High Speed Rail

Challenges for the High Speed Rail project in Norway

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Preface

This thesis marks the end of the bachelor-, and the master program at the Department of Economics, University of Oslo.

Deepest thanks to Professor Finn Førsund who has been my supervisor.

Summary

This Master Thesis has focus on parts of the public transport system in Norway. The main topic in this thesis is:

What variables must be calculated for the decision concerning the construction and implementation of the Norwegian High Speed Rail project, and how are the variables calculated?

High Speed Rail does not have a single standard definition. High Speed Rail definition, given in the European Union definition, Directive 96/48 is suitable for many different systems of rolling stock, infrastructure and operating.[1]

New lines shall be designed to guarantee safe uninterrupted travel at speed above 250 km/h on lines specially built for High Speed, while enable speeds of over 300 km/h to be reached in appropriate circumstances. Existing lines, which have been specially upgraded, shall be guaranteed a speed of 200 km/h. On other lines: Highest possible speed.[2] Infrastructure of the Trans-European High Speed system shall be built especially for High Speed travel. Connecting lines may be included, in particular junctions of new lines, which is upgraded, for High Speed with stations located in town center, on which speeds must be adjusted to local conditions.[3]

High Speed lines shall incorporate specially built lines prepared for speeds equal to or above 250 km/h and upgraded High Speed lines prepared for 200 km/h. Special features as a result of topographic, relief or town-planning constraints need to be adapted to each case on which the speed must change. High Speed train takes for granted that the characteristics of infrastructure and those of the rolling stock are compatible.[4]

Challenges concerning costs and benefits, and budget deficit/surplus of the High Speed Rail projects in other countries (e.g. HS1 and HS2 in England, AVE in Spain, and High Speed Rail in California) will be empirical cases in this thesis, which all are influenced by political and technical challenges, which are relevant for the Norwegian High Speed Rail.

[1] International Union of Railways (2010) p. 1
[2] International Union of Railways (2010) p. 1
[3] International Union of Railways (2010) p. 1
[4] International Union of Railways (2010) p. 1

During the work with this specific topic, many elements have been taken account of but the demand uncertainty is probably the most critical and essential element of the Norwegian High Speed Rail project and is close related to a second variable; the passengers' willingness to pay for high-speed rail.

The topics for this master thesis is of theoretical character and has no ambition to quantify the level of financial needs for construction costs and operating costs of the High Speed Rail project.

Producing a cost-benefit analysis (which is a list of quantified benefits and costs associated with the project, expressed in monetary values, calculated ex ante), with a valid conclusion turned out to be far out of reach for this thesis. The evolvement of the thesis has been a process with changing criteria for commenting selected High Speed Rail projects. An example is the decision (January 2012) to build the HS2 project in England.[5]

Some empirical cases from High Speed Rail projects bring interesting challenges to the surface. Even when the number of passenger in other countries with High Speed Rail are many times the number of passengers between regions around Norwegian urban areas, High Speed Rail projects will very seldom pay off. There will not be any conclusion in this thesis about which scenario to choose.

The number of passenger for each of the High Speed Rail projects in this thesis is too complicated to quantify. Aspirations for this thesis are therefore to focus on some of the challenges in these kinds of mega projects.

The conclusion is that timing of the construction and implementing of the High Speed Rail project is crucial for the result of the cost benefit analysis whether the Norwegian High Speed Rail project should be built or not. Timing influences all the variables of the cost benefit analysis in this thesis. Timing is therefore crucial for the result of the analyses. It's beyond the limit of this thesis to conclude whether the increasing demand for transport caused by population growth in the regions around cities in Norway should be solved by building the High Speed Rail project or not.

It seems as the Norwegian High Speed Rail project is many decades too early for an efficient use of resources.

[5] Department for Transport (2012) p. 1

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1 Introduction

The governments' ultimate target is to maximize the economic welfare of the community as a whole and achieve overall increase in the economic development.[6]

The government is in position to allocate resources from one activity to another activity with intention to improve the social welfare. Every activity is associated with limited resources; Human capital, economy, technology and land. Land is a critical resource. High Speed Rail infrastructure occupies a lot of expensive land and causes lot of external costs. Projects are connected to a well-defined framework: scarcity of time, human capital, capital, technology, land, location, changeability, and dynamic progression, tightness of the subsystems or components and mutual links between them.

This thesis focuses on, theory for a cost-benefit analysis. Demand for High Speed Rail is a result of willingness to pay for High Speed Rail. Net present value of the High Speed Rail has large variance. Empirical data from the transport infrastructure projects including the High Speed Rail-projects unveil a bias towards underestimation of costs and overestimation of benefits resulting in cost overruns.[7] Underestimation of costs and overestimation of benefit from the High Speed Rail makes the calculations of the cost benefit analyses appear more positive than the truth is. Some empirical examples will be discussed in this thesis.

Discrepancies of the cost-benefit analyses can be traced back to the planning period, and the stage in which the political decisions about the High Speed Rail were made. Investments in High Speed Rail infrastructure is fundamentally incapable of being reversed. First designed and implemented, the costs begin to accrue. The construction costs are easier to calculate and have lower variance than operating costs, which accrue, partly with little predictability, but the benefits are even less predictable.

Optimal timing of construction and implementation of the Norwegian High Speed Rail is therefore crucial for the outcome of the investment and the result from cost-benefit analyses. The opportunity cost caused by a deviation from optimal timing depends also on the priority of resources allocated to other transport modes. In what way and how fast other modes respond on the investment, influences the conclusion of the cost-benefit analysis. How other

[6] Ministry of Transport and Communications (2001)
[7] Flyvbjerg (2003) p. 77-88

modes respond on the High Speed Rail project influences the willingness to pay for High Speed Rail.

Whether any of the Norwegian High Speed Rail tracks should be built at all, and if any; when to build, requires an extensive analysis which is beyond the limit of this thesis. This thesis does not calculate these variables or calculate when to construct and implement any of the scenarios. This thesis limits the steps through the cost-benefit analysis to theoretical interpretation of break even points in the cost-benefit analyze model of Rus (2011).

Willingness to pay for High Speed Rail in Norway rely on the valuation of time and quality of the rolling stock, facilities connected to the infrastructure, and reliability of the schedules. The value of time is part of the uncertainty about willingness to pay for High Speed Rail, which leads to uncertainty about the demand.

Chapter 2 describes the scenarios and what has been done through phase 1, phase 2, and phase 3 given to Jernbaneverket mandated by the Norwegian Ministry of Transport and Communication.

Chapter 3 describes the provision of public transport in Norway and how the Government allocates resources to different modes. The characteristics of public transport are described including the Airport Express Train. Some examples of empirical data from other countries unveil large demand uncertainty. Challenges getting valid data are the main purpose for the sub-paragraph.

Chapter 4 goes through the formal steps of a cost-benefit analysis describing all costs and benefits of the Norwegian High Speed Rail Project.

Chapter 5 highlights some empirical High Speed Rail projects and comments of the cost benefit analysis made for these projects.

Chapter 6 focuses on challenges for High Speed Rail projects. Chapter 6 summarizes timing of constructing and implementing as the most critical challenge of the project but do not conclude whether to built any of the scenarios or not.

Chapter 7 focuses on communication with the project Manager Tom Stillesby and Professor Steinar Strøm's comments about the Norwegian High Speed Rail project.

2 The scenarios

The Norwegian National Rail Administration (Jernbaneverket) has been mandated by the Norwegian Ministry of Transport and Communication to assess the issue of High Speed Rail lines in Norway. The Norwegian High Speed Rail project is described in The National Transport Plan covering the period 2010-2019. The ministry wishes to implement a rail service provision in the form of higher speed and achieve socio-economically efficient and robust solutions for a future transport system with increased transport capacity, improved passability, and availability. The Norwegian National Rail Administration study has been divided into three phases:

Phase 1, which was completed in July 2010, included the knowledge base that was already collated in Norway, including outputs from previous studies, e.g. studies already conducted for the National Rail Administration and the Ministry of Transport and Communication, but also publicly available studies conducted by various stakeholders, such as “Norsk Bane AS”, “Høyhastighetsutredningen AS” and “Coinco North”.

The objective of phase 2 is to identify guiding principles to be used to assess a range of possible interventions on the main rail corridors in Norway, including links to Sweden.

Phase 3 makes use of the tools and the guiding principles established in phase 2 and will be used to test scenarios and options on the different corridors. This will provide assessments of options and enable recommendations for development and investment strategies in each corridor. The principles established in Phase 2 are to be used to test four scenarios:

Scenario A – Reference case. This is a continuation of the current railway policy and planned improvements, with relatively minor works undertaken shown in the National Transport Plan from 2010-2019. This forms the “do minimum” scenario to which the other scenarios will be compared up against.

Scenario B – Upgrade. A more offensive development of the current infrastructure, which look beyond the “InterCity” area.

Scenario C – Major upgrades to achieve high-speed concepts. This is to be based on an aggressive upgrade of the existing network to provide a shortening in journey times.

Scenario D – New High Speed Rail. This involves the implementation of newly built, separate High Speed Rail lines.

The Norwegian High Speed Rail project is divided into six different corridors. The numbers of passenger using all modes between these cities unveil the total demand for passenger transport between these cities for conventional modes. The generated numbers of passengers caused by the High Speed Rail projects adds to the initial demand.

The improvement is being considered on six corridors:

Oslo – Bergen

Oslo – Trondhjem

Oslo – Kristiansand and Stavanger

Bergen – Stavanger

Oslo – Stockholm (to Skotterud in Norway)

Oslo – Gothenburg (to Halden in Norway)[8]

HSR is a new concept in the travel market in Norway which makes willingness and demand uncertainty essential. This statement is discussed later in the thesis.

The choice of scenario is essential for this interpretation whether it is possible to look at the investment in HSR as an upgrade of existing conventional rail or a new concept of travel.

This thesis gives partially attention to the Swedish "Hõghastighetsutredningen" which add interesting interpretations of similar challenges for the Swedish High Speed Rail. The wealthy economic context in Norway and the fact that the High Speed Rail is a new concept in the travel market, stated preferences for demand and willingness to pay for High Speed Rail are needed, as well as the demand for High Speed Rail services, which are not predicted by existing models.

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[8] Narmo (2011)

3 Public transport in Norway

Public transport in Norway is divided into different modes; bus, rail, tram, subway, express boat, ferries, air, and rail. The government subsidizes all modes. The aggregated supply of each mode equals the demand for each travel mode.

The governments' allocation of resources to transport sector influences value added in the society.[9] Individuals' preferences for choice of transport modes are influenced by the governments' policy for public transport. Willingness to pay is founded on preferences.

The government is the legislative and has the power to make decisions concerning the welfare of the community. A shift of mode; transport by car to public transport is important for the environment to achieve reduction in negative external effects and the use of land.[10] As a result of an ongoing focus on both the passenger transport and the freight transport supply, the Government place great emphasis on the development of new solutions to meet demand growth in transportation.[11]

Political influence affects provision of transport modes through differentiated taxation of travel modes. Distortionary taxes influence the supply of public transport modes and private transport modes. The selected provision of travel modes is political justified trying to achieve a more efficient use of resources. Government's request is to lead consumers to choose designated travel modes. These decisions are based on the target to maximize the welfare of the community.

Adjustment of taxes (subsidies and distortionary taxes), and availability of modes are important tools for the Government to achieve its target. Maximization of welfare forces the government to differentiate the provision of transport modes to the population.[12] Supply of all modes of public transport is therefore not present in every region of Norway. Population density in Norway differs and has affected the evolvement of public transport to be differentiated among regions of Norway. Parts of infrastructures are closed and new modes replace previous modes. Not all relevant modes of public transport (or cooperation between private sector and public sector), are available in every part of Norway. Some regions do not

[9] Ministry of Transport and Communications (2001)
[10] Ministry of Transport and Communications (2001)
[11] Ministry of Transport and Communications (2001)
[12] Ministry of Transport and Communications (2001)

have public provision of transport at all. The provision of specific travel modes are many places absent.

Research from studies in other countries concludes that strategic misrepresentation of valid data, which means that true values of variables used for the decision process, which are not communicated, can be traced to political and organizational pressures. Where there is political pressure, there is misrepresentation, but misrepresentation can be moderated by measures of accountability.[13]

3.1 Demand

Demand uncertainty for High Speed Rail is very high. Evolving a new concept of travel, High Speed Rail, which never has been part of the Norwegian transport system, makes uncertainty aspects in the project to be key topics at the planning stage.

3.1.1 Empirical data outside Norway

Demand uncertainty is one of the problems caused by misinformation. Three models, the planning fallacy, the optimism bias, and the political economic explanations and misrepresentation contribute well for the overestimation of benefit found in the data of a survey (Priemus 2008b): 84 % of the forecasted numbers of passenger are wrong by more than +/- 20%.[14]

90 % of rail projects have estimated too high numbers of passenger. Differences between actual and estimated demand have not improved for 30 years.[15] Willingness to pay for the actual travel mode reflects the individuals' preferences. The hypothesis is that the consumers' preferences' are convex. Individuals' choices refer to convexity of preferences, which is equivalent to concave utility.

Valuation of time and the opportunities of choosing other modes influence willingness to pay for High Speed Rail. The opportunity cost is a kind of reference point, which needs to be taken into account when calculating willingness to pay for High Speed Rail.

[13] Flyvbjerg (2007a) p. 19/51
[14] Priemus, Flyvbjerg and Wee (2008) p. 15
[15] Priemus, Flyvbjerg and Wee (2008) p. 15

High Speed Rail reduces travel time on distances about 500 km from about six hours to three hours or less which is beyond the applicability of the parameters actual in conventional calculation models, meaning that potential mode-shift is poorly estimated. Alternative calculation models for High Speed Rail are needed but valid prognoses are hard to calculate.

The result is that the demand and revenue forecasting of High Speed Rail tailored models need to consider this hypothesis. Calculations of railroad projects around the world show that 9 out of 10 rail projects have overestimated prognoses for numbers of passengers. These data comes from the largest database of its kind.[16] Estimated travel-demand for rail covering 25 rail projects shows that 48,6% of the calculated prognoses were fulfilled. That means 51,4 % of the passengers prognoses for the rail projects were not fulfilled (with standard deviation of 28,1). Average overestimation of demand is then 105,6%, which means that more than half of the forecasted passenger never show up.[17]

Rail project cost estimates unveil an average cost overrun of 44,7 %.[18] Standard deviation 38,4. This inaccuracy of cost estimates shows large uncertainty and risk. Estimates of costs (which is defined as budgeted, or forecasted, construction costs at the time of decision to build), for twenty nations and five continents covered by a seventy-year period study of empirical data shows that overruns are constant.[19]

An ideal definition of these costs is to include financing costs, operating costs, and maintenance costs but it is difficult to find reliable, valid and comparable data on these types of costs across projects.

None of the High Speed Rail system in the world are built and operated without subsidies.[20]

3.2 Characteristics

Public transport in Norway is reflected through the governments' priority of long-term transport policy. The government has an ongoing development of the public transport system, which has lead to the characteristic of public transport in Norway now. The low share of public transport in Norway is related to the sparsely populated settlement and the lack of

[16] Flyvbjerg (2007b) p. 579
[17] Flyvbjerg (2007b) p. 580
[18] Flyvbjerg (2007a) p vi/ix
[19] Flyvbjerg (2007b) p. 579
[20] Enthoven, Grindley and Warren (2010) p. 26

investments in public transport infrastructures. Year 2000 the public transport (not include aircraft), accounted 15 % of total passenger transport in Norway.[21]

Most of the smaller rail tracks from the previous century are not in service today. Bus routes have replaced many rail track routes. Even areas with a population growth and tourism growth, has not succeeded keeping the rail track operating, e.g. Kragerø at the south coast of Norway.

Numbers of the sidetracks to the main rail track infrastructure in Norway has stopped to operate and are now out of service. There are only few sidetracks left which serve the tourism, e.g. Flaamsbanen.[22]

The result of this political process is that population in these areas have lost the opportunity to choose travel mode including the opportunity to travel by rail. Other sparsely populated areas have never had the opportunity to travel by train.

Because of termination of train monopoly, busses have grown in numbers over the last decades and the mode shift away from train to bus seems unbroken. An increasing numbers of passengers choose to travel by bus. This is not only the case on closed rail sidetracks but also alongside the operating rail track infrastructure where busses and rail are competing in the same passenger market.

The population of Norway travel more often and further than ever.[23] Since 1965 the number of travels is tripled, and the population travel five times the distance they traveled in 1965. The most increasing travel mode is travel by car. About every second Norwegian citizen is owner of a car and the distance driven by car is more than five times the distance in 1965.[24]

3.2.1 Airport Express Train

Norway do not have any experience of new technology for alternative rail to the existing network of conventional rail, except the Airport Express Train (Flytoget), which has a speed up to 210 kmh. This project is however not representative for the validity of the calculation of the demand for High Speed Rail on other routes in Norway. The Airport Express Train has

[21] Ministry of Transport and Communications (2001)
[22] Ministry of Transport and Communications (1996-1997)
[23] Ministry of Transport and Communications (2001)
[24] Ministry of Transport and Communications (2001)

the function of bringing passenger to and from a junction of aircraft routes. Building of a new High Speed Rail line in Norway is the substitute for aircrafts and is competitor to air mode.

From the beginning of the project, the Airport Express Trains was organized as an own independent company, Gardermobanen AS which was owned by the Government, which build the infrastructure of the railroad. Gardermobanen AS was financed through debt. The intention of the funding model was that revenues from ticket could cover the financial cost including the debt repayment and the operating cost.[25]

Sadly it turned out not to be realistic, and the government liquidated Gardermobanen AS and paid the debt. Therefore, the infrastructure was transferred to Jernbaneverket, and a new company was founded; Flytoget AS which operates the rolling stock.[26]

A survey (published 2006), shows that overall average customer satisfaction for the Airport Express Train is 83%.[27] 2010 the satisfaction increased to 96%.[28]

The operating income increased (2010) to NKr 776 million and an annual results before tax high NKr 148 million.[29] An important reason for the economical success is that the investment is not included in the account. These empirical experiences tell how difficult it is to make a valid conclusion for whether High Speed Rail is a success or not. One of the reasons is that the project last for decades, where conditions are changing all the time. The project is operating in a dynamic context of political evolvement and changes in the transport market.

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[25] Stillesby (2011)
[26] Stillesby (2011)
[27] Flytoget (2011)
[28] Skjørestad and Board of directors (2011) p. 8
[29] Skjørestad and Board of directors (2011) Årsrapport

4 Cost Benefit Analysis

4.1 Theory of the analyzes

The governments' basic tool for making decisions about mega-projects, in this case the Norwegian High Speed Rail project, is cost-benefit analyzes,[30] and also known as, benefit-cost analyzes. Cost-benefit analyses are a general review or a formal assessment of benefits and costs of a project. In this thesis: the High Speed Rail project in Norway. Cost-benefit analyses are a list of quantified benefits and costs related to the project, expressed in monetary values, calculated ex ante. Cost-benefit analysis is not an answer book, but a tool for calculating benefits and costs.

The topic in this section of the thesis is the discussion, within a cost-benefit analysis framework, under which conditions the expected benefits could justify the investment in High Speed Rail project.

Benefits and costs occur at different time. Benefits are based on consumers' preferences.[31] Because of time difference between costs and benefits, it is necessary to discount all costs and benefits to net present value.

One of the main problems in infrastructure evolution is incorrect information about critical facts for the cost-benefit analyses. The data used for analyzes are often misinformed by forecasters. Costs and risks are minimized to make the project look more reliable.[32] Very often, the planner lies about costs, benefits, and risk.[33] Even when the contriver knows the falsity of the conclusion, the truth about cost and benefit do not reach the politicians who make the decision.[34]

E.g.; the private owner of the Eurotunnel between United Kingdom and France told investors that 10 % "would be a reasonable allowance for the possible impact of unforeseen

[30] Wee and Tavasszy (2008) p. 40
[31] Wee and Tavasszy (2008) p. 41
[32] Flyvbjerg (2007c) p. 1/27
[33] Flyvbjerg (2007c) p. 9/27
[34] Flyvbjerg (2007b) p 585

circumstances on construction costs" (The Economist 1989),[35] but ended 80% over budget for construction and 140 % for financing.[36]

The more development of specific technologies that are needed the more complex is the project. If technologies cannot be bought, copied, and implemented in the Norwegian High Speed Rail project, but need to be developed specific for this project, the technology may cause large cost overruns. The planner and the decision maker experience diverging interests: The decision maker searching a valid conclusion based on unveiled true data, but the planner may often search the most viable conclusion; the conclusion, which is workable. The claim is that decision maker and planner to focus on two different interests.

Cherished aspiration changes over time and most of them are not taken into account through the benefit-cost analyses. Conclusions are often too positive about benefits and costs for rail projects, which makes budget overruns being typical.[37] An examples; Rail traffic measure the number of passengers. A survey for twelve urban rail projects shows average cost overrun to be 40.3% and the deficit to be 47.8%.[38]

The planner and the project partners knowingly keep the truth about costs, benefits, and risks, secret for the decision maker to achieve a will for their projects and favor their work to the competitors.[39]

The respondents of a survey trying to unveil stated preferences for willingness to pay for the Norwegian High Speed Rail are affected by a context of existing rail infrastructure, characterized by having been given low priority. Supplementary appropriations are resolved.[40] Investments in High Speed Rail replace some of the lag of investments in traditional rail.

This knowledge is important for benefit-cost analyses for the Norwegian High Speed Rail. It makes a threshold for calculating expenses' and investments as cost by investing in High Speed Rail.

The threshold can be divided into two parts;

[35] Flyvbjerg (2007b) p. 581
[36] Flyvbjerg (2007b) p. 581
[37] Priemus, Flyvbjerg and Wee (2008) p. 12
[38] Flyvbjerg (2007b) p.58
[39] Flyvbjerg (2007b) p. 1
[40] Midtbø (2011)

1. Investments in conventional railroad and other transport modes have not kept up with the increasing demand for transport. The result is congestion on e.g. intercity train to Oslo. Some of the investments in intercity train or roads can instead be allocated to the High Speed Rail infrastructure to lower the need for upgrading the capacity of these modes. Some of the investment in intercity trains or roads needs to be subtracted from costs of the High Speed Rail project. This is a kind of reference point or threshold for calculating costs. The Norwegian High Speed Rail project can replace some of the reinvestment lag caused by the maintenance cost of conventional travel modes, which is not refinanced to keep up with the maintenance cost.

2. Conventional railroad and other transport modes need new investments to meet the population growth and the increasing demand for transport. These two factors do not need any willingness-to-pay-survey to get it implemented, but is a perpetual task for the Government.

Therefore, the High Speed Rail project solves multiple targets. These conditions lead the consumer to perceive the High Speed Rail project to be a project paid by the Government. Respondents are therefore in state of mind to adopt virtually similar approach to the High Speed Rail project as if the government supplied a public good, regarding the willingness to pay for High Speed Rail. To reveal the marginal willingness to pay for High Speed Rail for all relevant individuals, the Government needs to know the respondents preferences. If the respondents know, they are not required to pay the price they reply in a survey for the good once it is produced, let’s say a «Yes/No»-survey and not «How much»-survey, they will adopt an attitude to ensure production of the goods by entering a willingness to pay, which is higher than the truth is. This statement leads to too high production of the collective good («Yes» to High Speed Rail) because the individuals have incentive not to expose their true preferences.[41]

To achieve construction, implementation and operation of the High Speed Rail project, the Government needs to subsidize the High Speed Rail project in an extensive way. Then respondents may deal with the willingness to pay-survey in a similar way as how they would respond on willingness to pay for public goods and a free rider problem occur caused by the ones who doesn’t pay tax.

[41] Perman (2011) p. 119-120

A psychological factor caused by High Speed Rail excitement experienced in other countries (E.g.; The High Speed Rail line Barcelona-Madrid), are one of many factors, which may lead to higher predicted willingness to pay for High Speed Rail today than the truth. Willingness to pay for High Speed Rail may be lower when the project is implemented. It may cause reduced validity of a willingness to pay survey.

Estimated data would benefit from adjusting for the kind of uncertainty, which is caused by utility of current consumption relative to utility of future consumption. Preferences may change over time. Omitting this knowledge is reasonable only if the preferences stay the same between two periods and the population was homogeneous.

Time consistency, time discounting and consumers' time preferences is crucial for data for the Norwegian High Speed Rail project. Distinguish between time discounting and time preference is that time discounting embraces any reason for caring less about a future consequence, including relation which reduces expected utility generated by a future consequence, such as uncertainty or changing tastes. Time preferences refer more specifically to the preferences for immediate utility over delayed utility.[42] The stability of the preferences may change caused by response to the High Speed Rail project from substitutes such as aircraft industry and traditional rail, pricing of other modes, quality and reliability. Willingness to pay is based on instant opinion about present time valuation but unveil less information about future preferences.

4.1.1 Utility

The portion of total financing of the Norwegian High Speed Rail, which comes from revenues from fares, makes the predicted data for willingness to pay to have a high variance because of reasons, which is explained above. High utility counts as high benefit.

Time preferences merging various intertemporal motives, and determine the prosperity of nations. The discounted utility model was concerned about intertemporal choices and the different motives of choices evolved to be the tool for the discount rate.[43]

[42] Loewenstein and O'Donoghue (2002) p. 352
[43] Frederick (2002) p. 351

The discounted model unveil, through empirically research, some anomalies, which are very important for the validity of data: Empirically observed discount rates are not constant over time but appear to decline over time.

4.1.2 The costs and benefits in the cost-benefit analyses of HSR

The Norwegian High Speed Rail project involves a huge spending of taxpayers´ money. The cost of travel must, additional to spending of taxpayers' money, also include the fare to be charged, which is an essential factor of the generalized cost of travel.

Recovery of producers cost of travelling by High Speed Rail differs from producers cost of other modes; road or air. Producers cost of travelling by road and air are part of the total cost of traveling by air and road. High Speed Rail differs in kind of pricing principle. High Speed Rail do not recover full cost when infrastructure costs are included.[44]

Building and operating a High Speed Rail line consist of *external costs, user costs*, and *producer costs*. These costs summarize the *total social costs*. *External social costs* are linked up to construction and operation of the line and include accidents and environmental costs but excludes congestion[45]. *User's social costs* include access time, egress time, waiting time, and travel time invested. Reduction of travel time is in the cost-benefit analyses a benefit for the project. Reliability, probability of accident, comfort, is all parts of users social costs. That means; if the reliability increases, or probability of accident decreases, or comfort increases, then users social cost reduces and is then a benefit for the project.

External costs are related to construction and operation of the line and include accidents and environmental costs but excluding congestion. External costs include noise, air pollution, contribution to global warming, use of land, and barrier effects. The operating cost and the costs of infrastructure are the two major types of *producer costs.*

The *construction costs* of High Speed Rail infrastructure involve three major types of costs:

[44] Rus (2011) p. 3
[45] Rus (2011) p. 10

- *planning and land costs* which includes feasibility studies, technical design, land acquisition, legal and administrative fees, licenses, permits to mention some of them. These costs can reach about 10 % of total infrastructure costs.[46] All definitions on this page refers to the same reference, Rus p. 4.

- *Infrastructure building costs* involve topography challenges and readying of platform building. Because of topography challenges, the uncertainty about these costs is very high and may constitute 15 to 50% of total investment.

- *superstructure costs* include rail-specific elements e.g. tracks, sidings along the line, signaling systems, catenary, electrification, communications and safety equipment, etc.

Empirical data from 45 actual High Speed Rail lines in service, (where High Speed Rail lines in Belgium, France, Italy, and Spain where among the important High Speed Rail lines) reveal average construction costs per km of a High Speed Rail line to be about 20 million euros. Topography challenges (which require the construction of bridges, and tunnels) and limited land for use for High Speed Rail lines in urban areas makes the construction costs of High Speed Rail line vary from 10 to 40 million euros per km High Speed Rail line. Construction of main station buildings are not included in these construction costs.

The *costs of building rail stations* and the associated services provided have an effect on the generalized cost of travel. The higher quality of these services, the lower is the individuals calculated cost of waiting time. Quality of stations affects the individual value of waiting time. The optimum for these qualities is the level where the marginal utility of the money spent on these services is equivalent to value of the disutility of waiting time and quality of the facilities connected to these services

Operation costs of the High Speed Rail services encompass *infrastructure maintenance costs*. Some of these costs are fixed, caused by routinely conducted operations within security and safety standards. Some of the costs are variable costs; costs of labor, energy and other material needed for maintaining and operating the infrastructure which include the rail tracks, the terminals, the stations, the energy supply and the signal systems, management, and safety systems. Whether the costs are variable or fixed depends on the character of the operations; the routinely performed operations are fixed. The costs which operations are influenced by the

[46] Rus (2011) p. 4

number of passenger and train intensity, are known as variable, e.g. operation of electric traction equipment depending on the number of trains in use.[47]

Infrastructure maintenance costs equal 100,000 euros per km.[48] The amount refers to average from the 45 High Speed Rail projects in service and an article written by Javier Campos and Gines de Rus 2009, "Some stylized facts about high-speed rail: A review of HSR experiences around the world";

Maintaining costs of a single track High Speed Rail line in Belgium, France, Italy and Spain ranges (2002) from about €28,000 to 33,000 per kilometer.

Total maintenance costs equal about 150,000 – 250,000 euros per km which makes infrastructure maintenance costs to constitute 40 – 67 %. Building a High Speed Rail track in one of the four countries Belgium, France, Italy or Spain with a length of about 500 km would cause a planning and land costs, (stations not included) to reach about 10 billion euros, based on an average total investment cost of 200,000 euros per kilometer. Planning, land costs and stations are not included in this calculation. Yearly maintenance costs of the line are calculated to be 50 million euros.[49] These fixed costs do not include the *operating costs* of the rolling stock.

The operating costs depend on numbers of variables across rail operators. The traffic density differs a lot. So does the technology specificities affected by challenging climate. The costs of keeping the rolling stock running are much higher in Norway than in countries with warmer climate. This increasing costs compared to other countries is caused by challenging climate and the fact that Norway is one of the most expensive countries to live in. Then empirical operating costs known from HSR projects may increase for the Norwegian High Speed Rail because of the high cost level in Norway. The estimated acquisition cost of rolling stock per seat is about 33,000 to 65,000 euros. The costs per seat-km depend on the train operating costs per seat and rolling stock maintenance costs as well as the number of seats per train, which are normally 330 to 630 seats.[50] The cost per seat km is therefore hard to predict.

[47] Rus (2011) p. 5
[48] Rus (2011) p. 5
[49] Rus (2011) p. 5
[50] Rus (2011) p. 5

The environmental costs of building and maintaining a High Speed Rail line depends on the density of the population. The costs of land occupied and land blocking, visual disturbances and noise are highest in the most populated areas. The population density is though less essential when it comes to air pollution and global warming. Studies show that the High Speed Rail reduces many greenhouse gases as a result from saving in energy over air, but construction period of the High Speed Rail causes emissions, which takes decades to offset.[51]

Another negative factor is the energy consumption caused by the speed and load factor compared to energy consumption by car. Then an allegation of emission reduction is less valid. It is debatable whether generated demand counts as costs or benefit. Travel takes time. That is one of the main reasons for constructing and implementing High Speed Rail in Norway. The access, egress (transit) and waiting time is the same as for traditional train and higher compared to car, but lower compared to air. The latter is then benefit for High Speed Rail.

Reduction of emissions counts as *benefits* from the Norwegian High Speed Rail. The increased quality encompasses higher comfort but not always. It depends on the mode of travel, which is compared. E.g., luggage is not so easy to carry by High Speed Rail as if traveling by car. In some cases High Speed Rail, generate higher reliability, which count as benefits. The higher speed of travel and extra capacity, are factors to alleviate congestion in traditional rail transport and other modes of transport.

Higher speed lowers the travel time and makes a benefit from time saving. Calculations of time saving make four factors essential. 1. Distance, (e.g. 450 km). 2. Operate speed for other modes, e.g. conventional rail. 3. The High Speed Rail speed (e.g. 250km/h, 300km/h). 4. Stop intensity (stations) between end destinations.

Time consumption travelling with High Speed Rail is competitive to car on distances where the reduction of in-vehicle time is higher than the sum of access, egress, waiting, and in-vehicle time travelling by High Speed Rail. Benefit from in-vehicle time require the length of travel to be higher for cars than for conventional train because of access, egress, and waiting time, which is about the same for conventional train as for High Speed Rail.

[51] Rus (2011) p. 5

Air transport has break-even point on time consumption on distances about 500 km. Above 500 km air is supreme on time consumption compared to all other modes of travel.

High Speed Rail may profit on higher quality (reliability, in-vehicle noise, disturbances, accidents, individual fear of flying) which may makes the break-even point reaching more than 500 km. These variables are subjective individual values, which are complicated to unveil in a survey. This is therefor one of the reason for the demand uncertainty.

Instead of defining High Speed Rail as a new concept of travel trying to find the willingness to pay for the new concept, the willingness to pay could be less important through focusing on HSR as an improvement of the conventional railway. Then there is a question of changes in surpluses. That means incremental changes in resource costs and willingness.[52]

The planning period starts many years before the investment cost I of the High Speed Rail project, which starts at time t=0. We will use the start of operation t=0, as the period of reference for the present value. The investment cost I includes planning costs and construction costs and is defined through equation (1). The investment cost I for the planning period, and the construction period, which last from $t = T0$ to t=0 would be defined as follow:

(1) $I = \int_{T_0}^{0} I_{p,t} e^{r_t} \, dt.$

Equation (1) is simplified and is not divided into planning costs and construction costs.

I choose to define the investments I to start at t = T_0 which is common with Rus. The investment cost I is sunk cost at time $t = 0$, which means that they have been incurred and cannot be recovered. The planning costs are needed to get basis for the decision whether to build the High Speed Rail project or not. The investment costs do have financial risks.

Equations (2) is an expanded equation based on Rus (2011) to calculate the social profitability of the investment. Ignoring transfers, concentrating on changes in net benefits and costs, the social profitability of the investment in Norwegian High Speed Rail assumes following condition to be fulfilled:

(2) $\int_0^T B(Q_t) e^{-(r_t - g_b)t} dt > I + \int_0^T C_f e^{-r_t t} dt + \int_0^T C_q(Q_t) e^{-(r_t - g_d)t} dt,$

[52] Rus (2011) p. 12

Where:

Consumption growth is captured by g_b.

Q_t : number of trips.

$B(Q_t)$: annual gross social benefits of the project at time t where conventional transport modes operates. Building a High Speed Rail defined as an improvement of an existing conventional transport mode generates an annual gross social benefit $B(Q_t)$ which includes time and cost savings from traffic turn-over from other modes to High Speed Rail. $B(Q_t)$ also includes subjective individual numerical quality increase, generated trips, value of decreased negative external effects, indirect effects on other transport modes such as increased value added for busses, taxis, rental car companies at destinations. Political priorities of resources to actual regions caused by the High Speed Rail are not included in $B(Q_t)$.

C_{ft}: annual fixed maintenance and operating cost at time t. Annual fixed maintenance and operating costs may change yearly even with fixed r_t and fixed g_t because of limited capacity of existing rolling stock. Investing in new rolling stock causes stepwise fixed costs. On the other side; economy of scale may lower the stepwise investments and fixed costs.

$C_q(Q_t)$: annual maintenance and operating cost at time t, depending on Q.

I: investment costs at time t=0.

T: project life. (The Norwegian project life is 40 year, the same as Californian High Speed Rail. The British HS1 and HS2 calculate the project life to be 60 year).

t: year.

r_t: social discount rate at time t.

g_{bt}: annual growth rate of benefit at time t.

g_{dt}: annual growth rate of costs at time t.

Uncertainty about future discount rate r_t at time t, and future annual growth rate of benefits g_{bt} and costs g_{dt} at time t, the following equations are simplified by keeping both variables r_t, and benefits g_{bt}, and costs g_{dt} fixed. These variables are now expressed through r, benefits g_b, and costs g_d. Simplifying equation (2) by eliminating t in Q_t, and assumes numbers of trips Q_0 defined at time $t = 0$, and increase with rate g_b for benefits and growth rate g_d for costs, which both growth rates are assumed fixed. Then:

Annual maintenance costs $C_q(Q_t)$ at time t is simplified to $C_q(Q)$ with growth $e^{g_d t}$. Annual benefit $B(Q_t)$ at time t is simplified to $B(Q)$ with growth $e^{g_b t}$. Provided transfers ignored, only concentrating on changes in net benefits and costs, the social profitability of the investment in Norwegian High Speed Rail assumes following simplified condition to be fulfilled:

(3) $\int_0^T B(Q)e^{-(r-g_b)t}dt > I + \int_0^T C_f e^{-rt}dt + \int_0^T C_q\,(Q)e^{-(r-g_d)t}dt.$

Where:

B(Q): annual gross social benefits of the project where conventional transport modes (which means other modes than High Speed Rail) operates. Building a High Speed Rail, defined as an improvement of an existing conventional transport mode, generates an annual gross social benefit *B(Q),* which includes time and cost savings from traffic turn-over from other modes to High Speed Rail. *B(Q)* also includes subjective individual numerical quality increase, generated trips, value of decreased negative external effects, indirect effects on other transport modes such as increased value added for busses, taxis, rental car companies at destinations. Political priorities of resources to actual regions caused by the High Speed Rail are not included in *B(Q)*.[53]

C_f: annual fixed maintenance and operating cost.

$C_q(Q)$: annual maintenance and operating cost, depending on Q.

I: investment costs at time $t = 0$.

T: project life. (The Norwegian project life is 40 year, the same as Californian High Speed Rail. The British HS1 and HS2 calculate the project life to be 60 year).

t: year.

[53] Rus (2011) p. 13

r: social discount rate.

g_b: annual growth rate of benefits.

g_d: annual growth rate of costs

Remembering; Annual maintenance and operating cost C_q at time t is depending on number of trips Q, with growth e^{gt}, where g is the average growth rate of benefit and costs. C_q is assumed homogeneous of degree 1, then $C_q(Q_t e^{gt})$ can be written: $C_q(Q_t)e^{gt}$.

Left hand side of equation (3) includes benefits, which can be divided into following factors to find the net present value of benefits included in equation (4):

$$(4)\ \int_0^T B(Q)e^{-(r-g_b)t}dt = \int_0^T [v(\tau^0 - \tau^1)Q_0 + C_c](1+\alpha)e^{-(r-g_d)t}dt + \sum_{i=1}^{N}\int_0^T \delta_i(q_i^1 - q_i^0)e^{-(r-g_d)t}dt.$$

Right hand side of (9) has interpretation as follows:

v: average value of time (including differences in service quality).

τ^0 average user time per trip *without* the project.

τ^1: average user time per trip *with* the project.

Q_0: first year diverted demand to High Speed Rail.

C_c: annual variable cost of the conventional mode.

δ_i: distortion in marked i.

α: proportion of generated passenger *with* the project with respect to Q_0 .

q_i^0: equilibrium demand in market i *without* the project.

q_i^1: equilibrium demand in market i *with* the project.

The value of diverted passenger from other transport modes is equal to the average gross benefit of a generated passenger-trip. It is assumed other transport operators to be breakeven on cost/benefit. By substituting equation (4) in equation (3), it is possible to calculate the initial volume of demand required for a positive net present value. Assumed the last term, indirect effects from other transport operators in equation (4) are zero.

Further assumption will simplify the evaluation of the timesaving and generated demand. Benefits from provision of additional rail capacity and from net reduction of accidents, benefit from decreased congestion on other modes and reduced environmental impacts due to diversion from other modes, are left aside. Then the model is easier to work with when focusing on undisputed effects of the Norwegian High Speed Rail investment. Assumptions summarizes as follow:

The benefit to users is the timesaving, and improved quality. Market prices are equal to opportunity costs; producer surplus stay the same in alternative modes; net reduction in externalities is not taken account of; the aggregated positive and negative indirect effects cancel out, and finally. Another assumption is that first years net benefits grow at a constant annual rate during the project life.

Then the condition to be satisfied for a positive NPV is expressed through equation (10):[54]

(5) $\int_0^T B(Q)e^{-(r-g_b)t}dt - \int_0^T C_q(Q)e^{-(r-g_d)t}dt - \int_0^T C_f e^{-rt}dt > I.$ It is assumed $r > g_b$ and $r > g_d$..

The interpretation of the symbols:

$B(Q)$: annual social benefits of the project. (Further comments are to find under equation (3)).

$C_q(Q)$: annual maintenance and operating cost variable with Q.

C_f: annual fixed maintenance and operating cost.

I: investment costs.

T: life of the project.

[54] Rus (2011) p. 15

r: social discount rate.

g_b: annual growth rate of benefits.

g_d: annual growth rate of costs.

Also in this equation it is assumed $r > g_b$ and $r > g_d$. The net benefit need to be larger than the investment I to get the High Speed Rail project socially desirable. Solving the integral of equation (5), the condition required to get the High Speed Rail project socially desirable is:

(5)’:

$$\int_0^T B(Q)e^{-(r-g_b)t}dt - \int_0^T C_q(Q)e^{-(r-g_d)t}dt - \int_0^T C_f e^{-rt}dt > I \Rightarrow \left[\frac{-1}{(r-g_b)}B(Q)e^{-(r-g_b)t}\right]_0^T - \left[\frac{-1}{(r-g_d)}C_q(Q)e^{-(r-g_d)t}\right]_0^T - \left[\frac{-C_f}{r}e^{-rt}\right]_0^T > I \Rightarrow \left[\left(\frac{-B(Q)}{(r-g_b)}e^{-(r-g_b)T}\right) - \left(\frac{-B(Q)}{(r-g_d)}e^{-(r-g_d)0}\right)\right] - \left[\left(\frac{-C_q(Q)}{(r-g_b)}e^{-(r-g_d)T}\right) - \left(\frac{-C_q(Q)}{(r-g_d)}e^{-(r-g_d)0}\right)\right] - \left[\left(\frac{-C_f}{r}e^{-rT}\right) - \left(\frac{-C_f}{r}e^{-r0}\right)\right] > I \Rightarrow \left[\frac{-B(Q)}{(r-g_b)}e^{-(r-g_b)T} - \frac{-B(Q)}{(r-g_b)}\right] - \left[\frac{-C_q(Q)}{(r-g_d)}e^{-(r-g_d)T} - \frac{-C_q(Q)}{(r-g_d)}\right] - \left[\left(\frac{-C_f}{r}\right)e^{-rT} - \left(\frac{C_f}{r}\right)\right] > I$$

$$\Rightarrow \left[\left(\frac{-B(Q)}{(r-g_b)}\right)\left(e^{-(r-g_b)T} - 1\right) + \left(\frac{C_q(Q)}{(r-g_d)}\right)\left(e^{-(r-g_d)T} - 1\right) - \frac{C_f}{r}\left(e^{-rT} - 1\right)\right] > I$$

Rearranging this expression, the condition needed to make the HSR project socially desirable is:[55]

(6) $\frac{B(Q)}{r-g_b}\left(1 - e^{-(r-g_b)T}\right) - \frac{C_q(Q)}{r-g_d}\left(1 - e^{-(r-g_d)T}\right) - \frac{C_f}{r}\left(1 - e^{-rT}\right) > I$.

The numerator shows annual net social benefits of the project with variable Q of introducing HSR where conventional transport modes operates divided by the difference between social discount rate and annual growth of benefits and annual growth of costs. The next equations are simplified by define g as the average value of g_b and g_d . This quotient is multiplied by a

[55] Rus (2011) p. 15

proportion (1 - $e^{-(r-g)T}$), which express the discount factor. Subtracting the annual fixed maintenance and operating cost C_f divided by the social discount rate r, the requirement is that this expression need to larger than the investment *I.*

Rearranging (6) and dividing by I, the expression (7) is then:[56]

$$(7)\ \frac{B(Q)-C_q(Q)}{I} > \frac{r-g}{1-e^{-(r-g)T}} + \frac{C_f}{I}\frac{r-g}{r}\frac{1-e^{-rT}}{1-e^{-(r-g)T}}.$$

Net benefit *B, (B(Q) –* C_q*(Q)),* of the first year divided by *I,* expresses a ratio of the investment costs. This ratio should be higher than the social discount rate minus the growth rate of net benefits plus a portion $\left(\frac{(r-g)}{r}\right)$ of fixed annual maintenance costs. The lower the lifetime of the project is (if not infinite), the higher is the demand for profitability. Expressed as follow:

$$\frac{1}{1-\ e^{-(r-g)T}} > 1, \qquad or: \frac{1-\ e^{-rT}}{1-\ e^{-(r-g)T}} > 1, when\ r > g\ and\ 0\ < T\ < \propto$$

Both expressions tend to 1 when $T \rightarrow \infty$.

In this model it’s revealed that net benefit of the first year is the crucial factor for social profitability of the Norwegian High Speed Rail project, because this model assume fixed growth rate for benefits as well as fixed growth rate for costs. Therefor the benefit of the first year is critical. It depends on the volume of demand to be served, the time savings compared to existing travel mode and the summarized average value of time for the travelers.

First year annual net benefits, (*B(Q)* - $C_q(Q)$) come from time savings, from improved quality, and from generated traffic and net of variable costs. (This is the case when externalities and indirect effects are not significant.) The minimum level of demand the first year of operation, need to be defined before investing in the Norwegian High Speed Rail. Assumed the conditions are right, a positive net present value the first year can be escalated during the lifetime of the High Speed Rail project. A positive net present value is affected by two main variables:

[56] Rus (2011) p. 15

- The higher threshold of demand which is required for a positive net present value, the less is; the value of time; -the average time reduction per passenger; -the ratio of generated traffic; -the growth of benefits over time; -the project life of other modes; -and the cost savings of other travel modes.

- On the other side; the more extensive are -the investment; -maintenance and operating costs; -and the social discount rate.[57]

Looking at the main parameters in equation (3) and (4), the required volume (of demand in the first year of the project for a net present value = 0, which is the lowest quantity acceptable, is expressed by equation (8):[58]

$$(8)\ Q_0 = \frac{1}{v(\tau^0 - \tau^1)(1+\alpha)}\left[\frac{r-g}{1-e^{-(r-g)T}} I + C_q + C_f \frac{r-g}{r}\frac{1-e^{-rT}}{1-e^{-(r-g)T}} - C_c(1+\alpha)\right]$$

Equation (9) includes α which express the proportion of generated passenger *with* the project with respect to Q_0. C_q expresses the annual maintenance and operating cost variable with Q.

The quantity of passenger trips depends on many factors, which are predicted in the following section:

The European Commission recommends (2008) a social discount rate for the evaluation of the project to be 5 %. Values of time are ranging from 15 to 30 euros per hour.[59]

A survey done 2010 by The Institute of Transport Economics, and Sweco, unveil higher variance for these time values in Norway.[60] The survey distinguishes between travel up to 100 km and travel more than 100 km. The longer the travel lasts, the higher is the value of time per passenger.[61]

The volume of demand is based under the assumption that benefits come mainly from willingness to pay of the generated demand, timesaving from deviated traffic, and cost reduction of decreased service supply in alternative transport modes.

The case for investing in High Speed Rail requires a lot of terms and conditions to be met:

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[57] Rus (2011) p. 15
[58] Rus (2011) p. 16
[59] Rus (2011) p. 17
[60] Samstad, et al (2010) p. 6-14
[61] Minken (2011) p. 15-16

- an ex ante high volume of traffic in the corridor where the new lines are built

- significant timesaving

- high average willingness of potential users to pay

- the release of capacity in the conventional rail network and airports

A key factor is that High Speed Rail is a long-term finance project, which requires to be based on sustainable elements. The operating cost of the High Speed Rail is adjustable but the depreciation rate is fixed. The financial cost relies on the general evolvement of the economy.

Investments in High Speed Rail may end in less efficient use of money. During the construction and the implementation period, new knowledge may change "direction" of the project, which may lead to huge sunk cost.

Data used in calculations of a cost benefit analysis are debatable. The time horizon of 40 year for this project and even longer time horizon for the cost and benefits of the project. In particular, this statement is important for the data to the benefit-cost-analysis used to calculate the benefit-cost ratio of the High Speed Rail, simply because data about future developments – i.e. from ex-ante analyses - do not exist.[62]

Generated journeys with High Speed Rail, including changes in mode choice for travelers to travel by High Speed Rail is part of the cost-benefit analyses.

Stated preferences for the Norwegian High Speed Rail project is found through surveys on how travelers consider High Speed Rail alternatives focusing on journey time, comfort, and access characteristics:

The survey referred to in *Jernbaneverket Norwegian High Speed Railway Assessment Project, Contract 5: Market analysis, Subject 2 and 3: Expected Revenue and Passenger Choices Final Report 18/02/2011* was piloted between 16th and 22th December 2010. The analyses of the surveys were undertaken between 6th and 14th January 2011. 3108 respondents were completed for the study.[63] The consulting company Atkins has defined a model for development of Stated Preference through a two stated preference experiments.

[62] Wee and Tavasszy (2008) p. 87
[63] Atkins and RAND (2011)

One experiment was an experiment to clarify different modes; choice between present mode and HSR. Nine choice scenarios were presented to each respondent. The second experiment was about the willingness to pay for more service; differentiation of standard on board, divided into classes.

The numbers of aircrafts between the High Speed Rail destinations will decrease because of willingness to pay for High Speed Rail; A resent survey unveil that 60-80% of the aircraft passenger will choose High Speed Rail if the fare price was equal to the aircraft ticket price.[64] The time saving for the passengers is, under these circumstances, not crucial because the time consumption for journeys by High Speed Rail and journeys by aircrafts are nearly equal, taken into account all the different time partitions (access time, waiting time, in-vehicle time, and egress time), which are included in the journeys from one city to another city by aircraft.

It is the time saving for other travel modes; cars, busses, boat, and traditional rail transport on distances 400-600 km, which makes the time saving for journeys by High Speed Rail to be a benefit for the analysis. That means that time saving is not an argument for substituting journeys by air (e.g. Trondheim – Oslo: There are 30-40 departures of airplanes between Trondheim and Oslo, about 6 departures by traditional railway, numbers of busses and numbers of cars travelling this route), by HSR. However, there is time saving for travel by cars, busses, boats, and traditional rail transport when changing mode to go by High Speed Rail. On longer distances, longer than 400-600 km, aircraft has the supreme position. Concerning time use on shorter distances, cars are superior.

The lifetime of the High Speed Rail is a long-term investment, stipulated to have a lifetime of at least 40 years. Because of the long-term operation, the depreciation rate and calculation rate are subjects to high uncertainty over the period the project is operative.

Time saving is the most important key data for the cost-benefit analyzes.[65] Benefits from time saving depend on individual preferences, which take different values depending on the respondents' various activities and time of the day, and which day of the week, and which week of the year

The Swedish and the Norwegian financial plan differ in many ways. E.g., there is a difference between Sweden and Norway about how the user is charged for the use of the line. User

[64] Hultgren, Bentzrød and Skjeggestad (2011) p. 2
[65] Wee and Tavasszy (2008) p. 41

charge is a type of levying which is still in practice in Sweden. The purpose with the charge is to let the user pay for depreciation caused by abrasion. Norway has liquidated this fee. Difference in collection of levying makes it necessary for alternative financial sources to cover up for this difference.

4.2 Pricing of High Speed Rail

Through different pricing of different modes or simply change the availability of selected mode routes, the government is able to change not only the proportion of travel modes in areas, but also consumers' preferences for choice of transport mode.

Calculating the Internal Rate of Return, this drives the project to zero profit. The Internal Rate of Return of the investment is the interest rate at which the net present value of costs of the investment equals the net present value of the benefits. Because of lack of data it is not possible to calculate the Internal Rate of the Norwegian High Speed Rail-project now.

A challenge is the demand to operate credible within defined timetables and comfort for traditional rail mode. By defining a more ambiguous long-term goal, the net present value of the project would increase the benefit-cost ratio, which again could improve the welfare of the community as a whole.

The topic for public private partnership is exemplified by looking at the HS1 line: 21. June 2010 the UK Transport Secretary Philip Hammond invited bids to buy HS1 Ltd. The Secretary of State for Transport had been the wholly owner of London & Continental Railways Ltd. HSR1.

The United Kingdom Transport Secretary Philip Hammond said the winning bidder would be "incentivized to attract new operators serving new routes". Selling the HS1 Ltd is part of the government's approach to making our national assets, and every taxpayer pound, work harder".

5 High Speed Rail Projects

High Speed Rail projects around the world justify the decision of building High Speed Rail projects by congestion relief on other conventional modes; on freeways and at airports. Faster travel on the ground between metropolitan areas, and improved movement of people, services and goods.

Worldwide, only two segments, one in Japan (Shinkansen system) and one in France (TGV system), reportedly break even.[66]

All other high-speed rail systems in the world are subsidized.[67] There are huge amount of money spent on construction and operating of the High Speed Rail systems. Cost-benefit analyses are necessary to unveil the outcome of a High Speed Rail project. The opportunity cost, which means the loss of other alternative spend of money when High Speed Rail alternative is chosen, may lead to contradictory conclusions for the High Speed Rail projects. Even when the theoretical cost-benefit analysis above in this thesis is well known for planners and decision makers around the world, the cost-benefit analyses are very different around the world: Some cost-benefit analyses include or exclude data, which are excluded or included in other cost-benefit analyses. Here are some examples:

5.1 High Speed Rail in Sweden

Sweden and Norway implement and connect both the Swedish High Speed Rail project and the Norwegian High Speed Rail project to the same infrastructure, which will bring generated demand to the High Speed Rail project.

Sweden has started planning and has mandated key authorities to assess the issue of High Speed Rail lines. "Höghastighetsutredningen" conducted a similar survey in Sweden as "Høyhastighetsutredningen I Norge". The Swedish infrastructure resembles the Norwegian infrastructure.

[66] Enthoven, Grindley and Warren (2010) p. 26
[67] Enthoven, Grindley and Warren (2010) p. 26

It has not been possible to obtain reliable data for all the cost-benefit analyses for High Speed Rail project below. But some topics for these projects are highlighted:

5.1.1 Cost-Benefit Analysis for the Swedish High Speed Rail Project

The cost-benefit analysis calculated for the two High Speed Rail-routes Stockholm-Malmø and Malmø-Gothenburg in Sweden for the Swedish High Speed Rail, computed a net present value ratio of 0,15,[68] which make the benefit of the project to be larger than the social cost. Net present value quota (ratio): Net present value quota means net present value divided by the investment cost[69] Net present value ratio of 0,15 means; for every krone invested, you'll get 1,15 krone back.

The depreciation period of the Swedish High Speed Rail is 40 year, which is equal to the Norwegian High Speed Rail project. Calculated costs with the proposals of building separate High Speed Rail-lines instead of upgrading and expanding the main rail line, is SEK 125 billion,[70] which is about 19 billion EURO. The Swedish Rail Administration has calculated these construction cost.[71]

5.1.2 Critics of the Swedish Cost-Benefit Analysis

The Cost-Benefit Analysis of the Swedish High Speed Rail has some underestimation of costs and overestimation of benefits, which make the Swedish cost-benefit analysis to fulfill the allegation of "overestimation of benefit and underestimation of cost", discussed earlier in this thesis. Costs for capacity increase of conventional infrastructure in Stockholm and Gothenburg, which is needed, is missing.

The economic cost of funding is calculated too low. The prognoses for passenger volume are too positive on both the level first year and the growth.[72] The access charge is counted twice.[73]

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[68] Malm (2009) p. 29
[69] Malm (2009) p. 163
[70] Malm (2009) p. 29
[71] Malm (2009) p. 29
[72] Malm (2009) p. 325
[73] Malm (2009) p. 326

5.2 High Speed Rail in Britain

Britain has formed a plan for making a Y-shaped national high speed rail network including the new HS2 line. The High Speed 1 (HS1) line, known as the Channel Tunnel Rail Link has been in operating since 14 November 2007.

HS1 is a 109 km of railway line between St Pancras International, London through Kent and all the way to the UK Channel Tunnel. It connects with the international high speed routes between London and London and Brussel. The cost of the HS 1 project was £5.8bn, of which £800m was spent on the St Pancras redevelopment and included extension of existing stations. The Y-shaped national High Speed Rail network HS2 linking London to Birmingham, Manchester and Leeds as well as link to the HS1 line and into Heathrow Airport would cost £32 bn to construct and generate benefits of around £44 bn, as well as further £27 bn revenues.

The stations along the HS1 line in Britain is put out for sale: The UK Transport Secretary Philip Hammond said the winning bidder would be "incentivized to attract new operators serving new routes". Selling the HS1 Ltd is part of the government's approach to making our national assets, and every taxpayer pound, work harder".

The higher quality of these facilities, the less is the value of waiting time. Benefit and costs are very complicated to calculate because the variables for the analysis are changing during the calculation of benefit and costs.

5.2.1 Cost-Benefit Analysis of the HS1 project

Calculating the cost-benefit analysis of the British HS1 is challenging caused by a continuous evolvement of the operating of the project. HS1 network has been calculated to worth 60% of its costs.[74] The demand has not fulfilled estimated demand. The train length levels have been cut and ordering of new trains has stopped.[75]

Then the Government respond: Two Canadian funds will pay £2,1 bn for a 30-year concession to operate HS 1 from London to the Channel tunnel.[76] £2.1 bn is far higher than

[74] Miles (2011) p. 1
[75] Miles (2011) p. 1
[76] Wright (2010) p. 1

the £1.5 bn originally expected for HS1 concession. The sale will change all previous results of a cost-benefit analysis. “This is great news for taxpayers and rail passengers alike” said the transport secretary Philip Hammond.[77]

5.2.2 Cost-Benefit Analysis of the HS 2 project

The HS2 project costs £25.5bn. Extra fares are estimated to be £15bn.[78] HS2 is not commercially viable. Net benefit ratio is calculated to be 2.7.[79] To get such a positive value of the cost-benefit analysis, the question of validity of the data is present. It is assumed excessive demand and illusory benefits with little reaction or responds from substitute modes.

5.2.3 Critics of HS2 Cost-Benefit Analysis

Demand increase is expected to be about 267% without bringing saturation of domestic travel demand into account. Rail growth, which is caused by modal substitution.[80]

The general world economy does have shocks nowadays that are not taken into account in the cost-benefit analysis. The cost-benefit analysis is built on an economy that is not present to day. Recent analyses that give lower growth factors are ignored. Development of new technology is not taken account of.

The Government’s own actions to decrease the travel demand are not part of the cost-benefit analysis. Air travel is overstated assumed the trends, pollution impacts (carbon), and the moderate air modal shift numbers.

There are overestimations of benefits from car occupancy. Multiple scenarios for demand are absent. Only one single case of demand is presented. Respond from the conventional rail on the HS2 project are assumed gone regardless of the huge consequences for HS1 and Channel Tunnel.[81]

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77 Wright (2010) p. 1
78 Miles (2011) p. 1
79 Miles (2011) p. 1
80 Miles (2011) p. 1
81 Miles (2011) p. 1

Work time for businesspersons caused by shorter travel time is included. Wrongly assumes that on board there is no work time. Data that are 10 years old draw earnings for rail business travelers unadjusted for a five times numbers of travelers by 2033.

Subsidy for HS2 is not adjusted for the fact that the rate of subsidy decreases as the amount of income increases. Far-fetched levels of travelers gathered in the other modes if HS2 does not be implemented, makes the £5bn overcrowding benefits less valid.[82]

HS2 Ltd has calculated the value of time saved based on that average business traveler earning £70.000 a year, which is an overestimation of 150%.[83]

HS2 project is evaluated against a scenario, which is "the lowest level of effort scenario" of other modes that is an unrealistic alternative, as it cannot fit in with the wishes of the forecasted demand.[84]

"Rail Package 2", which is the alternative investment to HS2, is not taken account of. This alternative meets the lower demand than the HS2 and has a cost of £2bn. It delivers benefits incrementally over time. The alternative investment could increase capacity by 65% with more rolling stock and without material downtime.[85]

Regions will not benefit from redistributive effects of the HS2. London is the winner of these effects.

Additional electricity generation is required to meet the technology but these calculations are not done. Energy saving in this era should be an every day habit but HS2 Ltd believes that just because the line exists an additional 135,000 passenger will use the line. This is wholly unproven and is not sustainable argument.

The carbon emissions will hardly be reduced. Probably attain neutral or worse; A net increase in carbon dioxide emissions is probably more likely. The carbon emissions from construction of the infrastructure are poorly estimated and are assigned too low a value to be valid. With

[82] Miles (2011) p. 1
[83] Miles (2011) p. 1
[84] Miles (2011) p. 1
[85] Miles (2011) p. 1

speed up to 400 km/h the noise levels is enormous and need to be measured and valued better in the cost-benefit analysis.[86]

5.3 The Channel Tunnel Project

The Channel Tunnel Rail project doubled the estimated construction costs, from £4,7 billion in the original estimate to £9,5 billion.[87] The ex post economic evaluation was concluded January 8, 2006.

5.3.1 Cost-Benefit Analysis of the Channel Tunnel

The Channel Tunnel between United Kingdom and France had a cost overrun of 80 % for construction and 140 % overrun for financing.[88]

Actual costs turned out to be about twice the forecast. Actual benefits were only half the estimated forecast. Actual net present value is $ -17,8 billion. Finally the internal rate of return = -14,45%. Conclusion is referred to Richard Anguera, Transportation Research A40, 2006: “The British Economy would have been better off had the Tunnel never been constructed”.[89]

A recent ex post evaluation shows quit a different result. In 2010, the Eurotunnel Group’s revenue increased to €263 million of revenue from it’s railway network.[90] The number of passenger going through the Tunnel rose by 3 % 2010 and ended on 9,5 million passenger.[91]

[86] Miles (2011) p. 1
[87] O'Connell (2006) p. 1
[88] Flyvbjerg (2007b) p. 581
[89] Flyvbjerg (2007c) p. 4/27
[90] Groupe Eurotunnel SA (2011) p. 27
[91] Groupe Eurotunnel SA (2011) p. 28

5.4 High Speed Rail in California

California's proposed high speed train connecting Northern and Southern California, which encompasses all urban areas of California, has a real cost represents more than $60 million per month of principal and interest commitment on only the voter approved $ 9.95 billion of general obligation bonds. At least 88 million Californians are expected to ride the proposed high speed train annually by 2030.[92] Then the state's population is expected to grow to 48 million people.[93]

The baseline of the California High Speed Rail Authority document AB3034 is that there is little if any chance the system will pay for itself.[94] On the other hand, there are many external benefits, which are hard to calculate. The most important external benefit comes through environmental factors.

5.4.1 Cost Benefit Analysis of the Californian High Speed Rail

The Californian High Speed Rail project creates thousands of jobs, estimated to be about 450.000 new jobs (including temporary and permanent jobs) to operate and maintain the High Speed Rail over the next 25 years.[95] The construction and implementation of the project creates temporarily about 100.000 jobs to build the trains and the train line.[96] I have assumed in equation (2) and (3) that there is no permanent job creation over the lifetime of the project. However if in the real life there is permanent job creation, this can of course be included as benefit on the benefit side of the cost-benefit calculation, if it otherwise had been permanent unemployment.

There are inconsistencies in Californian High Speed Rail Authority's forecast about the severity of their methodologies for computing employment. Many are left wondering what Californian High Speed Rail Authority means by permanent jobs.

The capital costs of phase I is suggested to be $42.6 billion. Using empirical overruns from previous estimates as a guideline, the amount could reach $100 billion. Some transport projects reach an overrun up to 600%. A realistic estimate of the costs of Phase I range from

[92] Randolph (2008) p. 1
[93] Randolph (2008) p. 5
[94] Enthoven, Grindley and Warren (2010) p. 14
[95] California High-Speed Rail Authority (2008-2010) p. 1
[96] California High-Speed Rail Authority (2008-2010) p. 1

$62 billion and up to $213 billion.[97] To achieve positive cash flow, the Government needs to transfer $19 billion of grants to fulfill the estimated $42.6 billion.[98]

The ticket prices (mile rates) in Californian High Speed Rail Authority's ticket pricing model are based on $0.24/mile. To make it profitable, ticket prices must be about 80% higher.[99] If they charge passenger at this level it will cause fewer passenger.

5.5 High Speed Rail in Spain

The High Speed Rail line (471 km) between Madrid and Barcelona opened in 2008 and takes about 2 hours and 38 minutes by High Speed Rail. It used to take 6 hours by car. Before the High Speed Rail line opened, nearly 90 percent of the six million travelers between Madrid and Barcelona went by air.[100]

During the operation period 2008 and to the present time, the numbers of passengers travelling by High Speed Rail are now more than 50 percent of the total numbers of travellers and are still growing.[101] Other Alta Velocidad Espanola lines connect Madrid with Seville and with Malaga. The number of flights between Madrid and Malaga dropped by half in the two years Alta Velocidad Espanola has operated.[102]

The High Speed Rail project in Spain has succeeded right timing of constructing and implementing the Alta Velocidad Espanola lines.

Cost-Benefit Analysis of the Alta Velocidad Espanola project is as in all High Speed Rail project depended on how the cost-benefit analysis is done and when it is done. The Alta Velocidad Espanola has built the first line, Madrid-Sevilla by reason of the opening of the International Exposition of Sevilla, Expo 92.

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[97] Enthoven, Grindley and Warren (2010) p. 16
[98] Enthoven, Grindley and Warren (2010) p. 17
[99] Enthoven, Grindley and Warren (2010) p. 26
[100] Wright (2010) p. 1
[101] Wright (2010) p. 1
[102] Wright (2010) p. 1

6 Conclusion

The Government's ultimate purpose is to maximize the welfare of the community as a whole. The allocation of resources to the Norwegian High Speed Rail project has to be evaluated up against the opportunity cost of not investing in the High Speed Rail project.

There are different ways to evaluate and conclude the project. The demand uncertainty is one of the two most critical elements. Timing of the project; when to construct and implement the High Speed Rail-project is the other element and is connected to demand uncertainty.

Demand uncertainty for the Norwegian High Speed Rail is tight connected to valuation of time. Value of time calculated by The Institute of Transport Economics, is helpful for making good predictions on time valuing of saved travel time. However, some factors in the High Speed Rail project are hard to calculate which are related to quality of the service.

When the level of quality of the facilities connected to the Norwegian High Speed Rail project is defined, the cost-benefit analysis will get more valid conclusion. The quality of the rolling stock and facilities along the infrastructure influence the value of time. The higher the quality of existing mode is, the lower is the value of saved time, because travel time is only one of many variables in the cost-benefit calculation. The value of egress time depends on the quality on facilities along the line and also on board.

The framework for the High Speed Rail project is under continuous development. Uncertainty about most of the factors concerning the Norwegian High Speed Rail makes it vital to focus more on trends in other countries. Norway is part of a very open economy and interacts with the rest of the world in a wide-open way. To be able to deliver an efficient public transport system at the same level as other competitive countries, it is necessary to keep up with the technology implemented in these countries. Transport and Communications priorities are among the most important tools to achieve this goal. Allocation of resources to the most efficient modes, which will remain efficient for decades to come, makes it hard to give priority to the High Speed Rail project because of the enormous investment of about 1173 billion NOK.

Implementing of High Speed Rail in other countries makes it easier for Norway to evaluate empirical results from other countries projects.

Building of High Speed Rail will define a new standard for transport, changing the paradigm of travel in Norway and represent the way of transport for decades to come, but whether the High Speed Rail project helps the government to maximize the welfare, is not settled in this thesis.

The theoretical steps through the cost-benefit analysis shown above, opens for lots of individual interpretations. Excerpts from cost-benefit analysis of selected High Speed Rail lines in this thesis cannot be compared but tells something about the problems calculations of costs and benefits of a High Speed Rail project have to deal with. One way to look at it is;

Investing in Norwegian High Speed Rail with speed of 300kmh+, not only speed of 250 km/h, would make High Speed Rail more competitive in the travel market compared to aviation.

On the other hand, it is probably not possible to get positive net present value of the investment in the Norwegian High Speed Rail, as long as the empirical data show that most of the High Speed Rail projects around the world do not achieve net break-even point.

Uncertainty, which encompasses most of the elements in the project, could be reduced by defining a long-term transport policy. High Speed Rail is not the target itself, but rather one of many tools to achieve other long-term goals, e.g. welfare improvement through more efficient use of resources, which include better environment. Time valuation and time saving are critical factors for aggregating more High Speed Rail traffic.

It is a prerequisite that political will across the politicians converge towards a common conclusion among all decision makers to ensure the project to be implemented, and a prerequisite is that the citizens living along the line interact with the High Speed Rail authorities in a positive way. Otherwise, it could be problems:

Environmental studies of infrastructure connecting the Central Valley to the Bay Area lead a coalition of cities and citizen groups in the San Francisco Peninsula to take the rail authorities to court.[103] Another example is the building of the Airport Express Train Tunnel, which caused a lake in Oslo to loose all the water because the mountain was destroyed during construction of the tunnel.

[103] Rice (2011) p. 1

Some criticism against the High Speed Rail-project is that environmental costs are huge. It is not always this criticism is reliable. The environmental cost of the alternative development of the alternative development of the transport capacity is downgraded or often not included.

At the present stage (January 2012) of the High Speed Rail project, the Norwegian level of investment is undefined.

The costs for other High Speed Rail projects around the world may be less valid for the Norwegian High Speed Rail. Because of a higher price level and higher valuation of Norwegian property, lower population density, a topography that is more challenging concerning tunnels and bridges, the benefit-cost ratio for the Norwegian High Speed Rail is not yet defined. A complete report about the Norwegian High Speed Rail project will be presented for the Norwegian Government January/February 2012.[104]

The need for more time efficient transport and communication may optimally be met by building the High Speed Rail project. The demand for greater capacity of transport may be solved by choosing older technology, which may lead to more efficient use of time. But:

Timing of the choice is essential. Choice of the Scenario A, B, or C is not the topic for this thesis. The three mode-scenarios A, B, and C are perpetual task for the Government to solve and are less relevant for this thesis, whether scenario D, the High Speed Rail should be built or not.

The unit price by meter rail of the Norwegian High Speed Rail project would benefit from building all six traces if it was possible to benefit from economy of scale. The problem is that it is hard to copy the construction and implementation of the six traces because there are very different topography and climate.

The Norwegian High Speed Rail project may benefit from a delay of the construction and implementation until the costs of the technology (e.g. building of rails, building of tunnels, or how to solve power supply) have fallen, caused by increasing return to scale concerning the construction of the infrastructure and the rolling stock in other countries. On the other hand, a delay of scenario D would require immediate investments in conventional modes, scenario A, B, or C, until the demand for High Speed Rail is verified. Before technology is chosen, it

[104] Stillesby (2011)

should be made tunnels for new rail lines to meet the growing demand for more rail capacity, whether they are being used for High Speed Rail or conventional rail.

Norway has a deficit in investments on conventional transport modes, which makes the High Speed Rail to profit on a threshold for calculating costs. Instead of investing in conventional modes, higher rate of investments should be allocated to the Norwegian High Speed Rail project with the target to change transport habits among the travelers. Lobbyism affects the decision makers to adopt an approach to the High Speed Rail with a biased attitude.

The financial commitment must be set up against alternative spending. Environmental benefits must be significant proved. The economic activity caused by the High Speed Rail project must be based on a certainty that its costs pay off. If the High Speed Rail-project returns are negatively correlated with the Gross Domestic Product, thus allowing the benefits of the project to be larger the worse it goes with the rest of the economy, then the Norwegian High Speed Rail project, that is more than the entire State budget, will influence cyclical fluctuations. The general economic situation in the world is under severe pressure and influences the State budget, which causes high variance on data in the cost-benefit analysis.

7 Aftermath:

The project manager Stillesby explains for me that the conclusion from Høyhastighetsutredningen will be a part of "Den Nasjonale Transportplan (NTP)" for the periode 2014-23. The NTP will be sent to consultation February 1st 2012. During 2012, the Department of Transport and Communication will make a parliamentary report, which will be presented for the Parliament spring 2013.[105]

Nobody knows the result of this procedure. If the government adopts one or more of the lines to be built, then the normal traditional procedure is to be done including "Konseptvalgutredninger (KVU)" and regulations. Whether The National Rail Administration is the constructor and builder, or if it is needed to establish a development company similar to Gardermobanen AS is to be concluded at that time of construction and implementation the Norwegian High Speed Rail project.

Steinar Strøm, Vista Analyse, professor at the University of Torino, is member of the international expert collegium who has evaluated the report from the consultant companies. The result of this evaluation is that the Norwegian High Speed Rail project is too costly and is not economically viable. The value of time reduction may increase caused by economic growth in Norway, but at the present time, the Norwegian taxpayers must cover a risk adjusted investment of 1171 billion NOK, which is a little bit more than the Norwegian State budget. The conclusion is that the Norwegian High Speed Rail project is not profitable in socioeconomic terms.[106]

[105] Stillesby (2011) Personal communication
[106] Strøm (2012) p. 3

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