

HSR and non HSR – Population

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.584
Bartlett's Test of Sphericity	Approx. Chi-Square	34.333
	df	3
	Sig.	.000

Anti-image Matrices

		Popplus3	Popplus6	Inhabitantssq
Anti-image Covariance	Popplus3	.417	-.307	.164
	Popplus6	-.307	.451	.008
	Inhabitantssq	.164	.008	.834
Anti-image Correlation	Popplus3	.553[a]	-.708	.278
	Popplus6	-.708	.563[a]	.014
	Inhabitantssq	.278	.014	.772[a]

a. Measures of Sampling Adequacy(MSA)

Rotated Component Matrix[a]

	Component	
	1	2
Popplus3	.893	-.263
Popplus6	.934	-.114
Inhabitantssq	-.191	.980

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Figure 161: Transnational sample - Statistical results of the PCA
(HSR and non HSR)

HSR only - Population

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.574
Bartlett's Test of Sphericity	Approx. Chi-Square	20.442
	df	3
	Sig.	.000

Anti-image Matrices

		Popplus3	Popplus6	Inhabitantssq
Anti-image Covariance	Popplus3	.321	-.263	.193
	Popplus6	-.263	.377	-.048
	Inhabitantssq	.193	-.048	.742
Anti-image Correlation	Popplus3	.545[a]	-.756	.396
	Popplus6	-.756	.561[a]	-.091
	Inhabitantssq	.396	-.091	.693[a]

a. Measures of Sampling Adequacy(MSA)

Rotated Component Matrix[a]

	Component	
	1	2
Popplus3	.879	-.347
Popplus6	.952	-.121
Inhabitantssq	-.216	.973

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Figure 162: Transnational sample - Statistical results of the PCA (HSR only)

Compiled

Berlin, July 29, 2011

DB International GmbH