



# **Master's degree thesis**

**LOG950 Logistics**

**Comparative analysis of the quality of appraisal practices  
for high-speed railway investment projects in Europe  
- A comparison of Norway, Sweden, Germany, the UK and Spain -**

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## **Preface and acknowledgements**

This thesis represents the mandatory last part for completing the Master of Science in Logistics program at Molde University College. A research proposal was presented and accepted in December 2009 and built the basis for this thesis. The work itself was written from January through May 2010.

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Molde, May 2010.

Silja-Berit Dreyer

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## Abstract

Investment in high-speed railway (HSR) lines is a prevailing topic in the media in several countries across Europe. Norway counts to one of the last countries that has not yet started to build an extensive HSR network. Several reports have been done on the topic, including feasibility studies and cost-benefit analyses (CBA) of such an installation for Norway. The outcomes have been very contrary. The decision on building an HSR was therefore postponed until more research has been conducted. A research mandate by the Norwegian government defined that CBAs according to enforced Norwegian calculation methods have to be done to outline how other countries deal with challenges in the appraisal, e.g. concerning the monetization of non-market goods.

Based on this, the rationale and topic of this thesis is a comparative analysis of the quality of appraisal practices for high-speed railway investment projects in Europe. The comparison includes Norway, Sweden, Germany, the UK and Spain. On the basis of the comparison, the main goal is to investigate the causes for the differences in outcomes of the Norwegian reports and if these are mainly of methodological nature or not. Furthermore, the aim is to examine if there is a potential need for adjustments in Norway's appraisal components for rail projects. CBA and multi-criteria analysis (MCA) as the most commonly used transport appraisal methods build the theoretical foundation of the thesis. The analysis of the appraisal methods used for HSR is done for each country separately and follows a specific scheme. Special focus is put on the three elements value of time, value of labor and environmental impacts (CO<sub>2</sub> and noise).

The comparison shows that the appraisal methods applied their components and degree of monetization as well as market structures and specific circumstances in the countries (e.g. topography, population density) are reasons for the diverse outcomes of the appraisals. Reflections following the comparison regarding the Norwegian setting include these main results: (i) CBA is based on a thorough methodological foundation, (ii) items and impacts included in MCA in other countries are covered by other additional methods in Norway, (iii) today's exclusion of value of labor and employment effects seems justified for the time being, (iv) the use of a Wider Impact Analysis might be useful in the long-run, (v) the value of time might need to be updated and aligned across modes of transport, (vi) CO<sub>2</sub> values should be revised and updated in order to take the climatic goals set by the Norwegian government into account appropriately, (vii) the exclusion of a value for noise in the CBA might be revised or based on scientific data.

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## Table of Contents

<b>Preface and acknowledgements.....</b>	<b>I</b>
<b>Abstract .....</b>	<b>II</b>
<b>List of Tables.....</b>	<b>V</b>
<b>List of Figures .....</b>	<b>VI</b>
<b>List of Abbreviations.....</b>	<b>VII</b>
<b>1 Introduction and description of the topic.....</b>	<b>1</b>
1.1 Structure of the thesis .....	4
1.2 Definition of high-speed rail (HSR) for this thesis .....	6
<b>2 Methodology.....</b>	<b>9</b>
2.1 Research Questions .....	9
2.2 Research Design.....	10
2.3 Data classification .....	11
2.4 Validity, reliability and objectivity .....	11
2.5 Data used.....	13
<b>3 Theoretical framework.....</b>	<b>15</b>
3.1 Political framework and the need of evaluation of transportation investment projects .....	15
3.2 Appraisal methods for large transport investment projects .....	20
3.2.1 Cost-benefit-analysis (CBA).....	21
3.2.2 Multi-criteria analysis (MCA).....	38
3.2.3 Criticism and limitations of the methods .....	42
3.3 A “typical” setting of an HSR case and its appraisal .....	50
3.3.1 Key parameters influencing the case for HSR .....	50
3.3.2 ”Typical” costs and benefits of an HSR case.....	52
3.3.3 Major controversial issues and debates .....	54
3.3.4 Limitation and reasoning of focus items.....	56
<b>4 Analysis.....</b>	<b>59</b>
4.1 HSR lines in Europe and the choice of the case study countries .....	60
4.2 Appraisal methods in Europe.....	62

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4.3	Analysis of the chosen countries .....	63
4.3.1	Norway .....	65
4.3.2	Sweden .....	81
4.3.3	Germany .....	91
4.3.4	UK.....	104
4.3.5	Spain.....	116
4.4	Comparison of the countries - main similarities and differences .....	126
4.5	Summary .....	140
<b>5</b>	<b>Reflections and conclusions on the Norwegian appraisal practice and further research .....</b>	<b>143</b>
5.1	Reflections on the Norwegian appraisal practice .....	143
5.2	Summary and conclusions.....	147
5.3	Limitations and further research.....	149
	<b>Reference List .....</b>	<b>151</b>
	<b>Appendix .....</b>	<b>163</b>
	Appendix A: Overview of available reports on the Norwegian HSR .....	163
	Appendix B: Methodological differences between the German and Norwegian evaluation procedure for HSR.....	170
	Appendix C: CBA of the potential HSR Götalands- and Europabanen in Sweden.....	173
	Appendix D: Values of time for Swedish private and business journeys.....	174
	Appendix E: Formulas for deriving values of noise from railways for the use in Swedish appraisal .....	175
	Appendix F: Illustrative CBA for an HSR in the UK.....	176
	Appendix G: NATA sub-objectives and other topics to be addressed within an Strategic Environmental Assessment (SEA) .....	177
	Appendix H: Transport study approach in the UK according to the most recent NATA documents .....	178
	Appendix I: Traded and non-traded values for CO <sub>2</sub> for use in the UK appraisal process .....	179
	Appendix J: Monetary valuation of changes in noise level in the UK.....	180
	Appendix K: Illustrative CBA for Spain for the Madrid-Seville corridor.....	181
	Appendix L: The price measures used in Spain and the EU for economic appraisal ...	183



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Appendix M: The variety of values of time for the Spanish appraisal .....	184
Appendix N: Method used for the estimation of external costs of noise for Spain.....	185

## List of Tables

Table 3-1: The major steps in CBA (modified after Boardman et al. 2006, p.8).....	32
Table 3-2: The four main phases of MCA (several sources) .....	39
Table 3-3: Strengths and difficulties of using MCA for public decisions (modified after Gamper and Turcanu 2007, p.300) .....	44
Table 3-4: Typical costs and benefits in an HSR appraisal; own table, information taken from (Nash Nov 2009; De Rus and Inglada 1997; De Rus and Nash Dec 2007; Econ Dec 2008; Nash 1991; EuropeanCommission 2008).....	52
Table 4-1: Institutional structure of the rail industry and basic documents for the appraisal process in Norway .....	68
Table 4-2: Consequence categories in the Norwegian rail appraisal (modified after Jernbaneverket 2006a, p.32).....	70
Table 4-3: Norwegian practice of monetizing impacts of rail investment projects (Jernbaneverket 2006a, p.33) .....	71
Table 4-4: Appraisal method summary for Norway .....	72
Table 4-5: Summary of the three items in focus in the Norwegian appraisal process .....	80
Table 4-6: Institutional structure of the rail industry and basic documents for the appraisal process in Sweden.....	82
Table 4-7: Appraisal method summary for Sweden .....	85
Table 4-8: Swedish practice of monetizing impacts of rail investment projects (information taken from SIKA 2009, p.7-12).....	86
Table 4-9: Summary of the three items in focus in the Swedish appraisal process .....	90
Table 4-10: Institutional structure of the rail industry and basic documents for the appraisal process in Germany .....	92
Table 4-11: German practice of monetizing impacts of rail investment projects (BMVBS 2003) .....	96
Table 4-12: Appraisal method summary for Germany .....	97
Table 4-13: Summary of the three items in focus in the German appraisal process .....	102
Table 4-14: Institutional structure of the rail industry and basic documents for the appraisal process in the UK.....	105
Table 4-15: Appraisal method summary for the UK .....	108

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Table 4-16: Practice of monetizing impacts of rail investment projects in the UK (information taken from TAG3.5.4d 2010, p.1-2) .....	109
Table 4-17: Summary of the three items in focus in the appraisal process in the UK.....	115
Table 4-18: Institutional structure of the rail industry and basic documents for the appraisal process in Spain.....	117
Table 4-19: Appraisal method summary for Spain .....	120
Table 4-20: Summary of the three items in focus in the appraisal process in Spain .....	125
Table 4-21: Summary of appraisal methods and items used in the case study countries (status May 2010).....	129
Table 4-22: Comparison of items used in appraisal in the case study countries – overview (status May 2010).....	133
Table 4-23: Comparison of components used in the case study countries – details (status May 2010).....	137
Table 4-24: Summary of main commonalities and differences in the appraisal methods and focus items among the case study countries (status May 2010) .....	141

## List of Figures

Figure 1-1: Structure of the thesis .....	5
Figure 3-1: Components influencing infrastructure investment evaluation and its assessment tools (own figure, information taken from Berechman 2009; Damart and Roy 2009; EuropeanCommission 1996).....	18
Figure 3-2: Pareto Efficiency (modified after Boardman et al. 2006, p.27; Jernbaneverket 2006a, p.10) .....	24
Figure 3-3: Basic theoretical foundation and principles of CBA (modified after Boardman et al. 2006, p.28).....	26
Figure 3-4: Consumer, producer and social surplus with connection to economic generalized costs (after Mankiw 2004, p.149; Grøvdal and Hjelle 1998, p.75 and 168)....	27
Figure 4-1: Structure of the analysis part .....	60
Figure 4-2: The HSR network in Europe, status 2009 (UIC 2009a).....	61
Figure 4-3: Evaluation components in the German CBA (BMVBS 2003, p.33) .....	95
Figure 4-4: Differentiation of the components in the evaluation procedure for traffic-related air pollutants in Germany (BMVBS 2003, p.87).....	101

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## List of Abbreviations

BCR – Benefit-cost ratio

CBA/ (COBA) – Cost-benefit analysis

CEA – Cost-effectiveness analysis

CIA – Cost-impact analysis

EC – European Commission

EGC – Economic generalized costs

EGMC – Economic generalized marginal costs

EIA – Environmental Impact Assessment

ERA – Environmental Risk Assessment

ETS – Emission Trading System

EU – European Union

HEATCO – Harmonised European Approaches for Transport Costing and Project Assessment

HSR – High-speed railway

ICE – Inter City Express (German HSR train)

MCA – Multi-criteria analysis

METRONOME – A Methodology for Evaluation of Project Impacts in the Field of Transport

NPV – Net present value

RPA – Revealed Preference Analysis

SEA – Strategic Environmental Assessment

SIA – Spatial Impact Assessment

SPA – Stated Preference Analysis

UIC – International Union of Railways

WI – Wider Impacts Analysis

X2000 – Swedish HSR train



## 1 Introduction and description of the topic

Investments in high-speed railway (HSR) lines is a prevailing topic in the media in several countries across Europe. Many countries in Europe have introduced HSR lines many years ago and have been successfully operating and amending the existing lines in recent years (UIC Jan 2009, p.21/22). Norway is one of the last countries that has not yet started to build an extensive HSR network. The only HSR that Norway is operating is the “flytoget” which is the express train commuting between the Oslo airport Gardermøen and the city center of Oslo.

The plans of Norway concerning the investment of building an HSR started already in the early 1990’s where also the first feasibility studies and cost-benefit analyses (CBA) were done (NSB 1992; Regjeringen 2008/ 2009, p.172; Bråthen and Hjelle 1993). One of the main rationales behind the investment in HSR lines is the high level of safety, high capacity in transport volumes, considerable travel time savings and most importantly being considered as one of the most environmentally friendly modes of transport (UIC 2007). The latter is so crucial due to the commitments of many countries around the world to the Kyoto protocol. In order to achieve these commitments, each country has set up its own goals and frameworks for each specific industry sector (e.g. for the European Union (EU) the White Paper on emissions in the rail sector (InvensysRail 2009). In line with this, Norway also has set up environmental goals for the transport sector in their recently published “National transportplan 2010-2019” (Regjeringen 2008/ 2009), which is that “[t]he transport politics should contribute to limit the emission of greenhouse gases, reduce polluting consequences of transport in order to fulfill the national goals and Norway’s international commitment to environment.”<sup>1</sup> (Regjeringen 2008/ 2009, p.290) One alternative to achieve this is to evaluate the possible concepts of building a high-speed railway in Norway in more detail (Regjeringen 2008/ 2009, p.290).

The potential investment in HSR in Norway represents the use of a considerable amount of public funds. Thus, the topic continues to be discussed and many contrary opinions arose among political parties, environmentalists and also the Norwegian population. In order to better judge the project as such, several reports have been done on the topic by different authors and institutions, including updated feasibility studies, cost-benefit analyses as well

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<sup>1</sup> Quotation translated by the author.

as reports on environmental impacts of such an installation (compare Appendix A for sources). The outcomes have been quite contrary, ranging from very positive cost-benefit ratios (VWI and partners Oct 2007b), to an HSR being totally non-profitable for Norway (Econ Dec 2008). Certainly, this led to extensive discussions concerning not only the outcomes but also the methodologies and data being used and their appropriateness concerning the specific and unique Norwegian setting. This is also one of the main reasons why the Norwegian government has not yet decided to build the HSR and has concluded in the National Transportplan for the time being that Jernbaneverket's remaining task will be to figure out "how possible concepts of HSR can adjust and better fit to the Norwegian setting"<sup>2</sup> (Regjeringen 2008/ 2009, p.175).

For that matter, the Norwegian government has recently handed over an "Utredningsmandat" (research mandate) to Jernbaneverket for the further consideration of an HSR on the 19<sup>th</sup> of February 2010 (Regjeringen 19.02.2010). The mandate amongst other things clearly demands a "socio-economic analysis and cost-benefit analysis according to enforced calculation methods."<sup>2</sup> (p.7) It furthermore mentions the challenge of "non-market-goods" and their monetization and asks for their description in the research report as far as possible and requires "to study how other countries handle these sort of problems and to evaluate their relevance with regard to the Norwegian setting."<sup>2</sup> (p.10) The Norwegian method of doing socio-economic analyses is the compulsory basis for the research, i.e. the "Veileder i samfunnsøkonomiske analyser"<sup>3</sup> by the Ministry of Finance must be followed (Finansdepartementet 2005). The due date of the further research on HSR is the 1<sup>st</sup> February 2012; relevant recommendations and analyses results will be included in the draft for the National Transportplan 2014-2023.

This is the starting point and relevance for the existence of this thesis. On the basis of the criticism, the main goal of this thesis is to investigate on the basis of a comparison between Norway and other European countries, whether the big difference in the outcomes of the Norwegian reports (CBA and feasibility studies) results from differences in the appraisal and decision making process and its components or rather from differences in transport markets or other factors.

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<sup>2</sup> Quotation translated by the author.

<sup>3</sup> English translation by the author: "Guideline for socio-economic analyses".

The goal is, based on the comparative analysis, to evaluate the potential need for adjustments in Norway's appraisal components for rail projects in order to capture the costs and benefits as well as non-market goods and effects of HSR in the best manner.

Thus, the topic of this thesis is a comparative analysis of the quality of appraisal practices for high-speed railway investment projects in Europe and can be seen as a relevant contribution to the research mandate for a potential HSR as released by the Norwegian government. The comparison is done from the view point of Norway and compares it to Sweden, Germany, the UK, and Spain. It should be made clear, that this thesis will include *no* calculations or estimations of specific parameters, it is instead dealing with the structure and criteria of the *methods* being used by the countries and their influence on the overall outcomes of the appraisal processes. Furthermore, no vote or recommendation concerning the general social profitability of a Norwegian HSR will be given, as again, the focus of the thesis is regarding the methodological issues of appraisal and not the accomplishment of a full CBA itself.

A similar report has been done by Steer Davies Gleave for the UK in 2004 and is called "High Speed Rail: international comparisons" (SteerDaviesGleave Feb 2004). The report is mainly about figuring out for the UK why the outcome from a CBA for a new HSR track in the UK was up to now less beneficial than for other countries. By looking at other countries and their appraisal methods for new transport projects it is figured out what should be changed in the appraisal criteria of the UK in order to better reflect costs and benefits of HSR. The report includes Germany, France, Spain, Japan, Italy and Australia and compares it to the UK.

The analysis part of this thesis will partly follow a similar structure as the report from the UK. However, the approach of this thesis distinguishes itself decisively from the UK report due to the following:

- The thesis will include Sweden and Norway in addition.
- The country in focus is Norway instead of the UK.
- The thesis will neglect some of the countries mentioned in the UK report (e.g. France, Japan, Australia).
- In case data and information is being used from the report from the UK it will be checked for updated versions of regulations and methods, since the report itself is from 2004 and it is assumed that changes could have taken place in the meantime. This

accounts especially for the UK itself, since it was focus country of the report and thus it is interesting to see whether and to what extent the recommendations of the report have been adopted.

### ***1.1 Structure of the thesis***

The thesis is split up into four main parts which include six main chapters. Figure 1-1 shows this in a systematic way.

- **Part I:** Chapter 1 and 2

*Chapter 1* gives an introduction into the topic and describes the overall setting. Furthermore, a short definition and termination of what is meant by HSR in this thesis is given. *Chapter 2* describes the methodology that is used by shedding light on the research design, research questions as well as comments on the data that is used and their validity and reliability. Thus, both chapters together represent the overall framework for the whole thesis.

- **Part II:** Chapter 3

Part II of the thesis builds up the theoretical and practical basis for the analysis in part III. *Chapter 3* contains the theoretical outline of the most relevant evaluation methods for transportation investment projects, namely Cost-benefit analysis (CBA) and Multi-criteria analysis (MCA). Definitions, conceptual foundations, major steps and the practical use in the transport sector is conveyed for both methods. It is rounded up by criticisms and limitations of both methods.

After that, the reader is provided with an introduction into the setting of HSR appraisal by displaying key factors that influence the case of HSR and the “typical” costs and benefits of an HSR appraisal case. On basis of this, major controversial issues and debates are deduced, leading to the limitation of items being focused in part III; which are value of time, value of labor and enviromental impacts (CO<sub>2</sub> and noise).

- **Part III:** Chapter 4

The third part of the thesis is *Chapter 4* and contains information on appraisal methods in Europe and the rationale behind the chosen case study countries (Norway, Sweden, Germany, UK and Spain) as well as the analysis of the countries. The analysis is done in



the same manner for every country, following a specific scheme, including general information on the HSR appraisal and on the three items in focus. The results of the analysis are compared in the end of the chapter, serving as basis for the reflections on the Norwegian setting in the subsequent part IV. This part therefore gives answers to the research questions 1 and 2.

- **Part IV:** Chapter 5

On the basis of part III, *Chapter 5* presents the conclusions and reflections on the Norwegian appraisal practice and gives information on limitations and further research on the topic. It therefore answers the research question 3.

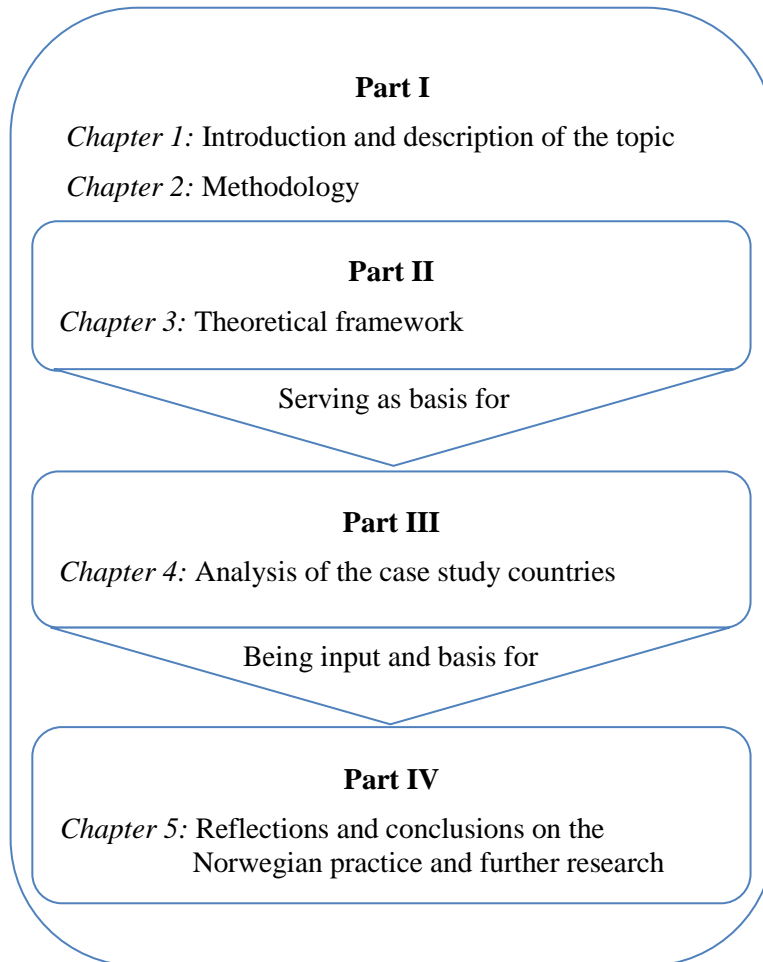


Figure 1-1: Structure of the thesis

## ***1.2 Definition of high-speed rail (HSR) for this thesis***

The definitions of high-speed itself and high-speed trains differ substantially and are depending also on the state of technological development regarding the publishing years of the sources and the definitions itself. Each paper and report about high-speed and HSR defines it according to the relevant setting; e.g. HSR are “rail systems which are designed for a maximum speed in excess of 200 km.p.h.” (Nash 2004, p.1), “By High Speed Rail (HSR) we normally mean rail technologies capable of speeds of the order of 300km ph on new dedicated track.” (De Rus and Nash Dec 2007, p.2), or “High Speed (HS) in this report refers to a speed higher than 250 km/h” (Hylén, Lindberg, and Nilsson Sep 2005, p.2).

The International Union of Railways (UIC) has an own high speed department, that tried to make up a general definition of HSR but concluded that it is almost impossible. UIC thus came up with several definitions that differ depending on three basic components: “infrastructure, rolling stock and operating”, while the latter represents a mix of the two first ones and is defined as the “[c]ompatibility of infrastructure and rolling stock” (UIC June 2008). UIC comments here that “[t]he definitions vary according to the criteria used since high speed rail corresponds to a complex reality.”

Concerning infrastructure, there are three main possibilities to be differentiated according to UIC (UIC June 2008):

- Newly build lines specifically for HSR, on which the trains should be able to reach a speed of more than 250 km/h.
- Old, specially upgraded lines for HSR, where it the expected operation speed should be in the range of 200 km/h or
- Old, specially upgraded lines for HSR “which have special features as a result of topographical, relief or town-planning constraints, on which the speed must be adapted to each case.”

UIC also mentions this: “[f]inally, in many countries where the performance of the conventional railway is not very high, the introduction of some trains capable of operating at 160 km/h and offering a significant level of quality - often as a first step towards a future genuinely high speed service - may already be considered as high speed.” (UIC June 2008)

This exactly applies to the Norwegian setting, where actually over 95% of the infrastructure consists of single-track lines and just 30% of today's lines are designed for speeds over 100 km/h (Regjeringen 2008/ 2009, p.170). A good first estimation figure for what high-speed can mean in Norway is the operating speed of the before mentioned "flytoget", which is going at a maximum speed of 210 km/h (Flytoget 2008). Furthermore, the design speeds mentioned in the feasibility studies and reports for a potential HSR in Norway can be considered. They also differ according to the circumstance if the the old railway lines are being upgraded or if totally new ones are built. The design speed that is mentioned most often and seems most reasonable to the author is not more than 250 km/h (MetierAS Oct 2007b; VWI and partners Oct 2007b; Regjeringen 2008/ 2009).

Thus, if nothing else is specified, the definition for high speed in this thesis is considered as trains and infrastructure allowing speeds of more than 160km/h (as a lower limit) and up to 250km/h.

After having defined what is meant by HSR, the following chapter will shed light on the methodology that is used in the subsequent part of the thesis.



## 2 Methodology

In this part it should be given short insight on the methodology that is going to be applied in the thesis, including the formulation of research questions, research design and comments on the data classification and data that is used.

### 2.1 Research Questions

According to Bell and Bryman (2007) research questions must fulfill some criteria to be considered as appropriate. Some of the most important criteria are (Bell and Bryman 2007, p.87):

- They must be formulated clear and understandable.
- They have to be researchable, i.e. it must be possible to develop a research design according to them and thus data collection must be probable.
- The questions must be connected to established theory and research in order to be able to prove that the author's research contributes to the field of study.
- The questions must be related to each other in order to formulate a well structured argumentation throughout the thesis.

With that in mind, the following research questions have been formulated for achieving the goal of this thesis (compare also Nakamura 2000):

1. What are the appraisal methods and criteria considered in the evaluation of HSR investment projects in other European countries?
  - a. What methodology is being used for transport/ HSR appraisal?
    - i. CBA
    - ii. MCA
    - iii. Other methods
  - b. Which items are monetized or quantified and to what extent (especially with regard to non-market goods)?
  - c. Which method of the above mentioned is used for which components (monetization vs. weighting)? Special focus is put on:
    - i. Value of labor
    - ii. Value of time
    - iii. Environmental impacts (CO<sub>2</sub> and noise)

- d. What estimation concept is the basis for monetizing of costs and benefits (market prices, shadow prices, willingness-to-pay etc.)?
  - e. To what extent are the evaluation and methods used compulsory in the countries?
2. Where do the crucial differences in outcomes for the evaluation of a Norwegian HSR as a transport investment project arise from?
    - a. Are the discrepancies arising from different appraisal methodology for such transport projects in the different countries?
    - b. Or are the different outcomes rather originated from the special transport market structure of Norway and other additional (yet unknown) factors?
  3. What useful input can the experiences from other European countries on appraisal for HSR projects give for a reflection on the Norwegian rail appraisal practice?

## **2.2 Research Design**

“A research design provides a framework for the collection and analysis for data.” (Bell and Bryman 2007, p.40) It is “the logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of the study.” (Yin 2009, p.24)

Generally, there are different research designs named in the literature, of which the qualitative and explorative research design in the form of a “case study” (Bell and Bryman 2007, p.62 ff.; Yin 2009) is most applicable to this thesis. “A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context.” (Yin 2009, p.18) The investment in HSR for Norway counts to a contemporary phenomenon and is a recent topic and will be studied in a real-life context. Additionally, the widespread use of economic appraisal techniques can be seen as an occurrence which contributes to the choice of a case study being appropriate for this thesis.

It is furthermore an appropriate design for this thesis because a case study is said to deal with a situation “in which there will be many more variables of interest than data points” (Yin 2009, p.18) i.e. the variables of interest are mainly of a qualitative nature, which applies to some of the appraisal criteria for investment projects (e.g. environmental impacts). A case study furthermore relies on multiple sources of evidence and makes use of “prior development of theoretical propositions to guide data collection and analysis.” (Yin 2009, p.18) This is true for the thesis as it will build up on reports, studies and governmental papers concerning the issue.

There are several variations within the design of case studies, of which this thesis will make use of the so called “comparative case method” (Yin 2009, p.19) since it will not just look at Norway but will compare it additionally to the before mentioned countries where each country can be seen as one “case”.

The analytic technique being followed in the thesis can be categorized as “explanation building” where one analyzes “how” or “why” something happened or is existent (Yin 2009, p.141). The explanations that are built up should reflect and include well known theories. If done thoroughly, such a technique in the area of public policy processes “can lead to recommendations for future policy actions.” (Yin 2009, p.141) Since this is what the thesis is aiming for, it is thought to be the most appropriate technique for carrying out the analysis in order to answer the formulated research questions.

### ***2.3 Data classification***

Generally, the theory distinguishes between **primary** and **secondary** data, while primary data is data where the researcher is actively involved in collecting it, secondary data is existent data that is studied and where the researcher has not been involved in its collection (Bell and Bryman 2007). The data can be of quantitative or qualitative nature.

This thesis will make use of qualitative and quantitative, empirical, secondary data such as the before mentioned reports, feasibility studies as well as books and a broad range of articles concerning the several topics surrounding HSR, project evaluation in transport and the specific Norwegian setting. The quantitative data that is used concerns both, the cost-part of the CBA, such as investment cost estimations but also cost-benefit ratios and the benefit side, where for instance time savings are measured quantitatively. Furthermore, the analysis of the transport market includes such as demand and capacity figures.

### ***2.4 Validity, reliability and objectivity***

The terms validity and reliability are normally more connected to the use of quantitative data. Nevertheless, also qualitative research needs to reassure a specific quality of data in order for the results being thought of as trustworthy (Bell and Bryman 2007).

- **Validity**

The term validity of data “refers to the issue of whether or not an indicator (or set of indicators) that is devised to gauge a concept really measures that concept.” (Bell and Bryman 2007, p.165) For the research design of a case study, validity can be split up into three sub-categories, which are (Yin 2009; Bell and Bryman 2007):

- *Construct validity*, which is to make sure that the correct operational measures were chosen for the subject being studied.
- *Internal validity* by which is meant to what extent the researchers’ observations are in line with the mentioned theory and whether a good causal relationship was developed between those two.
- *External validity* refers to the degree to which conclusions and findings can be generalized.

- **Reliability**

Reliability on the other hand is concerned with the question if the operations of a study (e.g. the data collection process) can be repeated with leading to the same results (Yin 2009).

- **Objectivity**

Other criteria for reassuring a good qualitative research is the objectivity respectively confirmability. Even though “complete objectivity is impossible in business research” the author should be able to show that “personal values or theoretical inclinations” (Bell and Bryman 2007, p.414) have not been influencing the research process and the results out of it.



### ***2.5 Data used***

The data that is used can as mentioned before be classified as secondary, qualitative and quantitative, empirical data. Concerning validity, even though the main case country is Norway and thus the conclusions will be drawn for Norway as well, the principles and steps of the analysis should be transferable to other settings and thus a generalization of the process itself should be possible.

Objectivity is secured by critically dealing with the sources that are used and by considering a broad range of different sources, trying to avoid biased and inappropriate ones.

The literature in the second part of the thesis (theory) is mainly based on relevant guidelines and books within project appraisal in the transport sector and CBA and MCA as appraisal methods. The third part of the thesis, namely the analysis, includes a broad literature study of the different country's guidelines concerning political frameworks in project appraisal, methods and relevant examples. The analysis was done on the basis of these reports and guidelines and was accomplished from a more qualitative point of view.



### **3 Theoretical framework**

Given the fact that there is a voluminous literature on the subjects and theories involved in this thesis, the theory part will be so called “problem-based”. Thus, there will be a selective illustration of elements of the theory for the relevant sector, i.e. transportation, that are necessary for the subsequent analysis of the case study countries.

First, the overall framework under which project infrastructure appraisal is done will be outlined. After that, a more detailed overview of the methodologies mainly being used in HSR appraisal processes in the analysis countries, which are cost-benefit analysis (CBA) and multi-criteria analysis (MCA) will be given. The last section of the chapter presents a “typical” setting of an HSR case appraisal, including key parameters influencing the case, costs and benefits considered, and major controversial issues and debates. Finally, the limitation of items that are analyzed for each country are explained.

#### ***3.1 Political framework and the need of evaluation of transportation investment projects***

The need for analyzing public projects arises from the fact that society just has a limited amount of resources available to accomplish the projects; if resources are used to fulfill one project, it means that the same resources are not available for others (NOU 1997:27). Additionally, within the public sector one finds competing projects with competing goals. The political framework is set by these facts and leaves the politicians with the choice of which projects should be taken in order to achieve the best allocation of the given resources, while at the same time reaching the highest targeted achievements (Grøvdal and Hjelle 1998). It is therefore necessary, that the decision-makers are before-hand conveyed with an almost comprehensive overview of how many resources the different projects will employ and all other impacts the project will cause to stakeholders like society, environment and alike (NOU 1997:27). Evaluation methods are therefore needed to give the decision-makers tools, that can help them rank and choose the public projects based on their costs, benefits and impacts in order to contribute best to society’s welfare.

Countries all over the world invest considerable resources in the building, maintenance and expansion of their infrastructure network (Berechman 2009; Damart and Roy 2009; Haezendonck 2007). Those decisions are matters of the public sector and in addition to technical and economic objectives, also represent political statements “regarding objectives, funding priorities, and targeted service recipients.” (Berechman 2009, p.1) The

reasons for planning and investing in (new) infrastructure are versatile and include such as overstrained and congested existing systems, trying to sustain an acceptable level of service, national or regional development issues, promoting local and regional economic growth, or safety and environmental objectives. Since these kinds of projects involve substantial amounts of financial resources and have a large number of different stakeholders, key questions become which projects should be prioritized with regard to their objectives and purposes, as well as what measures and analytical tools should be used in order to analyze and evaluate them in the best manner (Thomopoulos, Grant-Muller, and Tight 2009; Morisugi and Hayashi 2000; Arnott 1997; Johansson 2008; Salling and Banister 2009).

Transport project evaluation has become a very complex task (Gamper and Turcanu 2007; Walker 2000) due to “[i]ncomplete information on, for example, the environmental impact of certain investments, uncertainty of exact traffic evolutions and pay-offs, an increasing set of regulations and regulatory bodies and controversy on the methodology to be used for the valuation of environmental and social impacts.” (Haezendonck 2007, p.1) This reflects a good summary of the issues that are going to be relevant in the setting of this thesis. In addition it will be dealt with the question why “the use of complex methods and sophisticated evaluation tools” (Damart and Roy 2009, p.200) is necessary in order to take all these matters into consideration for a decision.

The following section and its quotations are, if not stated differently based on Berechman (2009).

Even though used as synonyms in many sources (e.g. Nas 1996; Haezendonck 2007), the terms “project evaluation”, “project assessment” and “project appraisal” should be distinguished from each other. In this thesis as mentioned by Berechman (2009), the term “project evaluation” refers to the overall process in which different investment alternatives are “conceptualized, generated, assessed, ranked and finally chosen” (p.2), involving economic as well as noneconomic criteria in the process of decision making. “Project assessment” respectively “project appraisal” on the other hand “refers to to the structured procedure by which the transport-economic worthiness of each planning alternative is determined.” (p.2) The project assessment/ appraisal is thus *a part of* the overall project evaluation. In the area of transportation projects the evaluation involves the contribution to

net social welfare by gaining an overview about costs and benefits of a specific project. The author of this thesis will subsequently use the terms as defined here.

The application of transport project evaluation is possible at four different levels of transportation planning, starting on a general level and finally being used for the assessment of single specific investment project, which are in focus for this thesis. The key objective of this project assessment is “to determine the welfare contribution of a specific project relative to a set of planning alternatives [...]. Economic measures, such as benefit-to-cost ratios, are the key criteria applied to these plans [...].” (p.5/6) For this thesis the specific investment project is represented by the investment in HSR. The two major alternatives for HSR are in most cases whether to build/ extend a (new) line or rather not; or as Haezendonck (2009) puts it “[t]he ultimate outcome of any transport infrastructure appraisal is a decision whether or not to proceed with a transport project proposal.” (p.19) For the focus country Norway it is clearly the main decision whether or not to invest in the construction of an HSR track at all and additionally – if yes – on which tracks to focus. The theoretical key decision principle for evaluating such investment projects is the criterion of whether they create a positive net social welfare (to be defined later).

The decision and evaluation of infrastructure investments are furthermore theoretically influenced by the four components/ areas, which are displayed in Figure 3-1 and where examples are given regarding what is meant by each subcategory.

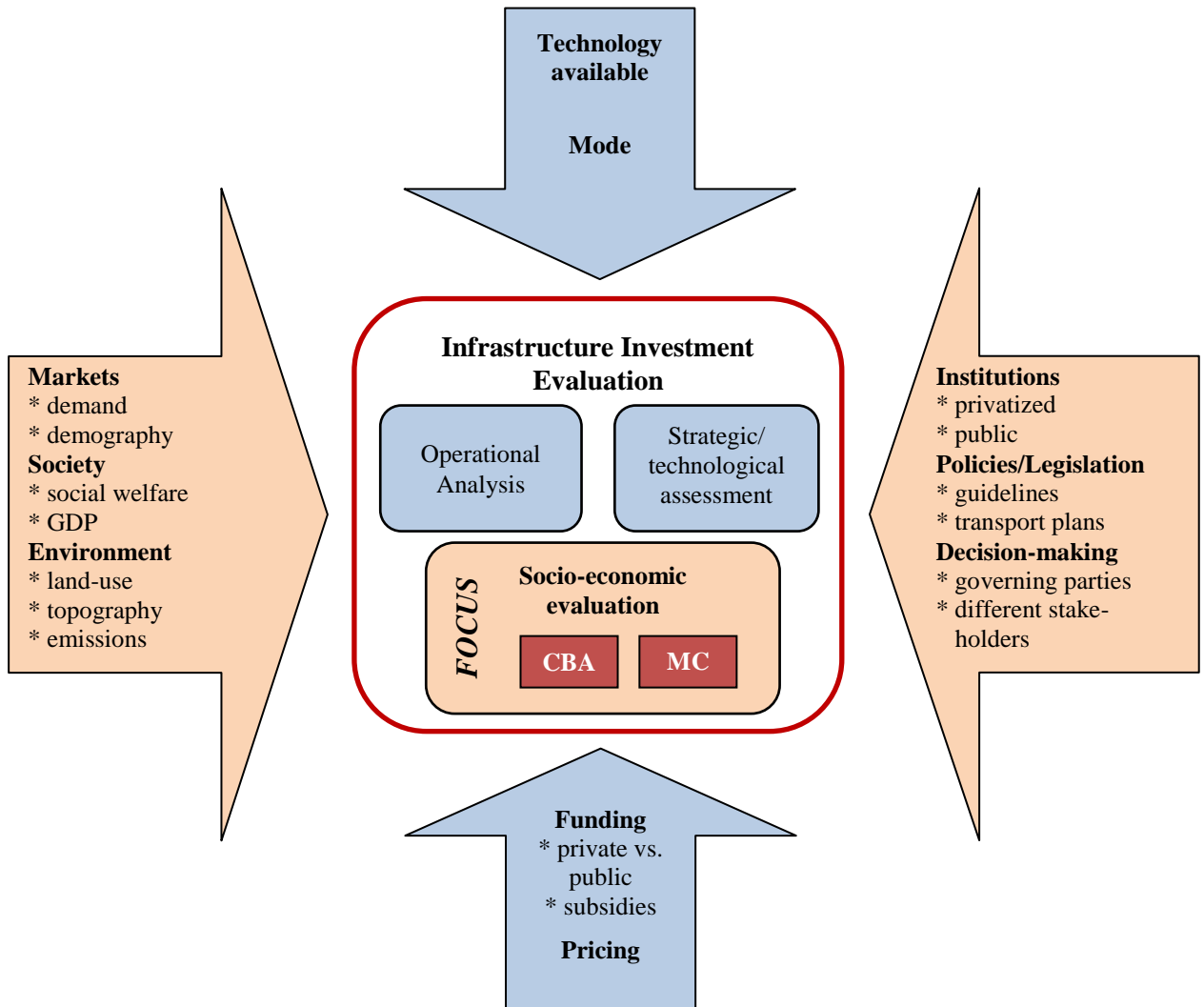


Figure 3-1: Components influencing infrastructure investment evaluation and its assessment tools (own figure, information taken from Berechman 2009; Damart and Roy 2009; EuropeanCommission 1996)

The blue arrows and their components like available technology, transport mode and funding and pricing have undoubtedly influence on the evaluation of an infrastructure project, they are of less importance for this thesis though. More important in the framework of the thesis are the red arrows; on the left-hand side including such as market structure, society issues and environmental matters, and on the other side the institutional set-ups concerning transportation, policies and legislation surrounding it and the different issues of decision-making.

There are three different main categories of evaluation which are relevant in the context of infrastructure investments (EuropeanCommission 1996). As it can be seen in Figure 3-1 in the centre, one of them is the **Operational analysis**, which addresses questions concerning technical effectiveness of the investment to find the technically most superior solution, but

it does not “contribute to questions of whether an investment is intrinsically worthwhile.” (European Commission 1996, p.5) The **strategic respectively technological assessment** is supposed to determine the potential of long-term, entirely new and innovative technology investments on a political level. Both, the operational analysis as well as the strategic assessment are influenced mainly by components in the blue arrows shown in Figure 3-1, like e.g. the latter by technology that is available.

The **focus** of this thesis is the **socio-economic evaluation** of infrastructure investments though. It tries to

- measure impacts of the investment on society now and in the future,
- evaluate and estimate the social worthiness/ social welfare of the project,
- achieve an optimal allocation of scarce resources.

The two most common used methodologies for socio-economic evaluation of infrastructure investments are Cost-benefit analysis (**CBA**) and Multi-criteria analysis (**MCA**) (compare Figure 3-1). The components mainly being connected to both evaluation methods are mentioned in the figure in the red arrows. CBA and MCA set out to quantify in monetary terms (e.g. the market demand or social welfare) or express in words (e.g. the environmental effects) components mentioned in the red arrows. Other aspects mentioned in the figure, like policies, guidelines and governing parties represent important influences on *how* and *if* the methods are used. As just mentioned, one of the key-terms in socio-economic evaluation is “social welfare”. Given that this thesis deals with transportation issues, the following definition of **social welfare** in connection with transportation is thought to be most appropriate.

“In the context of transportation, social welfare can be defined in terms of travel time savings, increased mobility, improved safety, and reduced negative externalities such as air pollution and release of greenhouse gasses. Yet, welfare maximization must be carried out under conditions of restricted resources, mainly of capital and space (e.g., land), as well as considerable uncertainty about the future value of key variables: transportation behavior, prices, interest rates, and demographics.” (Berechman 2009, p.10)

Though missing in this definition are political interests, including considerations concerning socio-economic user group benefits in relation to e.g. equity<sup>4</sup>, income and location (compare Damart and Roy 2009; Tsamboulas 2007; Johansson 2008; Thomopoulos, Grant-Muller, and Tight 2009; Haezendonck 2007). Due to considerable amounts of public funds being involved in transportation investments such as HSR, the final decision about investing is made at the political level. The identity of the institution(s) making the final decision for a project have a major influence; “Obviously, the identity and structure of the decision-making body critically impacts on the way choices are made.” (p.307) As Berechman (2009) mentions further, on this level the project “evaluation and selection is inherently influenced by value-based political considerations that frequently overlook the significance of other criteria” (p.10). This issue is of great importance in this thesis with connection to the research questions on the one hand, and on the other hand strengthens again the need to critically deal with the used sources and reports in the analysis part.

The following sections will focus on the relevant methodologies for this thesis used for making socio-economic transport investment appraisal, namely CBA and MCA.

### ***3.2 Appraisal methods for large transport investment projects***

The issues raised before state that the public funds for large scale investment projects need to be optimally used. Several sources state that within the area of transportation infrastructure investments the most common methodologies in practical use are CBA and MCA:

- “Among the various methods used to evaluate the impacts of large road transport infrastructure projects, the two major ones are CBA and MCA.” (Thomopoulos, Grant-Muller, and Tight 2009, p.2);
- “[...] attempts to use public funds optimally have led to widespread development of cost-benefit analysis (CBA) methods for transportation infrastructure investments.” (Damart and Roy 2009, p.201);

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<sup>4</sup> Equity is defined as “the fairness of the distribution of well-being among the members of society.” (Mankiw 2004, p.148)



- “[...] general method used [for transportation project appraisal] whether it is cost-benefit analysis (CBA) or multi-criteria analysis (MCA) [...]” (Morisugi and Hayashi 2000, p.73)
- “The two most favoured approaches to socio-economic evaluation are Cost-Benefit Analysis and Multi-Criteria Analysis.” (EuropeanCommission 1996, p.6)

Since this can be confirmed also for the case study countries of this thesis, the following two sections will describe the CBA and MCA as project assessment methodologies in more detail, introducing them generally as well as pointing out their relevance in the setting of the thesis, namely their use in the transportation or more specific rail sector and HSR. After that, criticisms and limitations for both methodologies are stated, discussed and are finally summarized.

### **3.2.1 Cost-benefit-analysis (CBA)**

The analysis part of this thesis is dealing with the comparison of how different countries perform project appraisal concerning HSR. Due to every case study country using (at least parts of) CBA, the following theoretical background is of importance. First, there will be a definition of core terminology, followed by the theoretical foundation of CBA itself. After that main steps in how to perform a CBA are described. In the end the use of CBA in the transport sector will be shortly presented.

#### **3.2.1.1 Definition and purpose of CBA**

Several sources mention the already early development of CBA. CBA is said to be first used by the French engineer Jules Dupuit in 1844 in order to determine net economic values for public improvements (Thomopoulos, Grant-Muller, and Tight 2009; Berechman 2009). The concept was explicitly introduced in the 1930s to evaluate water resource projects in the USA (Haveman and Weimer 2003).

There exist numerous definitions of CBA (e.g. Haveman and Weimer 2003; Boardman et al. 2006; Berechman 2009; Tudela, Akiki, and Cisternas 2006; Chung-Hsing et al. 1999), which have the basic components in common though (*in italics*). **CBA** is a decision-making methodology for the evaluation of *public policy issues*, and is seeking to assess the economic *efficiency* of a policy or project. CBA quantifies (social) *costs and benefits* in *monetary terms* and compares them to each other in order to find out from a *society's point of view*, if the policy is *Pareto* improving and if there will be a change in utilities due to it.

Nas (1996) and Boardman (2006) shall be quoted here since their definitions add up quite well to outline CBA as a decision-making tool. “CBA, a method distinctively developed for the evaluation of public policy issues. Under the CBA methodology, all potential gains and losses from a proposal are identified, converted into monetary units, and compared on the basis of decision rules to determine if the proposal is desirable from society’s standpoint.” (Nas 1996, p.1/2) It is furthermore a method to find out whether proposed policies are potentially Pareto improving, which means that it could gain positive net benefits in the sense of making resources available “to compensate those who bear costs so that some people are made better off without making anyone else worse off.” (Boardman et al. 2006, p.46)

As said before, CBA has the **purpose** of helping social decision-making by comparing all relevant information of a project/ policy in order to make a decision on the alternatives’ contribution to social welfare by using methods such as “net present value, internal rate of return, and/ or benefit-cost ratios [...]” (Nas 1996, p.2) The overall decision rule of CBA is to choose the project that maximizes net social benefits (Walker 2000), i.e. projects “that maximize the excess of social benefits over social costs.” (Haveman and Weimer 2003, p.2845)

### **3.2.1.2 Conceptual foundations of CBA**

The basic theoretical foundations of CBA are microeconomics, welfare economics and public finance (Dobes and Bennett 2009; Haveman and Weimer 2003; Boardman et al. 2006; Mankiw 2004). Public finance is important in the sense of governments raising funds by taxation and in turn use this money “to provide a variety of public goods and services.” (Nas 1996, p.3)

The basics in microeconomics, dealing with social welfare and the efficiency in resource allocation build the other root principles in CBA (Haveman and Weimer 2003; Boardman et al. 2006). “A public project will likely affect the welfare of three groups: those individuals who will be beneficiaries of the project, taxpayers who will be providing funds for the project, and those individuals who will be incurring losses once the project has been implemented.” (Nas 1996, p.58) The larger the projects, such as high-speed railways in this thesis, the more important becomes the need to assess the projects costs and benefits for these three groups from a society’s welfare point of view in the most accurate way.

- **Pareto efficiency and Pareto optimum**

Modern welfare economics presume that “aggregating the wellbeing (utilities) of the individuals who make up society is a valid measure of social wellbeing.” (Haveman and Weimer 2003, p.2845) At the heart of welfare economics and the practical basis for accomplishing CBA, lies the keyword “Pareto efficiency” (Haveman and Weimer 2003; Berechman 2009; Boardman et al. 2006). To explain Pareto efficiency, the following simple example from Boardman et al. (2006) is considered. Figure 3-2 shows different possibilities of allocation of a fixed amount of money of \$100 between two persons.

The vertical axis shows what person 1 is receiving, while the horizontal axis shows the same for person 2. Both can receive up to 100\$ if they agree on a split of the money; if they do not agree, both will end up with 25\$. As 100\$ is the maximum each one can receive, the line connecting these two points is the “potential Pareto frontier” and shows all feasible splits between person 1 and 2 that allocate the total 100\$ (orange line). All splits involving less than the 100\$, are lying in the big triangle (“potential Pareto frontier”, both axes) and the purple areas show potential gains and losses for both persons. The status quo point (\$25, \$25) is an example of a split point. This point shows the amounts, both persons receive if they do *not* achieve an agreement about how to split the \$100. Every amount below 25\$ represents a loss to both (red square). The “Pareto frontier” is the segment of the potential Pareto frontier which gives each person *at least* the 25\$ of the status quo (see blue brace in the figure). The green shaded triangle under the Pareto frontier and the extended lines from the status quo point shows all the alternative allocations that would make at least *one* of the persons better off, without making the other one worse off. That this shaded area exists, reflects that the current status quo point is *not* Pareto efficient and thus, the area represents Pareto improvements over the status quo.

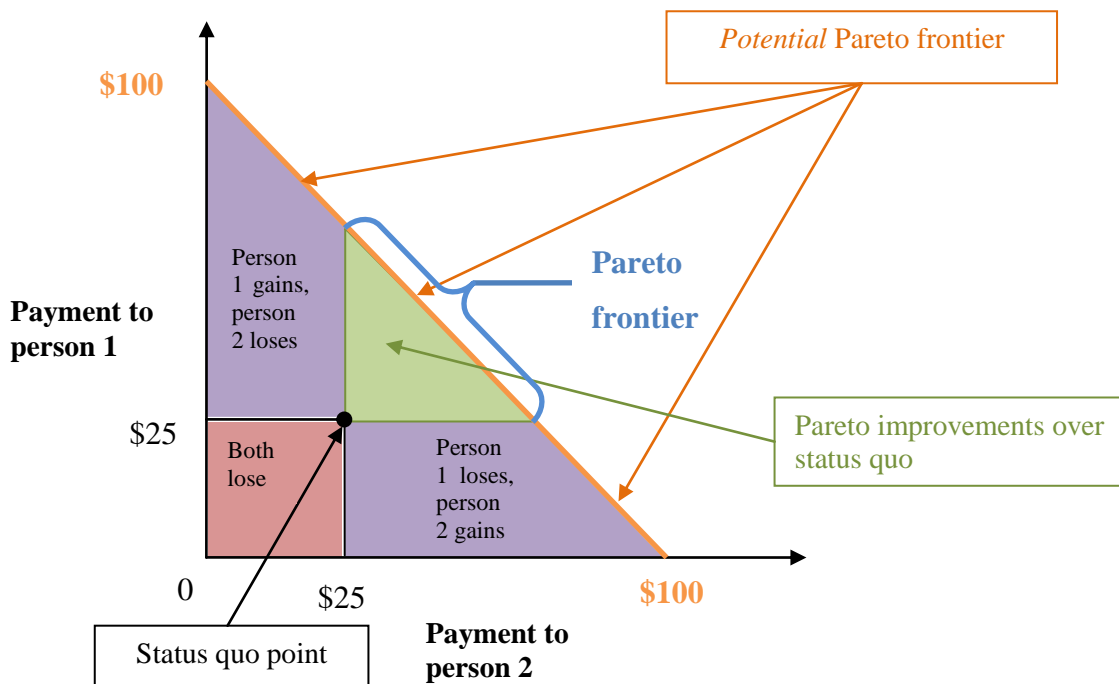


Figure 3-2: Pareto Efficiency (modified after Boardman et al. 2006, p.27; Jernbaneverket 2006a, p.10)

To sum it up: an allocation of goods is Pareto efficient, when no further Pareto improvement can be achieved, and thus no alternative allocation will make at least someone better off without making anyone else worse off (Haveman and Weimer 2003; Boardman et al. 2006).

In reality the alternative allocations are almost infinite and the settings are much more complex, but the whole idea behind this is that “the compensation needs not be direct” (Berechman 2009, p.30), which means that a Pareto optimum can also be achieved by a “potential” compensation of the “losers”. The concept “that a more efficient allocation overall can nonetheless result in some individuals being worse off” (Berechman 2009, p.30), was developed by Kaldor and Hicks and is therefore called Kaldor-Hicks compensation criterion. This is then called the “potential Pareto efficiency/ frontier” (compare also Nas 1996) as shown in Figure 3-2 by the orange arrows.

- **Willingness-to-pay, opportunity costs and net benefits**

As Pareto efficiency has just been defined, before explaining the whole foundation of CBA in one context, two more terms need to be made clear, which are willingness-to-pay and opportunity costs, since they are “the guiding principles for measuring costs and benefits.” (Boardman et al. 2006, p.46)

**Willingness-to-pay** describes the maximum amount a person or group is willing to pay, along with a change in policy without being worse off (compare Figure 3-3). It is a monetary measure of the benefit to them due to the policy change. If the outcome is negative, it represents their cost due to the change (Deardorff 2010).

**Opportunity costs** on the other hand are the costs of something in terms of a forgone opportunity (Deardorff 2010). In the context of CBA it means the “value of what society must forgo to use the input to implement the policy.” (Boardman et al. 2006, p.29)

Figure 3-3 provides an overview of the basic theoretical foundations of CBA in the context of the principles being applied, as well as the connection of Pareto efficiency to the other defined terms. When doing CBA, analysts need to value all outputs (which represent “benefits” to society – green in the Figure) and inputs (which represent “costs” to society – red in the Figure) in terms of willingness-to-pay or in terms of opportunity costs. The overall outcome are the **net benefits** of the project and thus reflect if it will be possible to make at least one person better off without making anyone else worse off (Boardman et al. 2006). It reflects the social surplus respectively the welfare of the society, and is normally expressed in a number, which is the so called “benefit-cost ratio” (BCR). The ratio can be either positive or negative as displayed in the figure. To sum it up shortly: “[p]ositive net benefits indicate the potential for compensation to make the policy Pareto efficient; negative net benefits indicate the absence of this potential.”

The measure of the net benefits of a project is the adaption of the before-mentioned Kaldor-Hicks criterion, because it determines if a project is “justified for society as a whole” and thus whether it is “moving economy towards Pareto efficiency and thus provides the fundamental rationale for COBA<sup>5</sup>.” (Berechman 2009, p.30)

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<sup>5</sup> COBA is the abbreviation for Cost-Benefit Analysis used in (Berechman 2009).

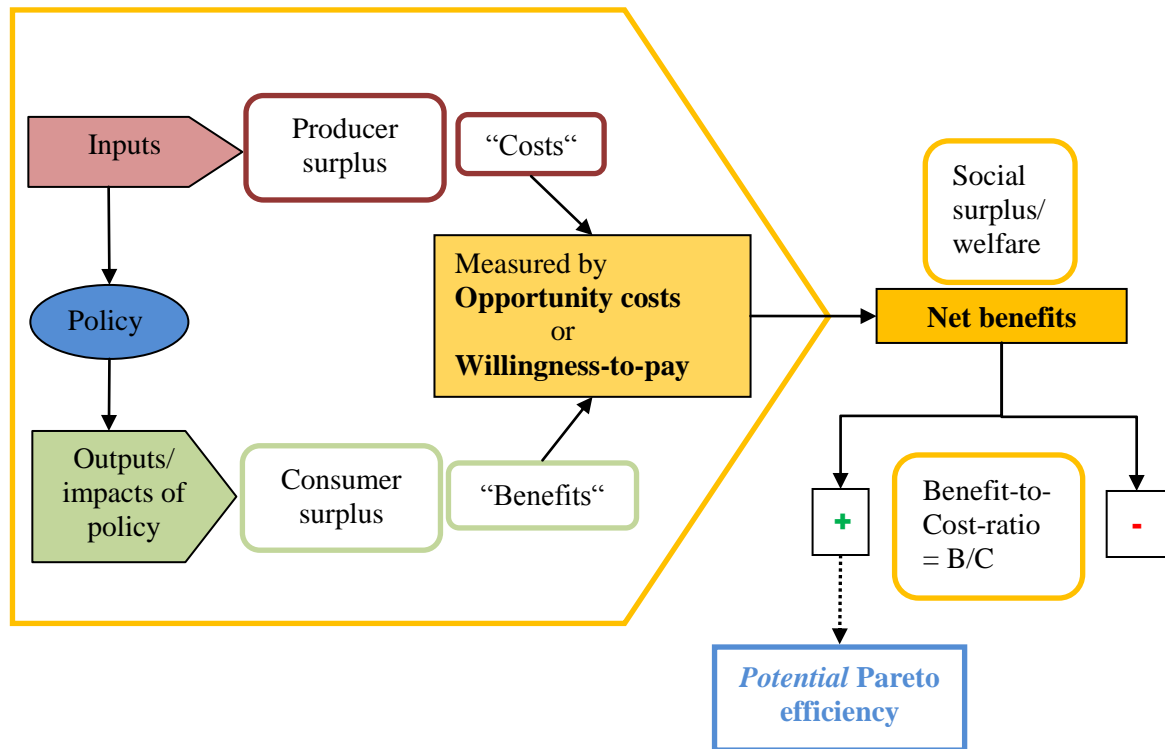


Figure 3-3: Basic theoretical foundation and principles of CBA (modified after Boardman et al. 2006, p.28)

After this it makes sense to show the concept of consumer, producer and social surplus/welfare<sup>6</sup> in more detail with an example out of the transport sector that is relevant for this thesis.

- **Social welfare, consumer surplus and producer surplus**

The **Social Welfare function (SW)** (Berechman 2009; Boardman et al. 2006; Mankiw 2004) is used for public project welfare evaluation in order to derive the total economic effect new or improved transport services have on society after their implementation. The function itself is to measure “the overall welfare effect [...] conceived in terms of total future changes in welfare” (Berechman 2009, p.30/31) and is considered as one of the key measures of CBA. From a theoretical point of view, social welfare is maximized, when the price equals the marginal costs (Grøvdal and Hjelle 1998). The function looks as follows and shows that total social welfare is a sum of consumer surplus, producer surplus and external costs (graphically compare green square in Figure 3-4):

<sup>6</sup> “Social welfare” and “social surplus” are in many sources used interchangeably, so are they in this thesis.

$$\Delta SW = \Delta CS + \Delta PS + \Delta E$$

$\Delta SW$  = net change in total social welfare

$\Delta CS$  = net change in total consumer surplus

$\Delta PS$  = net change in total producer surplus

$\Delta E$  = change in total external costs (can be negative)

Both, consumer surplus and producer surplus, are also connected to the before mentioned terms of willingness-to-pay and opportunity costs (compare Figure 3-3). Figure 3-4 shows the graphical context of consumer and producer surplus as well as social welfare.

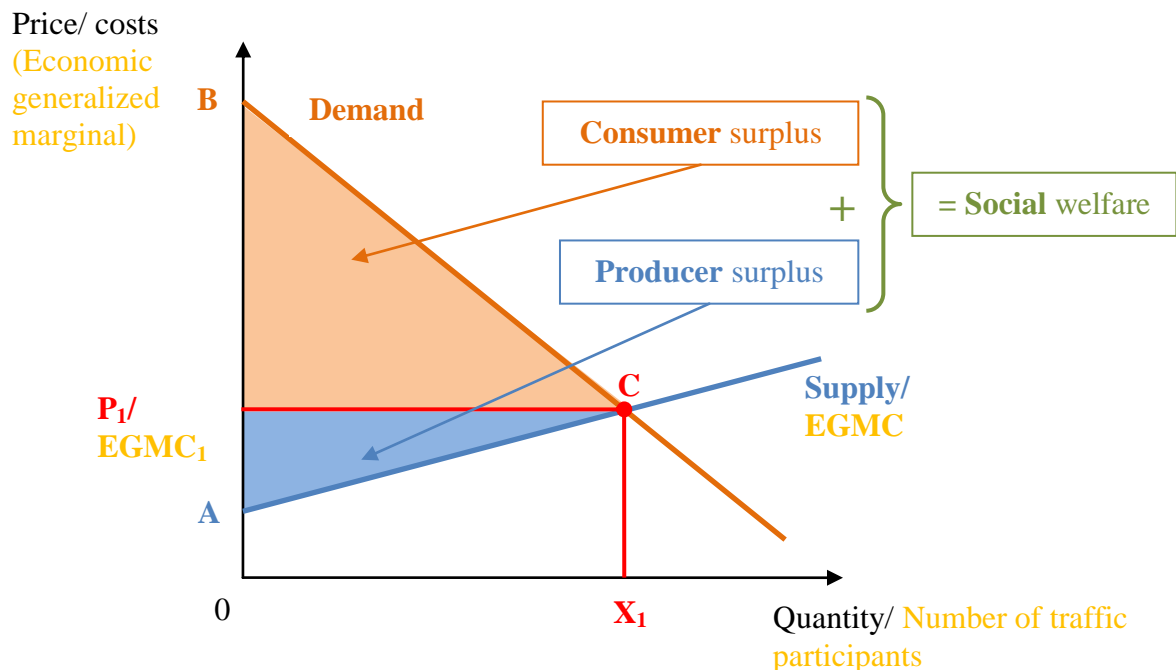


Figure 3-4: Consumer, producer and social surplus with connection to economic generalized costs (after Mankiw 2004, p.149; Grøvdal and Hjelle 1998, p.75 and 168)

It is a simplified example, displaying the surplusses in the case of a market equilibrium (point C) at the equilibrium price  $P_1$  and the equilibrium quantity  $X_1$  (red lines in the Figure). At the equilibrium, consumer and producer surplus are maximized and thus an efficient allocation of resources is realized. The reason for this is that with a higher quantity than the equilibrium, the costs for the producers exceed the value and the willingness-to-pay to buyers; a lower quantity than the equilibrium would lead to the value to the buyers exceeding the costs to the producers (Mankiw 2004; Grøvdal and Hjelle 1998).

“**Consumer surplus** is a monetary measure of the maximum gain that an individual can obtain from a product at a given market price.” (Nas 1996, p.67) It is representing the “difference between the maximum amount that an individual would be willing to pay for a good and the actual amount paid.” (Haveman and Weimer 2003, p.2848) Graphically as shown in Figure 3-4, it is the area between the equilibrium price  $P_1$  (red horizontal line) and the maximal willingness-to-pay (orange shaded triangle B, C,  $P_1$ ).

The **producer surplus** can be described as “the supply-side equivalent to consumer surplus” (Boardman et al. 2006, p.58) with the reasoning that changes in prices due to government policies do not only affect demand, but also change economic profits of firms in the market and thus their surplus. In definition “[p]roducer surplus represents the difference between the opportunity costs of adding another unit of service (e.g. transport) to the market [...] and the revenues earned by selling that additional unit.” (Berechman 2009, p.34) Graphically speaking, the producer surplus is the blue shaded triangle  $P_1$ , C, A in Figure 3-4.

Overall, the concept reflects the gain that the producer has due to increased demand and reduced costs which are driven by internal and external factors. External factors are such as subsidies or public investments that increase supply by increasing capacity. Internal factors can be such as technological improvements that are able to increase efficiency in producing services (Berechman 2009; Nas 1996).

- **Market failures and imperfections (externalities and unemployment)**

The SW function also includes **external costs**; they occur if there exist market failures or imperfect markets. **Market failures** are existent if there is “a mismatch between observed market prices and the true social value of the resources used in the production and consumption.” (Berechman 2009, p.40) When there is a market failure, the allocation of societal resources becomes inefficient and thus not Pareto efficient (Mankiw 2004). Since the estimations of social surplus of a project can be incorrect in an imperfect market, the true value of the project’s welfare contribution can influence the outcome of the CBA quite substantially (Berechman 2009). Overinvestment or no investment at all in a specific project can be named as an example. The main issue about market failures is, that it makes the exact measurement of change in social welfare very complicated and challenging (Boardman et al. 2006).



There are different examples of market failures such as monopoly or information asymmetry (Boardman et al. 2006); here just the two with most importance to the thesis shall be mentioned in more detail, which are externalities (Nas 1996; Boardman et al. 2006; Berechman 2009; Mankiw 2004) and unemployment (Riley 2006; Nas 1996).

**Externalities** are goods and services for which's production and consumption there is "no market" and thus prices and willingness-to-pay are extremely difficult to derive (Haveman and Weimer 2003; Boardman et al. 2006; Tudela, Akiki, and Cisternas 2006). Generally, external effects can be positive and negative and thus reflect "costs and benefits imposed on third parties [of a project or policy]" (Nas 1996, p.80). Examples for negative externalities in the transport sector are environmental damages, emission of greenhouse gases and traffic accidents; examples for benefits are increased transportation efficiency or positive spill-over effects of projects on neighbouring regions (Nas 1996; Grøvdal and Hjelle 1998). The main point is, that these effects should be accounted in the CBA, since their omission could lead to over- or underestimations of costs or benefits of a project as mentioned before. The value put on these "intangible goods" are so-called "shadow-prices" and refer to the marginal social value being used, when the measurement cannot be revealed through market prices (Haveman and Weimer 2003).

**Unemployment** is also considered as market failure as it represents an inefficient allocation of resources: "persistent unemployment is a sign of market failure because unemployment is a waste of scarce resources and leads to a loss of potential output and a reduction in allocative efficiency. The economy is operating below the maximum output it could achieve." (Riley 2006) An increase in unemployment is connected to social deprivation and could thus lead to negative externalities. The inclusion of valuation of labor in the CBA is challenging and the changes in social surplus need to be thoroughly accounted to find out whether society is losing output elsewhere because of the new project hiring additional workers. There exist several measures to evaluate the opportunity costs/ social costs of workers hired for a government project who would have otherwise been unemployed (Boardman et al. 2006). Measures for labor used are shadow wage rates and project budgetary costs tied to labor (Nas 1996).

- **Stated Preference Analysis, Revealed Preference Analysis and economic generalized costs**

The most important external effects in the transport sector are traffic accidents, environmental aspects and valuation of time (Grøvdal and Hjelle 1998). They are especially important when it comes to identify and evaluate the market (demand) potential for a transport project. At this point, the most commonly used methods for this (especially valuation of time) shall be mentioned shortly, the **Stated Preference Analysis** (SPA) (Phani Kumar, Basu, and Maitra 2004; Nossun 2003b; Fujii and Gärling 2003) and the **Revealed Preference Analysis** (RPA) (Bristow and Nellthorp 2000; Button 2010). SPA and RPA are used for figuring out individual's preferences and their valuations of e.g. travel time, choice of mode etc. This is done in order to forecast impacts on travel demand of (new) transport alternatives (compare e.g. Nash 1991). It is of importance since the SPA and RPA results represent an input to the economic generalized cost function (EGC) and are also further on methods being used by the case study countries to forecast demand for the potential HSR line(s). The SPA is based on microeconomic theory, where preference is assumed to determine choice, and is done in form of surveys where "respondents are requested to state their preferences in fictitious situations" (Fujii and Gärling 2003, p.390).

RPA studies try to figure out the behaviour of individuals when faced with situations where the choice of route or mode of transport involves trading time against money. Challenges of the method are to find suitable real life examples of trade-offs and the need for large sample sizes (Bristow and Nellthorp 2000; Morisugi and Hayashi 2000).

The data generated are used to estimate a utility function with which the behaviour is forecasted. The utility function shows the relations between external factors and preferences and thus gives a clue about the importance of each attribute. All the attributes considered in an utility equation have often different measuring units. In order to be able to compare or estimate the relative importance of each attribute, they are converted into a common unit. "Summation of these converted attributes is called the **generalized cost**." (Phani Kumar, Basu, and Maitra 2004, p.60) As an example, the study of Nossun (2003a)<sup>7</sup> shall be mentioned here, to show important aspects of travellers' valuation of time. Total

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<sup>7</sup> Which is called "Kollektivtilbudet i Osloregionen - Trafikantenes verdsetting av tid" and was done for the Transportøkonomisk Institutt (TØI) in 2003 (Nossun 2003a), with an English summary published in the magazine "Nordic- Road and Transport Research" the same year (Nossun 2003b).

journey time by public transport consists e.g. of the following factors: time to get to or from (bus, train) stations, waiting time (before the journey, between changing modes or lines or due to delays) and the time on board of the vehicle. The valuation for each component can be measured by using SPA or RPA in the country's currency, e.g. per minute or per journey. The choice of public transport mode is after Nossun generally dependent on "comfort, information and personal general preference for the form of transport." (Nossun 2003a, p.18)

To take up the connection to Figure 3-4 again, the **economic generalized costs** (EGC) of a given transportation journey consist of cost-elements, including the mentioned external effects of valuation of time, traffic accidents and environmental components and the fare for using the transport service itself (Nash 1991). Earlier, the marginal costs were mentioned and that social welfare is maximized, when marginal costs equal price; after the introduction of economic generalized costs, this needs to be redefined though. Social welfare in the presence of external effects is maximized when price equals economic generalized marginal costs (EGMC) (Grøvdal and Hjelle 1998). The function of EGC includes the following aspects (for detailed formula see Grøvdal and Hjelle 1998, p.167):

- Private generalized costs, including valuation of time, prices for used resources for travelling (e.g. fuel price)
- Valuation of weighted external time components, accident costs, environmental costs (including the use of shadow-prices for this element).

In the transport sector, quantity and price components are dependent on the traffic volume, thus, the EGMC are a function of it. This is also shown in Figure 3-4 (orange labels), where the supply curve can be seen as the EGMC as a function of the number of traffic participants (i.e. in that case the y-axis would represent the price and the EGMC, the x-axis the number of traffic participants instead of quantity in general).

After the basic terms have been clarified, the next section gives an overview of major steps followed in a CBA.

### 3.2.1.3 Major steps in CBA

This section shall give an outline of the seven major steps that are normally followed when accomplishing a CBA (Nas 1996; Boardman et al. 2006; Stevens 2004; Walker 2000; Hanley and Spash 1993; Hansjürgens 2004). The list of steps as shown in Table 3-1 is not comprehensive, and is primarily there for pointing out the most important stages and parts with relevance to the thesis, such as measurement of costs and benefits, more details on externalities, monetization of non-market goods and discount rates. Each named step is subsequently described in more detail.

Table 3-1: The major steps in CBA (modified after Boardman et al. 2006, p.8)

<b>A. Specify the set of alternative projects</b>
<b>B. Decide whose benefits and costs count (standing)</b>
<b>C. Catalogue the impacts and select measurement indicators</b>
<b>D. Monetize all impacts</b>
<b>E. Account for uncertainty and choose discount rates for benefits and costs</b>
<b>F. Perform sensitivity analysis</b>
<b>G. Ranking and selection of projects</b>

#### A. Specify the set of alternative projects

In this step, all the potential alternatives of a project should be listed and specified. As it has been mentioned before when doing CBA in the context of project appraisal the main two alternatives are normally, whether to invest in a project, or not (Hansjürgens 2004). This is also called the “with/ without evaluation principle” (Nas 1996; Haveman and Weimer 2003). Deciding to do the project represents the “with”, while the status-quo is often called the “counter-factual”, meaning that there is no change in policy, respectively the project is not being accomplished (Boardman et al. 2006). For both scenarios/ alternatives it is tried to figure out “if the value of the output in the economy with the proposed project would be greater than the value [...] without the project.” (Haveman and Weimer 2003, p.2846)

It needs to be highlighted, that defining the base case/ counter-factual is a crucial topic and requires an accurate characterization (Damart and Roy 2009). It is so essential to to define this case because costs and benefits taken into consideration in the process are the differences between *this* situation and the one that will occur if the project is accomplished. Thus, it has major impact on the outcome of the CBA.

Here also the issues “ex-ante” and “ex-post” CBA shall be mentioned (Boardman et al. 2006; Haveman and Weimer 2003; Stevens 2004). An **ex-ante** analysis is done before a project is done, helping to find an appropriate resource allocation decision for the project. Issues and challenges for this are that analysts face high uncertainty and have just estimates they can work with and thus this most common form of CBA done inherits the problem of failure (Haveman and Weimer 2003). **Ex-post** analyses are done after a project has been implemented. The advantages here are that analysts can use actual data instead of estimates. The best alternative, though done very rarely in practice yet is to compare the ex-ante and ex-post CBA in order to make “policy-makers learn about the efficacy of CBA as a decision-making and evaluative tool.” (Boardman et al. 2006, p.3)

### **B. Decide whose costs and benefits count (standing)**

As the title of the step already states, it is about deciding the so called “standing” (Haveman and Weimer 2003; Dobes and Bennett 2009), meaning which scale the costs and benefits that are taken into account should have and who is being affected by the project<sup>8</sup>. That is in most cases to decide whether the analysis should be carried out from the local, state or provincial, national or rather global perspective (Boardman et al. 2006). This becomes crucial when thinking of non-economic variables such as environmental impacts of large scale (transport) investment projects (Tudela, Akiki, and Cisternas 2006) like building an HSR which is in focus for this thesis. CBA seeks to comprehensively take into account effects accruing to all those with standing (Haveman and Weimer 2003).

### **C. Catalogue the impacts and select measurement indicators**

This step is about listing the physical impact categories (input and output)<sup>9</sup> and measurement indicators. It needs to be pointed out that there is *no* quantification being done yet.

Boardman et al. (2006) makes clear that “in order to treat something as an impact, we have to know there is a cause-and-effect relationship between some physical outcome of the project and the utility of human beings with standing.” (p.9/10) To figure out some of these relationships, extensive scientific research is necessary, while others are more obvious.

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<sup>8</sup> Also compare the three affected groups mentioned in 3.2.1.2 Conceptual foundations of CBA.

<sup>9</sup> Compare Figure 3-3.

Beneficial impact categories can be time savings, safety benefits (such as lives saved) or new users that could be gained by a new transport investment. Cost impacts include such as construction costs and maintenance. “The choice of measurement indicator depends on data availability and ease of monetization.” (Boardman et al. 2006, p.11) Measurement indicators are for instance such as number of lives saved per year, number of person-travel hours saved or tons of greenhouse gases emitted.

#### **D. Monetize all impacts**

Now the just listed impacts, both benefits and costs, need to be valued in monetary terms. Following the examples from step 3, the monetary values of time saved, lives saved as well as maintenance and construction costs need to be determined now.

There are two major groups of impacts to distinguish, tangible elements and intangible ones. **Tangible** elements are for instance capital equipment or land (Nas 1996). Their values and prices can be normally obtained from markets, though sometimes need to be used with caution if the market is e.g. not competitive (i.e. a monopoly), because then one would face a market imperfection again. This is the reason for the broad use of the before mentioned shadow-prices for these elements in CBA, which represent more realistic values because they are adjusted (Nas 1996).

**Intangible** elements are such as value of a human life, value of time, morality, noise, visual intrusion and other environmental factors (Nas 1996; Tudela, Akiki, and Cisternas 2006). They clearly represent elements, for which there is no market and thus their monetization is a challenging issue. The measurement methods for intangible elements remain one of the main critical issues within the use of CBA. This is mainly because of the reason that often neither the probability nor the potential damage to e.g. environment can be properly estimated (Hansjürgens 2004). This topic will be dealt with again in 3.2.3.1 Criticism and limitations of CBA.

As shown in Figure 3-3, the concept for measuring benefits and costs can vary. Some issues surrounding their measurement shall be mentioned here.

- **Monetization of social benefits**

The measurement principle for social benefits is as mentioned before the willingness-to-pay, or more specifically the the aggregate willingness-to-pay of those that have standing

for the impacts of a policy (Haveman and Weimer 2003). This aggregate willingness is depending on the level of wealth of every single one and the society overall. Therefore, the benefits used in CBA are contingent upon the distribution of wealth among the society (Boardman et al. 2006; Haveman and Weimer 2003).

In the transport sector, there exist four non-exclusive classes of macroeconomic benefits for transport projects (Arnott 1997) that are job creation, opening up the economy, shifting out the production possibility frontier and stimulating aggregate demand. Nevertheless, “[t]he treatment of such benefits remains one of the fuzziest areas of project appraisal and perhaps the most prone to political manipulation.” (Arnott 1997, p.45)

- **Monetization of social costs**

The measurement issues for social costs are very much the same as for the benefits, there is some basic difference concerning the basic concept behind it though. The costs put on society due to a policy change are most often measured by opportunity costs (compare Figure 3-3). Specific problems with measuring values for opportunity costs arise for categories like unemployed labor or potential government revenues of a specific investment project (Haveman and Weimer 2003).

Another important matter that needs to be pointed out is, that CBA looks “forward” respectively is trying to measure “future impacts”. Thus, expenditures and resources that have already been done *before* for a specific transport investment project, so called “sunk costs”, normally are and should be disregarded in CBA. This is for the reason that they are no longer available for other uses and therefore their opportunity cost is zero (Haveman and Weimer 2003).

#### **E. Account for uncertainty and choose discount rates for benefits and costs**

The need to discount costs and benefits is mainly because resources that are being available in some time in the future, are worth less than the same amount being available right now (Boardman et al. 2006; Haveman and Weimer 2003; Hansjürgens 2004). Thus, discounting weighs the policy impacts that occur in different years appropriately and adjusts the costs and benefits, since “[m]aximizing the present value of net benefits would maximize potential Pareto efficiency.” (Haveman and Weimer 2003, p.2849) In practice, future and present costs and benefits of society are aggregated to one single value of the

project, the net present value (NPV) of the project (Boardman et al. 2006). As Nas (1996) points out “[t]he critical issue at this stage is the choice of a discount rate” (p.63). This is mainly, because the choice of discount rate has influence on the public project’s benefit-cost ratio and thus on the potential to achieve the maximum social welfare. It should be mentioned that discount rates in CBA have nothing solely to do with inflation, even though inflation also needs to be taken into account for sure (Boardman et al. 2006).

For the further analysis part it is useful to look at discount rates that are employed in practice within the transport sector. From looking at discount rates used in different countries all over Europe (including all of the case study countries of this thesis as well) – the rates within the transport projects differ between 3% to 8% (Thomopoulos, Grant-Muller, and Tight 2009). One conclusion of this is, that the discount rate should be chosen in a way that “it is at least equal to the minimum rate of return obtained for this type of [transport] investment.” (Berechman 2009, p.103) An additional issue mentioned in the theory, are mandatory discount rates set up by national ministries of finance and federal treasury departments for *all* transportation projects within a country, without further specification concerning mode of transport or alike. In this case, the analysts doing the CBA for e.g. an HSR project should carefully consider the reasonableness of the obligatory rates and at least comment on the appropriateness for the specific project (Berechman 2009). Berechman (2009) stresses the consequences of improperly chosen discount rates. Too low rates for example “will not only permit making unworthy investments, it will also prevent implementation of more profitable ones.” (p.104)

Another important aspect concerning discounting costs and benefits, is the time horizon being used in the calculation, including values for e.g. the “life time” for transport infrastructure projects. These values, which differ in countries across Europe “from 20 years to infinity” (Thomopoulos, Grant-Muller, and Tight 2009, p.3), also have a crucial influence on the net present value of a project.

## **F. Perform sensitivity analysis**

CBA involves the prediction of future costs and benefits. The analysts might be uncertain about their estimations of these and their choice of impacts or values for e.g. the discount rate (Haveman and Weimer 2003). “The purpose of sensitivity analysis is to acknowledge the underlying uncertainty.” (Boardman et al. 2006, p.175)



The procedure is to test how sensitive the estimations are to particular assumptions. The analysis itself “typically involves changing the assumed values of a few key parameters to see how net benefits change.” (Haveman and Weimer 2003, p.2850)

Since in reality the assumptions within CBA can be varied almost infinitely (and specifically in transport projects the alternatives are very complex (Salling and Banister 2009), there apply limits in feasibility of a sensitivity analysis. Therefore, in practice, a sensitivity analysis is just done on the potentially most important assumptions, such as the discount rate, physical quantities of inputs or outputs or the project lifespan (Hansjürgens 2004). “Although this can mean that CBA is vulnerable to the biases of the analyst, carefully thought-out scenarios are usually more informative than mindless varying of assumptions.” (Boardman et al. 2006, p.17)

### **G. Ranking and selection of projects**

In this step, the analysts have to recommend which projects are most desirable from the society welfare’s point of view. In order to come to this decision, the alternatives need to be ranked (Boardman et al. 2006; Nas 1996). In most of the cases this is done by comparing either the NPV itself, or the “derivative of the NPV” (Berechman 2009) which is the benefit-cost ratio (BCR) of each alternative<sup>10</sup>. The benefit-cost ratio is the benefit of a single money unit invested, and “is appropriate only if the policies are independent of each other, in which case the set of projects with benefit-cost ratios greater than one corresponds to the rule of adopting policies with positive net benefits.” (Haveman and Weimer 2003, p.2850) Thus, the policy/ alternative with the highest positive value are the ones that are most likely Pareto improving, and which should therefore be recommended (compare yellow square in Figure 3-3).

#### **3.2.1.4 CBA in practical use in the transport sector**

The CBA method is a commonly used tool concerning transportation investment policies and decision-making. It needs to be pointed out though, that in most cases CBA represents just *one* input to the decision-makers (Berechman 2009). CBA “does not claim to be a positive (i.e. descriptive) theory of how resource allocation decisions are actually made.

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<sup>10</sup> In some countries, as e.g. in Norway, the **net** benefit-cost ratio is used for decision-making. The criterion for profitability is then that the result should be greater than **zero** (and not one as mentioned above).

Such decisions are made in political and bureaucratic arenas. CBA is only one input to this political decision-making process – one that attempts to push it towards more efficient resource allocation.” (Boardman et al. 2006, p.17)

CBA was originally meant for evaluating projects in the public sector. The trend in recent years though is that the distinct lines between public and private sector have become more blurry, since the private sector has started to participate in some areas of public sector investments (Campbell and Brown 2005; Bots and Lootsma 2000). The plans for a partial privatization of railways in Germany in 2008 is one example (Tagesschau 2008a, 2008b). This shows the new challenges that CBA as a method needs to meet: “CBA needs to encompass the full range of public and private sector concerns if it is to continue to make a useful contribution to public sector decision-making.” (Campbell and Brown 2005, p.1)

### **3.2.2 Multi-criteria analysis (MCA)**

Multi-criteria analysis is the second appraisal methodology of relevance for this thesis and belongs to the group of methods, referred to as multiple-criteria analyses<sup>11</sup>. This section gives an overview of the theoretical background of MCA as methodology for transport project appraisal. As for CBA, first the development of MCA, its definition and purpose will be described. Then the main phases of a MCA are outlined. After its use within the transport sector is outlined.

#### **3.2.2.1 Development, definition and purpose of MCA**

Several methods have been developed on basis of the criticism of CBA, mainly not being able to capture all conflicting interests of all stakeholders involved and affected by a project or policy (Thomopoulos, Grant-Muller, and Tight 2009; Munasinghe 2007). MCA is one of those methods “capable of eliciting the trade-offs between objectives (e.g. transportation efficiency, improved equity, and reduced environmental externalities) in ways that enable decision makers to make rational and systematic choices regarding the preferred project.” (Berechman 2009, p.306)

MCA has evolved as a multi-objective decision making approach for situations in which a single-criterion approach is incapable of providing the required assessment framework due

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<sup>11</sup> Multiple-criteria analysis is in many sources also abbreviated with “MCA”. In this thesis though, the abbreviation MCA is solely used for “multi-criteria analysis” as a method, if not stated explicitly different.

to usually conflicting criteria (Chung-Hsing et al. 1999; Thomopoulos, Grant-Muller, and Tight 2009; Berechman 2009). MCA aims to “to allow each decision-making environment to engender its own set of criteria, measure and score them, and then generate a system of relative weights specific to the given context.” (Berechman 2009, p.308) It needs to be pointed out clearly, that “[p]articipation of the decision-makers in the process is a central part of the approach.” (Thomopoulos, Grant-Muller, and Tight 2009, p.3)

MCA differs from CBA in the following two main areas (Munasinghe 2007; Gamper and Turcanu 2007):

- MCA has no limits in the forms of criteria in the sense of that MCA allows also for “intangible” elements like for instance equity considerations.
- MCA does not require the use of prices, MCA makes use of weights and scores (note that prices *might be* used though to derive these overall scores).

### 3.2.2.2 Main phases of MCA

By comparing several sources, the following four phases of a MCA can be summarized (Tsamboulas 2007; Berechman 2009; Thomopoulos, Grant-Muller, and Tight 2009; Munasinghe 2007; Stevens 2004; Gamper and Turcanu 2007).

Table 3-2: The four main phases of MCA (several sources)

<b>A. Identification of criteria and preferences</b>
<b>B. Evaluation of criteria and generating weights</b>
<b>C. Prioritization and ranking</b>
<b>D. Sensitivity analysis</b>

#### A. Identification of criteria and preferences

In this phase preferences need to be established between various alternatives, where each one is contrasted to a predefined set of objectives (defined by the decision maker). Measurable criteria indicators are made up to test if the objectives are met. All transportation and non-transportation impact categories need to be systematically scored, making use of measurement scales (e.g. cardinal, ordinal, interval or ratio) (Berechman 2009). Of special relevance for this thesis is the ordinal measurement scale. It is used when no cardinal (explicit numbers) score can be given or are too difficult to derive. By using an ordinal method, projects are ranked “on the basis of selected criteria without assigning

quantitative values to them.” (Berechman 2009, p.317) Using this method requires that objectives need to be set for all the chosen evaluation classes. In the end, a comparison of the ordinal ranks, gives a clue about the most desirable alternative. The challenge with this method is that a final ranking of the alternatives becomes difficult and thus there might be the need for further analysis.

## **B. Evaluation of criteria and generating weights**

In this phase the decision-makers define the significance of each indicator in form of a weight for each impact category. The weight is reflecting the relative importance of the criteria for decision-making.

Finding the appropriate weights for the categories within the MCA is the crucial factor (Berechman 2009). This means if the final ranking of the alternatives is invariant according to the weights, the MCA as a decision-making tool is useless. If on the other hand the ranking is sensitive to the weights chosen, the weights need to be critically proven for their appropriateness.

There are criteria categories for which weights can be easily made up due to available data, otherwise there must be made use of “quality attributes”, such as expert opinions and judgments (Tsamboulas 2007). After Berechman (2009), there are three approaches to reach values for weights:

- **Expert panel**, which is to consider expert opinions or well-informed individuals “relative to the nature of each criterion” (p.310), or do sampling, i.e. survey among professionals; e.g. in a pair wise comparison of different assessment criteria. A scoring of the answers could then lead to the weights.
- **Optimization**. For this approach, the decision-problem is formulated as an optimization problem in form of an objective function. “The variables, whose values must be determined, are the decision weights; constraints on these variables are derived from explicit preference statements made by decision-makers.” (p.310)
- **Ex-post analysis**. With this approach, the weights being generated are “regarded as the decision criteria’s shadow prices, reflecting their relative importance.” (p.310) Like the name of the method states, it estimates the weights (prices) by looking into data of “previous comparable situations (i.e., projects of the same type).” (p.310)

### **C. Prioritization and ranking**

In this phase, a final score is derived for each criterion, summed up to a total score for the alternative. The score is normally in between 0 and 1 respectively 0% to 100% (Thomopoulos, Grant-Muller, and Tight 2009). The weighted, total score aims to “assist decision makers to realize the time-order of implementation in the desired time horizon” (Tsamboulas 2007, p.19), which refers to short-, mid- or long-term respectively not at all.

### **D. Sensitivity analysis**

As for CBA, also within MCA it is common to do a sensitivity and/ or robustness analysis of the criteria/ weights chosen (Gamper and Turcanu 2007; Berechman 2009). For further information on how this is technically done, compare 3.2.1.3 Major steps in CBA, Step 6.

The explicit attempt of the MCA method is “to eliminate subjectivity in the generation of *decision weights* and thereby make the overall evaluation-selection process consistent and transparent.” (Berechman 2009, p.311)

#### **3.2.2.3 MCA in practical use in the transport sector**

MCA is in use in various disciplines and modes of transport to assess project impacts, mostly within environmental and social decision-making (Gamper and Turcanu 2007; Tudela, Akiki, and Cisternas 2006). Unlike CBA, MCA up to now “is rarely required by national laws or directives.” (Gamper and Turcanu 2007, p.298) However, some of the case study countries and the EU and United Nations “recommend the use of MCA in situations requiring consideration of criteria which cannot be easily expressed in monetary terms.” (Gamper and Turcanu 2007, p.299)<sup>12</sup> Due to the recommendations, “the use of MCA has lately increased in the public domain, e.g. in public transportation systems.” (Gamper and Turcanu 2007, p.299) Even though until now to a limited extent, MCA has been used “to provide a flexible means of assessing the multidimensional effects of transport projects [...]” (Thomopoulos, Grant-Muller, and Tight 2009, p.3)

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<sup>12</sup> For this for instance compare the manual of the Department for Communities and Local Government in the UK (DfCaLG 2009).

### 3.2.3 Criticism and limitations of the methods

CBA as well as MCA have been subject to criticism as methodologies in general, as well as their use for decision-making in the public sector. This section outlines the advantages, main criticisms for each method as well as their limitations and concludes with a summary and the recommended combinational use of them.

#### 3.2.3.1 Criticism and limitations of CBA

The main criticism and limitations of CBA led to the development of alternative methods, either as substitutes or supplements to CBA in the last two decades (Thomopoulos, Grant-Muller, and Tight 2009). As MCA represents one of them and is relevant for this thesis, this sub-chapter shortly discusses the most common criticisms and limitations of CBA.

An advantage of CBA as a methodology is its “broadness” respectively “generality” concerning its use in order to evaluate and compare very different projects from different industries and also different modes of transport (Hansjürgens 2004).

The limitations of CBA can roughly be split into three main areas, technical and qualitative limitations and the use of CBA in public decision-making (Boardman et al. 2006; Berechman 2009; Stevens 2004).

**Technical limitations** are mainly related to the challenge of putting the appropriate monetary values on all the relevant impacts. The technical limitations such as the before mentioned market imperfections or simply the existence of non-market goods, inherit considerable uncertainty about future costs and benefits (Berechman 2009; Hansjürgens 2004; Damart and Roy 2009). It leaves the decision-makers with “output criteria based upon ‘best guess’ estimates” (Salling and Banister 2009, p.800). The main point here is that CBA just represents an appropriate decision making tool if the Pareto principle can be applied (Boardman et al. 2006). Otherwise, “market failures, regulation, taxation, subsidization or institutional arrangements may render the results obtained as nonoptimal.” (Berechman 2009, p.91)

**Qualitative limitations** of CBA are twofold. On the one hand it is criticized, that the main underlying principle of CBA is efficiency and that – especially – when deciding upon policies, evaluations of other goals may be important, such as equity concerns (Thomopoulos, Grant-Muller, and Tight 2009; Boardman et al. 2006). It is criticized that

CBA neglects that “distribution of costs and benefits across socioeconomic groups and geographic space is nonuniform, often rewarding some at the expense of others.” (Berechman 2009, p.91) Other sources argue, that even though CBA is mainly used for making comparisons among alternative policies and their efficiencies, it can nevertheless be also used, when other measures than efficiency are of importance, then mainly as a “yardstick that can be used to provide information about the relative efficiency of alternative policies.” (Boardman et al. 2006, p.26)

Qualitative limitations of CBA in the use within the transport sector also include that the CBA may disregard indirect effects of large transport infrastructure projects if the analysis is not designed properly. Conventional CBA then hardly captures “socio-economic and regional development impacts over and above the direct transport impacts.” (Thomopoulos, Grant-Muller, and Tight 2009, p.1) Also underlying the efficiency principle is the criticism that CBA tries to “weigh-up” e.g. human life, health or environmental aspects against economic concerns (Damart and Roy 2009; Hansjürgens 2004). The criticism is based on ethical and moral reasons surrounding this. As it will be mentioned later on, one can argue though that such trade-offs are actually made in everyday life and policy and thus it is not necessarily immoral to explicitly express those issues in monetary terms.

One area of criticism regards **CBA and its use for public decision-making** (Hansjürgens 2004). The main critical concerns are the excessive weights being put on “hard quantitative facts” in CBA, neglecting that the “soft facts” such as effects on human health or the environment can often just be given in form of qualitative information (for more elaboration on this compare Angelsen and Sumaila 1995). The criticism is that “‘weak’ environmental effects are compared to ‘strong’ effects (because they are quantifiable)” (Hansjürgens 2004, p.248).

Even though inheriting limitations and criticism, “[t]hese issues notwithstanding, COBA<sup>13</sup> is still the most commonly used approach in transportation project evaluation.” (Berechman 2009, p.91)

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<sup>13</sup> COBA is the abbreviation for Cost-Benefit Analysis used in (Berechman 2009).

### 3.2.3.2 Criticism and limitations of MCA

MCA may overcome some major disadvantages of CBA, e.g. including the intangible elements that CBA is struggling with. Nevertheless, MCA has also been subject to criticism. Table 3-3 gives a summarizing overview of strengths and weaknesses of MCA for its use for public decisions.

**Table 3-3: Strengths and difficulties of using MCA for public decisions (modified after Gamper and Turcanu 2007, p.300)**

Strengths of MCA	Weaknesses of MCA
Openness to divergent values and opinions	Subjectivity of generated weights
Supports a broad stakeholder participation	Technical complexity, e.g. choice of parameters
Accountability (systematic, transparent)	Choice of stakeholders and timing of their participation
Preferences revealed in a more direct and practical way	Potentially time-consuming process
Capability to tackle qualitative and intangible factors	Experts' reluctance to share their knowledge/ power
Helps legitimize decision-makers' behavior	On a higher decision-level, experts are more suspicious of new instruments
	Information bias from certain stakeholder groups to strengthen their power

As the table shows, one of MCA's main criticisms lies within the involvement of the stakeholders in the process of making up preferences and weights and thus remains its major challenge (Gamper and Turcanu 2007; Dobes and Bennett 2009). "Paradoxically, the major weakness of the [MCA] method arises from its major strength: the value judgments by the decision makers." (Thomopoulos, Grant-Muller, and Tight 2009, p.4) This means that since the weights and criteria are chosen by the decision makers themselves, these preferences "do not necessarily reflect the preferences of the people as they are expressed when making choices under the restriction of limited resources." (Saitua 2007, p.31) Since various stakeholders will most likely have different priorities or objectives, MCA in that case could not help to find a single best solution (Munasinghe 2007). One way to avoid these potential negative effects for society is to set up rules and regulations for the decision-makers behavior in a manner that secures the preferences of the society (Gamper and Turcanu 2007).



Bots and Lootsma (2000) raise two other critical issues about MCA as a method. Firstly, what happens if the decision criteria and the assignment of weights to these criteria are accomplished by two different persons (which could well be the case in large scale transport projects like e.g. HSR)? The question becomes if the weights that are derived are still meaningful (Bots and Lootsma 2000). The threat is that in practice the criteria have often a vague nature and it follows that “inconsistent weights are often produced, which may lead to unreliable decision outcomes.” (Chung-Hsing et al. 1999, p.131) Secondly, another limit going into the same direction is concerning the data that is generated by experts and handed over to the decision-makers. The question is if the decision-makers can interpret the data delivered by the experts properly without any additional information. The bottom line of this is “the first problem can be tamed, while the second remains elusive.” (Bots and Lootsma 2000, p.4)

### 3.2.3.3 Summary and discussion

To round of the criticism of both the methodologies, a short summary of the main points for each shall be given and discussed. In this context, also Social CBA (SCBA) is shortly mentioned. After that the widely accepted and recommended combinational use of CBA and MCA for transport project appraisal is outlined.

The main advantages and criticism of **CBA** can be summarized as follows<sup>14</sup>:

- main advantage: being a general tool and accomplishable for every industry, transportation mode and alike. Thus, allowing comparisons also among different projects.
- uncertainty about forecasted values such as demand, future costs and benefits
- might have the lack of capturing equity and other socio-economic aspects
- there are political goals beyond the basic principle of CBA, namely efficiency
- the thought of unethical valuation of certain components, e.g. human life
- monetizing of intangible/ non-market goods in an inadequate manner; hard vs. soft facts
- critical issue of choosing the discount rate and time horizon.

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<sup>14</sup> Where the magnitude or applicability of each can differ from case to case, mainly depending on how the actual study is managed and accomplished.

The following discussion is mainly based on Hansjürgens (2004), Grøvdal and Hjelle (1998) and Damart and Roy (2009). **Uncertainty** due to insufficient and vague data e.g. on environmental risks and consequences of a project is indeed a serious problem. It is doubted though that this problem is rooted in CBA as a method itself; “[c]riticism of CBA in this respect would only be justified if it magnified the shortcomings described – but it doesn’t” (Hansjürgens 2004, p.246). Hence, the uncertainty is more based upon the uncertainty of data, than on CBA as methodology itself.

CBA also does to some extent ignore **equity and distribution considerations**. Its strengths are to figure out the before mentioned potential Pareto efficiency. The decision about welfare distribution matters are left to society respectively its representatives – the politicians. Whether this should be rated as good or bad for CBA as a method itself depends much on the scale of the project. However, CBA is said to be a more transparent tool, than some other decisions done by society in which the underlying values are often unknown.

Concerning CBA’s **ethical issue** e.g. the economic evaluation of life, several sources argue on this matter that the evaluation of a human life or death does not refer to a specific individual. It refers to the so called “statistical life”, i.e. the willingness-to-pay for a change in the probability of getting ill or dying. This measurement is also mentioned to be a standard practice in everyday life, since every individual makes choices about such things by e.g. choosing to smoke or not, investing in a qualitatively better and thus more secure car, or by simply taking out an insurance (life, travel, house etc.).

Another issue surrounding CBA is the challenge to **monetize intangible goods**, leading to “**hard facts**” being compared to “**soft facts**”. Again, also this criticism seems justified as mentioned by several sources (Damart and Roy 2009; Hansjürgens 2004). The predominance of “hard” economic data in political and public decision-making is undeniable. This limitation should be kept in mind but should not lead to the conclusion that CBA as an overall method is undesirable, because it can still offer a broad range of basic information and depicts also a guideline for collecting the necessary data in a systematic way. The later on mentioned combinational use of CBA and MCA is a solution to address this limitation in a good manner.

- **SCBA – Social cost-benefit analysis**

As mentioned in the introduction, the limitations of CBA have led to the development of supplements to CBA. The social cost-benefit analysis (SCBA) should shortly be mentioned at this point since some of the case-study countries of this thesis make partly use of SCBA.

The criticism that CBA has a “prime focus on economic efficiency and the lack of adaptability to the requirements of multi-actor settings of integrating different stakeholder opinions or choices” (Haezendonck 2007, p.4), has led to the development of the SCBA. SCBA is an extension of the classical CBA and is able to measure also “multi-dimensional aspects of project desirability, such as sustainability, ethics and other social values.” (Haezendonck 2007, p.5)

SCBA seeks to make a comprehensive analysis of the impacts of a project on *all* individuals of a society, not just the directly involved parties such as producers and consumers of the specific product or service (Saitua 2007; Thomopoulos, Grant-Muller, and Tight 2009). SCBA is furthermore said to be able to quantify the non-market goods that the common CBA is struggling with.

Main advantages and criticism of **MCA** can be summarized as follows:

- main advantage: can capture also intangible components
- main disadvantage: involvement of stakeholders and decision-makers in the creation of weights and preferences which can lead to biased scores
- generating the weights and scores is a complex and time-consuming process.

The issue of subjectivity of weights in MCA is said to be quite normal since “it is inevitable that decision-makers take decisions partly on subjective grounds” (Saitua 2007, p.31). Nevertheless, this means that MCA should not be part of the analysis step of a project because that should be kept free of value judgments. MCA should therefore be more relevant as a method in the stage of decision-making to systematize the weights of preferences, concerning trade-offs that lie beyond the scope of e.g. CBA (Saitua 2007).

A matter the author of this thesis realized while doing research on MCA was, that on the theoretical foundation and evaluation of MCA as a method there is quite little literature and research. It seems that MCA has mainly been developed out of the criticism of CBA and was in most cases specifically developed for certain circumstances (e.g. in form of

mathematical models), for specific industry sectors, transport modes or even single projects. While there exist various books and encyclopedia entries about CBA (Boardman et al. 2006; Nas 1996; Haezendonck 2007; Haveman and Weimer 2003), they hardly seem to exist for MCA; this is also reflected in the available sources on the matter, which are mainly journal articles dealing with MCA in a specific context<sup>15</sup>. Dobes and Bennett (2009) comment on the lack of theoretical foundation of MCA as follows; “Multi-criteria analysis has no single or overriding principle on which impacts (or so called criteria or attributes) of a policy proposal are determined.” (p.18) They in this context point out the special advantage of CBA over MCA. CBA allows comparisons between very diverse projects (e.g. in different industry sectors such as health, transport etc.) “because it evaluates all projects and policies on the basis of a common numeraire underpinned by a common theoretical construct.” (Dobes and Bennett 2009, p.20)

- **Combinational use of CBA and MCA**

To avoid the subjectivity and also to overcome the criticism of a solely used CBA, Berechman (2009) advises to select transportation investment projects “first and foremost, on the basis of their assessed transportation benefits [...]” (p.325) (by using CBA) and subsequently they should be ranked by weights, scores and values generated through a MCA. An overall sensitivity analysis of the final ranking should be done to ascertain the robustness of the results with regard to changes in the weights. This combinational use of MCA and CBA is recommended by several other sources as well and is also used in the transport sector in this manner already.

- MCA “remains an alternative and complementary [...] but is unlikely to replace CBA in the foreseeable future.” (Stevens 2004, p.110)
- “The multicriteria tools [...] could be used together with CBA tools for economic evaluation.” (Damart and Roy 2009, p.210)

More important in the context of this thesis is that also the manuals and guidelines for transport (rail) project appraisal from several of the case study countries suggest this:

- The manual in the UK on the use of MCA states “[s]ince 2000 it has become more widely recognized in government that, [...] MCA is not a substitute for cost-benefit

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<sup>15</sup> For this compare the sources used in the whole chapter 3.2.2 Multi-criteria analysis (MCA) and the Reference List.

analysis, but it may be a complement. [...] It therefore complements guidance to those techniques which primarily use monetary valuations [...].” (DfCaLG 2009, p.5/6)

- As one will see in the analysis later on, also Germany requires the use of CBA and MCA for appraisal of large investment projects (BMVBS 2003).
- The European Commission outlines their approach for evaluating rail infrastructure projects as “[u]ndertaking a cost-benefit analysis of the effect of the mandatory impacts on all relevant incidence groups. Undertaking a multi-criteria analysis of the mandatory and discretionary impacts on all relevant incidence groups [...].” (EuropeanCommission 1996, p.XIV)
- The so called EFECT framework, which is a framework developed for measuring environmental impacts and costs of transport initiatives, also makes use of “the combination of Multi-Criteria Analysis (MCA) with Cost-Benefit Analysis (CBA).” (Tsamboulas and Mikroudis 2000, p.283)

The bottom line for CBA, MCA as well as their combinational use for (transport) project appraisal is, that they represent tools and methods that are offered and recommended to politicians, and who in turn *can* – but most often are not obliged to – make use of. The EU for instance requires through the “Funds Regulation” the use of CBA for large investment projects in general since 2000; the criteria being used are not compulsory but rather recommendations though. MCA is also a recommended tool, but not obligatory in use (EuropeanCommission 2008). Their outcomes seem to be one of many inputs for the decision-makers, and “can serve as a supplement for final decision makers to support more efficient policies, i.e. not only as a decision making, but as a decision-aiding tool.” (Gamper and Turcanu 2007, p.305) Bots and Lootsma (2000) found out that in practice “the impact of the analyses on the policy decisions seems to be quite marginal” (p.4) though. In this context, also the influence/ power of media concerning specific projects and making respectively “forming” an opinion in society by selectively choosing what to report on should not be underestimated. The same counts for electoral cycles and thus governing parties and their goals and interests as amongst others mentioned in the Steer Davies Gleave report: “There was some evidence that perceived wider economic benefits of projects, national pride issues, and wider strategic impacts, were more important in decision making than the cost benefit analysis results from appraisals. In some countries, the appraisal criteria appeared to have been explicitly or implicitly skewed to generate

outcomes that were consistent with certain policy objectives.” (SteerDaviesGleave Feb 2004, p.4)

After the two main appraisal methods were theoretically presented, the following chapter gives insight into a “typical” setting of HSR appraisal.

### ***3.3 A “typical” setting of an HSR case and its appraisal***

This section will introduce some basic key parameters influencing HSR appraisal and costs and benefits considered in it as well as debates and issues surrounding it. This is on the one hand in order to give the reader an understanding about the “typical” setting for HSR, and on the other hand meant to limit the scope of items to focus on in the subsequent analysis.

First key parameters influencing the case of HSR are outlined and are followed by an overview of “typical” costs and benefits for HSR. After that, remaining controversial issues are summarized leading to the limitation of items studied for each country in the analysis and their reasoning.

#### **3.3.1 Key parameters influencing the case for HSR**

The case for HSR normally depends on “the capacity to generate social benefits which compensate for the construction, maintenance and operation costs” (De Rus and Nash Dec 2007, p.31). When doing project appraisal, there is normally as mentioned earlier a “base case” and some options. The base case should normally be a “do-minimum” option, while the other options should be “do something”. The comparison that needs to be done should figure out if “the additional cost of moving to a more expensive option is justified [...]” (Nash Nov 2009, p.4). After Nash (2009) the base case for HSR should include investments that would be necessary to keep the existing (conventional) rail service running and considerations how to deal with growth in traffic (e.g. investing in additional rolling stock or adjusting fares). The major other options should include investments in upgrading the existing infrastructure or thoughts about construction of additional airport and road capacity. For sure, there also have to be options dealing with the specific cases of which lines of HSR to build, service frequency, stop patterns etc. Sufficient options are needed to ensure that the best alternative is found in the end. “The range of potential options makes appraisal of high speed rail a difficult task.” (Nash Nov 2009, p.4)

The investment in HSR and whether it is meaningful or not was found to be dependent on some correlated factors (SteerDaviesGleave Feb 2004).

- There needs to exist a large market for travel. Journey distances of 200-800km and particularly 300-600km gain most benefits due to HSR investment, while the use of HSR for journeys of less than 150-200km represents almost no benefits. The “3-hour-journey-time” is often mentioned as competitive edge for HSR, because close to or below this travel time, HSR can be expected to take a major share of the aviation market (Nash Nov 2009).
- HSR can offer a high capacity, i.e. sufficient demand is needed for it in order to be used efficiently. Large cities or population centers within the proximity of the project are advantageous for the case of HSR.
- The construction of HSR is least difficult in sparsely populated countries whereas high population contributes to a better demand for HSR.
- By upgrading old lines to HSR lines, construction costs can be reduced significantly. The possibility for this is not given in every case though.

Furthermore, the following key parameters influence the case of HSR<sup>16</sup>.

The **breakeven volume of passengers** is quite crucial and needs to be estimated for every alternative scenario. Numbers differ quite a lot in European countries, ranging from 3 – 17 million passengers in the first year of operation. It was found out though, that even under most favorable conditions at least nine million will be needed to compensate for the high costs involved with building and operating an HSR. But it is not only the high number of passengers needed that is important, also the willingness of those to pay for the new facility, i.e. facing high (enough) benefits when switching to HSR.

In line with this, “it appears to be **construction cost** that is the key determinant of the breakeven volume of traffic” (Nash Nov 2009, p.11). Construction costs vary enormously from case to case. A major contributor to costs is the level of labor costs, and topography of the country that determine the amount of tunneling involved, which would be the case for many of the corridors planned for Norway.

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<sup>16</sup> The features mentioned here are mainly relevant for the setting of France, Germany and proposals for Britain, but might differ from those found in countries “with lower population density from the core of Europe” (De Rus and Nash Dec 2007, p.32), such as Norway and Sweden. As being the only benchmark available for HSR cases though, they are mentioned anyway.

The **pricing policy** and with it if subsidies, public or private **funding** are the basis of investment in HSR have a considerable influence on the outcome for or against the case. Moreover, the choice of the **discount rate** as mentioned earlier is quite crucial and varies a lot within Europe. The conclusion for HSR is “[g]iven that HSR is very capital intensive and has a long life with growing benefits over time, a low discount rate will favour investment in HSR.” (De Rus and Nash Dec 2007, p.8)

### 3.3.2 ”Typical” costs and benefits of an HSR case

In general, there is in fact nothing such as a “typical” case of HSR, since HSR cases differ quite a lot and need to be examined individually for every case. They are highly dependent on local conditions concerning labor prices, topography, funding, existing rail lines etc. Anyway, there are some costs and benefits that appear in most of the CBA appraisal cases for HSR. These are the ones that should be listed here to give the reader an overview and introduction of the setting.

Major costs and benefits mentioned in an HSR appraisal are displayed in Table 3-4, where its information is taken from several sources specifically for HSR. There will in real life be slight deviations for each case, i.e. the magnitude and impact of each item can differ according to the particular circumstances. The components will be explained in more detail below the figure.

**Table 3-4: Typical costs and benefits in an HSR appraisal; own table, information taken from (Nash Nov 2009; De Rus and Inglada 1997; De Rus and Nash Dec 2007; Econ Dec 2008; Nash 1991; EuropeanCommission 2008)**

<b>Benefits of HSR</b>	<b>Costs of HSR</b>
Time savings	Construction of lines, stations etc.
Additional capacity	Purchasing of new rolling stock
Reduced externalities from other transport modes	Train operating costs
Generated traffic	Externalities (land take, visual intrusion, noise, air pollution, global warming)
Wider economic benefits	Accident costs
	Safety costs



- **Benefits of HSR**

One of the key overall benefits from HSR are **time savings**. Those savings are most often split up after travel purpose/ different groups of travelers, namely business travelers, commuters and leisure travelers (Nash 1991; De Rus and Nash Dec 2007). Business people are normally willing to pay a high amount of money for speed, comfort and convenience; this is mainly because alternative costs for time used are based on the *gross* wage rate (instead of the net wage rate). Commuters and in specific leisure travelers are much more price sensitive and have lower valuations of time in terms of money.

**Additional capacity** just represents a benefit if demand is exceeding the capacity of the existing system and routes, i.e. congestions (De Rus and Nash Dec 2007). Is this the case though, then the running of train operations not close to capacity limits benefits both reliability and less overcrowded trains, which is in turn highly valued by rail travelers, in specific business ones (Wardman 2001).

**Reduced externalities** from other transport modes refer to the reason that a proportion of the new generated traffic will be diverted from other modes, mainly air and car in the case of HSR. For trips diverted from car and air, the impact on environment is likely to be an improvement (mostly concerning the energy consumption and emission of greenhouse gases) (De Rus and Nash Dec 2007). Another proportion is diverted from the conventional rail where the possible advantage of HSR is dependent on the primary fuel used to generate the electricity. Given the possibility of making use of carbon free energy sources, HSR represents an improvement over conventional rail, otherwise the environmental impact from the shift to HSR is somewhat worse (De Rus and Nash Dec 2007). External benefits of HSR become highest when road and air systems are congested and expansion in those modes is difficult and expensive.

**Generated traffic** represents direct benefits for users and is split up after “induction” and “substitution”, meaning those journeys which would not have been made if the new service did not exist respectively those journeys that would have been made by using another transport mode (Coto-Millán, Inglada, and Belén 2007).

**Wider economic benefits** can be quite influential for or against the case of HSR, their measurement and valuation remains a quite controversial topic though and is taken up in section 3.3.3 Major controversial issues and debates.

- **Costs of HSR**

On the cost-side there are mainly construction, purchase and costs for operation and maintenance. The costs for an HSR are generally categorized after fixed costs (e.g. for infrastructure), semifixed costs (for the moveable material, i.e. the trains) and variable costs (represented by operating costs). The latter are very dependent on the time span being considered in the appraisal (Carrera-Gómez et al. 2006). In corridors with low traffic-volume HSR has the drawback of a large amount of sunk costs (with regard to mainly infrastructure) (De Rus and Inglada 1997). Besides that HSR has its own external costs such as noise, land-take for building the tracks and stations, air pollution, visual intrusion or accident costs. The three first named externalities tend to have stronger impacts when the HSR is going through densely populated areas. Overall, the costs must be valued against its benefits (De Rus and Nash Dec 2007).

### **3.3.3 Major controversial issues and debates**

This section shall give a summary of major controversial issues and debates surrounding HSR and its appraisal. The section is if not stated differently based on De Rus and Nash (2007) and Nash (Nov 2009). The issues mentioned here are more of general nature; more will be named after the analysis with direct connection to the case study countries.

#### **Valuation of time**

There is no consensus on how to categorize time savings. As Bristow and Nellthorp (2000) point out, different European Countries use a large range of categories, ranging from differentiations by person and vehicle, over journey purpose, by transport mode and/ or distance to type of vehicle (compare also Button 2010, p.101). A special topic resulting out of this is whether to make valuations of time mode-specific. The main complexity behind this are the different aims of the two different approaches (Bristow and Nellthorp 2000). Including mode-specific values of time would ensure that differences in preferences are reflected adequately in the appraisal; for instance business air travelers have a much stronger preference for saving time, than private/ leisure travelers by rail or car do. Making use of aggregated values, not differentiating after transportation mode, has the aim to avoid letting differences in personal income influence the appraisal. In other words, meaning to avoid biasing investments towards faster and more expensive modes of transport which normally tend to attract individuals with higher incomes.

Different valuations of time exist and represent a basis for forecasts for demand for HSR. As the numbers for different passenger groups vary greatly, the influence on the profitability of HSR can also be quite significant. HSR is in general most likely used by business travelers and commuters, but there are debates if the full valuation of working time for business travelers can be applied. This is because when travelling by train it is possible to work. It was found out that companies are most often willing to pay the “full business value of time” even in those circumstances, because they perceive benefits from shortening long working days and have staff that is less tired. Time savings are in another sense also basis for a debate, because the savings will also strongly depend on the number of intermediate stations and stop patterns and different trip lengths. Without thorough consideration of these factors, time savings can easily be overestimated. Time savings generally have to be compared between the different options, to the “with” and “without” scenario and also to travel times in other transport modes to become meaningful.

### **Generated traffic**

Another discussed issue is the value for generated traffic and the benefit of it for the case of HSR and whether the newly generated trips reflect wider economic effects that are not captured by traditional CBA. Leisure trips for instance are most likely positive for the destinations’ tourism attractiveness (Masson and Petiot 2009). Commuter and business trips are in turn a basis for additional economic activity and could lead to an expansion and/ or relocation of jobs and homes. The debate remains if those journeys really represent an additional economic activity or rather a simple relocation.

### **Wider economic effects**

Wider economic effects and their measurement remain one of the most difficult issues. They *can* be quite significant “but vary significantly from case to case, so an in depth study of each case is required.” (De Rus and Inglada 1997, p.179) Overall, HSR might have additional benefits in form of wider economic effects, but generally they are of less importance than the direct transport benefits of HSR.

### **Environmental effects**

As mentioned for the method of MCA and for CBA in general, the valuation and measurement of environmental effects (positive and negative) from an HSR remains a lively discussed topic. E.g. the valuation of CO<sub>2</sub> emissions and which methods to use for it

is a debate on its own as for instance also discussed in the Econ report (Dec 2008) and the SIKA report for the Swedish setting (SIKA 2009). The environmental impact of HSR is thus still not clear, and very much depends on specific circumstances, respectively to what extent HSR “can really delay the need for additional airport or motorway capacity” (Nash 1991, p.351). Some sources as also mentioned before even argue that environmental benefits and costs of HSR are unlikely to be a significant influence for or against the case of HSR *given that* “load factors can be achieved and the infrastructure itself can be accommodated without excessive environmental damage.” (Nash Nov 2009, p.17)

### **The issue of double counting**

There is an issue tied to the so called threat of “double counting” (also compare De Rus and Inglada 1997). For example the increase of land-value and housing prices due to better accessibility because of HSR is generally already accounted for in the reduction of travel time. Including this benefit separately in the CBA, would lead to double counting and would distort the outcome. This is a major issue in all appraisal cases (not only for HSR); thus it is so important that analysts as well as the decision-makers in the end are aware of *what exactly* is included in the items of CBA and MCA to be able to fully consider the outcomes.

### **3.3.4 Limitation and reasoning of focus items**

As it was shown in this chapter, the case of an HSR appraisal involves many aspects, criteria as well as controversial and discussable issues and debates. Based on this review of cases, the author of this thesis has chosen to treat the issues value of time, value of labor and environmental impacts in more detail.

- **Value of time**

The value of time is a crucial issue as it is generally considered to be the major component of a project that is designed to improve transport efficiency (Button 2010) and hence time savings also represent one of the main benefits for an HSR case. For the Spanish setting it was well summarized: “Finally the importance of time savings in HST<sup>17</sup> projects justifies a major research effort in the estimation of the value of time for different types of travelers and different transport modes, in order to improve the socio-economic evaluation of

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<sup>17</sup> Used as abbreviation for high-speed train in the reference.

transport projects.” (De Rus and Inglada 1997, p.186) Even though in the mean time (from 1997 to now) there has been done some research on this topic, it is still an ongoing debate and thus a rationale to take a closer look at it in the analysis. Furthermore, the connection of valuation of time with regard to demand forecasts is interesting to look at. The rationale for this is because “[p]roposals to build entirely new infrastructure to more peripheral areas where extra capacity is not needed anyway should be looked at with much greater skepticism. In these areas, upgrading of existing lines and the exploitation of new technology such as the Italian or Swedish tilting trains, which can travel at higher speeds over existing infrastructure, is likely to be a more cost-effective solution.” (Nash 1991, p.353) This is a core issue for the Norwegian setting and should therefore be also included in the analysis by looking at how valuation of time is used in the case study countries.

- **Value of labor**

The valuation and inclusion of employment creation in the appraisal of HSR is a particularly interesting item for the Norwegian setting. As it was pointed out before, the valuation is handled very differently in Norway and Germany (also compare Appendix B). Therefore it will be looked at how the other case study countries handle this and which methods are used in practice.

- **Environmental impacts (CO<sub>2</sub> and noise)**

First of all, the inclusion as one core item has the rationale that the valuation debate of environmental impacts is also mentioned in the “Utredningsmandat” and it is clearly asked for a comparison how other countries deal with this. It becomes, however, even more relevant as being a major debate of HSR anyway in every country. One is aware of the environmental benefits and drawbacks of HSR in general (as mentioned in Table 3-4), but the measurement of environmental impacts is a controversial issue and it is difficult to define to what extent they should be monetized, or which methods to use. Respectively the question if HSR and its operation and construction imposes lower impacts on the environment than other modes of transport, and if so, whether they are able to divert enough demand from those modes to lead to a net environmental improvement in the end (Nash 1991). And as mentioned by De Rus and Nash (2007), the full impact (positive and negative) of environmental issues of HSR appraisal have not yet been fully determined. Thus, it is interesting to what extent the case study countries include these (also extending

and comparing it to competing modes of transport) in their appraisal for transport and HSR projects and what influence they have on the overall outcome.

The elements within environmental impacts that are looked at in this thesis will be limited to the following two major aspects:

- CO<sub>2</sub> as it accounts to one of the main greenhouse gases and is thus a part of global air pollution. Within the transport sector, global air pollution is linked to the contribution of emission of greenhouse gases and the subsequent global warming. CO<sub>2</sub> is most often measured for all modes of transport. The factors of local air pollution (like NO<sub>x</sub>, SO<sub>2</sub> etc.) are not discussed in this thesis.
- Noise and its measurement.

## 4 Analysis

This chapter represents part III of the thesis and deals with the analysis of the five different countries mentioned introductory and answers therefore research question 2. Figure 4-1 gives an overview of the structure of the analysis part. First a short introduction of HSR lines in Europe is given in order to then state the rationale behind the selection of the countries for the analysis. It is followed by a short introduction into appraisal methods used in Europe.

The next step is the comparative analysis of the chosen countries and their appraisal methods; it is done after a specific scheme in the same manner for each country. The main content is to show the European experience of HSR appraisal, the reasons for implementation of HSR (if already implemented) for each country and the impacts of that. It is focused on the general methods used for appraisal and three main items: value of time, value of labor and environmental impacts (CO<sub>2</sub> and noise) and how each country deals with those with respect to HSR appraisal. A summary is displayed for each country.

Subsequently, a comparison between the countries is done to show commonalities and differences in the appraisal methods among the countries. From this comparison there will be deduced reflections on the Norwegian setting and drawn conclusions, which will represent the answer to the third research question.

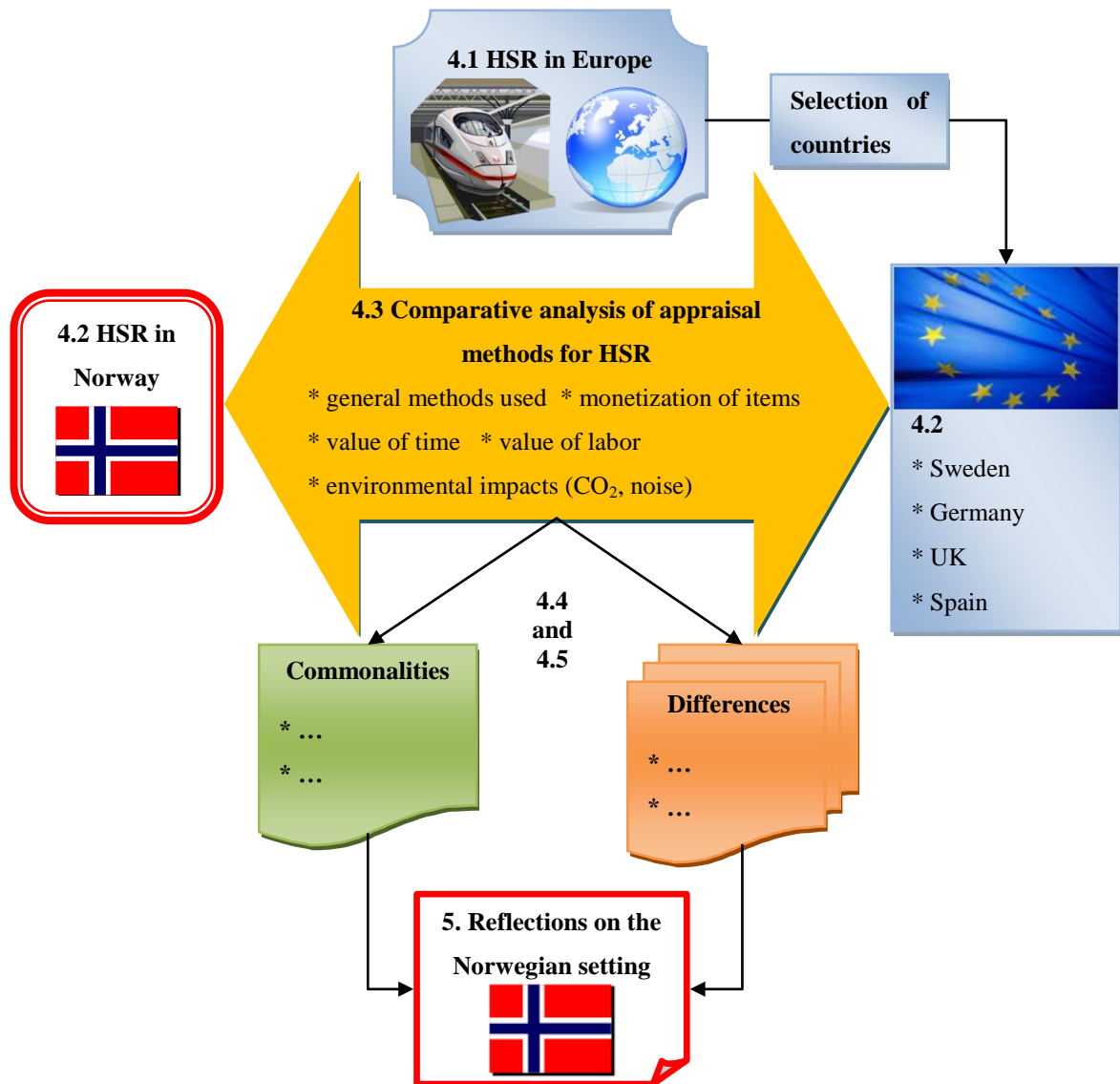


Figure 4-1: Structure of the analysis part

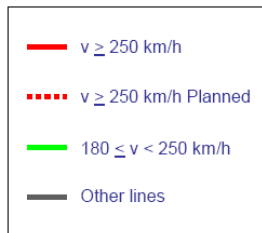
#### 4.1 HSR lines in Europe and the choice of the case study countries

Even though one can find HSR lines all over the world (UIC Jan 2009) the focus in this thesis is on Europe, respectively Norway and four other European countries. Figure 4-2 gives an overview of the European HSR network in operation as in 2009, the operation speed of each line as well as planned lines.



## European HS Network

Situation as at 06.2009



Information given by the Railways

UIC - High-Speed

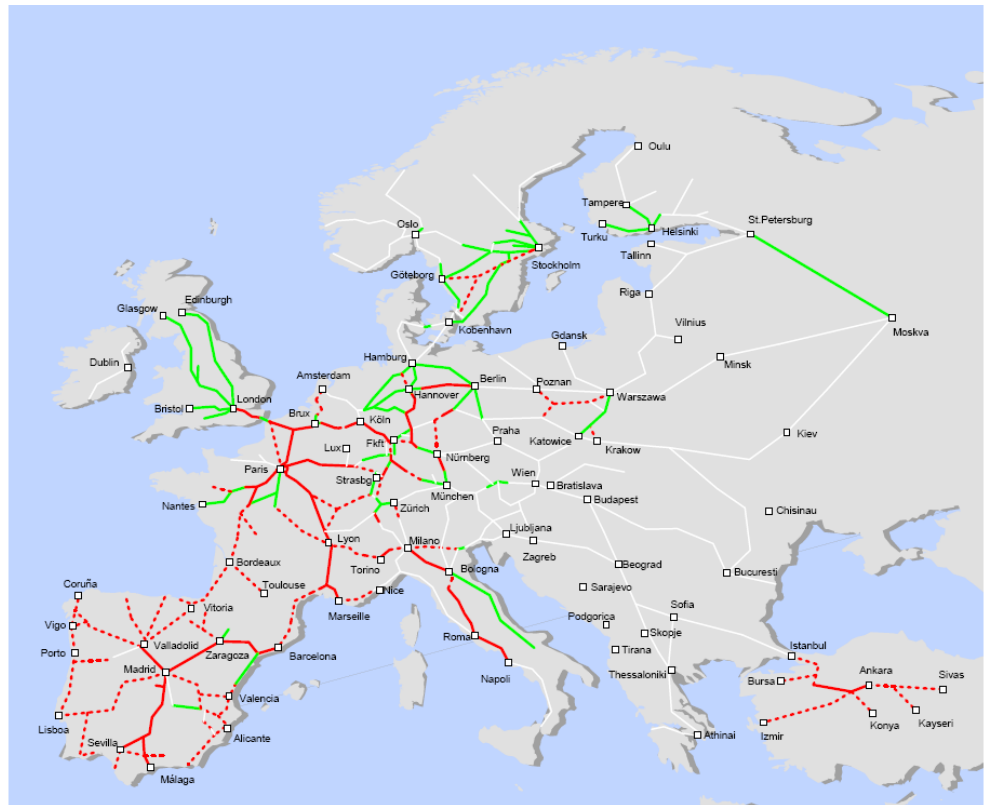


Figure 4-2: The HSR network in Europe, status 2009 (UIC 2009a)

Next to **Norway** as the country in focus, **Sweden, Germany, the UK and Spain** will be studied concerning the research questions. The rationale behind the chosen countries can in short be summarized as follows:

- Sweden and the reports about its HSR and further planning is clearly mentioned as a comparable setting to Norway in the research mandate by the Norwegian government; “The first step in the further research of a high-speed railway will be to give a comprehensive overview of the knowledge that exists in Norway as well as present research reports about the high-speed lines in Sweden.”<sup>18</sup> (Regjeringen 19.02.2010, p.5) Sweden furthermore represents an additional country to the Steer Davies Gleave report being mentioned earlier.
- Germany, as a country that has an extensive knowledge in building and operating HSR lines and thus also concerning appraisal methods surrounding this decision. Since some of the criticized reports for a Norwegian HSR have been done by a German committee, a comparison of the German to appraisal methods from other countries seems useful to

<sup>18</sup> Quotation translated by the author.

point out differences and to identify its reasonableness in general and with regard to the Norwegian setting.

- UK, Spain, Germany as well as Sweden operate mostly HSR lines in the range of 180 to a maximum of 250km/h (green lines in Figure 4-2). They thus represent the most relevant comparison countries in line with the definition of HSR as mentioned introductory in this thesis (compare 1.2 Definition of high-speed rail (HSR) for this thesis).
- Spain is additionally also interesting for the thesis because it is the only country among the case study countries that has done ex-post analyses of HSR investments (compare De Rus and Inglada 1997) and thus this information can provide useful input for other HSR projects, especially with regard to the setting of Norway.

In order to answer the first research question, the following sections analyze the chosen countries with regard to general appraisal methods used, and three specific items, namely value of time, value of labor and environmental impacts (CO<sub>2</sub> and noise).

## ***4.2 Appraisal methods in Europe***

In European countries one finds much diversity in the use of appraisal methods “regarding the scope and method of evaluation as well as the impacts of evaluation on actual decision-making.” (Nakamura 2000, p.5) The differences mainly arise from the countries’ distinct histories of development of theory and the practical application of the methods (Morisugi and Hayashi 2000).

There is the need for a standardization of process appraisal, especially for the transport sector (Arnott 1997). There have been initiatives from governments to work out guidelines and frameworks on this matter, leading to such as the HEATCO initiative (Harmonised European Approaches for Transport Costing and Project Assessment (Bickel et al. 2006)) or the attempts of the EU to align the evaluation of project impacts in the transport sector with the so called METRONOME project (A Methodology for Evaluation of Project Impacts in the Field of Transport (Tuominen 2008/ 2009)). As just mentioned, the EU requires the member countries to make use of CBA for large investment projects, and the European Commission has the task to provide guidance on these project appraisals (EuropeanCommission 2008). The guidebook on CBA gives useful input on how to apply CBA in practice including recommended values from the just mentioned METRONOME,

HEATCO and IMPACT study on the estimation of external costs in the transport sector. However, the EU does not oblige the member countries to make use of the criteria mentioned. Furthermore, two EU Directives (85/337/EEC and 97/11/EC) require environmental impact assessment (EIA) for large infrastructure projects (EC 1997). But again, the implementation of the Directives in the member countries differ greatly (Bristow and Nellthorp 2000).

Consequently, all these documents can mainly be seen as proposals respectively recommendations, since none of them represent a compulsory basis for transport project appraisal in Europe yet. Thus, the methods being used in practice still differ in many aspects from each other as the following analysis of the case study countries will show.

### ***4.3 Analysis of the chosen countries***

In order to answer research question 1 and its sub-questions, the analysis is done for each country separately and follows a specific scheme that is applied for each country in order to secure a useful comparison. The scheme follows three main steps that are mentioned subsequently.

#### **1. Outline of HSR case**

Since this thesis deals with the methodological issues of appraisal for HSR, the specific routes, rail technique, rolling stock etc used is of minor importance. This section for each country should thus give the reader just a rough overview to the setting of HSR in the specific country without the goal of being comprehensive. The overview will include such as

- how many lines are in use,
- development of the lines and network,
- strong vs. weak case for HSR, criticism (if applicable),
- remaining debates and issues (if applicable),
- specialties of the country like for instance population density and distribution, topography etc.

## **2. Institutional structure of the rail industry and basic documents for the appraisal process**

The appraisal for transport investment projects involves many players and documents. The institutional set up, existent guidelines and compulsory documents to follow when doing e.g. CBA and MCA differ quite a lot from country to country. This step in the analysis should thus give an overview of institutes and governmental departments involved in the appraisal set up of each country. It should furthermore outline the basic documents that need to be followed when doing appraisal of an infrastructure investment like HSR. These documents will also be the main input of data into the analysis and are thus of great importance.

## **3. Analysis of HSR appraisal**

In this sub section firstly the general methods applied in HSR appraisal are outlined, including information on the structure of CBA, whether MCA is used and in case other methods that are being used. Additionally, information on the impact of the results of the methods on decision-making in the country is given. This information is then summarized and displayed in a table, where “✘” represents “not being valued/ used/ applied”, “✓” “being valued/ used/ applied” and “(✓)” means “to some extent”. Furthermore, information is given on which impacts in CBA are monetized, partly monetized or not at all. Moreover, also information is conveyed concerning the appraisal horizon and economic lives of infrastructure and assets since they have influence on the outcome of the appraisal and are useful for the comparison later on.

After that, the three before defined items are analyzed for each country; that is how each country deals with them in the appraisal process, followed by a summary table:

- value of time
- value of labor
- and environmental impacts (CO<sub>2</sub> and noise).

And in more specific it will be looked at the degree of monetization of the different items and the methods applied for deriving the values. For achieving a meaningful comparison

later on, solely mentioning specific values in money terms is avoided<sup>19</sup> and instead there are rather used percentages and the expression of proportions.

Generally, the author tried to find out the same kind of information for each country. However, due to different methods applied and also data availability this is sometimes just possible to a limited extent, i.e. some aspects might be more detailed for some of the case study countries than for others. The order of the countries in the analysis is Norway, Sweden, Germany, UK and Spain.

### **4.3.1 Norway**

For the reason that Norway is the main focus of the thesis and being considered as the “reference case”, this section gives an insight on the general case surrounding HSR in Norway, the institutional set up that is relevant for the appraisal process, as well as relevant documents. After that, Norway’s appraisal methods in use are displayed, followed by an analysis of the three main items: value of labor and time, and environmental impacts.

#### **4.3.1.1 Outline of the HSR case**

Norway has except for the express train commuting from the Oslo airport to the city centre, no HSR train or network.

Thoughts about building one started already around 20 years ago though with the first feasibility studies being done in the beginning of the 1990s (NSB 1992; Bråthen and Hjelle 1993). Ever since it has been an issue in politics due to HSR representing some major benefits for the transport sector and its traffic participants. Nevertheless, HSR has not been considered seriously again until 2006/7 where the widely criticized feasibility studies from VWI were published.

The main issue for the CBA of an HSR in Norway is that the country does not yet have much experience in the construction and operation of HSR. Norway is therefore dependent on experts from other countries, such as Germany and the UK, and their opinions and knowledge. As mentioned in the introduction of this thesis, the main debate that arose was due to the feasibility reports (including a CBA) done by a German expert committee on the potential HSR in Norway, containing also different route alternatives (VWI and partners

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<sup>19</sup> This is mainly due to two reasons: firstly, the five case study countries have four different currencies and secondly the reference years for price levels given in the available reports differ decisively.

Dec 2006, Oct 2007a, Oct 2007b). The report of the second phase (2007a) also included a simplified CBA made according to the method of Jernbaneverket. In order to compare the German appraisal method, a report by Econ Pöyry was commissioned, doing a thorough CBA according to the Norwegian method (Econ Dec 2008). The goal next to comparing the methods was to find amendments and/ or adjustments for the planning work surrounding a Norwegian HSR. A separate Econ report was done for environmental impacts of an HSR (Econ Oct 2008).

The VWI report based on the German method found the routes Oslo-Trondheim, Oslo-Bergen and Oslo-Göteborg to be socially beneficial. If the Norwegian method was used as a basis, all the tracks would have negative benefit-cost ratios. This is mainly due to the differences of criteria and values used for the appraisal of HSR. The main differences in the methods being applied, leading to so different results are included in Appendix B. There, an example of a CBA result is given for one of the main tracks that are considered, namely the Oslo-Trondheim route with explanations and highlights regarding the differences in methodology.

Furthermore, there exist numerous other reports and studies on the issue of HSR in Norway which represent a main input for the analysis of Norway. Therefore, the author of this thesis finds it useful to convey a summarized overview to the reader in Appendix A, including such as a short summary of contents and outcomes for each, as well as sources and alike.

The criticism on the VWI studies led to ongoing publications of new reports and studies that try to use the appraisal methods and criteria as used in practice in Norway. Here, the most recent one published by the “Næringslivets Hovedorganisasjon (NHO)”<sup>20</sup> can be mentioned (Haugan 10.05.2010). However, since HSR represents a huge investment of public funds, the government has still adjourned the decision on the construction of an HSR until 2012, with the possibility of being included in the National Transport Plan (NTP) for the period 2014-2023. Until then, Jernbaneverket is commissioned to make more research on how the case of HSR can be adjusted more to the specific Norwegian setting, including analyses after the enforced Norwegian appraisal methods and to compare and report on how other countries deal with e.g. the monetization of non-market goods.

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<sup>20</sup> English translation: Confederation of Norwegian Enterprise (NHO 2010).

Some specialties making the case for HSR in Norway very demanding in comparison to the other case study countries is firstly the challenging topography of the country itself, with many steep mountains, fjords and national parks that are asking for a high proportion of tunnels when building an HSR. This has a major impact on construction costs. Secondly, Norway with an overall population of just close to five million people is in big parts of the country sparsely populated. The main five big cities (Oslo, Stavanger, Bergen, Trondheim and Frederikstad/ Sarpsborg) are the only ones having more than 100 000 inhabitants and are spread all over the country. This has crucial influence on the potential demand for an HSR. Due to topography and population as well as the fact of a very old conventional rail infrastructure network, the market share of air transport is quite high in Norway, especially for the routes considered for a potential HSR. Just recently, a study done by "Future in our hands"<sup>21</sup> on train traffic in 27 European countries, found out that due to the very old conventional rail network Norway has an "extremely slow train supply" and is the "worst in West-Europe and at the bottom level in Europe as a whole."<sup>22</sup> Without train changes, passengers transport averages a speed of just 75km/h and hence Norway holds just place 20 out of 27 (Dagbladet 10.05.2010; VG 10.05.2010). HSR is interesting in specific due to that fact, because it could contribute to increase market share for rail in general and to possibly also gain share from the air transport industry and from road transport and could thus contribute to a reduction of emissions.

After giving this short introduction into the setting and case of an HSR in Norway, the following section shows the main institutional players in the rail sector and for the appraisal of infrastructure investments as well as the basic documents of relevance for the appraisal process of HSR.

#### **4.3.1.2 Institutional structure of the rail industry and basic documents for the appraisal process**

The main institutional players relevant for the rail industry and for the appraisal of transport projects are listed below, together with a short overview of their tasks. The same is done for the most important documents for the HSR appraisal process for the Norwegian setting.

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<sup>21</sup> In Norwegian: "Framtiden i våre hender" (Framtiden.no 2010).

<sup>22</sup> Quotation translated by the author.

Table 4-1: Institutional structure of the rail industry and basic documents for the appraisal process in Norway

<b>Name of institution</b> (translated to English) (Source)	<b>Task</b>
<b>Samferdselsdepartementet</b> (Ministry of Transport and Communications) (Samferdselsdepartement 2010)	The Ministry of Transport and Communications is responsible for transport of people and goods, telecommunication and postal services.
<b>Finansdepartementet</b> (Ministry of Finance) (Finansdepartementet 2010)	The Ministry of Finance is responsible for planning and implementing the Norwegian economic policy and for coordinating the work with the Fiscal Budget. It conveys therefore also information and guidelines on project appraisal respectively socio-economic analyses such as CBA.
<b>Jernbaneverket</b> (Norwegian National Rail Administration) (Jernbaneverket 2010)	Jernbaneverket is the national railway authority. Jernbaneverket is responsible for the management of the national railway network, on behalf of the Ministry of Transport and Communications.
<b>Norges Statsbaner (NSB)</b> (Norwegian state railroad) (NSB 2010)	The Group's main activities are passenger transport by train and bus and rail freight operations. The NSB Group consists of a number of wholly-owned and partly-owned subsidiaries.

<b>Title of document</b> (English title) (Source)	<b>Relevance for HSR appraisal</b>
<b>NOU 1997:27 “Nytte-kostnadsanalyser – Prinsipper for lønnsomhetsvurderinger i offentlig sektor“</b> (Cost-benefit analyses – principles for profitability evaluations in the public sector) (NOU 1997:27)	Basis for the recent Guideline for socio-economic analyses, prepared by the Ministry of Finance.
<b>NOU 1998:16 “Nytte-kostnadsanalyser – Veiledning i bruk av lønnsomhetsvurderinger i offentlig sektor”</b> (Cost- benefit analyses – Guidelines for the use of profitability evaluations in the public sector) (NOU 1998:16)	Basis for the recent Guideline for socio-economic analyses, prepared by the Ministry of Finance.
<b>Veileder i samfunnsøkonomiske analyser 2005</b> (Guideline for socio-economic analyses) (Finansdepartementet 2005)	Prepared by the Ministry of Finance. It is the most recent document and basis for how CBA for public investment projects and reforms



	should be accomplished. It mentions the Metodehåndbok from Jernbaneverket as basis for the rail sector accomplishment of socio-economic analyses.
<p><b>Metodehåndbok JD 205 - Samfunnsøkonomiske analyser for jernbanen</b></p> <p>(Method guideline JD 205 - Socio-economic analyses for the railway)</p> <p>(Jernbaneverket 2006a, 2006b)</p>	<p>Prepared by Jernbaneverket. It contains guidelines and methods how to accomplish a CBA for the rail sector in Norway.</p>

### 4.3.1.3 HSR project appraisal

If direct quotations are used or concrete numbers, references will be stated otherwise the analysis is based mainly on the documents just listed above.

The following four sub-sections will deal with the overall methods applied in Norway for rail/ HSR appraisal, general structural issues of CBA and its criteria and the analysis of the three main items (value of time, labor and environmental impacts).

#### ***General analysis of methods applied***

Jernbaneverket has the task to do research and evaluation (CBA) on different investment projects, which represents valuable input for the NTP of Norway. The main goal with the set up of guidelines by the Ministry of Finance is to improve the analysis tools and to achieve comparability of projects within the rail sector on the one hand, and among other parts of the transport sector on the other. The analyses types that are described in the “Veileder” are to be used for different kinds of project for the rail sector, of which infrastructure investments are the type that it is used most often for. CBA is mainly used for rail infrastructure investments because it is often possible to value almost all costs and benefits. However, CBA is not the only recommended analysis tool; for investment projects where most parts of the benefits are difficult to quantify, other methods like Cost-effectiveness-analysis (CEA) and Cost-impact-analysis (CIA) are to be used as alternative or supplement to CBA. CEA is supposed to be used for projects where costs may be quantified easily, while the benefit side is not. CEA can help to identify the alternative that minimizes cost while achieving a preset goal. CIA is based on the same problem that CEA helps out with, but the main rationale is that the impacts of each alternative are different. CIA gives the possibility of supplementing the cost calculations with a verbal description

of benefits. It is allowed to consider totally different analysis methods for specific rail projects in Norway, but this has then to be approved by the Research Department.

There is made use of socio-economic analysis for different transport projects, of which investment in infrastructure is one, and the one where CBA is mostly used for in Norway. The methods used are the same for all investment project within the rail sector, the differences regard mainly which consequences have most impact and which challenges the analyst faces when collecting data for the potential valuation of impacts. In the theoretical part generalized costs were mentioned as an expression of valuation of time for travelers (Nossum 2003b). In the Norwegian appraisal procedure for rail, the generalized costs are not only used for the valuation of time, but also for the quality of the train proposal.

The consequences of an investment project used in CBA in Norway are classified after traffic participants. There are four main groups to distinguish: passengers, operators, the public and society as a whole respectively third parties. The method guideline from Jernbaneverket shows the four groups and potential consequences that need to be considered for each in the following table<sup>23</sup>:

**Table 4-2: Consequence categories in the Norwegian rail appraisal (modified after Jernbaneverket 2006a, p.32)**

<b>Group</b>	<b>Consequences</b>
<b>Passengers</b> (train passengers & passengers from other transport modes that are affected by the project)	<ul style="list-style-type: none"> <li>• Travel time</li> <li>• Waiting time</li> <li>• Feeder costs</li> <li>• Congestion costs</li> <li>• Delay time</li> <li>• Comfort (at the stations and on the train)</li> <li>• Accident costs</li> <li>• Ticket price</li> <li>• Health costs</li> </ul>
<b>Operators</b> (companies that operate passenger- and freight transport)	<ul style="list-style-type: none"> <li>• Income (ticket price)</li> <li>• Operation costs</li> <li>• Capital costs</li> <li>• Public purchase</li> </ul>
<b>The public</b> (infrastructure owners like Jernbaneverket, communes)	<ul style="list-style-type: none"> <li>• Investment costs</li> <li>• Operation- and maintenance costs of infrastructure</li> </ul>

<sup>23</sup> Translated by the author.

etc.)	<ul style="list-style-type: none"> <li>• Charges</li> <li>• Public purchase</li> </ul>
<b>Society/ Third parties</b> (all individuals, groups, organizations etc. not included in the other categories)	<ul style="list-style-type: none"> <li>• Accident costs</li> <li>• Local air pollution</li> <li>• Global air pollution (greenhouse gasses)</li> <li>• Congestion</li> <li>• Barrier effects</li> <li>• Regional impacts</li> <li>• Land use</li> </ul>

As one will see later on, this categorization differs from the approaches of the other case study countries.

As shown in the theoretical part of this work, CBA includes components that are valued in monetary terms, while others are not or cannot be quantified. The following table shows which impacts are monetized in Norwegian rail appraisal projects, which just partly, and those that are not valued at all. Thus, this table is the answer to research question 1b.

**Table 4-3: Norwegian practice of monetizing impacts of rail investment projects<sup>24</sup> (Jernbaneverket 2006a, p.33)**

<b>Monetized</b>	<b>Partly monetized</b>	<b>Not monetized at all</b>
Investment costs	Punctuality	Health
Operation costs	Environmental impacts	City development
Maintenance costs	Congestion costs	Regional development
Travel time, feeder time, waiting time	Comfort	Barrier effects
Accident costs	Land use	

For partly monetized and non-monetized items, the before mentioned CEA and CIA methods are recommended in use, respectively at least a verbal description of impacts on the four groups need to be included in an appraisal for a rail project. Jernbaneverket mentions that the lack of quantifying some consequences is mainly due to methodological issues; possibilities to solve those issues and to develop a proper method of valuation is most likely feasible for the components punctuality and health costs.

MCA as an explicit method is not used in Norway. For non-market goods a consequence analysis is used that is similar to MCA. A verbal description of impacts is done with no

<sup>24</sup> Translated by the author.

numeric scores, but scores in the form of “++++” (very positive impact) and “----“ (very negative impact), with several increments in between. A final ranking is done after one summarized score for each impact category (Jernbaneverket 2006a; Finansdepartementet 2005).

The time horizon is established for each rail project in specific. However, for infrastructure investments an analysis period with 25 years of operation after the construction is recommended. Shorter or longer time horizons need to be justified. Life times of infrastructure of rail in Norway is between 75 years (tracks) and 40 years (superstructure, electrical system, stations etc.) (Jernbaneverket 2006a). Nevertheless, the life time might differ in specific cases, but again, differences need to be justified.

The robustness of the results of a CBA in the Norwegian rail sector is of great importance, since many of the input parameters of the CBA are uncertain. That requires that uncertainties are stressed and different values and scenarios are tested in a sensitivity analysis. The impact of the results of the analyses on overall decision-making in Norway is the same as mentioned before: they represent *one* important input (among others) and are mainly used in order to rank and prioritize different alternatives.

The issues and information on general methods applied in Norway are summarized and displayed in the table below.

Table 4-4: Appraisal method summary for Norway

Appraisal methods used	Norway	Comments/ notes
CBA	✓	<p>CBA is done including all the steps mentioned in the theory part. Costs and benefits (impacts) are distinguished between four groups (Jernbaneverket 2006a):</p> <ul style="list-style-type: none"> <li>• passengers,</li> <li>• operators,</li> <li>• the public,</li> <li>• society/ third parties.</li> </ul> <p>The output of the CBA is a <b>net</b> benefit-cost ratio, a project is profitable if the value is &gt;0.</p>
MCA	✗	<p>A consequence analysis is used that is similar to MCA, including a verbal description of impacts. There are no numeric scores, but scores in the form of “++++” (very positive impact) and “----“ (very negative impact), with several increments. A final ranking is done after one summarized score for each impact category and</p>

		displayed in a consequence matrix (Finansdepartementet 2005, p.31; Jernbaneverket 2006a, p.51).
<b>Other methods used:</b> * Cost-effectiveness analysis * Cost-impact analysis * Consequence analysis	✓ ✓ ✓	Are to be used as alternative or supplement to CBA for investment projects where most parts of the benefits are difficult to quantify (Jernbaneverket 2006a, p.18-20).  Is used for including non-market goods in the appraisal process (Jernbaneverket 2006a, Finansdepartementet 2005).
<b>Impact of results on decision-making</b>		The results represent an important part of the decision-basis for public investments and reforms. A strong focus lies on the thorough accomplishment of ex-ante analyses. Results are mainly used for ranking and prioritizing different alternatives. (Finansdepartementet 2005)

After the general overview of appraisal methods in use in the Norwegian setting, the three before defined items will be analyzed in the following in more detail concerning monetization and methods applied.

### ***Value of time***

The Guideline by the Ministry of Finance differentiates between two different kinds of valuation of time in the transport sector (Finansdepartementet 2005). The one is concerning the case when individuals are indifferent about their use of time and that other use of time than for work does not generate income. In that case, the time savings can be valued by taking the earnings before tax (in case of perfect competition in the labor market); is the alternative use of time not working, but free time, then the time savings need to be valued by the earnings after tax. The other case is when individuals do indeed have strong preferences how to spend their time, also concerning the possibility of doing activities simultaneously. This is concerning especially journeys done within working hours, and that some means of transport offer the possibility of working while travelling. The value of earnings before tax would in this case overestimate the potential time savings. Since different means of transport offer different travel times, waiting times and the possibility of doing something else while travelling, makes it necessary that time savings need to be analyzed for each single project specifically. Yet, since this means to deviate from standardized values, a sensitivity analysis of the values derived is compulsory.

A specialty mentioned for the transport sector with regard to methods and values used is, that central variables like for instance travel time and travel costs are correlated. This makes it difficult to analyze how much of the behavior and preferences are explicable by each factor. In order to overcome this problem, the Ministry of Finance mentions the use of the “transfer price method”, where traffic participants are asked for their willingness-to-pay for a new service in a way that is similar to the SPA that was described in the theory part.

Summarized, the Norwegian appraisal method asks for market based methods for the valuation of time. In some cases it is necessary to make use of other methods like the transfer price method or the SPA. The quality of the analysis is crucial and needs a strong focus. For the use within CBA, there should be developed standard values for time savings for same situations, e.g. saved time for business journeys with the same transport mode.

If no own analyses about values of time are accomplished for a project, the recommended valuation bases are

- Income incl. tax and employer contributions in case the saved time is used for working or
- Income excl. tax and employer contributions if the time saved is a gain in free time (Finansdepartementet 2005).

The valuation of time is mostly important for parts of the valuation of the benefits for the “consequence group” of passengers. Time use of passengers is tied to travel time on board of the train, walking time, waiting time, time for changing trains and delays. Waiting time is defined as the difference between the point in time one would like to travel, and the point in time where it is possible to travel due to the existing time tables. Waiting time is valued normally by taking 50% of the time between departures (according to the time tables). This is the basic value that is then being multiplied with weights that are dependent on short or long journeys and the overall travel time.

Generally, Jernbaneverket uses time values for the time categories mentioned based on recommendations of the time studies in TØI-report 459/1999 (Tilli 1999). The report includes values of time from the Norwegian Value of Time Study that was grouped by income, travel purpose etc, and weighted it with the most recent data of the Norwegian travel habit study (NRVU) from 1997/8. The purpose of the TØI report was to form

updated national and consistent values for time. The report differentiates commuters, business and private travelers. The second differentiation is between short (<50km) and long trips (>50km). Values are given in NOK per hour and are in accordance with the income index as given by Statistics Norway (SSB) (Jernbaneverket 2006a). A work done by Økland that compared time values used for infrastructure investment appraisal in road (as published by Statens Vegvesen<sup>25</sup>) in comparison to rail (Jernbaneverket) shall be mentioned here (Økland 2008). It was found out that time valuations are crucially different. The biggest difference is for commuter trips by train and leisure journeys, where Jernbaneverket values both 16% lower than Statens Vegvesen.

Since just concrete numerical values are not useful for the further comparison between countries, just some proportions in values shall be mentioned here. The valuation of time for rail business journeys is in all time categories the highest, always followed by commuters and the least monetized value for private travelling. The time value for the plain *travelling time on board* of the train for journeys over 50km for business travelers is 179NOK/ hour and thus for instance approx. 25% higher than for commuters (137NOK/hour), respectively 50% higher than for private journeys (94 NOK/ hour) in 2006 prices (Jernbaneverket 2006a). This can be also supported by the analysis that was done by Urbanet Analyse on the market potential for an HSR in Norway and in specific for preferences of air passengers towards an HSR (Kjørstad and Norheim 2009). A customer survey shows that the valuation of time for business travelers and commuters is three times higher than for leisure journeys (77NOK/ hour vs. 378NOK/ hour (2008 prices)). In line with that it is mentioned how important it is to take the different purposes of travelling into consideration (and with that their different impacts on market demand) when further evaluating an HSR for Norway. For all *other time value components* like waiting time, delays etc. the just mentioned values are used, and are multiplied by a specific weight factor that converts the time into regular travel time on board of the train.

### ***Value of labor***

First and most importantly, it needs to be mentioned that Norway is not making use of valuation of employment effects in the CBA for HSR (VWI and partners Oct 2007a). It is assumed that there is full employment all through the construction as well as operation

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<sup>25</sup> It is the “Norwegian Public Roads Administration” that is responsible for the planning, construction and operation of the national and county road networks (StatensVegvesen 2010).

period of the HSR. This is mainly due to the reason that Norway has faced almost no unemployment after the Second World War. The only structural unemployment that happened to a limited extent was due to closed down factories in the industry sector; it was however possible to create new/ alternative employment for the affected persons within a short period of time (Econ Dec 2008). Thus, “[a]ssuming insignificant unemployment, Jernbaneverket does not include employment impacts as a benefit of the project.” (VWI and partners Oct 2007a, p.44)

A country like Norway that has a more or less balanced employment market can indeed face negative effects in the economy when investing in a large infrastructure project like HSR. Such a large-scale project consumes resources from other operations and could thus lead to increased prices for labor, material and other input factors, which in turn affect other players. Generally, those effects should be included in a CBA for public investment evaluation. Norway’s guidelines for appraisal do not include compulsory criteria or methods for it, most likely because it has up to now not been relevant for the Norwegian setting. Additionally, projects of the scale of HSR are not common and there is little experience about it (VWI and partners Oct 2007a). If the HSR should be built and be used massively, the inclusion of value of labor and employment creation could become necessary in a CBA.

Even though not included in the HSR appraisal (yet), the Ministry of Finance mentions some methodological issues about the value of labor in general which are named in the following. Concerning the valuation of labor in form of calculation prices, the price must not be the market salary of being unemployed, but the value of the lost free time the unemployed faces when starting with a job again. For work-intensive projects that lead to an increased budget, it would be correct to prioritize projects after socio-economic profitability by using calculation prices. The calculations for each project should not follow different patterns in general, and therefore normally when calculating the calculation-salary, it is not corrected for unemployment. Two exceptions are mentioned though. Calculation prices can be corrected within a CBA when the project explicitly addresses long-time unemployed people or other groups of individuals that are not participating in the normal labor market. The other exception where adjusting the market salary is useful is for projects that address concrete geographical areas with very high unemployment.



Those cases are said not to be of importance for the building of an HSR though and those corrections about unemployment have not been done in CBAs for other infrastructure projects in the Norwegian setting either (Econ Dec 2008). Therefore, the valuation of labor respectively unemployment is not thought to be necessary for the Norwegian CBA for the time being.

### ***Environmental impacts***

Different modes of transport have different impacts on the environment. The Norwegian guideline on socio-economic analyses requires to split these effects up into congestion, local and global pollution. The valuation of environmental costs is supposed to be in NOK per driven kilometer in the specific mode of transport.

Many of the environmental impacts of public investments are difficult to quantify. The Norwegian guideline for CBA mentions different methods how to deal with this challenge (e.g. SPA)<sup>26</sup>. The general overall rule is that if impacts cannot be quantified, they need to be described in words or in physical dimensions (Jernbaneverket 2006a). CEA and CIA are an alternative to be used when the quantification of benefits is difficult.

If parts of the environmental impacts can be monetized (which accounts for both items in focus: CO<sub>2</sub> and noise), the choice for the method to be used depends on the item being looked at. The valuation should be limited to the direct and indirect effects on the different “consequence groups” mentioned before. The question remains what to include in the valuation. The Norwegian guideline mentions two alternatives:

- One alternative is to take the aggregated willingness-to-pay for the issue in focus of the CBA.
- The other alternative is to limit the valuation to just some of the environmental impacts of the project in focus. In these cases it needs to be added a thorough and justified description of which parts are valued and which methods are used for it. A comment on the uncertainty inherent in the methods and numbers gained is also compulsory.

Subsequently, some more details on the valuation of CO<sub>2</sub> and noise are given.

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<sup>26</sup> A good overview of these methods is given in (Finansdepartementet 2005, p.44).

- CO<sub>2</sub>

For non-market goods where preferences of individuals are almost impossible to gain, like the emission of CO<sub>2</sub>, implicit valuation is used. Implicit valuations are valuation methods that are based on political priorities and resolutions. As an impact for the consequence group “society as a whole/ third parties” as mentioned before, the diversion of traffic from other modes to HSR can lead to saved environmental costs and can lower environmental charges. Both have to be shown as pre-tax values in the CBA.

In Norway, costs for emissions are based on costs that the country faces due to their commitments in the Kyoto protocol (Regjeringen 22.06.2007). Among all case study countries (and also worldwide), Norway has one of the most ambitious emission reduction goals. In 2008 the Norwegian government committed to even outperform its goals from the Kyoto protocol by 10%. Norway is aiming to cut CO<sub>2</sub> emissions by 30% by 2020 and to become carbon neutral by 2030 (Regjeringen 17.01.2008). The goal of carbon neutrality comprises that even though Norway can buy quotas from other countries, the national emission of CO<sub>2</sub> needs to be cut by two thirds.

Today’s indicator for the costs to achieve these goals is the price for CO<sub>2</sub> quotas (emission-trading) on the market. For the valuation of CO<sub>2</sub>, the direct method of market prices is used, i.e. the prices rates of the most long-dated contracts as noted at the Nordic Power Exchange (NordPool<sup>27</sup>). The CO<sub>2</sub> prices are given in Euro and need to be transformed to NOK; thus the value shifts together with the currency shifts. The prices given in the *Metodehåndbok* can be used as long as the carbon prices do not change more than 20%, which gives the lower boundary of 23€, and an upper one of 34€. Changes beyond these prices, request a proportional adjustment of the values for global pollution after transport mode (given in NOK per vehicle-km). Quota prices used need to be indicated in every case.

The amount of emissions for rail depends on the source of how electricity is generated. Jernbaneverket points out that most of the trains in Norway today are operated with electrical power, as well as any expansion in the rail network will be operated accordingly.

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<sup>27</sup> Nord Pool ASA operates the world’s largest power derivatives exchange and among Europe’s largest carbon exchanges for standardized contracts for emission allowances (EUA) and carbon credits (CER). Nord Pool ASA holds the exchange license and is responsible for operating all the exchange traded products. It is owned by Statnett and Svenska Kraftnät with fifty per cent each (NordPool 2010).

Electrical power in Norway is by today almost totally produced through hydropower. This has impact on emissions also with regard to a new HSR. The electricity that is “consumed” by the trains could be used alternatively; with that in mind it has impact on the amount of power im- and/ or exported to other countries<sup>28</sup>. Indirectly this could then have impacts on power production and thus emissions in other countries as well (Econ Dec 2008).

Two reports deal with explicit estimations of CO<sub>2</sub> emissions and reductions for the potential HSR in Norway, coming to two very different outcomes. While one report concludes that HSR could contribute just marginal if at all to Norway’s reduction in CO<sub>2</sub> and greenhouse gases (Econ Oct 2008), the other one shows that HSR indeed has potential and has best results compared to air and road traffic (Naturvernforbund Sep 2008). More details on both studies, including numbers can be found in Appendix A.

- **Noise**

Noise, just as other environmental effects belongs to non-market goods. For valuation of noise hedonic pricing and contingent valuation is recommended by the Norwegian Ministry of Finance. Hedonic pricing is mostly with regard to how noise and e.g. housing prices are correlated; therefore it can mostly be used for cases where relevant market prices are available. Contingent valuation on the other hand is not based on market prices but can help finding out the willingness-to-pay for a change in quality of quantity of common assets.

And just as CO<sub>2</sub>, theoretically also noise has to be valued in NOK per vehicle kilometer for rail (Finansdepartementet 2005). Nevertheless, for the HSR appraisal, the Norwegian method does not numerically include noise annoyance because even if there is assumed to be noise reduction due to lowered traffic from other modes like air and road, nobody will distinctly face noise reduction (VWI and partners Oct 2007a).

### **Summary**

The following table summarizes the main aspects and issues for the three focused items in the Norwegian appraisal process.

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<sup>28</sup> This is because Norway takes part in the European power market.

Table 4-5: Summary of the three items in focus in the Norwegian appraisal process

Item	Comments on use in the appraisal process in Norway
<b>Value of time</b>	<p>Valuation of time is an important part in Norwegian project appraisal and a part of CBA. Generally, it is asked for market based methods for the valuation. A differentiation is made between</p> <ul style="list-style-type: none"> <li>• commuters, business and private travelers and</li> <li>• short (&lt;50km) and long trips (&gt;50km).</li> </ul> <p>Values are given in NOK per hour and are in accordance with the income index as given by Statistics Norway (SSB). To make valuation and comparison possible, value components like waiting time, delays etc. are multiplied by a specific weight factor that converts the time into regular travel time onboard of the train.</p>
<b>Value of labor</b>	<p>Norway's guidelines for appraisal do not include compulsory methods for the valuation of labor because it has up to now not been relevant for the Norwegian setting with almost no structural unemployment since WWII. Therefore, the valuation of labor respectively unemployment is not thought to be necessary for the Norwegian CBA for the time being.</p>
<b>Environmental impacts</b> * CO <sub>2</sub>  * Noise	<p>Environmental costs and impacts are compulsory and included in the appraisal in Norway and count to monetized impacts.</p> <p>CO<sub>2</sub> is explicitly one factor in CBA, counting to the emission of greenhouse gases and is valued by the price rates of these emissions on the stock market.</p> <p>Noise annoyance is theoretically a numeric value in the CBA (NOK per vehicle km), but is not included in the HSR appraisal, because even if there is assumed to be noise reduction due to lowered traffic from other modes like air and road, nobody will distinctly face noise reduction, thus the value is zero.</p>

### 4.3.2 Sweden

Following the scheme mentioned, also for Sweden the basic case for HSR is outlined, followed by the institutional set-up and basic documents for the appraisal process. Thereafter, the three main items are analyzed.

#### 4.3.2.1 Outline of the HSR case

The thoughts surrounding the investment in HSR started already in the 1960s in Sweden, considering the potential benefits of HSR. The main reasons for this was the increasing competition from road and air transport in that time and the general pessimism about the future development of railways. As typical for consideration of HSR, also increasing demand was forecasted. The long delay from the planning to actual accomplishment of constructing an HSR (the X2000), was mainly the lack of competence that was required for the procurement (Edquist, Hammarqvist, and Hommen 2000).

The first track to be upgraded to HSR was between the two largest cities of the country, Gothenburg and Stockholm, and was taken into operation in 1990. The journey times could be reduced by 25% due to the HSR and also the market share of rail in this corridor increased decisively; the X2000 has by now more than 50% of all rail journeys for this route (RailwayTechnology 2010). The X2000 is therefore in the same source referred to as the investment “saving the Swedish passenger rail network from extinction”. Since then, several lines have been built (upgraded tracks) as it can be seen in Figure 4-2 between Gothenburg and Copenhagen as well as Stockholm and Copenhagen. Moreover, several branches to connect the biggest cities with some smaller ones have been built. All tracks are upgraded for speeds to a maximum of 250km/h (UIC 2009b). Direct links with newly built tracks between the named three cities and to Malmö are planned with speeds over 250km/h, but neither construction nor years of taking them in operation are stated explicitly yet; the time horizon for realization is 2020-2030 though. However, several reports and feasibility studies have been published on the topic and potential tracks and are well summarized in the SOU document (2009:74, p.72-83). The main rationale and aim for the potential investment in enlarging the HSR network is the limitation of capacities on the main links (Näringsdepartementet 2009a) and also a large increase in freight traffic on the tracks that asks for a potential separation of passenger- and freight traffic (Akhtarzand 2008). Thus, HSR could relieve these limits and represents a strong case for the Swedish setting.

Also the location of Sweden itself, being a “connector country” of Scandinavia to the European continent, made and still makes the case for HSR strong. There is the idea of a future “Europabanen” between Jönköping via Malmö with a short cut from Helsingborg to Helsingör to the continent and “Götalandsbanen” between Stockholm and Göteborg (Näringsdepartementet 2009a).

HSR or rail in Sweden is in general facing more competition of car transport than air transport, which is unique in the European area (Fröidh 2008). This is mainly because there were made extensive investments in upgrading roads to motorways. Due to this and the introduction of the X2000, the air travel market “has developed only weakly since then.” (Fröidh 2008, p.270) Sweden has a relatively centralized population in the south, where the larger cities are located, but a very low population density in the northern parts of the country. The distances between those larger cities are in the range of the “typical beneficial case for HSR”, namely in the range between 300 and 600km. Sweden has in the southern part of the country a less challenging topography than Norway, with less mountains and fjords, which has an impact on construction costs.

#### 4.3.2.2 Institutional structure of the rail industry and basic documents for the appraisal process

The main institutional players relevant for the rail industry and for the appraisal of transport projects are listed below, together with a short overview of their tasks. The same is done for the most important documents for the HSR appraisal process for Sweden.

Table 4-6: Institutional structure of the rail industry and basic documents for the appraisal process in Sweden

Name of institution (translated to English) (Source)	Task
<b>Näringsdepartementet</b> (Ministry of Enterprise, Energy and Communications) (Näringsdepartementet 2010)	The Ministry deals with matters related to the business sector, energy, IT, communications and infrastructure, and regional development. Regarding the transport sector it deals with issues concerning the transport of passengers and goods (roads, air traffic, shipping, railways) in the country and transport between Sweden and other countries. Furthermore, competition conditions for Swedish transport companies and infrastructure decisions for roads and railways are a key responsibility area.
<b>Trafikverket</b> (Swedish Transport)	The Swedish Transport Administration began operations on April 1, 2010. It is a new public authority that takes on

Administration) (Trafikverket 2010; Näringsdepartementet 2009b)	responsibility for long-term planning of the transport system for road, rail, maritime and air traffic. The authority is also responsible for the construction, operation and maintenance of public roads and railways. The Trafikverket will substitute the Swedish Rail Administration, the Swedish Road Administration and the Swedish Institute for Transport and Communications Analysis (SIKA). Therefore Trafikverket is also responsible for forecasting, official statistics and information on appraisal methods within the transport/ rail sector that was done by SIKA before.
<b>Transport Styrelsen</b> (Swedish Transport Agency ) (TransportStyrelsen 2010)	The Agency was founded in January 2009 and is working to achieve good accessibility, high quality, secure and environmentally aware rail, air, sea and road transport. It has overall responsibility for drawing up regulations and ensuring that authorities, companies, organizations and citizens abide by them.

<b>Title of document</b> (English title) (Source)	<b>Relevance for HSR appraisal</b>
<b>SIKA 2009:3 “Värden och metoder för transportsektorns samhällsekonomiska analyser – ASEK 4“</b> (Values and methods for socio-economic analyses in the transport sector) (SIKA 2009)	The most recent guideline for socio-economic analyses and CBA, prepared by the former SIKA Institute. It contains information on how to accomplish appraisal in the transport sector, with specific examples for the rail sector.
<b>SOU 2009:74 “Höghastighetsbanor - ett samhällsbygge för stärkt utveckling och konkurrenskraft “</b> (High-speed trains – a socio-economic investment for strong development and competitiveness) (Näringsdepartementet 2009a)	It is the answer to a research mandate by the Näringsdepartementet and was commissioned to a group of experts. The report presents considerations about a potential enlargement of the HSR network in Sweden.

#### 4.3.2.3 HSR project appraisal

Again, the above listed documents are the main sources for this section if not explicitly mentioned otherwise.

**General analysis of methods applied**

CBA is a basic, compulsory decision-making document for infrastructure investments in Sweden. The guideline published by SIKa aims to harmonize economic analyses across transport modes and the methods that are published are compulsory to be used for projects in the plan period 2010-2021. The expert team (ASEK 4) that worked out the guidelines has made use of recommendations from the earlier mentioned HEATCO<sup>29</sup> initiative wherever applicable to the Swedish setting.

Impacts from transport projects are categorized into:

- Traffic participants
  - Consumer surplus (e.g. time savings, saved costs from other modes)
  - producer surplus (e.g. ticket costs)
  - effects on governmental budget (e.g. change in VAT, fares or tax on fuel)
  - external effects for society as a whole (e.g. employment, emission of greenhouse gases, noise, accidents etc.)
- Freight operators (Freight customers time savings, transport costs, external effects)

These effects are opposed to the costs of a project, and split up into

- Costs for infrastructure owners (re-investments, operation and maintenance costs)
- And the general investment costs.

The CBA of the potential Götalands- and Europabanen can be found in Appendix C to give an example for a case where the categories are applied.

The outcome of the CBA is categorized for different circumstances (SIKA 2009):

- For ranking and prioritizing projects that are financed by the same budget, the net present value (NPV) and the NPV-ratio<sup>30</sup> have to be calculated.
- For appraisal of different scopes and different budgets, the NPV and the benefit-cost ratio have to be given.

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<sup>29</sup> Compare 4.2 Appraisal methods in Europe.

<sup>30</sup> Which is defined as the NPV divided by the NPV of the investment costs.



As it can be seen in Appendix C, for the case of HSR, the first circumstances are applied (NPV and NPV-ratio).

For large investment projects (more than one billion SEK) or for strategically important projects, sensitivity analysis of the most important parameters (e.g. investment costs, environmental costs and generated traffic) is compulsory.

The appraisal horizon is dependent on the economic life of the assets used in the project, though with a maximum of 40 years (SIKA 2009). For life times/ projects longer than that, the time has to be set to 40 years and all impacts after that year have to be added as a rest value to the last year of appraisal and need to be discounted. The economic lives of infrastructure assets for rail vary between 20 and 60 years, where the latter value is for a newly build track and 20 to 30 years are used for such as the rails and signaling equipment. Additionally to CBA, Cost-effectiveness analysis is used. It is used for finding the alternative that has the lowest cost while contributing best to the preset goals. The Swedish appraisal asks for key figures to express the degree of achieving an aim within the transport sector. Key figures are for instance the costs of decreasing the travel time by one hour (in SEK/ hour) or the cost for reducing the risk of accidents (in million SEK/ saved life) (SIKA 2009). An example of this can also be found in the status report about large investment projects in Sweden (Trafikverket 2008, p.92).

MCA is neither mentioned, nor used within the Swedish appraisal framework.

All information named about general methods in the Swedish appraisal process are summarized in the table below.

**Table 4-7: Appraisal method summary for Sweden**

Appraisal methods used	Sweden	Comments/ notes
CBA	✓	<p>CBA is a compulsory method of transport infrastructure appraisal in Sweden. The guideline conveys information on methods and values, including recommendations from the HEATCO initiative.</p> <p>Costs and benefits are split up after the following groups: traffic participants, freight operators, infrastructure owners and society as a whole (general investment costs). The appraisal horizon has an upper limit of 40 years.</p> <p>The outcome of the CBA is dependent on the type of project and budgeting; NPV, NPV-ratio and BCR are used.</p>

<b>MCA</b>	<b>x</b>	Not mentioned or used as an explicit method for appraisal.
<b>Other methods used:</b> <b>* Cost-effectiveness analysis</b>	<b>✓</b>	It is used as supplement to CBA. The Swedish appraisal asks for key figures that express the degree of achieving an aim within the transport sector. Key figures are for instance the costs of decreasing the travel time by one hour (in SEK/ hour) or the cost for reducing the risk of accidents (in million SEK/ saved life).
<b>Impact of results on decision-making</b>		CBA is a basic, compulsory decision-making document for infrastructure investments in Sweden. Depending on the type of appraisal, the results are used for ranking and prioritizing projects as well as deciding which projects become part of the National transport plan.

It is not clearly stated which of the partly-monetized impacts are captured by which methods. Overall, it is difficult to figure out which impacts remain evaluated if not monetized in Sweden. The table below gives an overview of the data that can be obtained from the Swedish appraisal guideline. It might not be comprehensive.

**Table 4-8: Swedish practice of monetizing impacts of rail investment projects<sup>31</sup> (information taken from SIKA 2009, p.7-12)**

<b>Monetized</b>	<b>Partly monetized</b>	<b>Not monetized at all</b>
Investment costs	Travel comfort	Barrier effects
Operation and maintenance costs	Congestion	(Visual) intrusion
Ticket costs	Other environmental impacts (e.g. health effects)	Regional development impacts
Journey time (savings)		
Accident costs		
Noise		
CO <sub>2</sub>		
Generated and diverted traffic		

Subsequently, the three items in focus are analyzed and how they are included and dealt with in the Swedish CBA and appraisal setting.

<sup>31</sup> Translated by the author.

**Value of time**

The valuation of time is split up into private sector and business sector (SIKA 2009) and counts to monetized impacts in the Swedish CBA. The **private** sector has two categories that are distinguished: short trips ( $\leq 100\text{km}$ ) and long-distance trips ( $> 100\text{km}$ ). Time valuations include travel time on the vehicle, changing time, and frequency of departures and are shown in Appendix D. The values are given in SEK per hour (2006 prices) and are based on recommendations from a time value study and the HEATCO initiative (Bickel et al. 2006).

The values of time for the **business** sector are split up after mode (car, plane, bus and short and long-distance rail trips). Values are given again for the time on the vehicle, changing time and for different departure frequencies. The valuation for business trips is as recommended by HEATCO, based on the “cost-savings”-principle, i.e. there is a connection between the value of time saved and the wage level and data are gained by using SPA. Values are derived by the Hensher-approach that is assuming different values of time depending on the different work productivity of individuals in different modes of transport. The values are again given in SEK per hour in 2006 prices and include also social contributions. They can be found in Appendix D.

To get an impression of the overall values, the time value for long-distance rail trips (to which HSR counts) for business travelers is almost three times higher than the one for long-distance trips for private travelers (275SEK vs. 102SEK).

**Value of labor**

Employment effects are mentioned as a part of the prognosis for demand of the new transport investment project, but the inclusion in the CBA is not explicitly stated. Under the category of “regional development”, employment effects are mentioned, but just as an impact that should *not* be taken into account if it represents just relocation within the country (SIKA 2009).

The Swedish guideline allows though for including growth effects for the area affected by the investment project in the appraisal, if those effects have not yet been included in the CBA and are considerably big enough to be taken into account. In that case, they can be qualitatively or quantitatively described, but have to be displayed separately and are not allowed to be calculated into the CBA.

The Swedish CBA on HSR available does not mention any employment effects either (Banverket 2008). Thus, it can be concluded that either way, employment is no part of the CBA and furthermore that neither specific values or methods on how to consider the value of labor are available, nor used in Swedish appraisal.

### ***Environmental impacts***

Both items in focus, CO<sub>2</sub> and noise belong to monetized, compulsory parts in the Swedish CBA.

- **CO<sub>2</sub>**

CO<sub>2</sub> is monetized and the value is given in SEK per kg CO<sub>2</sub> emitted. The most recent value in use as proposed in the guideline is 1,50SEK/kg CO<sub>2</sub>. This equals a value of 1 500 SEK per ton (SIKA 2009). The value for CO<sub>2</sub> is neither differentiated after mode nor traction type nor alike. The basis of valuation is the governmental climate commitment made, that states to reduce the CO<sub>2</sub> emissions from transport by 2010 to the same level that the sector had in 1990. Thus, the value that is used in recent practice is quite old and the Swedish guideline mentions the need for an update. Therefore several methods how to derive and calculate values for CO<sub>2</sub> emissions are mentioned, including recommendations from HEATCO and other studies done in the EU. Nevertheless, because of the remaining great uncertainty about which methods are most appropriate, Sweden will for the time being use the current CO<sub>2</sub> value based on the environmental goals. As soon as the Swedish government has set up new goals concerning the reduction of greenhouse gas emissions for the *transport sector*, the current value will be revised (which is within the course of 2010) (SIKA 2009, p.64). The *national* goal has been updated in the beginning of 2009 and states that the emission of greenhouse gases in Sweden in the period 2008-2012 has to be at least 4% lower than 1990 (Näringsdepartementet 2009a).

However, as mentioned before, CO<sub>2</sub> is one parameter that has to be included in the sensitivity analysis if the project is of large scale, which HSR investment is. For that purpose, the alternative value to be taken for the sensitivity analysis is 3,50SEK per kg CO<sub>2</sub> emitted.

- **Noise**

Noise is also a theoretically monetized part of CBA (SIKA 2009). The value of noise for railways is derived by a sophisticated formula (which can be found in Appendix E). The resulting noise value is given in SEK per person affected per year (2006 prices). The valuations are split up into two categories:

- Traffic levels with 150 trains per day or less
- Traffic levels with more than 150 trains per day.

The formulas take into consideration maximum in-house noise levels measured in dB and are based on an updated noise-value study that was already used in earlier versions of the guideline. The noise values have thus to be calculated for each railway project in specific, which presumes data availability concerning traffic levels of the areas and thus persons affected by the investment project.

With regard to HSR and Swedish appraisal practice, it seems that the data availability is still limited. It is stated that the noise impact of Swedish HSR is still unclear and there is the need for further detailed research on it (Näringsdepartementet 2009a) and the CBA of the Götalands- and Europabanan simply states "Noise is not valued."<sup>32</sup> (Banverket 2008; Attachment 9, p.3)

The conclusion for noise valuation in the Swedish appraisal is that it is basically supposed to be a monetized impact, that is included in "external effects"; but for the specific case of HSR it does not seem to have been included numerically yet due to a lack of data availability.

### **Summary**

The following table summarizes the main aspects and issues for the three items in focus in the Swedish appraisal process.

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<sup>32</sup> Translated by the author.

Table 4-9: Summary of the three items in focus in the Swedish appraisal process

Item	Comments on use in the appraisal process in Sweden
<b>Value of time</b>	<p>It is a monetized part of the CBA.</p> <p>Values are split up after private and business sector and are given in SEK per hour (2006 prices). The private sector is split up after short trips (<math>\leq 100</math>km) and long-distance trips (<math>&gt; 100</math>km). For the business sector, values are split up after transport mode. Values are based on recent time value studies for Sweden and recommendations from the HEATCO initiative. The value of time for business travelers is almost three times higher than for private ones.</p>
<b>Value of labor</b>	<p>Employment effects are not part of the CBA or appraisal up to now in Swedish appraisal practice.</p>
<b>Environmental impacts</b> * CO <sub>2</sub>  * Noise	<p>Both effects are monetized, compulsory parts of CBA in Sweden.</p> <p>CO<sub>2</sub> is valued in SEK per kg emitted. The value for CO<sub>2</sub> is neither differentiated after transport mode nor traction type nor alike. It is based on the climatic goal of Sweden and represents the cost for the transport sector to contribute to this goal. The value will be updated as soon as new goals have been defined for the Swedish transport sector and is 1,50SEK/kg CO<sub>2</sub> emitted for the time being. CO<sub>2</sub> is part of the sensitivity analysis.</p> <p>Theoretically, noise is valued for railways via a specific and sophisticated formula that is based on noise value studies. Two scenarios are differentiated (traffic levels up to, and over 150 trains per day in the affected area). Thus noise values have to be calculated for each project in specific and are given in SEK per person affected per year (2006 prices). In practice for HSR appraisal though, no values for noise have been included in the CBA yet due to a lack of data availability.</p>

### 4.3.3 Germany

This section gives an insight of the general HSR network in Germany, the institutional set up that is relevant for the appraisal process, as well as relevant documents. Subsequently, appraisal methods that are in use for transport projects are shown followed by an analysis of the three main items.

#### 4.3.3.1 Outline of the HSR case

Germany has considerable knowledge in appraisal, construction, and operation of HSR networks, which is also the reason why expert teams from Germany are asked to do reports and feasibility studies for other countries within Europe (Intraplan 2008; VWI and partners Dec 2006, Oct 2007a, Oct 2007b). The following section should give a short insight into HSR development in Germany and what issues and reasons were taken into account. The section is mainly based on (Nash Nov 2009; SteerDaviesGleave Feb 2004). The overview of the network itself can be seen in Figure 4-2, where most of the lines are capable of speeds in between 180 and 250km/h, and fewer ones for higher speeds.

The rationale behind the introduction of HSR was in line with the general cases for HSR a shortage in capacity (congestion of the classic rail network), while demand was forecasted to grow, partly due to the reunification in 1990. This accounted in particular for the north-south routes, which represented considerable bottlenecks. The objective of introducing HSR was most importantly to let rail compete with other transportation modes, especially with the growing air and car market. This was attempted not only by increasing speed, but also service quality by applying very high standards on board of the trains.

The geography of Germany, especially with regard to the location of the biggest metropolises, makes it impossible that a single key route could serve most of them. The population is widely dispersed and due to that long distance trains need to make several stops to serve the potential market sufficiently, leading to increased journey times. That meant for the initial planning of HSR that mainly *sections* were planned and also constructed, in particular for routes where bottlenecks occurred. The initial design had thus to be for both passenger and freight traffic; however, the use for freight traffic accounted just for a small percentage. First constructions of HSR started in 1973 but were detained by environmental protests. Finally in 1985, the first Inter City Express (ICE) high speed train was introduced.

Generally, the support for HSR from the public as well as policy has been strong in Germany. The exception were the early environmental protests and opposition from those affected (because living alongside) the new constructed lines. This is also one of the reasons why environmental mitigation measures have been strongly focused, leading to increased costs, e.g. due to more construction of tunnels and cuttings to minimize noise and landscape impacts.

The conventional rail network in Germany is of varied quality, whereas services on all main routes are reliable and frequent. The ICE trains covered step by step the inter city routes all across Germany and also to Switzerland, Belgium and the Netherlands, where long parts of the conventional tracks were upgraded, allowing speeds up to 200km/h. It can be pointed out that in comparison to other countries (e.g. France), the journeys made on the ICE today are shorter and according to Nash (Nov 2009) also load factors of 50% on average are tolerated.

Today's HSR network in operation consists of ten lines with a total length of 1285km. Three more lines are under construction and will be finished between 2010 and 2017, adding another 378km to the network. Detailed information on the routes and further plans of extensions can be found in (BMVBS 2008, 2007; Sorge July 2009; UIC 2009b).

#### 4.3.3.2 Institutional structure of the rail industry and basic documents for the appraisal process

The main institutional players relevant for the rail industry and for the appraisal of transport projects are listed below, together with a short overview of their tasks. The same is done for the most important documents for the HSR appraisal process for Germany.

**Table 4-10: Institutional structure of the rail industry and basic documents for the appraisal process in Germany**

<b>Name of institution</b> (translated to English) (Source)	<b>Task</b>
<b>Eisenbahn-Bundesamt</b> (Federal Railway Authority) (Eisenbahn-Bundesamt 2010)	The Federal Railway Authority is the supervisory and authorizing authority for railroad traffic companies as well as infrastructure companies - mainly for the Deutsche Bahn AG.
<b>Deutsche Bahn AG (DB)</b> (German Railway AG) (DB 2010)	DB AG is still 100% state-owned and operates passenger and freight trains and is responsible for the maintenance of the rail infrastructure.



<p><b>Bundesministerium für Verkehr, Bau und Stadtentwicklung (BMVBS)</b> (Federal Ministry of Transport, Building and Urban Development) (BMVBS 2010a)</p>	<p>The Federal Ministry is responsible for planning and researching in the areas of transport, building and urban development and achieve improvements for the German citizens. It conveys guidelines on how to accomplish macroeconomic evaluation for the named sectors.</p>
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<p><b>Title of document</b> (English title) (Source)</p>	<p><b>Relevance for HSR appraisal</b></p>
<p><b>Bundesverkehrswegeplangesetz (BVWP)</b> (Federal Transport Infrastructure Plan) (BMVBS 2010b)</p>	<p>Prepared by the BMVBS. It is a framework investment plan and a planning tool, but not a funding plan or program. Basic law for the appraisal of HSR program and infrastructure programs in other transport modes.</p>
<p><b>Bundesverkehrswegeplan 2003: Die gesamtwirtschaftliche Bewertungsmethodik</b> (Federal Transport Infrastructure Plan 2003: methodology macroeconomic evaluation) (BMVBS 2003)</p>	<p>Prepared by the BMVBS. The publication describes procedures for the macroeconomic evaluation of investment measures under consideration for transport infrastructure. It is split up after transport modes, one part deals specifically with the appraisal methods of rail infrastructure projects (CBA and MCA).</p>
<p><b>Bundesschienenwegeausbaugesetz</b> (Federal Railway Infrastructure Upgrading Act) (BMJ 2010)</p>	<p>It is regulating the need and accomplishment of upgrading of the railway infrastructure net in the Federal Republic of Germany. BVWP is its basis and this one in turn needs to be passed by both houses of parliament.</p>

#### 4.3.3.3 HSR project appraisal

The appraisal method that is used in Germany is used for *all* projects in transport and hence also for rail and HSR. Thus, it makes a good contribution to the comparability of projects for the decision-makers. Main sources used for the analysis of Germany are the documents listed above and additionally the VWI reports and the Steer Davies Gleave report because they include useful information on the German appraisal process for HSR.

#### ***General analysis of methods applied***

CBA is the main tool for economic appraisal in Germany. The overall goals for setting up appraisal methods is to achieve the greatest possible contribution to public well-being. All

necessary impacts are qualified and quantified and a comparison is done for a “with” and a “without” scenario as already mentioned in the theory part of this thesis. All appraisals undertaken for the recent BVWP were done for impacts to 2015 for both just mentioned scenarios, thus the uniform forecast horizon is 2015 (BMVBS 2003). However, the appraisal period is furthermore dependent on the economic lives of the components of the project. The life time of infrastructure for rail has for example definite set values and most parts have a life time of 75 years (roadbeds, tunnels, crossings etc.), followed by 50 years for buildings and structures and between 20 and 25 years for the superstructure and signaling systems.

CBA applied for HSR appraisal is the one recommended by the government for large long-distance transport projects (rail and road) and is undertaken for *all* HSR appraisals in the same manner. There is a separation of transport effect calculations (modal shift) and calculation of costs and benefits. The output of the CBA is a benefit-cost ratio.

The evaluation components of the German CBA are displayed in the figure below.

♦	Reduction of transportation costs (NB)
	NB1      Decreased vehicle standby costs
	NB2      Decreased vehicle operation costs
	NB3      Changes in transport costs due to modal shifts
♦	Transport infrastructure preservation (NW)
	NW1      Transport infrastructure renewal
	NW2      Transport infrastructure maintenance
♦	Increased traffic safety (NS)
♦	Improved accessibility of destinations (NE)
♦	Spatial advantages (NR)
	NR1      Employment impacts from building transport infrastructure
	NR2      Employment impacts from operating transport infrastructure
	NR3      Contributions to promoting international relationships
♦	Environmental relief (NU)
	NU1      Reduction in noise exposure
	NU2      Reduction in exhaust emissions
	NU3      Reduction of community severance
♦	Impacts from induced traffic (NI)
♦	Improved links to and from seaports and airports (NH)
♦	Fulfilment of non-transport functions (NF)
♦	Investment costs (K)

Figure 4-3: Evaluation components in the German CBA (BMVBS 2003, p.33)

For all components/ impacts monetary values are supposed to be used; where no suitable competitive (market) prices are available, they can be replaced by derived monetary values. All competitive prices applied have to reflect the value of the resource consumed.

All components that cannot be quantified through market prices, have to be scored by a MCA that is done via either Environmental Risk Assessment (ERA) or Spatial Impact Assessment (SIA). ERA and SIA are “alongside benefit-cost analysis, independent modules of the overall system for appraising impacts” (BMVBS 2003, p.23). It needs to be mentioned that major components of environmental impacts, under them also the two focus items CO<sub>2</sub> and noise are part of the monetary evaluation system (compare Table 4-11). ERA and SIA are just addressing aspects that go beyond the CBA. Explicit weights are given for the use of SIA in order to achieve a combined appraisal outcome. Thus, there are numerical values derived, using a scoring system. The outcome is a combined CBA-

spatial impact valuation. The advantage of this is that impacts that cannot be given in monetary terms are not neglected by the decision-makers. Furthermore, it leads to consistent and comparable evaluations of projects in different modes of transport. The only drawback is that it might lead to reduced flexibility when it comes to interpreting the non-monetary results.

ERA also has a numerical score as result, but it is neither combined with CBA nor SIA results, but is considered separately. The overall aim is again to give the decision-makers input for ranking and prioritizing projects. The standardization of appraisal methods across all modes of transport makes the results meaningful for a comparison. Plans for investment in infrastructure (including results of CBA and MCA) are included in the BVWP (federal transport infrastructure plan). Final decision on construction is made when the BVWP is debated. Thus, CBA and MCA results are major input factors for decision-makers.

The table below displays which components in the German appraisal are monetized, just partly and which are not at all monetized. The partly monetized impacts are captured by SIA, the non-monetized ones by the ERA.

**Table 4-11: German practice of monetizing impacts of rail investment projects (BMVBS 2003)**

<b>Monetized</b>	<b>Partly monetized (captured through SIA)</b>	<b>Not monetized at all (captured qualitatively via ERA)</b>
All components for CBA (compare Figure 4-3)	Regional planning: * distribution and development * relief and modal shifts	Landscape Water and soil Human health and well-being

The just mentioned information on general appraisal methods in Germany is summarized in the following table.

Table 4-12: Appraisal method summary for Germany

Appraisal methods used	Germany	Comments/ notes
<b>CBA</b>	✓	CBA applied for HSR appraisal is the one recommended by the government for large long-distance transport projects. Separation of transport effect calculations (modal shift) and calculation of costs and benefits.  The output of the CBA is a benefit cost ratio.
<b>MCA</b>	✓	MCA is done for environmental and spatial effects via Environmental Risk Assessment (ERA) and Spatial Impact Assessment (SIA) (see below).
<b>Other methods used:</b>		Used when no suitable competitive (market) prices are available (e.g. nature, landscape, water, soil, human health). ERA and SIA are together with benefit-cost analysis, independent modules of the overall system for appraising impacts.
<b>* Environmental Risk Assessment (ERA)</b>	✓	ERA is supposed to qualitatively take spatial environmental impacts into account, but it is neither combined with CBA nor SIA results. Results are considered separately in a matrix displaying the effects rated by impacts of the categories “very low/ low, intermediate, high and very high”. It is assigned to the decision-maker level in the federal transport infrastructure planning process.
<b>* Spatial Impact Assessment (SIA)</b>	✓	Explicit weights are given for the use of SIA in order to achieve a combined appraisal outcome. Thus, there are numerical values being done, using a scoring system. The outcome is a combined CBA/ spatial impact valuation.
<b>Impact of results on decision-making</b>		The overall aim is again to give the decision-makers input for ranking and prioritizing projects. The standardization of appraisal methods across all modes of transport makes the results meaningful for a comparison. Plans for investment in infrastructure (including results of CBA and MCA) are included in the BVWP (federal transport infrastructure plan). Final decision on construction is made when the BVWP is debated. Thus, CBA and MCA results are major input factors for decision-making.

### ***Value of time***

In the German appraisal, the overall reduction of travel time in the transport system of all modes is shown. Journey time reductions due to an infrastructure investment are defined as “when the expected demand for transport can be met with less time required in the “with” scenario than in the “without” scenario.” (BMVBS 2003, p.73)

Shorter journey times are said to arise firstly project-related for the rail investment, and secondly from shifts from other modes of transport. Valued time savings are according to customary international procedures derived from willingness-to-pay studies. For rail transport, time savings for travelers for commercial as well as private transport are considered in the calculation of benefits. This is also the only split made; just commercial travel (business) and non-commercial travel (other) are distinguished. The different monetary approaches for the both categories arise mainly from the difference in frequency/number of journeys taken on a specific route (for detailed formula see BMVBS 2003, p.132).

Taking into account that disposable household incomes can change over time, the most recent values used are 5,47€ per person and hour for non-commercial travelers and 19,94€ for commercial travelers (both in 1998 prices). Thus, also here the value for business travelers is almost four times higher than the one for non-commercial journeys.

It might be interesting to mention that the valuation of time varies for different modes of transport. For road trips for example just the saved time on non-commercial journeys (commuting, leisure) is valued as benefit. The value is 30% lower than the one for rail (3,83€ per person per hour). The derivation for this value is not quite transparent as it is just justified by “experience”. The point to make here is that a comparison among transportation modes becomes more difficult if the components included are not everywhere the same (Econ Dec 2008; BMVBS 2003).

### ***Value of labor***

Employment while construction and in operation is totally included and covered in CBA. Since regional and national effects can be affected by employment (creation), value of labor is indirectly sometimes part of MCA/ SIA.

Components included in the CBA are split up after “Employment impacts from building transport infrastructure” and “Employment impacts from operating transport infrastructure”. The first regards direct effects of employment during the construction time and additionally takes into account that gaining knowledge for major projects and due to that being able to get active on other markets is a benefit as well. The latter impacts are based on the hypothesis that regional structural unemployment is strongly influenced by the factors that are available in the region. This includes next to labor and capital also the

provision of technical and social infrastructure in the region. The accessibility to that infrastructure is said to be crucial. Better accessibility could lead to promote the interregional division of labor and could improve the competitive attractiveness of the region.

To evaluate both employment impacts, a uniform valuation system was developed which is based on “the amount of subsidies needed to create one new, long-term job by promoting the regional economy.” (BMVBS 2003, p.74) By having in mind that creating a job costs twice as much as securing a job, the alternative cost unit rate per job per year was set to 13 000€ (for specific formulas and calculations see BMVBS (2003), p.75).

For the value of labor for the *building period* of a project, the starting points are eight different project types, split up after road, rail and waterway sector. The goal is to “estimate the labour force required to execute the project or the proportion of earned income in the investment costs.” (BMVBS 2003, p.75) Via a sophisticated calculation method, first the total employment effect for the project in investigation is figured out; secondly, by making use of regional differentiation factors for the 97 spatial planning regions in Germany, the regional employment factor is calculated. The value is given in man-years per 100 million € investment cost in the given project region. The interpretation of the value is the probability that a person is employed as a result of the investment and would have remained unemployed if the project would not have been done.

For the value of labor from *operating the transport infrastructure* again a very advanced calculation method is used. Net employment effects (job shifts between regions within Germany) are not taken into account. The regional labor market is taken into account though; for that again, the number of jobs created are multiplied by a regional preference/differentiation factor.

### ***Environmental impacts***

Both CO<sub>2</sub> and noise are covered numerical in the CBA. The number of residents affected by the proposed project must always be included. Again to achieve the best possibility for comparisons, standardized urban model components are used. The following will give an insight of these for CO<sub>2</sub> and noise reduction.

- **CO<sub>2</sub>**

It is also rated as global environmental impact. The differentiation into emissions and immissions was done newly for the Infrastructure Plan 2003 and was according to the 23<sup>rd</sup> Regulation implementing the Federal Immission Control Act. The valuations are subdivided into four subsections, as a function of the impact area the type of impacts as well as types of pollutants. This is displayed in Figure 4-4, where is shown that the pollutant in focus (CO<sub>2</sub>) has a global impact area, counts to emissions, causes climate changes and is valued by avoidance costs.

The calculation for pollutant emissions is based on specific energy consumption and current emission factors. For rail transport this needs to be done in line with the type of transport (standard passenger vs. freight trains), and has to take into account the traction types (diesel vs. electric).

Since there is still great insecurity on how to capture impacts of global climate change accurately, Germany has chosen an “avoidance cost approach” to evaluate traffic-related emissions. This means that one has to estimate the expenditure that is necessary to achieve a CO<sub>2</sub> reduction target as e.g. set in the Kyoto protocol. The goal of the Federal Republic of Germany is to reduce CO<sub>2</sub> emissions by 2050 to 80% below 1987 levels. The technical costs estimates to achieve this target have a range of 163-205€ per ton CO<sub>2</sub>. The cost unit rate has been fixed to 205€ per ton of CO<sub>2</sub> (number from 2003, but the most recent) emitted and thus exceeds market prices of emissions trading by far (BMVBS 2003). The upper limit has been chosen as value, because it additionally takes into account impacts of other trace gases that amplify the greenhouse effect, which is also in line with proposals made by the Federal Environmental Agency.



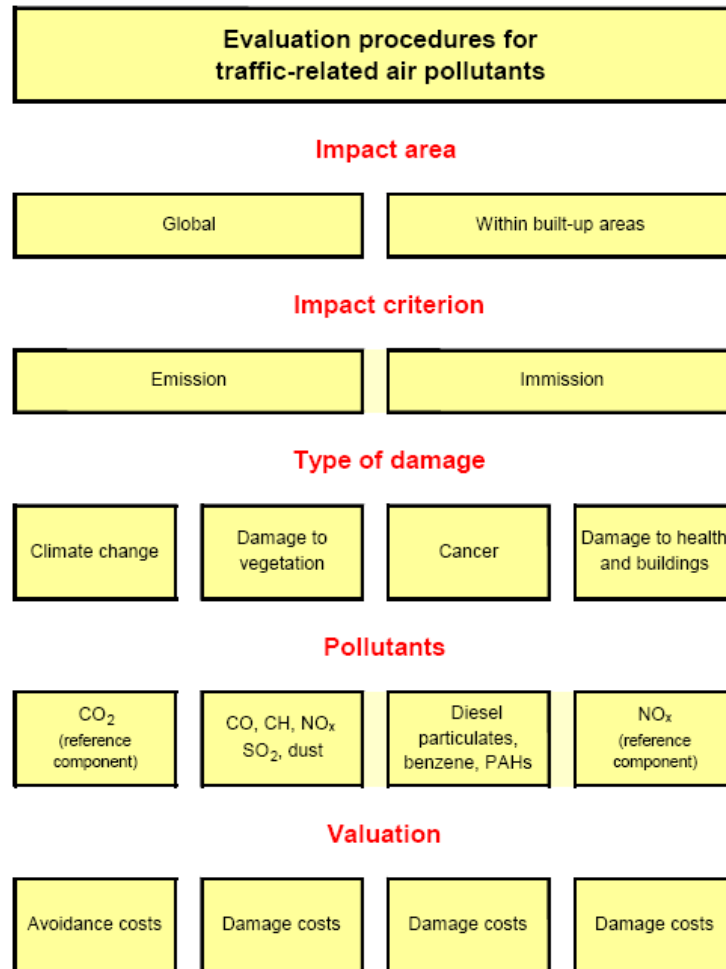


Figure 4-4: Differentiation of the components in the evaluation procedure for traffic-related air pollutants in Germany (BMVBS 2003, p.87)

- **Noise**

The change in noise exposure due to an infrastructure investment is valued by setting a price for the changes in vehicle-km in every transport mode (positive if increasing, negative if decreasing). Noise exposure is split up into built-up areas and outside built-up areas. For built-up areas, noise reduction is taken into consideration in CBA if the predetermined immission target level of 37 dB during night is exceeded or if the difference in noise exposure between the “with” and the “without” scenario is  $\geq 2$  dB. This is because surveys of willingness-to-pay have shown that there is no more willingness-to-pay for a reduction in noise below 37 dB (BMVBS 2003). The noise costs are determined by the amount by which the target level is exceeded and the degree of impacts on the affected residents. This is then the so-called “noise-resident equivalent value” and is given in cost

or value unit rate per year. In the BMVBS 2003, noise exposure is valued at 54,71€ per noise-resident equivalent value (1998 prices).

Noise exposure outside built-up areas takes into account forecasts of traffic levels and is done according to the recommendations by the Transport Infrastructure Noise Mitigation Guidelines. Tests for affected areas are carried out, and the areas are sub-divided and evaluated according to the results. A comparison to the target levels is taken into account for the final valuation, which is an avoidance cost estimate which is based on the costs of technical measures (e.g. noise barriers) to reduce the levels for the affected residents accordingly.

### **Summary**

The following table summarizes the main aspects and issues for the three items in focus in the German appraisal process.

**Table 4-13: Summary of the three items in focus in the German appraisal process**

<b>Item</b>	<b>Comments on use in the appraisal process in Germany</b>
<b>Value of time</b>	<p>Value of time is a monetized item in the CBA of Germany. Journey time reductions due to an infrastructure investment are required to be calculated for the “with” and the “without” scenario. The differentiation in valuation of time savings for rail passengers is made between:</p> <ul style="list-style-type: none"> <li>• Commercial travelers (business) and</li> <li>• Non-commercial travelers (other)</li> </ul> <p>Valued time savings are according to customary international procedures derived from willingness-to-pay studies. The most recent values for business travelers are almost four times higher than for non-commercial journeys.</p>
<b>Value of labor</b>	<p>It is a crucial, monetized component in the CBA. Employment effects are split up after</p> <ul style="list-style-type: none"> <li>• “Employment impacts from building transport infrastructure”</li> <li>• “Employment impacts from operating transport infrastructure”</li> </ul> <p>The reason for the importance in the German CBA is the partly high structural unemployment in specific regions. Through a sophisticated calculation including the inclusion of region differentiation factors, the value of labor is calculated region-specific.</p> <p>The value is given in man-years per 100 million € investment cost in the given project region. The interpretation of the value is the probability that a person is employed as a result of the investment and would have remained unemployed if the project would not have been done.</p>

<p><b>Environmental impacts</b></p>	<p>Both CO<sub>2</sub> and noise are covered numerically in the CBA. The number of residents affected by the proposed project. Again to achieve the best possibility for comparisons, standardized urban model components are used. The valuations of emissions/ immissions are sub-divided into four subsections, as a function of the impact area the type of impacts as well as types of pollutants.</p>
<p>* CO<sub>2</sub></p>	<p>CO<sub>2</sub> is valued by avoidance costs. The calculation is based on specific energy consumption and current emission factors; for rail transport this needs to be done in line with the type of transport (standard passenger vs. freight trains), and has to take into account the traction types (diesel vs. electric). The cost unit rate has been fixed to 205€ per ton of CO<sub>2</sub> emitted.</p>
<p>* Noise</p>	<p>The change in noise exposure due to an infrastructure investment is valued by setting a price for the changes in vehicle-km in every transport mode (positive if increasing, negative if decreasing). The value is called “noise-resident equivalent value” and is split for built-up areas and outside built-up areas. The inclusion in the CBA has different preconditions to be fulfilled (e.g. ≤37dB during night).</p>

#### **4.3.4 UK**

This section gives insight according to the outlined scheme from before on appraisal for transport projects/ HSR in the UK, including the set-up of institutions and documents for it, general methods applied and an analysis of the three main items.

##### **4.3.4.1 Outline of the HSR case**

Generally, there has been strong public support for the case of HSR, but the development of it was indeed quite controversial. Reasons for this were uncertainties inherent in the publications of early studies on possible links for the Channel Tunnel Rail Link in the end of the 1980's, together with the fact that the British government had the goal up to the early 1990's to use less public subsidies for the transport sector (Nash Nov 2009). A huge investment like in HSR did not seem as a very feasible option. Nevertheless, in the beginning of the 2000's more studies were done.

There is just one line, the link from London to the Channel Tunnel that has a length of 113km and an operation speed of over 300km/h. The other lines as can be seen in Figure 4-2 have an operation speed of 180-250km/h and are from London to Bristol, Glasgow and Edinburgh. According to UIC (2009b) no further lines are neither under construction nor planned.

Britain considered building HSR lines seriously in European comparison quite late, except for the Channel Tunnel link to France. It was not before 2003 that a thorough study commissioned by the Strategic Rail Authority was done by Atkins (Atkins 2003). This version was updated recently in 2008 (Atkins 2008). The update is mainly concerning updated policy considerations (CBA criteria and appraisal), climatic goals and the increasing awareness of the need to move away from fossil fuel and thus the need to achieve more modal shifts towards rail. Also considerations concerning how a potential HSR and the decreased journey times between the South and North of the UK could actually lead to a regeneration of economic benefits and diminish the difference in economic growth in these regions. The Atkins study analyzed fourteen options and alternative routes. The most attractive one considered was the one from London to the West Midlands because of the high population density in those areas. The geography and spreading/ high density of population of the UK make it possible, that most of the main

cities could be served by a single HSR line. The CBA for this option can be found in Appendix F, displaying the cost and benefit categories and further explanations.

The rationale behind HSR considerations at that time were rapid growth in passenger and freight traffic and due to that forecasts that predicted heavy overcrowding for commuters in the London region as well as long-distance travels. Also a shortage in capacity for freight traffic was forecasted. So the goal by considering HSR was mainly to relieve the existing rail system and to provide faster services to be able to compete with other modes of transport connecting the major cities of the country (De Rus and Nash Dec 2007).

Overall, the UK is a strong case for HSR, mainly due to the fact that a “single-line link” could connect the biggest metropolises. Furthermore, Britain faces the typical setting in which investment in HSR is said to be worthwhile, i.e. capacity constraints, congestion of the existing rail network and increasing demand forecasts for rail.

#### 4.3.4.2 Institutional structure of the rail industry and basic documents for the appraisal process

The main institutional players relevant for the rail industry and for the appraisal of transport projects are listed below, together with a short overview of their tasks. The same is done for the most important documents for the HSR appraisal process for the UK.

**Table 4-14: Institutional structure of the rail industry and basic documents for the appraisal process in the UK**

<b>Name of institution</b> (Source)	<b>Task</b>
<b>Strategic Rail Authority (SRA)</b> (DfT 2010b)	A government agency, responsible for strategy and planning the rail network.
<b>Department for Transport (DfT)</b> (DfT 2010c)	The Department for Transport provides leadership across the transport sector to achieve its objectives, working with regional, local and private sector partners to deliver many of the services. It additionally provides frameworks and guidelines for valuations of strategically important transport policies. The department has a programme of research work on modelling, appraisal and evaluation. The aim of this work is to support the continuing development of the New Approach To Appraisal by improving the advice on transport modelling and economic appraisal.
<b>High Speed 2</b> (DfT 2009)	A company set up by the government to consider a potential HSR between London and Scotland, providing research and

	publications on the topic.
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Title of document (Source)	Relevance for HSR appraisal
<b>Treasury Green Book</b> (DfT 2010d)	Prepared by the DfT. The Green Book, Appraisal and Evaluation in Central Government, provides guidance on appraisal and evaluation for public investments. All central departments and executive agencies use this guide, the latest version of which was released on 17 January 2003. The Green Book aims to make the appraisal process throughout government more consistent and transparent
<b>New Approach to Transport Appraisal (NATA)</b> (DfT 2010d)	Prepared by the DfT. NATA has evolved since its original launch in 1998, most recently to take account of the latest Green Book recommendations. It is now the basis for appraising multi-modal studies in several agencies and authorities, and also for the Strategic Rail Authority's appraisal criteria. The appraisal framework in NATA is made up of four distinct parts: <ul style="list-style-type: none"> <li>• Appraisal Summary Table (achievement of Government objectives)</li> <li>• Achievement of regional and local objectives</li> <li>• Effectiveness of problem solving</li> <li>• Supporting analyses</li> </ul>
<b>Transport Analysis Guidance (TAG)</b> (DfT 2010f)	It is published by the DfT and guidance for conducting transport studies. The guidance provides advice on how to set objectives and identify problems, develop potential solutions, create a transport model for the appraisal of the alternative solutions and how to conduct an appraisal which meets DfT's requirements. The guidance is a requirement for all projects/studies that require government approval. The units are split up after "Overview", "Project Manager" and "Expert" and vary in their scope of detail.

#### 4.3.4.3 HSR project appraisal

The just named documents build the basic references for the subsequent analysis.

#### ***General analysis of methods applied***

The UK has been revising their appraisal process, components and methods, summarized in the guideline "Transport Analysis Guidance" (TAG). Therefore many TAG units are "in

draft” and were expected to become definitive, without significant changes the 15<sup>th</sup> of April 2010. Other units are in draft “for consultation” and represent changes to the former appraisal units and might be changed substantially before becoming definitive. For the use in this thesis, the most recent units available online were used for the analysis. “In draft” units are denoted by the suffix “d”, those for consultation with “c” (DfT 2010e). The reasoning to consider also units for consultation is mainly to take into account the considerable changes and realization of recommendations that have been done in comparison to the Steer Davies Gleave report in 2004 up to now. The TAG is a very complex governmental paper and the attempt here is to give a short overview on the methods applied and three items in focus, trying to capture all necessary facts.

Specifically for appraisal in the rail sector, TAG unit 3.13.1 is of importance. The unit has not been changed since 2007 and is compulsory for “all initiatives with rail elements that are submitted to DfT for funding.” (TAG3.13.1 2007, p.3) HSR investment clearly counts to these initiatives.

CBA is compulsory for all large investment projects, more details are conveyed in the summary table. MCA is the overriding principle of the appraisal in the UK, *including* the CBA. The Appraisal Summary Table (AST) contains information both from the CBA. The AST is one of the main document outputs of the appraisal and shall give insight to which degree the five Government goals for transport would be achieved by the investment (TAG2.5d 2010). The table is done for each option/ alternative separately. Supporting analyses take into consideration that beyond the public interest at a national level, also other groups of users, non-users, operators and public sector authorities can be affected by the project in focus.

The appraisal period is dependent on the lifetime of the assets/ infrastructure in focus for the project. A differentiation is made between projects for which an estimation of lifetime is difficult, i.e. having indefinite lives, and projects with finite lives. The first named has an upper boundary of 60 years from the opening year, while the latter should have a justified shorter appraisal period than 60 years (TAG3.5.4d 2010; TAG3.13.1 2007).

Other methods applied in the framework of appraisal for projects are Strategic Environmental Assessment (SEA) (TAG2.11d 2009) and Wider Impacts (WI) (TAG2.8c 2009). All information on basic applications of methods is summarized in the table below.

Table 4-15: Appraisal method summary for the UK

Appraisal methods used	UK	Comments/ notes
<b>CBA</b>	✓	CBA is compulsory for large investment projects in transport and specifically also for rail. Benefits are split up after users, non-users and benefits from revenues from the new transport project.  The output is a benefit-cost ratio (BCR).
<b>MCA</b>	✓	Is the overriding method in the whole appraisal process, <i>including</i> CBA. The main outcome of the MCA is the Appraisal summary table, including results from CBA and all other impacts that are both monetized and non-monetized.
<b>Other methods used:</b>  * <b>Strategic Environmental Assessment (SEA)</b>  * <b>Wider Impacts (WI)</b>	✓  ✓	SEA for transport plans and programs in the UK is compulsory through an EU Directive and has the goal to assess effects on the environment of transport projects. The objectives and how the NATA objectives are linked in the case for the UK can be seen in Appendix G. The methods are numerous and differ a lot. That is why they are not named here.  Following recommendations of former reports, WI was introduced as a separate assessment of impacts that are not yet covered (wholly) by the conventional appraisal framework (NATA). The WI assessment includes such as labor supply effects, impacts on agglomeration or output change in imperfectly competitive markets (TAG2.8c 2009).
<b>Impact of results on decision-making</b>		Appraisal is a <i>part</i> of the overall study process for a transport investment. The outcome of the appraisal is important input for the decision-makers (compare step 12 in Appendix H for the figure of the transport study approach). The four parts of NATA mentioned above are supposed to provide the decision-maker with all information needed to reach a thorough judgment of the project.

The unit of account is money. Monetary values are used as far as possible also for non-market goods and impacts (TAG3.13.1 2007). The main two methods are market prices for impacts for consumers (gross of indirect taxes), while impacts for governments and business users are measured in factor costs, i.e. resource costs (net of indirect taxes). However, in order to avoid two units of account in the same appraisal, all impacts are converted to market prices by “up-rating” them, using a specific factor (for more details compare, TAG3.13.1 2007, p.7).



As in other countries as well, one base-year is chosen for valuation of market prices for investments that cover a long period of time. There are three basic cases differentiated when it comes to monetizing and quantifying impacts (TAG2.5d 2010):

- Quantifiable and able to be monetized, then those values are used.
- Quantifiable, but not possible to monetize, then the assessment has to be quantitative.
- Not quantifiable: then it is made use of a seven point scale (not necessarily of cardinal nature). Noteworthy is that the scales can be very different and thus a comparison to other scales can be difficult. For that reason, a supplementary assessment in “real life units” should be named under the metrics heading.

Impacts that are not included in monetized CBA, must be taken into account by measuring their overall value of money. Guidance on their assessment is given in several TAG units, of which the only two of importance for this thesis are “The Environment Objective” and “The Economy Objective” (TAG3.5.4d 2010).

An overview of which impacts are monetized to what extent in the appraisal in the UK is displayed below.

**Table 4-16: Practice of monetizing impacts of rail investment projects in the UK (information taken from TAG3.5.4d 2010, p.1-2)**

<b>Monetized</b>	<b>Partly monetized<sup>33</sup></b>	<b>Not monetized at all</b>
<ul style="list-style-type: none"> <li>• Journey time savings (business and consumer)</li> <li>• Operating costs and fares</li> <li>• Changes in number of accidents</li> <li>• Impacts on private sector’s revenues and costs</li> <li>• Better accessibility</li> <li>• Noise</li> <li>• Greenhouse gas emissions (CO<sub>2</sub>)</li> </ul>	-	<ul style="list-style-type: none"> <li>• Personal and freight security</li> <li>• Service quality</li> <li>• Local air pollution (currently excluded, but are planned)</li> <li>• Impacts on landscape, townscape, water and soil (no money values established yet)</li> <li>• Wider economic effects</li> </ul>

<sup>33</sup> The author of the thesis could not find specific examples from the TAG units.

**Value of time**

The values of time provided in TAG unit 3.5.6d are the most recent ones available and are compulsory for economic appraisals within transport in the UK, including the use in CBA. The journey time savings are valued by willingness-to-pay and market prices and are given in £ per hour per person (2002 prices).

It is differentiated between commuters, business and “other” travelers. Therefore a distinction is made between values for non-working and working time and different values for each transport mode are given. Thus, the given values take into consideration the different valuation of time from travelers in different modes of transport (e.g. time valued by air passengers is naturally much higher than for those travelling by car). The values of time used in the appraisal are average values and are based on studies undertaken by the Institute for Transport Studies; while non-working time valuations are based on SPA and RPA studies, working time is based on wage rate and costs. To cover the whole appraisal period it is also considered that the values of time grow annually. For that, tables are provided taking this annual growth into consideration, also conveying a formula how to calculate the final value then (TAG3.5.6d 2010, p.7). In order to correctly calculate values of time per vehicle for the average vehicle of a mode, vehicle occupancies and journey purpose splits are taken into consideration. Detailed tables with the relating proportions are given (TAG3.5.6d 2010, p.10-11). It should be noted that for rail investments, and especially for large ones, project specific public transport models will be used for both the estimation of vehicle occupancies and proportion of trips made. Therefore, the figures given in the tables in the TAG unit are said to be used just to a limited extent.

The distinct values for time savings in the recent UK appraisal are 4.46£ per hour for leisure passengers, 5.04£ for commuters and 36.96£ for business travelers (valued with market prices from 2002) (TAG3.5.6d 2010, p.4/5). Thus, the valuation of time saved for business travelers is more than eight times as high as for leisure passengers respectively more than seven times as high as for commuters.

The results of travel time savings (as part of user benefit calculation) are required to be displayed in a supplementary table (TAG2.7.1d 2010). Six groups of time savings have to be distinguished: less than -5 minutes, -5 to -2 minutes, -2 to 0 minutes, 0 to 2 minutes, 2 to 5 minutes and greater than 5 minutes.

**Value of labor**

Employment effects respectively the value of labor were not included in CBA up to today at all due to the reason that national employment is (as in Norway) assumed to remain constant and not influenced neither by the construction, nor operation of an HSR. Due to recommendations by Steer Davies Gleave in 2004 though, the recent update of the TAG takes employment effects into account. The TAG units 3.5.14 and 2.8 deal with this, while the first takes into account parts that are already included in the conventional analysis (CBA), while 2.8 focuses on impacts that are not captured yet, and thus are estimated in a Wider Impact assessment (WI) (TAG3.5.14c 2009).

Under the “Economy Objective” one sub-objective is to provide “beneficial wider impacts through productivity and wider welfare gains” (TAG2.8c 2009, p.1). The wider impacts include amongst others, impacts on **labor supply** and **moving towards more / less productive jobs**. The WI is therefore supposed to capture effects on labor supply that have not yet been captured wholly by conventional appraisal, i.e. the NATA framework. The same accounts for impacts on more or less productive jobs.

There are impacts on both, labor supply and move to more/ less productive jobs, captured partly in “commuter user benefits”, but they are not fully captured because those benefits are based on the willingness-to-pay, which “implicitly reflect post-tax wages (i.e. the labour supply gain to the individual)” (TAG2.8c 2009, p.4). Thus, it neglects the productivity gain to society as a whole, which exceeds the individual benefit and is equivalent to the difference between pre-tax and post-tax wages.

Concerning **labor supply**: a change in transport costs can affect the incentive for individual to work, because by deciding whether or not to work, an individual constantly weighs up travel costs against wages gained through the job that one is travelling to. So a change in travel costs could affect the overall level of labor supplied in the economy. The employment rate in turn has an effect on the GDP of the UK. Generally, higher GDP means allowing for higher consumption and therefore resulting in an impact on social welfare. Because of that, the UK decided to capture employment effects in the appraisal for transport projects under the WI analysis (and thus not part of CBA). Labor supply impacts have to be estimated and reported for all projects exceeding investment costs of £20 million (TAG2.8c 2009). This is done in three steps, always considering the “with” and the “without” case (TAG3.5.14c 2009; TAG2.8c 2009):

1. The estimation of the change in commuting costs and travel time savings that result due to the transport investment and by that estimate the change in net benefits from working.
2. Secondly, the level of labor supplied is based on the latter (change in net benefits) and its effect on overall labor supply. The calculation is done by “applying an evidence-based elasticity value to the net wage change.” (TAG2.8c 2009,p.8) That means that the elasticity with regard to wages in absolute values is used to derive the relative change in net earnings to the relative change in labor supply.
3. The additional productivity gained through an increase in labor supply is calculated by multiplying the change in number of people working by the average contribution to GDP one worker has.

The overall output of this calculation is the annual output change in monetary terms that results from the increased or decreased level of labor supply.

For the **move to more or less productive jobs**: here the rationale of the inclusion in the WIs is that changes in transport costs can change incentives for individuals to work in different locations and thus a relocation of employment could lead to a change in productivity. The move to more or less productive jobs are a compulsory element of the WIs, when the transport investment increases accessibility in an area that is close to an economic centre or large employment centre. This can be assumed to be true for HSR investment in the UK, since it would connect major cities and thus employment areas with each other. The DfT has because of this identified areas across the UK, where if the project falls within these, a WIs appraisal has to be made; these areas are called “Functional Urban Regions” (FURs) (TAG2.8c 2009, p.5). There are again three steps, of which the first one is the same as for impacts on labor supply, the estimation of changes in commuting costs.

- The second step includes estimating employment relocation and the resulting change in productivity.
- Taking into consideration productivity indices from Local Authority Districts (LADs), the move to more or less productive jobs is estimated by multiplying the change in employment in the area by the index of GDP contribution of each worker in that area.

The final result is the annual total output effect from more or less productive jobs (TAG3.5.14c 2009, p.14).

There are clear boundaries and rules for the calculation and estimation of the labor supply impacts in order to avoid double counting of effects that have already been included in the conventional appraisal.

### ***Environmental impacts***

CO<sub>2</sub> and noise account to sub-units of the overall governmental goal of environment, which deals with impacts on both, built-up areas and natural environment of people (TAG3.3.1 2004). Both items are however monetized and part of the CBA.

- **CO<sub>2</sub>**

CO<sub>2</sub> belongs to the sub-category “The Greenhouse Gases Sub-Objective” (TAG3.3.5d 2010). The sub-unit is based on the Climate Change Act 2008 that was created because of the UK’s goal to reduce greenhouse gas emissions to at least 80% below 1990 levels by 2050. Like Germany, the UK thus defined “carbon budgets”, i.e. the emissions allowed in each five year period up to 2050 in order to reach the preset goal. The monetized inclusion of CO<sub>2</sub> represents another major change to the report from Steer Davies Gleave from 2004.

Firstly, the project impact on emissions has to be estimated by measuring carbon (equivalent) emissions for the “with” and the “without” scenario. Emission calculations need to be done for every single year of the appraisal period. The amount of fuel consumed varies considerably among vehicle types as do the emissions per vehicle-km. Therefore, a differentiation between road and rail schemes is done for the UK. For the rail sector the traction type (diesel vs. electricity) will be taken into account. For the time being there are no values available, but the DfT is currently developing emission factors that will be published in the course of 2010 (TAG3.3.5d 2010). Generally, the approach taken is that of avoidance costs, i.e. the cost per ton of CO<sub>2</sub>-equivalent emitted to achieve the government’s emission targets. The estimated amount of CO<sub>2</sub> emissions is converted into monetary terms and the NPV is calculated over the appraisal period.

For the valuation, the UK differentiates between the sectors in which the pollutants are emitted and provides tables for their valuation (the table can be found in Appendix I). There are two sectors to be distinguished:

- The “traded sector”, i.e. concerning emissions from sectors that are taking part in the Emission Trading System (ETS) (e.g. the energy-intensive industry, and from 2012

onwards also aviation). Their values in the table conveyed are based on EU ETS allowance prices because they reflect avoidance costs for those sectors.

- The “non-traded sector”, i.e. all sectors that are not part of the ETS. Values in the table for this sector are based on target-consistent marginal avoidance costs in line with the Government’s climatic commitments.

To have an idea of the scope of the numbers, in general, the central values for e.g. 2010 are more than double as high for the non-traded sectors, than for the traded sectors (156,52£ vs. 65,51£ per ton CO<sub>2</sub>, 2002 prices).

- **Noise**

Noise annoyance, disturbance and due to that people’s dissatisfaction have been surveyed in the UK already for a long time. The innovation in this year’s TAG unit is the fact that noise is now a monetized element (the section is based on TAG3.3.2d 2010).

The assessment involves two major steps, of which the first one is based on noise annoyance. For that, the number of people that will suffer from noise due to the investment are estimated and then the difference between the “with” and the “without” scenario is calculated. The second step is “based on the effect of noise on house prices and involves calculating the present value of households’ willingness to pay to avoid transport related noise over the whole appraisal period for each scenario.” (p.3)

One core value for noise measurement in the UK is the annoyance response relationship. “The relationship shows the percentage of a population annoyed by road traffic noise in the longer term as a function of the noise level.” (p.5) For the rail sector this relationship has been developed recently for the TAG. The monetization of noise is readily done and conveyed in the TAG unit. It conveys monetary annual values for the impact of a 1dB change in exposure for noise levels from 45 to 81dB (in 2002 £). They are said to be standard appraisal values and are based on the UK average household income. They are supposed to be used with a positive sign to value the benefit of noise reductions and with a negative sign if the noise level increases due to the planned investment. The monetary values are shown in Appendix J.

Additionally, in the appraisal document, noise impacts for different social groups have to be displayed, because different individuals are affected by noise differently as well. This is

done by a categorical grading for different groups (more info on this can be found in the TAG unit p.21).

### **Summary**

The following table summarizes the main aspects and issues for the three items in focus in the appraisal process of the UK.

**Table 4-17: Summary of the three items in focus in the appraisal process in the UK**

<b>Item</b>	<b>Comments on use in the appraisal process in the UK</b>
<b>Value of time</b>	The journey time savings are valued by willingness-to-pay (through RPA and SPA) and market prices (wage rates and costs) and are given in £ per hour per person (2002 prices). A distinction is made between business, leisure travelers and commuters. Following the typical case, values for business travelers are several times higher than for the other categories. Results of travel time savings for a specific project need to be presented in a separate table, showing information for six pre-defined “time saving categories”.
<b>Value of labor</b>	No valuations of labor or employment effects were included until recently. To capture impacts on labor supply and the “move to more or less productive jobs”, a Wider Impact Assessment (WI) was introduced. It is a separate analysis that is approaching to capture labor effects wholly, beyond those accounted for in conventional appraisal (in commuters benefits). The valuations are given in annual, monetary output changes due to the impact in focus (area-specific for more or less productive jobs).
<b>Environmental impacts</b>	Both impacts are monetized elements of the CBA and are sub-units of the “environment objective”.
* CO <sub>2</sub>	Measured by avoidance cost, i.e. the cost per ton of CO <sub>2</sub> -equivalent emitted to achieve the government’s emission targets. Differentiations are made between modes and sectors and their participation in the Emission Trading System. Specific values for rail are for the time being not available, but will be published in the course of 2010 by the DfT.
* Noise	It is valued by the willingness-to-pay of households to avoid noise over the appraisal period for each alternative. A basic value used for deriving monetary values is the annoyance response relationship, which specific values for the rail sector have been recently developed. The monetized values of noise are given in annual values for the impact of 1dB change in exposure of noise level (for data compare Appendix J).

### 4.3.5 Spain

Following the structure as for the previous countries, also for Spain the HSR case is outlined, followed by the institutional structure of the rail industry and then analyzing methods used for HSR appraisal with a focus on the three items in focus.

#### 4.3.5.1 Outline of the HSR case

The first HSR that was built and operated in Spain was the Madrid-Seville line in 1992, mainly influenced by the demand of the world exhibition (EXPO) held in Seville that year. The ex-post analysis for this corridor done in 2006 summarizes that “[d]efinitely, from the analysis made, it can be concluded that from the point of view of economic efficiency and social benefit optimization, the high-speed train should not have been implemented in 1992 in the Madrid-Seville corridor” (Carrera-Gómez et al. 2006, p.140). The reason for the remaining poor performance of the HSR in Spain is the low traffic volume of a maximum of five million passengers per annum more than ten years after the opening (Carrera-Gómez et al. 2006; De Rus and Nash Dec 2007). It means the willingness-to-pay for the additional capacity seems to be lower than the costs of it. An illustrative CBA of this line is given in Appendix K including some explanations.

Other lines that were built like Madrid-Valencia and Barcelona-Valencia have been more economically beneficial in operation (SteerDaviesGleave Feb 2004). According to UIC (2009) there are ten lines up to now with operating speeds over 200km/h equaling to almost 1 600 km of track. Several tracks are also under construction and to be finished by 2012. Even more lines are planned and the Spanish government has the ambitious goal to have the largest HSR network (in operating km) in Europe by 2020 (MdF 2010b). This goal is formulated in the PEIT<sup>34</sup> by the promise that all regional capitals will be reachable within four hours from Madrid and within six hours from Barcelona until 2020. Just recently, 200 million € have been assigned to the new construction of an HSR line between Antequera and Granada in line with this goal (MdF 21.04.2010).

Spain has received quite an amount of money for investment in HSR (and other infrastructure) from the European regional development funds, which are said to be reduced in the medium term. This is why Spain started intensively to build on public-

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<sup>34</sup> Compare Table 4-18 for further explanation.



private partnerships for investments in transport infrastructure (ADIF 2008). Madrid is the largest city in Spain and located centrally in the country. Most of the other major cities in Spain are on or close to the coast and therefore in a radius of 400-600km from Madrid. These are actually distances that make the case for HSR quite beneficial as mentioned before in this thesis. The rest of the country has a rather low population density, which made the construction of HSR easier concerning impacts on inhabitants, but the hilly terrain on the other hand makes it more challenging. Generally, Spain has a very poor conventional rail network when it comes to quality and set up (Nash Nov 2009). More than 70% of the tracks are single-track lines and over 40% of all tracks are not electrified (Cámara 2007). The single tracks lead to capacity constraints. Additionally, speeds on the conventional tracks are very low due to curves and gradients in the hilly country. Because of that, HSR with offering considerable time savings and capacity improvements is such a strong case in Spain. Additionally, Spain was and is like Germany in some parts of the country facing large scale unemployment, which again *can* contribute positively to the HSR case. Competition of (conventional) rail in Spain is mainly the air market but also the extensive and well-established long distance bus system and conventional car traveling.

#### 4.3.5.2 Institutional structure of the rail industry and basic documents for the appraisal process

The main institutional players relevant for the rail industry and for the appraisal of transport projects are listed below, together with a short overview of their tasks. The same is done for the most important documents for the HSR appraisal process in Spain .

**Table 4-18: Institutional structure of the rail industry and basic documents for the appraisal process in Spain**

Name of institution (translated to English) (Source)	Task
<b>Ministerio de Fomento (MdF)</b> (Ministry of Public Works and Transport) (MdF 2010a)	The Ministry is amongst others concerned with the control and the administrative regulation of the services within the transport sector. Furthermore it is in charge of the planning and programming of the investments related to new infrastructure.
<b>ADIF</b> (Administrator of Railway Infrastructure) (ADIF 2010)	A new established body, because EU law asks for a separation of operations and management from infrastructure. ADIF is promoting the railway sector, and working towards converting it into the ideal mode of transport and facilitating access to the infrastructure under fair conditions.

<b>RENFE</b> (RENFE 2010)	Is state-owned, and operates trains as well as manages the rail infrastructure.
<b>Fundación de los Ferrocarriles Españoles (FFE)</b> (Spanish Railways Foundation) (FFE 2010)	Aims to enhance the railways and strengthen its position with accomplishing research and development, cultural activities, technological services, educational training and alike.

<b>Title of document</b> (English title) (Source)	<b>Relevance for HSR appraisal</b>
<b>Plan Estratégico de Infraestructuras y Transporte (PEIT)</b> (Strategic Infrastructures and Transport Plan) (MdF 2005)	The PEIT deals with the planning of all action in the field of infrastructures and transport which are the competence of the Ministry of Public Works and Transport. The plan's design takes account of the necessary cooperation and agreement with other Territorial Administrations. It contains the general criteria by which to frame any decisions made in the named sectors.
<b>Guía del análisis costes-beneficios de los proyectos de inversión</b> (Guide for Cost-benefit Analysis of investment projects) (Florio et al. 2003)	Prepared by a Spanish expert committee as an answer to the EU directives requiring CBA for major investment projects. It is a guideline for CBA for projects in all kinds of sectors, including the transport sector.

#### 4.3.5.3 HSR project appraisal

As for the other countries, also for Spain the before defined scheme is applied for the analysis. The main references for this section are the just listed documents and additionally the Guideline on CBA of investment projects by the European Commission represents a basic source.

#### ***General analysis of methods applied***

Economic analysis for rail projects in Spain is done according to Guidelines provided by the Ministerio de Fomento (MdF). However, publicly available are just the overall guidelines for economic appraisal (Florio et al. 2003), without any detailed specification of data. As the author of this thesis found out, specific railway data for appraisal are

unpublished. The general guide mainly follows the structure as provided by the EC (European Commission 2008) because Spain has received considerable funding through the regional development funds and therefore needs to fulfill the criteria as mentioned in the EU guideline. The Spanish practice deviates considerably though when it comes to values that are applied (as it can be seen in Appendix K), respectively distinct values to be used are not conveyed publicly as said before. Most commonly used for transport project appraisal is CBA, and also the number of projects being evaluated are by far the most in the transport sector in Spain. The EC requires for all countries that get financial subsidies by the development funds to accomplish thorough ex-ante analyses of large infrastructure projects. Therefore also the Spanish appraisal guideline includes it as a compulsory element in the appraisal for rail infrastructure to give the decision-makers a detailed overview of the project. Generally the time horizon of appraisal is dependent on the specific projects and life times of the assets for the project. An average appraisal period for large transport projects in Spain is given the guideline for projects between 1992 and 1999 and equals 26.6 years (Florio et al. 2003). The recommended appraisal time horizon for future rail projects (until 2013) is based on the average number and is set to 30 years, which is in line with the OECD/ EC recommendations. As mentioned in the theory part of this thesis, also Spain requires a risk assessment and sensitivity analysis of critical parameters of the appraisal. Overall, the CBA is included in the “economic analysis” of the project, where input is added from the financial analysis. Both analyses have to include valuations and comparisons for the “with” and the “without” case. The outcome of the CBA is a benefit-cost ratio or the NPV of the investment.

The structure is as it also can be seen from the CBA displayed in Appendix K, the calculation of (social) costs, (social) benefits; where costs are split up after costs for infrastructure, maintenance and operation and reduction of costs in several categories (Carrera-Gómez et al. 2006). Market prices are used for market goods, while non-market goods are split up after minor items and major items, while the latter is again split into input and output factors. The figure that shows the price measures that should be used for each item for appraisal in Spain (and the EU) can be found in Appendix L. In short:

- There is an extensive use of shadow prices and sector conversion factors<sup>35</sup> for specific tradable goods.
- Marginal costs or willingness-to-pay is used for non-tradable goods.
- A conversion factor is also used for labor costs, depending on the magnitude of regional unemployment.

MCA is used as mentioned in the theory for costs and benefits that are difficult to monetize and/ or quantify like equity, like equity and environmental impacts. The use for appraisal purposes is following the theoretical steps mentioned for MCA, setting up criteria relevant for the appraisal, collecting impacts for each category and measuring them with percentages or scores. An overall matrix should be given to show the relative weights of each criterion with regard to the overall goal. By multiplying scores and weights, the overall impact of the project is obtained. For Spain no more detailed requirements for impact categories, scores or weights are conveyed. Concerning the impact of results of the appraisal on decision-making, firstly, ex-ante CBA analysis are supposed to give a comprehensive overview of the project in focus (especially with regard to funding by the EU). However, the economic appraisal undertaken is mainly for prioritizing projects, rather than making decisions on which projects to really accomplish (SteerDaviesGleave Feb 2004).

Additional methods to CBA and MCA are used and their content and more information are displayed in the summary table. The table below summarizes the information on appraisal methods used in Spain.

**Table 4-19: Appraisal method summary for Spain**

Appraisal methods used	Spain	Comments/ notes
CBA	✓	CBA represents a part of the Economic analysis. Costs and benefits are derived for the “with” and the “without” case. The cost side includes data from the financial analysis. Ex-ante CBAs are compulsory for large infrastructure projects in Spain due to funds from the EU.  The outcome of the CBA is a BCR or NPV.

<sup>35</sup> When market prices do not reflect the social opportunity cost of inputs and outputs, the common approach is to convert them into accounting prices by making use of conversion factors (EuropeanCommission 2008).

<b>MCA</b>	✓	MCA is used according to the theory for non-market goods or those goods that are difficult to quantify and monetize and is categorized as complement to CBA. Environmental impacts count to them. No detailed scores or weights are publicly available, neither generally nor for the rail sector in specific.
<b>Other methods used:</b>		
* <b>Economic analysis</b>	✓	Is the overriding principle, where CBA is a part. It includes comparisons and data from the CBA and the Financial analysis for both the “with” and the “without” case.
* <b>Financial analysis</b>	✓	It is done apart from the economic analysis and includes estimations of investment, operation and maintenance costs, sources of financing, return on national capital and alike. The time horizon for it must be in line with the economic life of the main assets in the investment project.
* <b>Cost-effectiveness Analysis</b>	✓	Both are recommended to be used under specific circumstances, but again as complements to CBA. No more details beyond the theoretical approach are given for the use in Spanish appraisal.
* <b>Economic impact analysis</b>	✓	
<b>Impact of results on decision-making</b>		Ex-ante CBA analysis are supposed to give a comprehensive overview of the project in focus (especially with regard to funding by the EU). However, the economic appraisal undertaken is mainly for prioritizing projects, rather than making decisions on which projects to really accomplish.

Theoretically, according to the EU guideline, Spanish appraisal practice should take all impacts and externalities into account and they should be monetized as far as possible. Since Spain does not make a specific distinction in monetization or partly monetization of impacts, the table that is shown for all other countries will not be included here as it would be superfluous. It is understood from the guideline that the use of monetary values is dependent on each specific project for each specific sector and the data used in actual Spanish appraisal (at least for environmental impacts) are based on the most recent INFRAS/IWW values (Florio et al. 2003) that is also recommended by the UIC. The guideline once again does not give any more detailed input on how to deal with impacts of rail investment projects. It can be derived from different sources though that all three items in focus are monetized parts of the CBA (CBAs mentioned in the Appendix, time values in the EC guide and the Spanish guideline). More details will follow subsequently for each item, taking into consideration the most recent values and methods as proposed by INFRAS/IWW.

**Value of time**

The guideline explains generally how values of time can differ (e.g. after purpose of travelling, mode of transport etc.) and that time savings represent one of the biggest benefits from investment in improved transports. Values in European comparison for value of working time per person are shown in a table, but just for the year 1995. Spain belongs to one of the five countries with the lowest values per person with round about 14€. It remains unclear if these values are supposed to be used for appraisal and if any adjustments or specific valuations for different transport modes or travel purposes have to be distinguished. It appears though, that the common approach of differentiating between business trips and “others” is made (including both leisure travel and commuters), because rough proportions are given that in most of the European countries values for business travel exceed the “others”. Non-professional trips are said to have an average value between 10-42% of the value of business trips (Florio et al. 2003).

The Steer Davies Gleave (2004) report finds out as well that no specific values are mentioned in the publicly available guidelines and that values of time are supposed to vary between projects and transportation mode. They convey specific values of time for HSR time savings, obtained from an unpublished CBA, equaling €8.98 per hour per person for rail. It is neither clear though how values are calculated, nor how they are obtained and therefore cannot be verified.

Another recent source elaborates on the large variety of values of time being used within Spanish CBA practice and thus supports the fact that values of time differ decisively from project to project, especially in appraisal within the transport sector (Riera, García, and Brey 2006). It is pointed out by the authors that there is a “great deal of dispersion in the resulting values” and a “lack of consensus on which values to use in cost-benefit analysis”<sup>36</sup> (p.51). The values differ not only numerical, but also concerning the concepts of valuation behind them (per hour per person per vehicle, or per purpose of travelling, per mode etc.). The different values of time that were derived by different studies over time which show the variety and non-uniformity within Spanish appraisal practice are provided in Appendix M. In most cases though, the average wages are used to estimate the value of one hour journey time for travelling in working time, of which a percentage (most often ca.

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<sup>36</sup> Quotation translated by the author.

50%) is used for the valuation of non-business travelling. The article concludes by pointing out the need for more uniform values and a consensus about distinct values for the use in CBA appraisal practice for transport infrastructure investments in Spain to achieve a better comparability. At this point it should be referred to De Rus & Inglada (1997), mentioning the same urgent need for more research on values of time for different types of travelers in different transport modes for achieving more comprehensive results for socio-economic analyses in Spain.

### ***Value of labor***

As mentioned before, Spain faces a high proportion of unemployment. Thus, as for Germany, employment effects are a monetized part of the CBA, also because of the reason that the EC guideline explicitly asks for the measurement of increase in employment in the appraisal (European Commission 2008, p.245). As opposed by the EC, conversion factors are used for valuation, based on shadow wages (compare Appendix L). Once again, the Spanish guideline does not provide any explicit values for the use in (rail) appraisals.

Several CBAs are available for Spanish HSR lines (De Rus and Inglada 1997; Carrera-Gómez et al. 2006; Coto-Millán, Inglada, and Belén 2007). From any of those it is possible to figure out where and to what extent employment effects/ values of labor are included. It is on the basis of several sources for the purpose of this thesis therefore accepted that the value of labor is a monetized impact of CBA and that no more detailed, verifiable information on values is publicly available.

### ***Environmental impacts***

As mentioned before, basically both items (CO<sub>2</sub> and noise) have to be monetized and are part of the economic analysis respectively CBA. However, if methods for valuing specific impacts inherent considerable controversies or alike, the guideline proposes the use of qualitative methods of description, with the note that an estimated monetary value via a thorough MCA is then needed. As it is seen from different CBAs for HSR in Spain, both impacts are in every case monetized via CBA though.

For the values to be used for CBA, the Spanish guideline requires that they should be based on scientific studies. The guideline refers at this point to a study done by INFRAS/ IWW (2004) on external costs of transport, including valuations for noise and CO<sub>2</sub>. For the purpose of Spanish CBA they have to be conveyed in passenger-kilometers. Since no more

specific values are conveyed in the guideline, the named study is used for input on valuations of noise and CO<sub>2</sub> for Spain (INFRAS/IWW 2004).

The rationale behind using the INFRAS/ IWW report is furthermore, that also one of the CBAs available for Spain made use of data from this study (Coto-Millán, Inglada, and Belén 2007).

- **CO<sub>2</sub>**

Values for CO<sub>2</sub> emissions are used not per ton, but per passenger-kilometer per mode (Florio et al. 2003; SteerDaviesGleave Feb 2004).

Costs for climatic change due to CO<sub>2</sub> make up approx. 30% of total costs (under specific conditions)(INFRAS/IWW 2004). The methodology is basically that the amount of CO<sub>2</sub> emitted is multiplied by a cost factor. The shadow value of ton CO<sub>2</sub> in the country's currency is said to be the crucial factor for calculations of climatic change costs. The final values are based as for other countries before mentioned also on avoidance costs. The study defines two scenarios with which the costs for CO<sub>2</sub> can be calculated, a “high scenario”, where the shadow price per ton CO<sub>2</sub> emitted equals 140€ and a “low scenario” where the value is 20€. With that as a basis, the following marginal climate change costs in € per 1000 passenger-km have been derived specifically for HSR (for both scenarios and again for vehicle-and passenger-km, where vehicle-km are neglected here) (INFRAS/IWW 2004, p.101):

- 0.3€ per 1000 passenger-km (low scenario: 20€ per ton CO<sub>2</sub>)
- 2.2€ per 1000 passenger-km (high-scenario: 140€ per ton CO<sub>2</sub>).

- **Noise**

Costs for noise make up approx. 7% of total costs (under specific conditions).

The noise cost is based on the willingness-to-pay of a person disturbed by a specific noise exposure level. The value that is given in the end is average noise costs per passenger-km. The methodology on how these values are derived, are provided in Appendix N.

The marginal costs have been calculated according to the methodology not only for rail, but also HSR in specific. Values are given by area (urban and inter-urban) and for both, in



€ per 1000 vehicle-km and passenger-km (2000 prices), of which just the passenger-km are of interest here because of Spain's requirements. The marginal cost of noise for HSR is:

- 0.09€ per 1000 passenger-km for inter-urban journeys
- 0.73€ per 1000 passenger-km for urban journeys.

### Summary

The following table summarizes the main aspects and issues for the three items in focus in the appraisal process of Spain.

**Table 4-20: Summary of the three items in focus in the appraisal process in Spain**

Item	Comments on use in the appraisal process in Spain
<b>Value of time</b>	It is a monetized impact and part of CBA. Values differ decisively from project to project, not only numerical, but also methodologically. There exists a great non-uniformity within Spanish appraisal and except for guidelines on the inclusion of valuations of time the major guideline does not present any specific values. There is a need for reaching consensus on which values to use within appraisal for transport infrastructure projects.
<b>Value of labor</b>	Is a monetized impact in CBA. Conversion factors, based on shadow wages are used for valuation. Again, no explicit values for the Spanish appraisal of HSR are publicly available.
<b>Environmental impacts</b>	Both impacts are monetized and part of the CBA. Their valuation should be based on scientific studies; the most recent INFRAS/IWW (2004) study is mentioned for this and values mentioned here are based on it. Both impacts have to be given in values per passenger-km.
* CO <sub>2</sub>	The valuation of CO <sub>2</sub> is based on avoidance cost and is given in € per 1000 passenger-km, split up after transportation mode and for a high and low-scenario of emission-prices (140€ vs. 20€ per ton emitted). For HSR the values are 0.3€ per 1000 passenger-km (low-scenario), and 2.2€ for the high-scenario.
* Noise	The valuation of noise is based on willingness-to-pay of a person that is disturbed by a specific noise exposure level. The prices given are differentiated after transport mode and area of travelling (urban vs. inter-urban). Specific values for HSR trains are 0.09€ per 1000 passenger-km (inter-urban) and 0.73€ for urban journeys.

#### ***4.4 Comparison of the countries - main similarities and differences***

After the five countries were now analyzed following a specific scheme, this chapter is comparing the results from the analysis in order to point out main commonalities and differences and thus represents the answers to research question 2 and parts of 3. The outcome from the comparison is summarized in point 4.5 and then used to draw conclusions and reflect on Norway's practice subsequently.

The structure of this part is as follows. First there is displayed a table about general application of methods (including information on appraisal horizons and economic lives of rail assets). The second table provides a general overview of the inclusion of the three items in focus in the methods for the case study countries. The last table conveys details on *how* the three items are included in the appraisal processes and methods. All tables<sup>37</sup> are followed by verbal descriptions of the major outcomes.

Input for this section was next to the analysis made specifically for this thesis also the articles from Bristow and Nellthorp (2000) and the Steer Davies Gleave report (2004).

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<sup>37</sup> As earlier mentioned “✘” represents “not being valued/ used/ applied” and “✓” “being valued/ used/ applied”, “(✓)” means “to some extent”.



Method/ item	Norway	Sweden	Germany	UK	Spain
<b>CBA</b>	✓	✓	✓	✓	✓
<b>MCA</b>	✗	✗	✓	✓	✓
<b>Other methods</b>	<ul style="list-style-type: none"> <li>* Cost-effectiveness analysis</li> <li>* Cost-impact analysis</li> <li>* Consequence analysis</li> </ul>	<ul style="list-style-type: none"> <li>* Cost-effectiveness analysis</li> </ul>	<ul style="list-style-type: none"> <li>* Environmental Risk Assessment</li> <li>* Spatial Impact Assessment</li> </ul>	<ul style="list-style-type: none"> <li>* Strategic Environmental Assessment</li> <li>* Wider Impacts</li> </ul>	<ul style="list-style-type: none"> <li>* Cost-effectiveness Analysis</li> <li>* Economic analysis</li> <li>* Financial analysis</li> <li>* Economic impact analysis</li> </ul>
<b>Impact of results on decision-making</b>	<ul style="list-style-type: none"> <li>* part of decision-making</li> <li>* mainly used for ranking and prioritizing projects</li> <li>* used as basis for decision in inclusion in national transport plan</li> </ul>	<ul style="list-style-type: none"> <li>* part of decision-making</li> <li>* mainly used for ranking and prioritizing projects</li> <li>* used as basis for decision in inclusion in national transport plan</li> </ul>	<ul style="list-style-type: none"> <li>* firstly used for ranking and prioritizing projects</li> <li>* used as basis for decision in inclusion in the BVWP</li> </ul>	<ul style="list-style-type: none"> <li>* important part of decision-making</li> <li>* four main parts of NATA are meant to give a comprehensive overview for judgment of the project</li> </ul>	<ul style="list-style-type: none"> <li>* part of decision-making</li> <li>* mainly used for ranking and prioritizing projects</li> <li>* results important because of potential funding by EU</li> </ul>
<b>Appraisal horizon</b>	<ul style="list-style-type: none"> <li>* project specific</li> <li>* generally recommended 25 years (discrepancies need to be explained)</li> </ul>	<ul style="list-style-type: none"> <li>* dependent on economic life of assets</li> <li>* maximum of 40 years</li> </ul>	<ul style="list-style-type: none"> <li>* uniform forecast horizon is 2015</li> <li>* but additionally dependent on economic life of assets</li> </ul>	<ul style="list-style-type: none"> <li>* dependent on economic life of assets</li> <li>* differentiation made between “indefinite lives” and “definite lives”</li> <li>* indefinite lives: ≤60</li> <li>* definite lives: &lt;60 years</li> </ul>	<ul style="list-style-type: none"> <li>* project specific</li> <li>* dependent on economic life of assets</li> <li>* recommended 30 years for rail projects</li> </ul>

<b>Method/ item</b>	<b>Norway</b>	<b>Sweden</b>	<b>Germany</b>	<b>UK</b>	<b>Spain</b>
<b>Economic life times of rail infrastructure</b>	* 75 years (tracks) * 40 years (rest)	* 60 years (tracks) * 20-30 years (rails, signaling etc.)	* 75 years (tracks, tunnels etc.) * 50 years (buildings and structures) * 20-25 years (superstructure, signaling etc)	* see above: indefinite and definite lives differentiation	* no specific values published

**Table 4-21: Summary of appraisal methods and items used in the case study countries (status May 2010)**

- **General comparison**

Firstly, it can be noted that there are significant differences in the institutional set ups of the rail sectors among the case study countries. Nevertheless, there are some main commonalities in the guiding principles behind the methodologies applied in transport project evaluation which are described in more detail in the following.

*Intentions for the investment* in HSR (in those countries where it had already been implemented) were / are mainly capacity constraints (UK, Germany, Sweden), while for other countries it represents a transportation mode that can contribute to reduce CO<sub>2</sub> emissions in the transport sector and that could improve market share of rail (in comparison to air) due to considerable time savings (Norway, Spain and also Sweden).

*Conventional rail networks* are of different quality, thus representing different settings (capacity constraints or rather speed constraints). Here most outstanding are Spain and Norway facing a very old conventional rail network with long tracks still being just one-track lines. Hence, this contributes to not only capacity constraints today, but also to speed constraints for a (potential) HSR.

*Population densities and different topographies* are making the case for HSR stronger or weaker. The countries where main metropolis are in the most advantageous distances for HSR (Sweden, UK) face more beneficial cases for HSR than other countries where the population distribution asks for more intermediate stops and influences the average speed that can be achieved in operation (e.g. in Germany). It also has influence on investment costs where e.g. more density means more noise protection is needed and more hilly means more tunnels and bridges are needed. These issues also make it so difficult to come up with a general method with compulsory and uniform criteria. This is also mentioned as one of the remaining problems reaching a European appraisal methodology: “A key problem [...] is in deriving values and measurements that can sensibly be applied to all member states.” (Bristow and Nellthorp 2000, p.57)

Overall, the different bases for the different valuations make it very difficult to compare the CBA for a project like HSR from one to the other country.

- **CBA**

CBA is used in all case study countries as appraisal method for transport projects, but there are major differences in *how* CBA is applied. In some countries CBA is used for *all* rail projects (Germany, Spain, Britain) in others, just for some.

Norway, Germany and the UK are alone in using a consistent or similar methodology across all transport modes with the overall aim to secure comparability. So the obvious trend as already recognized by Bristow and Nellthorp (2000) is the “move towards the development of comprehensive multi-modal appraisal methodologies” (p.58).

The “impact categories” for which costs and benefits are measured (the groups with “standing”) and valuated differ quite a lot across the countries. While Sweden and Norway choose a split after traffic participants, the UK split impacts after users, non-users and revenues of the new investment. Spain solely differentiates between social costs, social benefits and reduction of costs in other transport modes and impact categories. Germany uses a totally unique way of categorizing costs and benefits.

The scope of quantified monetary costs and benefits included differs. For Spain the degree of monetization could not be figured out in specific and is therefore left out of the comparison concerning this issue. All the other case study countries monetize the major components of CBA such as investment, operation and maintenance costs as well as the most common benefits (e.g. travel time, revenues etc.). The differences occur in the valuation of environmental impacts, regional/ national development and such as health effects. Here the monetization differs. Germany is the only country monetizing regional development at least partly, while Norway, Sweden and the UK do not monetize this at all. Sweden is the only country partly monetizing health effects, while all the other countries include it just in qualitative assessments. Environmental impacts in general are in almost all countries counted to “partly monetized”, but the components under this main category differ in the degree of monetization again. CO<sub>2</sub> and noise are tried to be monetized *if* regarded in the appraisal, e.g. local air pollution is not included in the UK’s appraisal up to now at all with a monetary value.

- **MCA**

MCA is used less consistently: UK, Spain and Germany use it formally. However, only Germany assigns numerical scores to the MCA that are then added to the result of the CBA to give a combined appraisal score. The UK chose to take the MCA as the overriding principle and CBA is included within it. Norway and Sweden do not make use of MCA at all. Nevertheless, Norway uses a consequence analysis for non-market goods in which also scores are given and the method is somewhat similar to a MCA.

- **Additional methods**

Additional methods are mainly used as qualitative or quantitative supplements to include impacts that are not monetized for e.g. technical or political reasons (Bristow and Nellthorp 2000). Three of the countries use cost-effectiveness analysis (Norway, Sweden and Spain). Germany and UK use beyond MCA also separate environmental assessments. Germany, UK and Spain also include the impacts on the (national) economy through special impact analysis methods.

- **Impact on decision-making**

In all countries the results of CBA, MCA and additional methods used for transport project appraisal give mainly an input for ranking and prioritizing projects, rather than decisions which ones will finally be accomplished. In some of the countries decisions concerning the inclusion of the project in the next terms transport plan is made based on the results (Germany, Norway and Sweden). Overall the economic appraisal results represent just *one* input for an overall investment decision in HSR since in most countries the decision is made at the highest level of government. Decision criteria respectively the outcome of the CBA differs also slightly among the countries, being a BCR in most cases, a *net* BCR in Norway and a NPV in Sweden.

- **Appraisal horizon and economic life times of rail assets**

The appraisal horizon is not uniform at all among the countries. They differ from 25 years as the lowest value (Norway) up to 60 years (UK). This has quite some influence on outcomes of appraisals, since values need to be discounted over the time of appraisal. The longer the appraisal period, even though discounted, the more value the aggregated benefits have. The fact the countries have in common concerning the appraisal horizon is



that they are most often project specific and thus dependent on the economic lives of the assets involved in the investment. For that reason the economic lives of the most important rail assets are also compared. As one can see the exact lives are not the same among the countries, but the scale for the tracks is everywhere the same, i.e. the longest life time. Economic lives for other parts of the infrastructure like signaling, rails, superstructure etc. vary between 20 to 40 years. The reason for this could not be pointed out specifically but is thought to be dependent on the quality of material purchased, the degree of usage (wear and tear) and also the different weather conditions in each country.

- **The three items in focus**

In the following, an overview shall be given about the inclusion of the three items in focus in the methods for the case study countries. The table below shows if and to what extent the three focus items are being used in the five case study countries<sup>38</sup>.

**Table 4-22: Comparison of items used in appraisal in the case study countries – overview (status May 2010)**

Item	Norway	Sweden	Germany	UK	Spain
Value of time	✓	✓	✓	✓	✓
Value of labor	✗	✗	✓	✓	✓
<b>Environmental impacts</b>					
* CO <sub>2</sub>	✓	✓	✓	✓	✓
* Noise	(✓)	(✓)	✓	✓	✓

As one can see, **value of time** and **CO<sub>2</sub>** are the only items that are used throughout all the countries within project appraisal.

**Value of labor** is neither included in Norway nor Sweden, for different reasons. Norway's guidelines mention its irrelevance for the Norwegian setting, Sweden does not comment on reasons for its exclusion at all.

**Noise** is theoretically a monetized impact of appraisal in all of the case study countries, but as it can be derived from practical examples of appraisal of HSR in Norway and Sweden, noise is not included. An assumption made for this for Sweden is that it is due to data

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<sup>38</sup> As earlier mentioned “✗” represents “not being valued/ used/ applied” and “✓” “being valued/ used/ applied”, “(✓)” means “to some extent”.

unavailability, while for the Norwegian setting the impacts on the appraisal were estimated to be so marginal that it does not make sense to include it. Table 4-23 below gives a more detailed comparison of the three items in focus for all five countries.



Item	Norway	Sweden	Germany	UK	Spain
<b>Value of time</b>	<ul style="list-style-type: none"> <li>* NOK per hour</li> <li>* mode-specific</li> <li>* business, commuters, private travelers</li> <li>* short vs. long trips</li> <li>* different part-values are multiplied by a weight factor to convert the time to “on board time”</li> </ul>	<ul style="list-style-type: none"> <li>* SEK per hour</li> <li>* private vs. business travelers</li> <li>* private split up after long and short trips</li> <li>* business split up after mode</li> </ul>	<ul style="list-style-type: none"> <li>* € per hour per person</li> <li>* mode-specific</li> <li>* calculated for “with” and “without” scenario</li> <li>* commercial and non-commercial travelers</li> <li>* based on willingness-to-pay</li> </ul>	<ul style="list-style-type: none"> <li>* £ per hour per person</li> <li>* mode-specific</li> <li>* business, leisure and commuters</li> <li>* based on willingness-to-pay (RPA, SPA) and wage rates and costs</li> </ul>	<ul style="list-style-type: none"> <li>* monetized part of CBA</li> <li>* not specified in guideline: values differ from project to project (numerically and methodology wise)</li> </ul>
<b>* mode-specific values for time</b>	✓	(✓)	✓	✓	✗
<b>Value of labor</b>	<ul style="list-style-type: none"> <li>* not included in appraisal because irrelevant for Norwegian setting</li> </ul>	<ul style="list-style-type: none"> <li>* not included at all</li> </ul>	<ul style="list-style-type: none"> <li>* crucial part of CBA</li> <li>* valued in man-years per 100 million € investment cost</li> <li>* split up after impacts in construction and operating period</li> <li>* region differentiation factors</li> </ul>	<ul style="list-style-type: none"> <li>* not part of CBA but of a separate analysis (Wider Impacts)</li> <li>* area specific</li> <li>* valued in annual, monetary output changes in the area</li> </ul>	<ul style="list-style-type: none"> <li>* monetized part of CBA</li> <li>* valued by conversion factors based on shadow wages</li> <li>* no specific values conveyed in the guideline</li> </ul>
<b>Environmental impact</b>	<ul style="list-style-type: none"> <li>* based on climatic goal of Norway</li> </ul>	<ul style="list-style-type: none"> <li>* based on climatic goal of Sweden</li> </ul>	<ul style="list-style-type: none"> <li>* based on avoidance costs</li> </ul>	<ul style="list-style-type: none"> <li>* based on emission targets of the UK</li> </ul>	<ul style="list-style-type: none"> <li>* based on avoidance costs</li> </ul>
<b>* CO<sub>2</sub></b>	<ul style="list-style-type: none"> <li>* price based on</li> </ul>	<ul style="list-style-type: none"> <li>* valued per kg CO<sub>2</sub></li> </ul>	<ul style="list-style-type: none"> <li>* valued in € per ton</li> </ul>	<ul style="list-style-type: none"> <li>* valued in £ per ton CO<sub>2</sub></li> </ul>	<ul style="list-style-type: none"> <li>* valued in € per 1000</li> </ul>

Item	Norway	Sweden	Germany	UK	Spain
	emission price rates on the stock market per ton CO <sub>2</sub> emitted  * mode- and traction-differentiation (NOK per vehicle-km)	emitted  * no mode nor traction differentiation	* based on energy consumption and emission factors  * mode- and traction-differentiation	equivalent emitted  * mode and sector differentiation and their participation in the Emission Trading System	passenger-km  * mode-specific (high and low scenario)  * specific values for HSR
<b>* mode-specific values for CO<sub>2</sub></b>	✓	✗	✓	✓	✓
<b>Environmental impact</b>  <b>* Noise</b>	* theoretically monetized part of CBA  * NOK per vehicle-km  * in practice neglected in HSR appraisal	* theoretically valued for rail in specific via a special formula based on traffic levels  * SEK per person affected per year  * in practice not valued for HSR appraisal (yet)	* measured as change in noise exposure  * € for change in vehicle-km in transport mode  * split up after built-up and non-built-up areas	* valued by willingness-to-pay for a change in noise exposure (annoyance-response-relationship)  * mode-specific  * £ per year of impact of change in 1dB of noise	* based on willingness-to-pay  * valued in € per 1000 passenger-km  * mode- and area (urban, inter-urban) specific
<b>* mode-specific values for noise</b>	✓	✓	✓	✓	✓

Table 4-23: Comparison of components used in the case study countries – details (status May 2010)

Even if the items are included in every country, the methods and bases of valuation remain considerably different.

- **Value of time**

Values of time used are categorized differently. The outcome is everywhere almost the same, being a value per hour saved (per person). However, the distinct categories and methods for derivation of the values vary quite a lot. All countries (except for Spain due to a lack of information) make differentiations between the purpose of the journey (business vs. private), some in addition also differentiate after travelled distances (Norway and Sweden). Those countries that distinguish between journey purposes, all have considerable higher values of time for business travelers.

All countries except for Spain and Sweden make transport **mode-specific** valuations. Sweden's main split is between private and business travelers, and just for the latter time values are further sub-divided by mode. Thus, with reference to the theory part, most of the countries choose to rather let preferences be reflected in the appraisal adequately than avoiding income differences influencing the appraisal. Anyhow, Germany and the UK use mode-specific values for time, but are attempting to reach standard non-working values for time across modes for the use in appraisal (these values are not used for forecasting though) (compare also Bristow and Nellthorp 2000).

It can be concluded also from referring to the articles mentioned before in several sections of this thesis, that there has still not been reached a consensus on how to include values of time in appraisal processes, neither for infrastructure projects in general, nor for rail nor HSR in specific.

- **Value of labor**

Germany and Spain include it as a monetized part of CBA and the values are based on the alternative cost of providing a job. The UK captures employment effects of large infrastructure projects since the most recent Transport Analysis Guide in monetary terms, though not in the CBA but in a separate analysis (Wider Impacts). Norway and Sweden do not include employment effects at all due to the specific circumstances of the job markets in the countries that make it superfluous according to the guidelines and governmental documents published.

Employment effects and value of labor is an example of impacts that are subject to substantial policy relevance in the countries (Bristow and Nellthorp 2000). As it also can be seen from the analysis of this thesis, the methods being applied are quite sophisticated. There are theoretical and practical problems to forecast the input data with meaningful levels of accuracy and thus the output of the formulas need in most cases to be treated with caution. Furthermore, there is no agreement on which monetary value to use if employment effects are included, because it is difficult to measure the exact change of output/ employment *just* due to the infrastructure investment.

- **Environmental impacts**

All countries try to include environmental impacts, just the methods and valuations used differ and also which items are monetized and to what extent. And while there is a consensus of which impacts to include in the appraisal, there is less agreement on the suitability of valuation in monetary terms. Both components in focus – CO<sub>2</sub> and noise – are (theoretically) monetized impacts in all case study countries though.

- **CO<sub>2</sub>**

CO<sub>2</sub> as being part of greenhouse gases is the main reference parameter used for global air pollution. There is consensus about including CO<sub>2</sub> as a monetized impact in the appraisal, but the methods being used vary decisively.

Great uncertainty remains about methods being used that best cover all impacts from CO<sub>2</sub> and also concerning which values to use in order to take the emission targets of the countries into account. It is reflected in the case study countries, where the basis is most often the country's emission targets, but the price basis for the amount of CO<sub>2</sub> emitted differs quite a lot. While Norway bases it on the price rates of CO<sub>2</sub> quotas on the stock market, Germany and Spain for example base the prices on avoidance costs.

Also the reference measure differs, for most of the countries it is a monetary value of the amount of CO<sub>2</sub> emitted (in tons), while the UK uses CO<sub>2</sub> equivalents per ton emitted as measure and Spain uses monetary valuation per 1000 passenger-km.

**Mode-specific** values are used in every country except for Sweden where just a sector specification is made (values given are for the transport sector). Since the CO<sub>2</sub> values and

methods for Sweden will be updated in the course of 2010, it cannot be concluded with certainty if the lack of mode-specification will remain though.

- **Noise**

There is again consensus about the fact that noise should be a monetized value of CBA but there is no agreement on the method for valuation. The valuation basis vary from willingness-to-pay (UK and Spain) over estimations on numbers of people disturbed (Sweden), to avoidance costs used by Germany.

The great differences can be explored by looking at the benchmarks of valuation (per reduced dB, per 1000 passenger-km, annual values for affected persons per year etc.). Thus, the comparability of this measure is limited and when one develops this thought further, it makes it very difficult to compare the CBA for a project like HSR from one to another country. All countries have in common that they make use of transport **mode-specific** values for noise.

#### 4.5 Summary

This chapter has dealt with the comparative analysis of the five case study countries concerning appraisal methods used within the transport sector/ rail sector. Furthermore, it was analyzed to what extent impacts are monetized in the appraisal and how the three focus items are dealt with in each country (value of time, value of labor and environmental impacts of CO<sub>2</sub> and noise).

On basis of the analysis, a comparison was given to show major differences and commonalities between the countries concerning the before defined items and focus areas. They are summarized and displayed in the tables under.

<b>Commonalities</b>
Use of CBA as transport project appraisal method
Additional methods used to CBA
Impact on decision-making limited
Time and CO <sub>2</sub> valuation in monetary terms in CBA



<b>Differences</b>
“Case for HSR” differently strong due to: conventional rail network (quality), topography, population density etc.
CBA components and structure/ split of costs and benefits
Application of MCA (not at all or overriding principle vs. supplement to CBA)
Length of appraisal horizons
Theory vs. practice → theoretical inclusion of items (e.g. noise), but not applied in practice
Degree of monetization of impacts
Inclusion of value of labor and valuation of noise
Basis and reference measures for valuation of the items in focus
Use of mode-specific values (of time, CO <sub>2</sub> and noise)

**Table 4-24: Summary of main commonalities and differences in the appraisal methods and focus items among the case study countries (status May 2010)**

On the basis of the table, the research question 2 can now be answered. The crucial differences in outcomes for the evaluation of a Norwegian HSR arise from both stated hypotheses questions (2a and 2b). Firstly, they arise from discrepancies in the appraisal process itself and the items applied respectively their degree of monetization. Secondly, also differences in the transport market structure in comparison to the other countries contribute to a different outcome for an evaluation for a potential Norwegian HSR. This especially with regard to different degrees of competition of rail with other modes of transportation, a relatively poor quality of the Norwegian conventional rail system as well as a mountainous topography, a low population density and a relatively little number of overall citizens that represent a specific challenge for the Norwegian setting.

The next chapter will make use of the summary and reflections and conclusions on the Norwegian appraisal practice are given.



## **5 Reflections and conclusions on the Norwegian appraisal practice and further research**

This chapter represents part IV of the thesis and will answer the third research question. The differences and commonalities in the methods of the other countries are used to reflect on the Norwegian appraisal practice. The structure will follow the scheme used for the analysis, i.e. first there will be reflections on the general methods applied, followed by the three items: value of time, value of labor and environmental impacts. After this, a summary and conclusions are given. Finally, limitations and further research areas are pointed out.

### ***5.1 Reflections on the Norwegian appraisal practice***

Subsequently, reflections on the Norwegian appraisal practice are given.

#### **General methods applied**

The use of CBA in Norway for transport and rail projects is reasonable and based on a thorough methodological foundation. Norway is using a consistent and similar methodology across modes of transportation to secure comparability of appraisals. The categorization of costs and benefits after traffic participants cannot be complained about, since there is obviously nothing that is ex- or included in the wrong manner in comparison to the other countries.

The appraisal horizon is in comparison to the other case study countries relatively short with 25 years while the economic lives of the rail assets are in comparison relatively long and considerably longer than 25 years. Therefore, for the case of HSR it might be worth to think about adjusting/ prolonging the appraisal horizon project-specifically.

The non-use of MCA also seems justified, since impacts considered in an MCA in other case study countries, are covered by the additional methods (in specific by the consequence analysis) in Norway.

A project like HSR *could* have an impact on Norway's national economy since it would also represent a better connection to the whole European rail and thus transport network. This connection in turn could lead to more tourism, but also to more frequent and easier transport of not only passengers but maybe also freight in the long-run. A Wider Economic Impact Analysis as described and used in the UK for such large scale projects like HSR

could thus be useful because it might capture impacts of an HSR that have not yet been taken into account, making the case of HSR in Norway more clear (in either direction).

As mentioned in the theoretical part the definition of the “base case”/ counter-factual is quite important. Even if the HSR would *not* be built in Norway, the current train and track situation could not stay the same either and would ask for considerable investments in any case. Due to that, one might reconsider the “without scenario” in Norway to a case with more double-tracks and e.g. the before mentioned tilting trains which would offer a considerably higher average speed than what is state of the art in Norway today.

### **Value of time**

As one can see from the theory and the analysis, there are numerous ways of deriving and structuring the values of time (time savings), and as long as they are used in a methodologically consistent way they can generally not be criticized. Values of time across the countries differ primarily because of the different wage rates that are basis for e.g. the valuation of time savings for journeys within working time.

It is not clear though, why values *within* Norway for the same modes of transport differ so greatly, as the methodological basis should be the same. As mentioned in the Norwegian analysis, the time valuations between Jernbaneverket and Statens Vegvesen differ substantially (Økland 2008). The biggest difference is for commuter trips by train and leisure journeys, where Jernbaneverket values both 16% lower than Statens Vegvesen. This shows that values are still mode-specific as also found out in the analysis of this thesis. Hence, the intentional goal of the guidelines (from both Jernbaneverket and Statens Vegvesen) to create common time values across modes in order to make CBA outcomes comparable for the decision-makers has not yet been fulfilled. Thus, the valuation of time for the use in CBA especially with regard to investment in HSR should be further researched and if needed updated and/ or adjusted. This is specifically important as the valuation of time represents one of the major benefits of HSR as mentioned in the theoretical part of this thesis.

### **Value of labor**

Up to today, unemployment and thus the inclusion of employment effects as a benefit in appraisal has not been an issue in Norway. Additionally the methods applied in other countries and the level of accuracy concerning the data output are still controversial.

Therefore it can be concluded that the exclusion of this in the Norwegian CBA and overall appraisal seems reasonable.

However, HSR represents a large scale project with possible impacts on a nation's overall economy, which *can* include also labor supply and demand. A separate analysis of Wider Impacts like just mentioned for the setting of the UK, might be of relevance in the long-run. If the HSR should be built and used massively in Norway, the inclusion of labor effects might therefore become an issue and might be at least theoretically taken into account in appraisal of investment projects that exceed e.g. a specific sum of investment costs or are known to influence the nation's economy.

### **Environmental impacts**

As Jernbaneverket was commissioned to compare and report on how other countries deal with the monetization of non-market goods, this implies that Norway is willing to change and adjust their valuation processes if based on good methods and explanations. Therefore, some reflections based on the comparative analysis for the valuation of CO<sub>2</sub> and noise are presented subsequently.

- **CO<sub>2</sub>**

There is great uncertainty on how to include and measure CO<sub>2</sub> in the right manner in appraisal in general, and also within HSR appraisal. The most recent and comprehensive overview of the underlying methods and possible valuations is given in the Swedish SIKA report (SIKA 2009, p.61-64).

In comparison, Norway has as mentioned before quite ambitious climatic goals, while at the same time having the lowest CO<sub>2</sub> value of all case study countries. Norway is by monetizing and making use of mode-specific differentiations in valuations of CO<sub>2</sub> emissions in line with the main approach being used in the case study countries. The discussable part of the valuation is the basic prices of CO<sub>2</sub> Norway base its calculations on. As also Econ Pöyry concludes, the valuation of CO<sub>2</sub> after this planning period (that reaches up to 2012) needs to be revised (Econ Dec 2008).

Thus, the need for adjustment of valuation of CO<sub>2</sub> is obvious. A number of studies done by Statistics Norway (SSB) and the Climate and Pollution Agency (former SFT) show that the price per ton CO<sub>2</sub> would have to be increased considerably to achieve Norway's climatic

goals (SFT 2009). The just cited study concluded prices from 40 to 60 € per ton CO<sub>2</sub> by 2020 (ca. 320-480 NOK<sup>39</sup>), which is already noticeably higher than the ones in use now (highest value 34 €/ 272 NOK<sup>39</sup> per ton). The most recent available study by SSB evaluates different scenarios, taking into consideration the shifting quota prices on the market and proposes prices of at least 1 500 NOK per ton CO<sub>2</sub> for 2020 and for another scenario even over 3 000 NOK (Fæhn, Jacobsen, and Strøm April 2010). These values are at least more than five times as high as the ones in current appraisal use and show that a change of values for CO<sub>2</sub> is necessary in order to realistically take the emission targets of Norway into consideration.

Even though the overall effect on *one* specific HSR project might be small, the effect of a different CO<sub>2</sub> value being used not only for all rail projects, but also for the whole transport sector and other sectors might be significant. It could thus potentially have a crucial effect on appraisal of projects in all economy sectors in Norway.

- **Noise**

Noise is a monetized impact and is normally considered in the CBA of investment projects in the transport sector in Norway.

It is not quite clear from the available documents for Norway why exactly noise is not monetized for the use in CBA for HSR. It is doubtful that just on basis of the *expectation* that nobody would face any noise reduction or increase, the whole impact is left out of the CBA. It might well be that there is - as also in other countries like Sweden - still too little research or numbers available concerning the noise values for an HSR in operation. Might this be the case also for Norway, then the studies done by the EU and UIC as well data conveyed in the HEATCO initiative might represent a good starting point for including noise levels for HSR (Bickel et al. 2006; Tsamboulas and Mikroudis 2000; Tuominen 2008/ 2009; INFRAS/IWW 2004) since those initiatives put major effort into estimating data especially for HSR. This might help to revise the expectation or to prove the exclusion of valuation with scientific data at least.

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<sup>39</sup> Taking an average exchange rate of 8 (1 EUR to NOK in 2010) as basis (x-rates.com 12.05.2010).

## 5.2 *Summary and conclusions*

By accomplishing this thesis, the introductory mentioned goals of the thesis can be rated as fulfilled. Part I and II of the thesis built the basis and theoretical foundation for subsequent chapters by giving an outline of the most commonly used appraisal methods CBA and MCA as well as an introduction into the setting of an HSR evaluation. Typical costs and benefits were identified together with theoretical key parameters influencing the case of HSR.

Part III (chapter 4) answered the research questions 1 and 2 that were concerning the analysis of appraisal methods used for HSR in other countries and the reasons for the crucial differences in outcomes for the evaluation of an HSR in Norway. The comparative analysis led to commonalities and differences in the use of appraisal methods. CBA is used by all case study countries for rail/ HSR appraisal, while MCA is used less consistently. Furthermore, additional methods are used to cover further impacts of transportation investments. Main differences occur regarding the inclusion of the three items in focus (value of time, value of labor and environmental impacts), the methodological basis used and their degree of monetization. Moreover, market structures and specific circumstances in the countries (e.g. topography, population density) make the case for an HSR variably strong. Thus, both, methodological differences and varying market structures are reasons for the diverse outcomes of the appraisals.

The last part of the thesis (chapter 5) then answered the third research question and included reflections on the Norwegian appraisal practice based on the comparative analysis. The reflections on the Norwegian appraisal practice of rail/ HSR can be summarized as follows:

- The accomplishment of CBA is based on a thorough methodological foundation.
- The appraisal horizon of 25 years might be prolonged project-specific for the case of HSR, since the economic lives of rail assets are in comparison to other countries relatively long.
- Items and impacts included in MCA in other countries are covered by other additional methods in Norway.
- The use of a Wider Impact Analysis to capture impacts that have not yet been included in Norway's overall appraisal process might be useful in the long-run.

- The redefinition of the “base-case” for the Norwegian setting might be necessary since the rail network situation today will neither be able to cope with future transport demands nor to contribute to considerable emission reductions.
- The value of time might need to be updated and aligned across modes of transportation to reach the goal set in the guidelines to make use of common values of time.
- Today’s exclusion of value of labor and employment effects seems justified. In the long-run and in specific for a project of the scale of HSR, the theoretical inclusion of that parameter in such as the Wider Impacts Analysis might be useful.
- The CO<sub>2</sub> values in use in today’s appraisal should be revised and updated in order to take the climatic goals set by the Norwegian government into account appropriately.
- The exclusion of a value for noise in the CBA for HSR might be revised or based on scientific data as e.g. provided by the UIC or the EC.

Overall, it can be concluded that Norway is in comparison with other countries doing a thorough appraisal for transport projects. However, from all the countries studied, the appraisal process of the UK (when all the changes will come into force) from the author’s point of view can be rated as a best practice example.

As it became clear throughout this work, socio-economic appraisal methods do generally not give explicit and final answers regarding the social profitability of projects. The reasons for this are various, but as shown in the analysis, basic methodological differences and country specific settings can lead to very different results for similar projects.

Altogether, Norway faces a specifically unique setting for HSR regarding such factors as the very low total number of inhabitants, the widely spread population over the whole country and at the same time a demanding topography. These factors influence the appraisal of HSR (e.g. the potential demand, construction costs etc.) and therefore also parts of the evaluation of HSR might need to be more project-specific.

On the whole, a systematic comparison of the appraisal methods applied for HSR in specific, for this particular set of countries and this set of appraisal items has not been done before. Therefore, this thesis represents a relevant contribution to the field of study and all the more to the research mandate as released by the Norwegian government.



### ***5.3 Limitations and further research***

As it became clear throughout the thesis there are still some problematic and challenging areas concerning the topic of this work which are reasonable to be in focus of further research. Therefore, this section states the limitation(s) of this thesis as well as gives an insight on what further research should and could be done in the future.

One of the challenges that occurred was the limited availability of input data and information for the chosen countries. This did not only apply to the data itself, but especially to the language in which the most important documents are published. The author experienced that lots of information is just available in the native language of the country (e.g. national transport plans and methodologies). The author is capable of understanding English, German, Norwegian, Swedish and Spanish but it nevertheless represented a time-consuming challenge to deal with multilingual sources.

Another challenge faced were the “updates” the countries made in a very late phase of the writing process of this thesis. This concerned e.g. appraisal methodologies itself or institutional set ups that have influence on the whole appraisal practice (e.g. TAG units in the UK, Trafikverket establishment in Sweden). This made it necessary to set a last date of inclusion of data and information (which is the 10<sup>th</sup> May 2010) which could be seen as a limitation.

Furthermore, the comparison was done for three items out of numerous being included in a CBA. To give a more comprehensive overview and reflections, this should be done for all impact categories that are included in the CBA but were not discussed in this thesis. Preferably, this should include those impacts that also have major influence on the outcome of an appraisal (e.g. discount rates, inclusion of optimism bias etc.). Thus, a remaining research field for the Norwegian setting might be a comprehensive comparison of all components/ items being applied in other countries in appraisals for HSR.

Moreover, there is still considerable insecurity about how to measure and value CO<sub>2</sub> in all case study countries. There should be made further research on how to include this value in HSR appraisal. For Norway in specific there should be reached a consensus on what values per ton CO<sub>2</sub> emitted to use, since up to now there has still been considerable disagreement as shown by the reports from SSB and SFT (Fæhn, Jacobsen, and Strøm April 2010; SFT 2009).

It can be assumed that further research in these areas and for the named specific components, can lead on the one hand to a more accurate assessment of the items and on the other hand to methodological improvements for the Norwegian appraisal process in general.

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## **Appendix**

### ***Appendix A: Overview of available reports on the Norwegian HSR***

The following pages give an overview of available reports on the Norwegian HSR. The overview includes titles, (translated to English if needed), authors, publishing dates and whom the report was commissioned by. Furthermore, references are given as well as a short summary of contents.

Title of original report Title translated to English (Reference)	Author	Publishing date Commissioned by	Keywords of content & results
<p><b>Høyhastighet Oslo-Kornsjø (Gøteborg), Jernbaneutredning Hovedrapport</b></p> <p>High-speed Oslo-Kornsjø (Gothenburg), Railway appraisal Main report  (NSB 1992)</p>	<p>NSB konsernstab strategi og miljø</p>	<p>Oct. 1992  NSB AS</p>	<ul style="list-style-type: none"> <li>* Reasons for building a HSR in Norway</li> <li>* 3 alternative corridors for the track Oslo-Gøteborg via Kornsjø</li> <li>* Market analysis → possible demand</li> <li>* infrastructure and operation planning</li> <li>* Cost-benefit analysis</li> <li>* Economical impacts of building it for Norway</li> <li>* results: NSB recommends building the HSR with a double track from Oslo-Gøteborg (via Kornsjø) with a speed of min. 200km/h – use for both: passenger and freight traffic.</li> <li>Reasons for the recommendation are: <ul style="list-style-type: none"> <li>- economically beneficial for NSB</li> <li>- travel time reduction by more than 50%</li> <li>- positive impacts on train users, businesses in the Oslo-region and the society in total (employment market, reduced emissions etc.)</li> <li>- gaining market share from air traffic market and (private) road traffic</li> </ul> </li> </ul>
<p><b>Høyhastighet Oslo-Kornsjø (Gøteborg), Kvalitetssikring av de samfunnsøkonomiske lønnsomhetsberegningene</b></p> <p>High-speed Oslo-Kornsjø (Gothenburg), Quality assurance of the social economic profitability</p>	<p>Bråthen, Svein Hjelle, Harald M.</p>	<p>Oct. 1993  NSB AS</p>	<ul style="list-style-type: none"> <li>* report written for NSB, going through methods, preconditions and calculations of the mentioned report</li> <li>* focusing on just Oslo – Kornsjø (Alternative A) that NSB at that point had decided on</li> <li>* description of CBA as a model and method and the assumptions and basis of calculations</li> <li>* market analysis of the passenger market</li> <li>* CBA for mentioned corridor, including monetizing some environmental aspects like CO2 and NOx(also neglecting any side effects during the building phase)</li> </ul>



evaluations (Bråthen and Hjelle 1993)			though) * sensitivity analysis for different variables and stating alternative preconditions for factors with high uncertainty * results: - most uncertain and sensitive affecting the outcome is the further development of traffic → considerable variations in the cost-benefit ratio outcome depending on which forecasts to rely - cost-benefit ratio of 0.58, which is less than the one mentioned in the NSB report with 0.65 - main comment on report from NSB is the lack of documentation and verification of how the cost-benefit calculations were done
<b>Feasibility Study Concerning High-Speed Railway Lines in Norway – Report Phase 1</b> (VWI and partners Dec 2006)	Verkehrswissenschaftliches Institut Stuttgart (VWI) and partners	Dec. 2006  Jernbaneverket	* definition of HSR by a European comparison of existing HS-concepts * Transport market analysis for Norway and potentials for HSR * result of these 2 steps is the decision of which corridors to focus on in Phase 2 (also evaluating their potential positive outcome in a CBA) * result: corridors to be focused in Phase 2 are Oslo-Trondheim and Oslo-Gjøteberg
<b>Feasibility Study Concerning High-Speed Railway Lines in Norway – Report Phase 2</b> (VWI and partners Oct 2007a)	Verkehrswissenschaftliches Institut Stuttgart (VWI) and partners	Oct. 2007  Jernbaneverket	* for the 2 chosen corridors of Phase 1 a operation and infrastructure planning is worked out as well as a CBA (note: neglecting environmental impacts and their monetization that can occur during the phase of building the HSR) * impacts and effects of HSR are analyzed * conclusion and recommendation about the realization of HSR in Norway * announcement of a Phase 3 parallel to Phase 2 * recommendation of Phase 2: both chosen corridors result in a positive cost-benefit-ratio and VWI advises that “further steps leading to realization should be done” (p.57)
<b>Feasibility Study Concerning High-Speed</b>	Verkehrswissenschaftliches Institut	Oct. 2007	* detailed analysis of corridors in the south-west of Norway

<p><b>Railway Lines in Norway – Report Phase 3</b> (VWI and partners Oct 2007b)</p>	<p>Stuttgart (VWI) and partners</p>	<p>Jernbaneverket</p>	<p>* regarded corridors are: Oslo to</p> <ul style="list-style-type: none"> <li>- Bergen (different variants)</li> <li>- Kristiansand</li> <li>- Stavanger (different variants)</li> </ul> <p>And the corridor Bergen – Stavanger (different variants)</p> <p>* again infrastructure and operation planning was done as well as cost estimates (overall a more simplified evaluation than for the corridors from Phase 2)</p> <p>* main goal is to find out if “HSR-lines in Norway show a positive result in an economic evaluation” (p.IX)</p> <p>* results: based on the simplified evaluation also positive benefit-cost-ratios for the corridors</p> <ul style="list-style-type: none"> <li>- Oslo-Trondheim</li> <li>- Oslo-Bergen</li> <li>- Oslo – Kristiansand – Stavanger</li> </ul> <p>* overall recommendation: HSR in Norway is possible and advisable for the reason of reduced travel times, greenhouse gases, exhaust of emissions, improved accessibility between major cities and reduced domestic air traffic</p>
<p><b>High-Speed Railway Lines in Norway, Concept Evaluation, Cost Estimate and Uncertainty Analysis – Report 1</b> (MetierAS Oct 2007a)</p>	<p>Metier AS</p>	<p>Oct. 2007</p> <p>Jernbaneverket</p>	<p>* Basic assumptions and methodology (relying on the data from the VWI report Phase 1)</p> <ul style="list-style-type: none"> <li>* Calculations for the corridor Trondheim-Oslo (and its different sub-sections)</li> <li>- Operational and technical concept</li> <li>- Investment cost estimate</li> <li>- Uncertainty analysis</li> </ul> <p>*results:</p> <ul style="list-style-type: none"> <li>* Operational and technical concept:</li> </ul>

			<ul style="list-style-type: none"> <li>- just passenger traffic</li> <li>- single track with crossing sections</li> <li>- design speed of 300km/h (with some exceptions)</li> </ul> <p>Main uncertainties: planning still in feasibility stage, contractor and materials market, project ownership</p>
<p><b>High-Speed Railway Lines in Norway, Concept Evaluation, Cost Estimate and Uncertainty Analysis – Report 2</b> (MetierAS Oct 2007b)</p>	Metier AS	<p>Oct. 2007</p> <p>Jernbaneverket</p>	<ul style="list-style-type: none"> <li>* seen as an amendment and only in conjunction with Report 1; relying on VWI's report Phase 1</li> <li>* Quantitative results of investment costs for all corridors, including the share of bridges, tunnels and open-line</li> <li>* results: <ul style="list-style-type: none"> <li>- design speed reduced to 250km/h (with some exceptions)</li> <li>- hourly train departures in peak times for all corridors</li> <li>- basis is today's HSR technology (some exceptions for tunnels or special fjord-crossings)</li> <li>- single-track lines on all corridors except Oslo-Bergen and Oslo-Stavanger (double-track lines)</li> </ul> </li> <li>* Main uncertainties and its drivers are the same as in Report 1</li> </ul>
<p><b>St.melding. nr. 16: Nasjonal transportplan 2010-2019</b></p> <p>National transportplan 2010-2019 (Regjeringen 2008/ 2009)</p>	Det Kongelige Samferdselsdepartement	<p>2008/ 2009</p>	<ul style="list-style-type: none"> <li>* HSR dealt with on p.172-176</li> <li>* high-speed standards in the Inter-City traffic, pointing out the most important factors for a potential HSR in Norway e.g. the stop-pattern, design speed, curve radius etc.</li> <li>* short summary of VWI and Econ reports</li> <li>* conclusion: the government is of the opinion that due to the results of the reports [Econ, VWI], the concept of HSR must be further developed and adjusted to the Norwegian setting before it can be topical for Norway.</li> </ul>
<p><b>Klimaeffekter av høyhastighetstog</b></p>	Econ Pöyry AS	Oct.	<ul style="list-style-type: none"> <li>* background for report: the VWI reports and their broadly discussed outcomes → Samferdselsdepartement asked for a more detailed study of climatic changes and</li> </ul>

<p>Climatic consequences of a High-speed train</p> <p>(Econ Oct 2008)</p>		<p>2008</p> <p>Samferdselsdepartement</p>	<p>intrusion of nature and wildlife of building an HSR</p> <ul style="list-style-type: none"> <li>* finding out the potential reduction of greenhouse gases and CO<sub>2</sub> through an HSR</li> <li>* which framework conditions need to be changed in order to achieve a gain of market share for the HSR from air traffic</li> <li>* the impact of technological development within HSR until 2020 on the reduction of emissions due to substitution effect from air and road to HSR</li> <li>* results for looking at the corridors Oslo-Trondheim and Oslo-Bergen: <ul style="list-style-type: none"> <li>- building HSR represents quite an extensive intrusion on nature and wild life</li> <li>- the potential of HSR contributing to a reduction of emissions in Norway is limited (approx. 3 per mill)</li> <li>- the possible emission reduction is dependent on the amount of people taking the HSR instead of a flight or the car</li> <li>- technical improvement until 2020 will most likely reduce the emissions of an HSR</li> <li>- the emissions emitted due to the building of the HSR are quite high as well</li> <li>- investments in other initiatives like bio-fuel or electrified cars are much cheaper with a much higher potential of reducing emissions</li> </ul> </li> </ul> <p>(HSR would have costs of 40-50 000 NOK per reduced ton CO<sub>2</sub>, while in comparison all other feasible alternatives have highest costs of 1 300 NOK per ton)</p>
<p><b>Nytte-kostnadsanalyse av høyhastighetstog i Norge</b></p> <p>Cost-benefit analysis of a high-speed train in Norway</p> <p>(Econ Dec 2008)</p>	<p>Econ Pöyry AS</p>	<p>Dec. 2008</p> <p>Samferdselsdepartement</p>	<ul style="list-style-type: none"> <li>* background for report being written: the VWI report(s) and their broadly discussed positive outcomes → main criticism: different methods for CBA done by VWI compared to the one used in Norway for such projects</li> <li>* therefore: new CBA done according to the Norwegian method, like the VWI report neglecting environmental impacts and their monetization that can occur during the phase of building the HSR</li> <li>* Comparison of CBA methods (different components) in Norway and Germany</li> <li>* results: HSR for the corridors Oslo-Trondheim and Oslo-Gøteborg are social-</li> </ul>

			<p>economically not profitable for the reason of</p> <ul style="list-style-type: none"> <li>- too low passenger numbers</li> <li>- benefits of both corridors too low to justify the high investment costs of building the lines</li> </ul>
<p><b>Energi- og klimakonsekvenser av moderne transportsystemer – Effekter ved bygging av høyhastighetsbaner i Norge</b></p> <p>Energy- and climatic consequences of modern transport systems – effects of building a high-speed railway in Norway</p> <p>(Naturvernforbund Sep 2008)</p>	<p>Norges Naturvernforbund (Friends of the Earth Norway)</p>	<p>Sept. 2008</p> <p>Independent work</p>	<ul style="list-style-type: none"> <li>* background for report being written was the lack of knowledge concerning long-term energy- and climate effects of transport as seen from a life-cycle perspective of a project (building, maintenance and operation)</li> <li>* focus on middle and long distance travels</li> <li>* this was done for the planned HSR project in Norway comparing several aspects (CO<sub>2</sub>, greenhouse gases etc) and their outcome to air as well as road traffic and their environmental performance</li> <li>* results: <ul style="list-style-type: none"> <li>- HSR has best results for long-distance journeys concerning energy consumption and emissions (in comparison to air traffic and road) and can contribute a lot to the reduction of Norway’s emissions</li> <li>- Building a single-track line for Oslo-Trondheim saves ¼ of the emissions during the building phase in comparison to a double-track, while the difference of impact on the climate of both versions when operating is even less than that</li> <li>- biggest potential for HSR lies in reduction of emissions due to gaining market share from air and road traffic (passenger and freight transport) → therefore important to invest in corridors that can compete with air travel times, e.g. Oslo-Stockholm</li> </ul> </li> </ul>

**Appendix B: Methodological differences between the German and Norwegian evaluation procedure for HSR**

The German one is represented by the use in the VWI report, the Norwegian one by Jernbaneverket (VWI and partners Oct 2007a, p.85).

	German method	Norwegian method
Basis	Physical numbers Valuation of definite, physical changes	Market reflecting the society's valuation. Correction of market imperfections
Discount rate	Risk premium not included	Risk premium included
Passengers' benefit	Is calculated direct on the basis of changes in <ul style="list-style-type: none"> <li>• costs of driving</li> <li>• time costs (incl. waiting time)</li> </ul> for travellers transferred from one mode of transport to another  The benefit does not reflect changes in other factors (e.g. comfort) due to change of mode  The benefit is calculated for existing and transferred travellers. Utility for new travellers results in an add-on of 10 per cent	Is calculated direct on the basis of changes in <ul style="list-style-type: none"> <li>• operator's payment</li> <li>• consumer surplus</li> </ul> Operator's payment is included in the operators utility (see below)  Consumer surplus reflects the difference between the total willingness to pay and the actual price/payment. In principle the value of all elements of supply are included.  Travellers' benefit is calculated as change in the consumer surplus where current travellers are credited for the value of the whole improvement (e.g. shortening of travel time). Transferred and new passengers are credited for half the value.
Operators' benefit	Computing the costs only	Both income and expenses are computed. Changes of income reflect changes of travellers' benefit partly (see above)
Public utility	Infrastructure investments and maintenance (road is a part of reduced travel cost, see above)	Infrastructure investments and maintenance Changed public purchase Changes in government decided taxes
Remaining sectors of the society	Cost due to accidents Cost due to air pollution (rates for emissions of greenhouse gasses exceed price on the stock market)  Specific valuations of <ul style="list-style-type: none"> <li>• Employment</li> <li>• International relations</li> <li>• Better connections to key points as (sea) ports and airports</li> </ul>	Cost due to accidents Cost due to air pollution (rates for emissions of greenhouse gasses correspond to the price on the stock market 2008/2009). Noise reduction due to lowered traffic  No valuation of effects on employment (given no unemployment)  It is assumed that value of international relations and connection to key points are reflected in operators' and travellers' utility

**The HSR appraisal case of Norway vs. Germany**

While the cost-elements in both methods are almost the same including such as construction, maintenance, operation, purchasing of trains etc; the benefits of an HSR are categorized very differently. The following table should give a short overview of that (information taken from Econ Dec 2008, p.3). It can be seen that the main difference is that in Norwegian practice benefits are split up after which “participant” of transport is affected.

Differences in categorizing benefits for HSR in the German and Norwegian method (Econ Dec 2008, p.3)<sup>40</sup>

Benefit categories of HSR after the German method	Benefit categories of HSR after the Norwegian method
Modal shift (i.e. passengers choosing HSR instead of plane or car)	Transport user benefit, i.e. the benefits for users of HSR (like reduced travelling time and better mobility)
Increased safety	Operators benefits, i.e. changes in costs and income for the operators
Time savings and better accessibility	Public benefits, i.e. income and costs for the public
Employment effects in the building and operation phase	Other social benefits, concerning e.g. congestions, environmental effects and accidents
Improved international connection	
Decrease in congestions	
Reduced emission of greenhouse gases and local pollution	

For the purpose of showing what has been explained before, an example for the potential Oslo-Trondheim route shall be mentioned here, showing the great differences in outcomes between the two methods applied. The bottom line is that the route is highly profitable after the German method, while being totally unprofitable when the Norwegian one is applied<sup>41</sup>.

Not only are the costs approx. 20% higher using the Norwegian method, but also the benefits calculated are just one fourth of those calculated after the German method.

<sup>40</sup> Translated by the author. The reports from Econ Pöyry are just available in Norwegian.

<sup>41</sup> Even after also fulfilling a sensitivity analysis for the Norwegian numbers, using values from the German method like higher CO<sub>2</sub> prices, shifts in demand, discount rate etc.

One of the main benefits calculated after the VWI method are benefits from “modal shift”<sup>42</sup> which represent in the case of the Oslo-Trondheim corridor approx. 44% of all benefits. The Norwegian method does not value this shift separately, since it is argued that these effects are already included in the calculation of benefits for generated traffic and time savings (Econ Dec 2008). Due to the assumption that in the long-run marginal costs will equal the ticket price for a transport mode, i.e. less costs will lead to less income, it is argued that in the long-run the net-effect for transport operators will be zero. This is also the main reason for the difference in the numbers of the category “time savings and traffic” in the table above.

The value of labor respectively positive impacts of an HSR on employment creation are another important part of benefits in the German method. In the Norwegian method this is not included at all, since due to its special labor market, it is supposed full employment during the investment and operation phase of an HSR project. The German method puts a significantly high value on employment creation (e.g. for the Oslo-Trondheim corridor, these effects make up 38% of all external benefits according to VWI (VWI and partners Oct 2007a, p.51)). The reasoning for the high value for employment creation in the German method is the structural unemployment in regional parts of Germany. Projects creating jobs are therefore highly valuable. The Norwegian setting, however, is totally different, having faced almost none unemployment since the Second World War. That is the reason why employment creation is not included in the Norwegian CBA method. A large project like building HSR can in fact have the opposite effect, i.e. putting financial pressure on the national economy and subsequently leading to increased labor prices (Econ Dec 2008). Anyway, the Econ report concludes that the inclusion of some of the regional effects mentioned for other countries might in the long-run become interesting for Norway as well.

After this it should be pointed out that employment creation and modal shift account for already 82% of all benefits for the Oslo-Trondheim route after the German method.

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<sup>42</sup> Modal shift is said to be a benefit in the sense of leading to a decrease in costs for operators in other modes of transport (e.g. airlines) due to customers using HSR instead.



### *Appendix C: CBA of the potential HSR Götalands- and Europabanan in Sweden*

The effects are given in million SEK (2006 prices) (Banverket 2008, p.38).

Götalands- och Europabanan och frigjord kapacitet på stambanorna	Effekter i Mkr under ett år enligt prognos för 2020	Effekter i Mkr under 60 år diskonterade till 2010
<b>Sanhällsekonomisk anläggningskostnad</b>	<b>-3 909</b>	<b>-91 437</b>
<b>Effekter för infrastrukturhållaren</b>	<b>-205</b>	<b>-4 787</b>
Reinvesteringar	-82	-1 915
Drift och underhåll	-123	-2 873
<b>Effekter för persontrafik</b>	<b>11 499</b>	<b>268 969</b>
Konsumentöverskott	5 806	135 812
Producentöverskott	5 610	131 224
Statens finanser	-292	-6 822
Externa effekter	374	8 755
<b>Effekter för godstransporter</b>	<b>1 252</b>	<b>29 279</b>
Godskunders tidsvinster	66	1 536
Transportkostnader	501	11 718
Externa effekter	685	16 025
<b>Summa Nyttor</b>	<b>12 546</b>	<b>293 461</b>
<b>Nettonuvärde</b>	<b>8 637</b>	<b>202 024</b>
<b>Nettonuvärdeskvot</b>	<b>2,2</b>	<b>2,2</b>

*Appendix D: Values of time for Swedish private and business journeys*

Prices are given in SEK per hour (2006 price levels) (SIKA 2009, p.33).

	<i>Regionala resor</i>	<i>Långväga resor</i>
Åktid	51	102
<i>Turintervall</i>		
< 10 minuter	87	42
11-30 minuter	28	42
31-60 minuter	24	42
61-120 minuter	15	22
> 120 minuter	8	10
<i>Bytestid</i>		
Alla fm utom flyg	102	203
Flyg	102	174

	<i>Bil</i>	<i>Flyg</i>	<i>Långväga tågresor</i>	<i>Regionala tågresor</i>	<i>Buss</i>
Åktid	275	275	275	275	275
<i>Turintervall:</i>					
< 60 minuter		211	192	244	147
61 – 120 minuter		176	134	171	147
> 120 minuter		140	115	171	122
Bytestid		275	275	275	275

### ***Appendix E: Formulas for deriving values of noise from railways for the use in Swedish appraisal***

The values derived are given in SEK per person per year at 2006 price levels. There are two categories to be distinguished: traffic levels with up to 150 trains per day (formula 7.1 has to be used), and levels with more than 150 trains per day (formulas 7.2 and 7.3) (SIKA 2009, p.52).

För järnvägsbuller rekommenderas fortsatt användning av nedanstående formler som har anpassats för att visa värden i 2006-års penningvärde. Formel (7.1) gäller för en trafikmängd på 150 tåg per dygn eller mindre.

$$BV \text{ (kr / person och år)} = 6,9(70 + t)^{1,1} [\exp(0,18(N - 45)^{0,88}) - 1] \quad (7.1)$$

t = antal tåg per dygn (t ≤ 150)

N = maxbuller inomhus, dBA

Vid trafik med mer än 150 tåg per dygn skall bullervärdet beräknas enligt formel (7.2) och (7.3).

$$M = 1 + (T - 150) / 1050 \quad (7.2)$$

T = antal tåg per dygn (T > 150)

$$\text{Bullervärde (kr/person och år)} = BV(\text{för } t=150) * M \quad (7.3)$$

För luftfart och sjöfart rekommenderas att värderingen av buller görs på samma sätt som för järnväg.

### **Appendix F: Illustrative CBA for an HSR in the UK**

The table below shows the CBA for the London- West Midlands route where the numbers are given as percentages of total costs or benefits. 78% of the benefits were from time savings for the users and reduced overcrowding as well as less accidents, while 19% came from increased net revenue. Only 3% were because of reduced congestion. Released capacity was not taken into consideration in that analysis, but as mentioned by the authors would have added 7% to the overall benefits (De Rus and Nash Dec 2007).

CBA of the HSR project in the UK for the London-West Midlands corridor (After Atkins (2003) cited in De Rus and Nash Dec 2007, p.12)<sup>43</sup>

<b>HSR UK: London – West Midlands corridor</b>	<b>in % of Total Benefits or Costs</b>
<b>Benefits - Revenue</b>	
HSL Revenue	64%
Classical rail revenue	-45%
<i>Net rail revenue</i>	<b>19%</b>
<b>Benefits - Users</b>	
Journey time/ reduced overcrowding	76%
Accidents	2%
<i>Total user benefits</i>	<b>78%</b>
<b>Benefits – Non-users</b>	
Journey time/ vehicle operating costs	3%
<i>Total Non-user Benefits</i>	<b>3%</b>
<b>Present Value Benefits</b>	<b>100%</b>
<b>Costs</b>	
Capital	<b>69%</b>
HSL Operating	<b>41%</b>
Classic Operating	<b>-9%</b>
<b>Present Value Costs</b>	<b>100%</b>

To sum it up, the line in the UK represented a strong case for building HSR since the rail network in the UK was congested and close to its capacity limit, additionally growing demand was forecasted. The CBA for the corridor lead to a positive cost-benefit-ratio (>1). Beneficial for the case was/ is also the geography of the main cities in the country, which could be more or less served by one line.

<sup>43</sup> The author of the thesis did not have access to the report, since the numbers cited in De Rus and Nash refer to an *unpublished* full report of Atkins (2003): High Speed Line Study, London.

**Appendix G: NATA sub-objectives and other topics to be addressed within an Strategic Environmental Assessment (SEA)**

(TAG2.11d 2009, p.9)

NATA Objective	NATA sub-objective	SEA topic (SEA Directive, Annex If)
Environment	Noise	Human health, population <sup>1</sup> , inter-relationships
	Local air quality <sup>2</sup>	Air, human health, population
	Greenhouse gases	Climatic factors
	Landscape	Landscape
	Townscape	
	Heritage	Cultural heritage including architectural and archaeological heritage
	Biodiversity <sup>3</sup>	Biodiversity, fauna, flora, soil <sup>4</sup>
	Water environment	Water
	Physical fitness	Human health, population
Safety	Accidents	Human health, population
	Security	
Accessibility	Community severance	Population
	Access to the transport system	
Economy	Public Accounts	Material assets <sup>5</sup>
	Business Users & Providers	
	Consumer Users	

<sup>1</sup> Population is interpreted broadly, referring to effects on people and quality of life. Many NATA indicators incorporate population.

<sup>2</sup> The NATA local air quality indicator does not cover regional air quality, though guidance is given on its assessment. Where regional air quality is likely to be an issue, a local objective may be formulated.

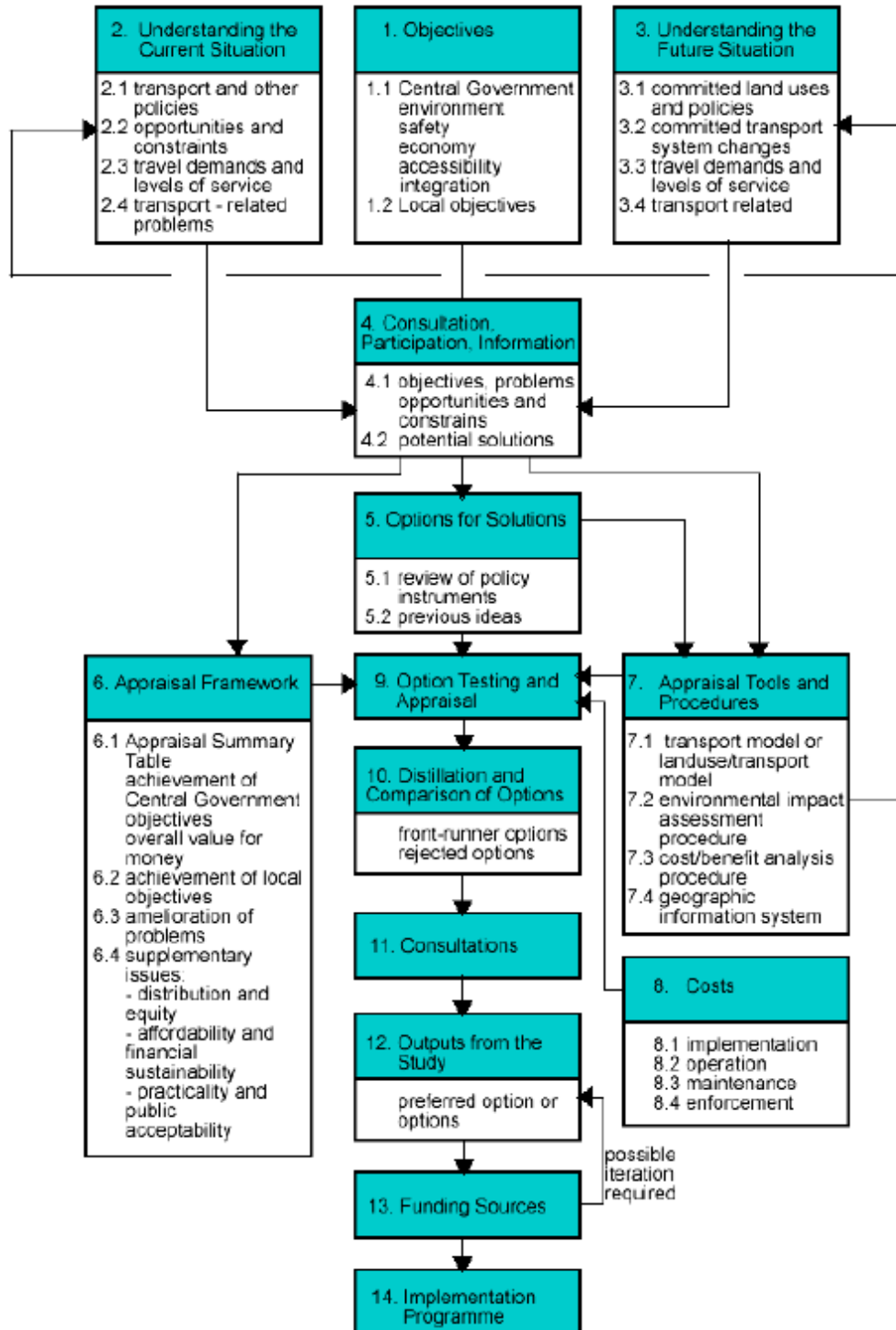
<sup>3</sup> Biodiversity also covers geological interests.

<sup>4</sup> Soil is not explicitly covered by NATA sub-objectives, but is an underlying factor affecting landscape, heritage, biodiversity and the water environment. Where effects on soil are likely to be important, a local objective should be formulated.

<sup>5</sup> Material assets are not explicitly covered by NATA sub-objectives, but are reflected in the money costs incurred when they are consumed. Where effects on material assets such as infrastructure, property and sterilisation of mineral or other resources are expected to be of particular importance, a local objective should be formulated.

**Appendix H: Transport study approach in the UK according to the most recent NATA documents**

(TAG1.1d 2010, p.4)



## ***Appendix I: Traded and non-traded values for CO<sub>2</sub> for use in the UK appraisal process***

(TAG3.3.5d 2010, p.6)

Carbon values are provided until 2050. There are higher and lower estimated values included for the use in sensitivity analysis.

<b>Table 2 : Traded and Non Traded Values, £ per Tonne of Carbon for use in Appraisal (2008-2050) expressed in 2002 prices</b>						
<b>Year</b>	<b>Traded</b>			<b>Non traded</b>		
	<b>Low</b>	<b>Central</b>	<b>High</b>	<b>Low</b>	<b>Central</b>	<b>High</b>
2008	36.03	63.58	79.27	75.96	151.93	227.89
2009	36.58	64.53	80.46	77.10	154.21	231.31
2010	37.12	65.51	81.66	78.26	156.52	234.78
2011	37.67	66.51	82.89	79.43	158.87	238.30
2012	38.25	67.48	84.15	80.63	161.25	241.88
2013	38.81	68.50	85.40	81.84	163.67	245.51
2014	39.39	69.52	86.68	83.06	166.13	249.19
2015	40.00	70.57	87.98	84.31	168.62	252.93
2016	40.60	71.64	89.30	85.57	171.15	256.72
2017	41.20	72.70	90.65	86.86	173.71	260.57
2018	41.83	73.79	91.99	88.16	176.32	264.48
2019	42.46	74.91	93.39	89.48	178.97	268.45
2020	43.08	76.02	94.78	90.82	181.65	272.47
2021	49.37	89.61	117.09	92.34	184.68	277.02
2022	55.66	103.20	139.40	93.85	187.70	281.56
2023	61.95	116.79	161.71	95.37	190.73	286.10
2024	68.23	130.38	184.02	96.88	193.76	290.64
2025	74.52	143.97	206.33	98.39	196.79	295.18
2026	80.81	157.56	228.64	99.91	199.81	299.72
2027	87.10	171.15	250.95	101.42	202.84	304.26
2028	93.39	184.74	273.26	102.93	205.87	308.80
2029	99.67	198.33	295.58	104.45	208.90	313.35
2030	105.96	211.92	317.89	105.96	211.92	317.89
2031	115.80	231.60	347.40	115.80	231.60	347.40
2032	125.64	251.28	376.92	125.64	251.28	376.92
2033	135.48	270.96	406.44	135.48	270.96	406.44
2034	145.32	290.64	435.96	145.32	290.64	435.96
2035	155.16	310.32	465.48	155.16	310.32	465.48
2036	165.00	330.00	494.99	165.00	330.00	494.99
2037	174.84	349.68	524.51	174.84	349.68	524.51
2038	184.68	369.35	554.03	184.68	369.35	554.03
2039	194.52	389.03	583.55	194.52	389.03	583.55
2040	204.36	408.71	613.07	204.36	408.71	613.07
2041	214.20	428.39	642.59	214.20	428.39	642.59
2042	224.03	448.07	672.10	224.03	448.07	672.10
2043	233.87	467.75	701.62	233.87	467.75	701.62
2044	243.71	487.43	731.14	243.71	487.43	731.14
2045	253.55	507.10	760.66	253.55	507.10	760.66
2046	263.39	526.78	790.18	263.39	526.78	790.18
2047	273.23	546.46	819.69	273.23	546.46	819.69
2048	283.07	566.14	849.21	283.07	566.14	849.21
2049	292.91	585.82	878.73	292.91	585.82	878.73
2050	302.75	605.50	908.25	302.75	605.50	908.25

These values are equivalent to those given in Annex 4 in the DECC guidance 'Carbon Valuation in UK Policy Appraisal', July 2009. They differ because they are expressed in 2002 prices. They are also expressed in £ per tonne of carbon rather than CO<sub>2</sub>. These values will be updated annually to reflect updates published by DECC.

Values for appraisal beyond 2050 will soon be published by DECC. Please consult the Department if you have any doubts about which values should be used.

**Appendix J: Monetary valuation of changes in noise level in the UK**

(TAG3.3.2d 2010, p.9)

<b>Table 2: Monetary valuation of changes in noise level (per household, 2002 prices)</b>		
<b>L<sub>Aeq, 18hr</sub> dB(A)</b>		<b>£ per household per dB change</b>
<b>Low</b>	<b>High</b>	
	<45	0.0
45	46	8.4
46	47	11.1
47	48	13.7
48	49	16.3
49	50	19.0
50	51	21.6
51	52	24.2
52	53	26.9
53	54	29.5
54	55	32.1
55	56	34.8
56	57	37.4
57	58	40.0
58	59	42.7
59	60	45.3
60	61	48.0
61	62	50.6
62	63	53.2
63	64	55.9
64	65	58.5
65	66	61.1
66	67	63.8
67	68	66.4
68	69	69.0
69	70	71.7
70	71	74.3
71	72	76.9
72	73	79.6
73	74	82.2
74	75	84.9
75	76	87.5
76	77	90.1
77	78	92.8
78	79	95.4
79	80	98.0
80	81	98.0



**Appendix K: Illustrative CBA for Spain for the Madrid-Seville corridor**

The illustrative CBA for the Spanish case is an ex-post one for the Madrid-Seville corridor. The line was constructed from 1987 to 1992, where in the latter year it was also put into operation. The table below shows the ex-post CBA. All taxes have been eliminated in the cost-section, since they represent rather revenue for the whole society than costs according to the authors.

CBA of the HSR project in Spain in the Madrid-Seville corridor (Coto-Millán, Inglada, and Belén 2007, p.921 (corrected))

<b>HSR Spain: Madrid-Seville corridor</b>	<b>in Million € of 2002</b>
<b>Total costs of infrastructure, maintenance &amp; operation</b>	<b>5 190.9</b>
Infrastructure	2 450.5
Residual value	68.8
Movable material	666.4
Infrastructure maintenance	450.3
Operation	1 692.4
<b>Total benefits</b>	<b>3 154.4</b>
Time savings for users	1 900.2
Other modes of transport	631.1
Travels generated	1 269.1
<b>Reduction of costs in</b>	<b>1 254.2</b>
Conventional train	254.1
Plane	261.0
Buses	24.4
Operating costs of car	300.5
Congestion	15.5
Accidents	145.5
Environment	78.1
Maintenance	175.1
<b>Net present value of the HSR</b>	<b>-2 036.5</b>

The main benefits for the line were due to time savings and generated traffic (44%), and also a percentage from reduced operating costs from other modes of transport (22.5%), i.e. shifts from other modes. Diverted traffic for the new line came mainly from conventional train and air transport (De Rus and Nash Dec 2007). Due to the HSR, rail is now the

dominating mode in Madrid-Seville corridor, even exceeding the market share of cars, which is a very rare case in Spain (Carrera-Gómez et al. 2006).

The summary of the ex-post CBA of the Madrid-Seville HSR is that the costs of the project exceed the benefits, and is even in the best case scenario<sup>44</sup> having a negative outcome of 2 036 million € (2002)<sup>45</sup>, which represent social costs to society. One reason for the poor performance is that the demand forecast and actual traffic volume was influenced mainly by the Universal Exhibition (EXPO) held in Seville in 1992.

Noticeable in the Spanish case is though, that construction costs are much lower than e.g. in UK, Germany or Norway. This is also due to a large amount of subsidies Spain received for building their infrastructure network by the regional development funds (SteerDaviesGleave Feb 2004)).

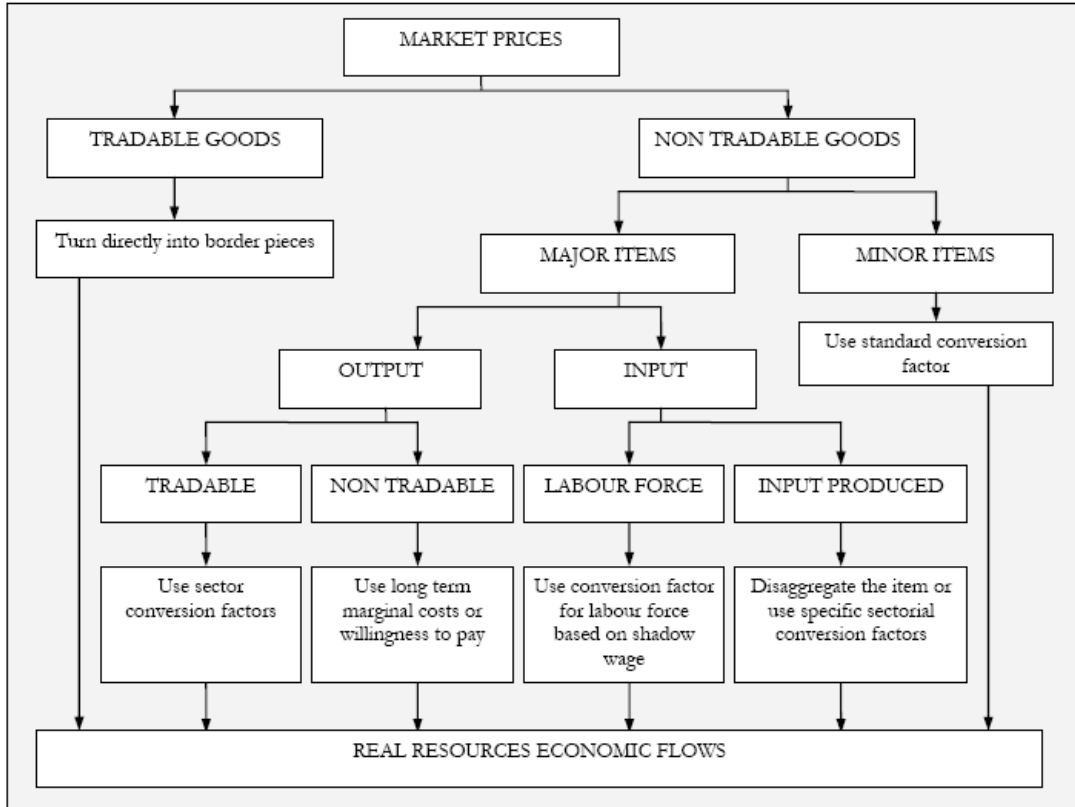
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<sup>44</sup> There was done a sensitivity analysis for different assumptions: a different project life length, shadow pricing for labor, GDP rate growth and an increase in generalized costs of car, train and bus.

<sup>45</sup> The numbers in the table are taken from the ex-post analysis of De Rus and Inglada from 1997, but instead of Pesetas, are converted by Coto-Millán et al. to € of 2002.

**Appendix L: The price measures used in Spain and the EU for economic appraisal**

(EuropeanCommission 2008, p.50)



Source: Adapted from Saerbeck (1990).

***Appendix M: The variety of values of time for the Spanish appraisal***

Below the different values of time are shown that were derived by different studies over time and show the variety and non-uniformity within Spanish appraisal practice. The first column states the reference, the second the concept being used (e.g. per hour per person and vehicle, value of one hour in a specific mode of transport like ferry, the motive of travelling etc.). The third column shows the value of time unit in Euros of 2005 (Riera, García, and Brey 2006).

Referencia	Concepto	Valor (euros 2005)
<b>Tiempo</b>		
Matas (1991)	Hora de viaje en vehículo por persona	2'98
Matas (1991)	Hora a pie	3'54
MOPT (1992)	Hora de viaje en vehículo por persona	6'65
Hunt (1992)	Hora de viaje por vehículo	17'45
Ortúzar y González (2002)	Valor de 1 hora para usuarios de avión	12'51
Ortúzar y González (2002)	Valor de 1 hora para usuarios de <i>jet-foil</i>	13'49
Ortúzar y González (2002)	Valor de 1 hora para usuarios de ferry	2'36
Riera (1997)	Hora de viaje en coche particular por motivo de ocio	5'96
González-Savignat (2004)	Hora de viaje de trabajo en vehículo por persona (corta y larga duración)	12'86,11'93 *
González-Savignat (2004)	Hora de viaje de ocio en vehículo por persona (corta y larga duración)	7'36,6'84 *

**Appendix N: Method used for the estimation of external costs of noise for Spain**

(INFRAS/IWW 2004, p.35)

