Bachelor thesis

SCM600 Logistics and Supply Chain Management

Contributing to carbon neutrality and privatization of rail: what can the Norwegian government do to increase travels by rail? A case study considering generalized travel costs for a student travelling between universities

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Preface

This bachelor thesis concludes my program for a Bachelor's degree in Logistics and Supply Chain Management at Molde University College. This thesis is written spring 2021 and is worth 15 ECTS credits.

The purpose of this thesis is to explore the effects of privatizing the rail sector through existing literature and to make a case study in an attempt to find out the total costs of both rail and air travel, for both leisure and business travels (generalized travel costs).

This has been challenging, but also quite rewarding. I've made several interesting discoveries and I feel I've gained an understanding in the rail sector.

Acknowledgments

I would like to express my appreciation towards my supervisor PhD Eivind Tveter for valuable comments, insights, and follow-up work throughout the process. I also want to give thanks to all my lecturers from my previous courses. I am grateful for my family and friends for motivation and encouragement. Finally, thanks to my girlfriend for her support and patience throughout the process. I could not have completed this thesis without the people mentioned in this acknowledgment.

Abstract

A transition towards a higher share of rail usage has the potential to reduce emissions in Norway. Therefore, the Norwegian government should make it more attractive to travel by rail. However, in many cases, the ticket prices for rail costs less than the equivalent airline tickets and travelling by rail is in most cases a more environmentally friendly way to travel compared to air. This thesis empirically examines the generalized travel costs of air and rail travel, both as a leisure travel and as a business travel, in Norway's five largest cities. The calculations shows that the generalized travel costs of a rail travel, when travelled as a leisure travel, is higher than the equivalent air travel. For business travels, the difference in generalized costs is even higher than leisure travels. Even if travelers were offered a free rail ticket, some might still choose to travel by air. In some situations, travelers would choose to travel by air even if they got paid to travel by rail. The large difference in costs limits the scope for the government to contribute to an increase in rail travels. One solution is increasing tax on air travel and fuel. As a policy, increase of tax is not popular among the population. This thesis suggests increasing the tax on air travel gradually. By implementing this change slowly, it will be easier for passengers to accept this necessary change.

Keywords: privatization, air, rail, policy instrument, generalized costs

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1.0 Introduction

The railway markets in most European countries have been organized as governmentally owned monopolies controlling both infrastructure and railway services. The organization of changed in the 1990s when the European Union introduced the idea of deregulation of rail in 1991, thus EU Directive 91/440 was introduced (1991). The Norwegian government decided on 29.05.2018 that a part of the fourth railway package had been passed (Ministry of Transport , 2018). The legislation was named:

"Regulation (EU) 2016/2338 of the European Parliament and of the Council was legalized 14 December 2016 amending Regulation (EC) No 1370/2007 concerning the opening of the market for domestic passenger transport services by rail" (EC, 2016).

The background for why the rail is regulated comes from the fact that it is often seen as a natural monopoly. This means that a single actor can produce the service cheaper than several players due to high fixed costs, while the extra cost of offering an additional unit (the marginal cost) is low. The main purpose of deregulating the railway market (privatization) is to reduce European rail subsidies and improve the efficiency in the rail network through increased competition. Greater competition usually means higher efficiency and productivity (Leibenstein, 1966; Sjöstrom & Weitzman, 1996), which in turn should result in reduced ticket prices for the passengers. Several studies shows that deregulation in different sectors improve efficiency immediately in the following years after privatization (Boubakri & Cosset, 1998; Megginson & Netter, 2001; Chong & López-de-Silanes, 2004; D'Souza, et al., 2005; Wu, 2006; Otchere, 2009; Fang, et al., 2011). A study on the long-run effects of privatization in Canada shows that privatization increases productivity, at a decreasing rate, and reaches its peak after about 14 years (Boardman, et al., 2016). The study suggests that State-owned enterprises (SOEs) operating in *reasonably competitive markets* should be fully privatized – meaning it should not be partially-owned by governments nor through sovereign wealth funds. The aforementioned studies dealt with regulation in the finance industries. These results do not necessarily carry over for the rail, because of the aspects of a natural monopoly. Studies considering the railway market also indicate that privatization and competition increase efficiency. In an empirical study, Liu, et al. (2019), find that triggering competition leads to lower transportation costs, more selection and higher productivity for high-speed rail (HSR) in China. Their findings suggest increased productivity for private firms, but not for State-owned enterprises (SOE). Their empirical results are consistent with other empirical findings from China (Faber, 2014; Yang, 2018; Huang & Xiong, 2018). However, according to literature, competition does not seem to increase efficiency and productivity for non-high-speed rail (NHSR), nor for private rail firms in other parts of the world – with the most notable example being the privatization of British railway.

The main focus of private companies is to optimize profits; thus, they have incentives to cut costs and be more efficient. A government-owned enterprise does not optimize profit, since its main focus are public policy objectives, i.e., make transportation more accessible. The railways used to be owned by the government. It used to be a natural monopoly, because of high fixed costs with low marginal costs (e.g. the cost of an extra passenger using the rail). Due to this, only the operation itself is exposed to competition. In an attempt to utilize market forces to improve efficiency, the Norwegian government approved the proposals for a reform in the rail sector (Minsitry of Transport, 2015). The purpose of the reform was to create more competition in domestic rail transport and by making it more efficient, thus providing a better offer and service to passengers, whilst keeping the subsidies to a minimum. Norway used competitive tendering to award licenses to operate domestic passenger services (Minsitry of Transport, 2020). The aim of competitive tendering is to create competition for the market and hence exploit the benefits that competition can bring in terms of lower costs, higher efficiency, greater quality and innovation. Competitive tendering is in general an effective instrument for identifying the most efficient company that would serve a market, but this doesn't necessarily apply to the rail sector. A government can't allow a rail service operator to go bankrupt, thus when these companies face difficult commercial challenges it would be more profitable for them to default on its obligation instead of fulfilling them. An economic efficient solution is to set the prices equal to marginal costs of providing railway service. But because of the high fixed costs such prices will not cover these costs and the railroad company will go bankrupt. Setting prices to cover average costs will make the company cover the fixed costs, but the prices and usage of railroads will not be optima and create a deadweight loss. These challenges could arise because the operating costs proved to be higher than calculated, demand lower than forecast or other events, such as a pandemic (OECD, 2013). On the other hand, studies show that countries using competitive tendering has led to efficiency gain of 20-50% compared with directly awarded contracts, which improved efficiency by 0-10% (McNulty, 2011).

Rail, under most circumstances, is more environmentally friendly than travelling by ICE-car and plane. According to Grimme and Jung (2018), short-haul flights produce more than double the amount of CO_2-emissions per km compared to long-haul flights. Travelling by public transport will often be the most efficient way of traveling, in terms of emissions released. According to the annual sustainability report of Vy, one of the largest transport companies in Norway, in 2020 alone they saved 668 093 tons CO_2-equivalents by transporting people and freight cargo. This amount is equal to the emissions of 336 000 cars per year (Vygruppen, 2021). Vy are further working on reducing their emissions by transitioning to more electrical buses and rail. Note that the report may contain self-interest.

Most of the rail in Norway is powered by electricity (with exceptions, such as the Rauma Line that is running on diesel), which means it's more environmentally friendly than transport modes that rely on fossil fuel. The global electric vehicle fleet expanded significantly over the last decade, underpinned by supportive policies and technology advances. 2.1 million electric vehicles were sold globally in 2019, surpassing 2018 to boost the stock to 7.2 million electric vehicles. As technological progress in the electrification of two/three-wheelers, buses, and trucks advances and the market for them grows, electric vehicles are expanding significantly (IEA, 2020). 62 273 electric vehicles (personal and corporate) were sold in Norway in 2019 (OFV, 2020) and 84 734 EVs (personal and corporate) were sold in 2020 (OFV, 2021). By the end of 2020 there were 340 002 personal EVs in Norway (SSB, 2021). It is not given that rail is more environmentally friendly compared to personal vehicle in the future. It's projected that the sales of private electric vehicles will increase in the future.

1.1 Research questions

My choice to focus on rail is motivated by the fact that rail is driven on electricity and it being an attractive alternative to fossil fueled transport modes, in order to achieve fossil independence and being climate neutral. This thesis will be adding to the literature by comparing short-haul flights with existing non-high-speed-rail in the major cities in Norway. The analysis will compare generalized travel costs for different transport modes. A formula for generalized travel costs will be used in the calculation. The aim of this thesis is to get a deeper understanding of the advantages and disadvantages of deregulating rail and how these regulations can impact the environment. This thesis is also trying to explore if the EU directive about deregulation of rail increases productivity and efficiency. European Union has made laws / directive about deregulation and vertical separation to make rail more competitive with the hypothesis that this will make rail more efficient. From personal experience the rail tickets have increased in price, leading me to choose transport modes for longer travels (500km) that are not as environmentally friendly as rail. This includes both personal vehicles (ICE) and aircrafts. The rail in Norway are non-high-speed rail (NHSR) and I believe I would choose rail as transport of choice if it was cheaper. However, after a quick look up it seems like airline tickets are more expensive, but the monetary value (price of ticket) doesn't tell the whole story. Time is valuable – is the total cost (monetary cost, travel time, waiting time) for an air travel more than an equivalent rail travel? I believe the opposite to be true. My hypothesis is:

Hypothesis: The total cost of an airline ticket is higher than the total cost of an equivalent train ticket.

This hypothesis will be examined, and its results will be presented and discussed in section 5.0. This leads to my research question:

> *What can the Norwegian government do to increase travels by rail? A case study considering generalized travel costs for a student travelling between universities*

I will look at the differences in travel between campuses in the five largest cities in Norway with rail and air. Both the Norwegian government and the EU wants to be carbon neutral. Travelling by rail can, under most circumstances, contribute to a green future. Therefore, travelling with rail should be cheaper than travelling with air to attract more passengers.

1.2 Structure

The thesis is structured as follows. Section 2.0 provides a literature review of previous research in the area. Section 3.0 presents the empirical strategy, a general formula for generalized costs and the expanded formula. Section 4.0 presents the methodology. Section 5.0 presents the calculation, results, and an analysis. Section 6.0 and 7.0 presents the discussions, and conclusion, respectively.

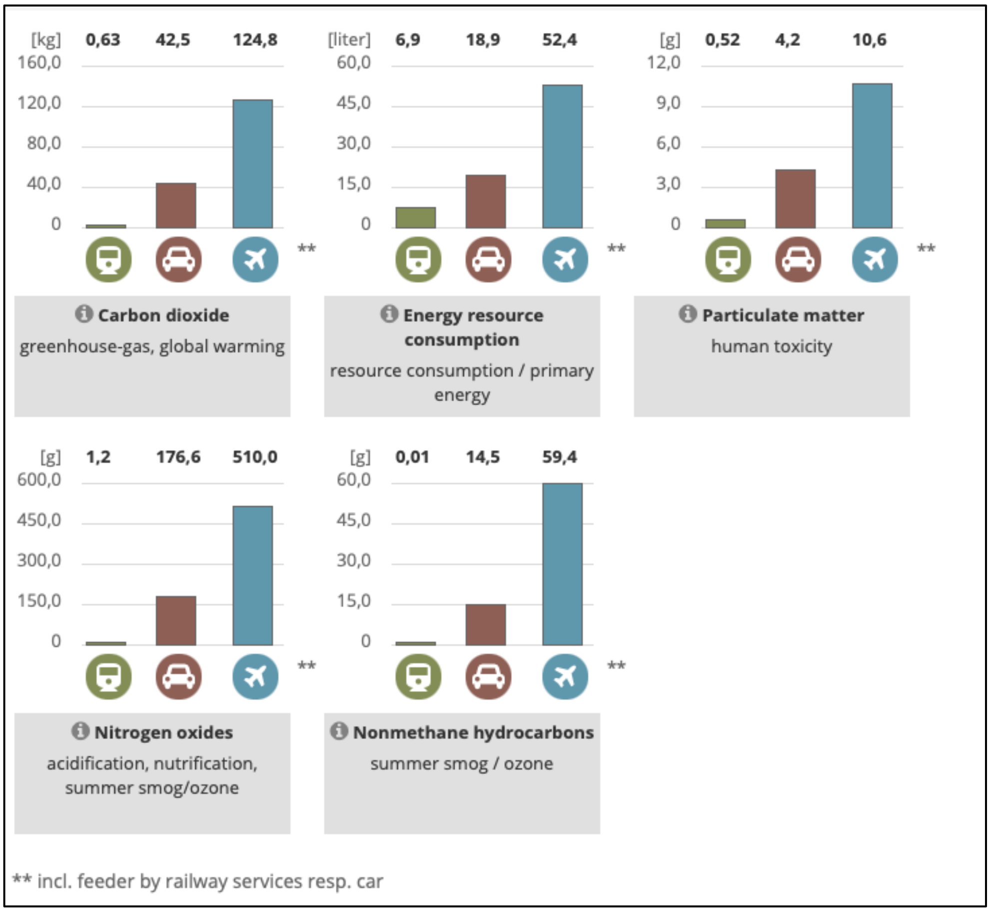
2.0 Literature review

2.1 Environmental

Rail, under most circumstances, is more environmentally friendly than travelling by fossil fuel vehicles and aircraft. The transport sector is still growing and in spite of technical development, the sector has not been able to reduce its environmental impact. The reason is the increased global demand for transportation. One solution to reduce this environmental impact is to be continuing to develop and improve rail transport, as a means to shift transportation from air and road to rail. Rail is limited and not suitable for all types of transportation. Rail can provide great solutions as urban transportation and medium distance travel between regional cities, since it can be energy efficient, cost effective, provides good passenger comfort, and has low environmental impact (Lundberg, 2016).

Travelling by public transport will most of the time be the most efficient way of traveling. According to EcoPassenger a rail travel from Stavanger to Oslo city centre (about 550km) emits just 0.63kg of carbon dioxide per passenger, while it's 42.5kg for car (average 1.5 passengers per car) and 124.8kg for air. It's to be noted that the number for air includes emissions from Oslo airport to Oslo city centre (EcoPassenger, 2021). This is presented in Figure 1. It's to be noted that these numbers can be different due to the pandemic.

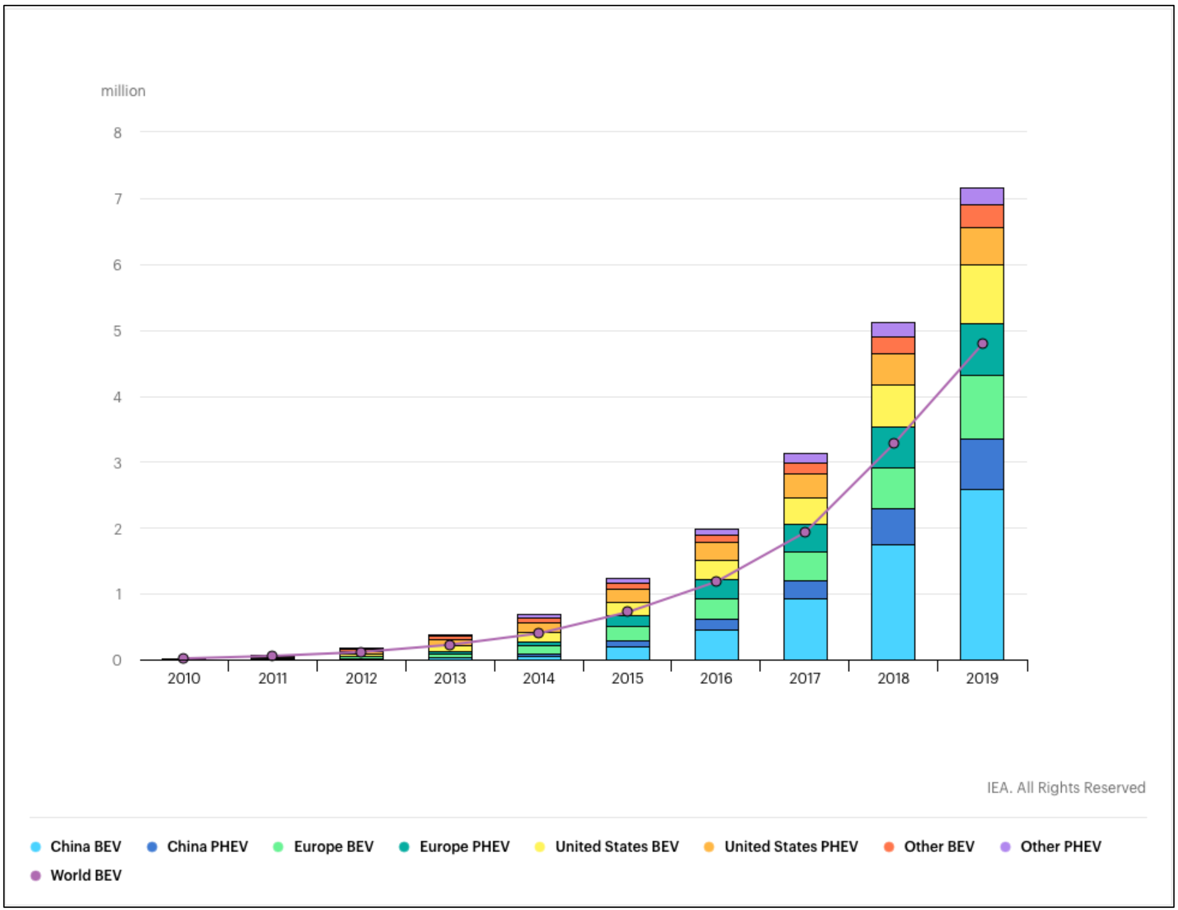
Figure 1: Stavanger to Oslo city centre



Baumeister & Leung compared short-haul flights with existing non-high-speed-rail (NHSR) in 16 Finnish cities, suggesting that if all short-haul flights were replaced with NHSR it could reduce emissions by 95% (2021). They also find that NHSR travels can compete against air travels in terms of travel times on distances up to 400 km, door-to-door. According to Grimme and Jung (2018), short-haul flights produce more than double the amount of CO_2-emissions per km compared to long-haul flights. This is because of the intensive energy usage during take-off and climbing, distributed over a shorter distance. Flight lengths between 1100 – 1500 km are considered as short-haul flights, although there are no international standards. Most flights in Norway are short-haul flights, with the most notable exception being flights to and from Tromsø, the most populous city in Northern Norway.

The global electric vehicle fleet has expanded significantly over the last decade, because of supportive policies and technology advances. In 2019, 2.1 million electric vehicles were sold globally, surpassing 2018 (already a record year) to boost the stock to 7.2 million electric vehicles. Electric vehicles, which accounted for 2.6% of global car sales and about 1% of global car stock in 2019, registered a 40% year-on-year increase. As technological progress in the electrification of two/three-wheelers, buses, and trucks advances and the market for them grows, electric vehicles are expanding significantly (IEA, 2020).

Figure 2: Global electric car stock, 2010 – 2019 (IEA, 2020)



62 273 electric vehicles (personal and corporate) were sold in Norway in 2019 (OFV, 2020) and 84 734 EVs (personal and corporate) were sold in 2020 (OFV, 2021). By the end of 2020 there were 340 002 personal EVs in Norway (SSB, 2021).

2.2 Economic

The main focus of private companies is to optimize profits; thus, they have incentives to cut costs and be more efficient. A government-owned enterprise does not have to prioritize profit as highly, since its main focus are public policy objectives, i.e., make transportation more accessible. The rail markets in most European countries have been organized as governmentally owned monopolies controlling both infrastructure and railway services in the past. The European Union first introduced the idea of deregulation of rail in 1991. EU Directive 91/440 (EC, 1991) was introduced, and its aim was to create a more efficient rail network by deregulating the rail industry thus creating greater competition. Studies suggest greater competition leads to more efficiency and productivity (Leibenstein, 1966; Sjöstrom & Weitzman, 1996). Regulations that impact freight train length (longer trains are more efficient than shorter trains) and new technology have a major impact on efficiency. Differences in asset utilization, staff productivity, freight rates, and cost/revenue ratios are all key indicators regarding railway efficiency. Delivering the best possible return on invested capital and public benefits are of high importance, while minimization of costs and subsidies is critical. Nations with high concentrations of mountain terrain makes the construction and maintenance of infrastructure more expensive. An efficient railway from a national perspective maximizes revenues and minimizes costs while providing the desired level of service. (Beck, et al., 2013). Furthermore, the study also finds evidence that efficiency and public funding and financing of railways are linked. It is critical for rail companies to be able to plan with relative assurance that expected government funding will delivered consistently. Public funding is critical to all parties involved. Even if it is decided that railways should operate in competitive markets with little government regulation, public funding is often critical to supporting major projects that improve both railways efficiency and the quality of life around railways. Definitions of efficiency varies, because of different aims. One nation can measure efficiency based on profits, while a different nation can measure efficiency based on market share, based on punctuality, etc. This is supported in a study by Thompson and Bente (2014). In their findings, there are several purposes for measuring efficiency and the single most important factor is asset utilization of infrastructure and fleet. Most studies of railways efficiency are focused on technical costs efficiency, but the service to the customer should be the most important factor since they are the consumers. More effort needs to be invested in providing data and KPIs on the service quality related to how users choose between transport modes. (Makovsek, et al., 2015)

However, railway efficiency in Norway shouldn’t be calculated from a financial perspective, since the main goal is to decrease emissions. Most European railways still needs to develop and experiment with more efficient and transparent capacity allocation procedures to foster more competition which can yields substantial social benefits (Ait Ali & Eliasson, 2021). Ait Ali & Eliasson finds that opening the market for railway services to competition can potentially create significant social benefits. The reason for this is that the operators need to supply according to consumer demand, which in turn gives them incentives to become more cost-efficient.

Most of the rail is driven by electricity and as public transportation its competition includes aircraft, personal vehicles, buses, rail and more. In an American empirical study, the impact of government incentives (e.g subsidies) on hybrid electrical vehicles adoption were examined (Diamond, 2009). The study found out the fuel price to be the main driver, while government incentives were found to have a weaker effect. In agreement with Diamond (2009), Beresteanu & Li (2011) also suggest fuel price to be the main driver of hybrid electrical vehicles adoption in their findings. Other studies found evidence that increasing financial subsidies lead to higher sales of electrical vehicles (de Haan et al., 2007; Chandra et al., 2010; Gallagher & Muehlegger, 2011).

2.3 Deregulation

Lower transportation costs lead to more selection and higher productivity for high-speed rail (HSR) in China by triggering greater competition (Liu, et al., 2019). Their empiric findings suggest increased productivity for private firms, but not for State-owned enterprises (SOE). Their theoretical results are consistent with empirical findings from China (Faber, 2014; Yang, 2018; Huang & Xiong, 2018). Several studies shows that competitive industries improve efficiency immediately in the following years after privatization (Boubakri & Cosset, 1998; Megginson & Netter, 2001; Chong & López-de-Silanes, 2004; D'Souza, et al., 2005; Wu, 2006; Otchere, 2009; Fang, et al., 2011).

A study on the long-run effects of privatization in Canada shows that privatization increases productivity, at a decreasing rate, and reaches its peak after about 14 years. It suggests that SOEs operating in reasonably competitive markets should be fully privatized – meaning it should not be partially-owned by governments nor through sovereign wealth funds (Boardman, et al., 2016) These studies are mostly done in the competitive finance industries. Rail is not reasonably competitive markets, because of the high initial costs / upfront. The rail sector can be considered a natural monopoly. Estache et al. in their findings regarding an operator providing all the services (the normal model) suggests that both Argentina and Brazil have benefitted from privatization – the overall performance of railway services has improved, both for passengers and freight in various degrees. Their findings were done by computing the total factor productivity (TFP) of each business unit (2002). Total factor productivity is the part of output growth not explained by the amount of input growth used in production (Comin, 2010). The five main determinants of productivity are innovation, education, market efficiency, infrastructure, and institutions (Kim, et al., 2016)

Private sector will not be the main source of infrastructure-financing. Building, investing and maintaining infrastructure requires government spending (Estache, 2008). Likewise, Bogart & Chaudhary also uses TFP in calculating productivity. In their study about India purchasing private rail companies, they expected productivity to decrease. The findings suggests that state ownership is no worse than private companies regarding productivity, since the TFP remained the same (Bogart & Chaudhary, 2015)

The main rolling stock maintenance operator, rehabilitation and service provider in Norway is Mantena which is owned by Vy (Vygruppen AS), formerly Norges Statsbaner (NSB). Vy is owned by the Norwegian Minsitry of Transport. Track maintenance, rehabilitation and service provision are normally included as one single service provided by an operator. In countries such as the United Kingdom the different services are provided by several operators. Very few countries follow the UK model (Estache, et al., 2002). There is not enough data to confirm which model is the most efficient (Vatn, 2008).

2.4 Railway in other countries

Sales of SOE’s has historically been used to transfer wealth from the public sector to the private sector, meaning only the owners of the rail companies and the providers of capital has benefitted from regulation (Jupe & Crompton, 2006). Jupe & Crompton also finds that Great Britain only achieved one out of five main objectives they set at the start of regulation: the number of rail passengers were increased. They failed the four other main objectives: managing franchises in the interests of passengers; efficiency and economy of passenger rail services were not encouraged; investment in rail services were not encouraged; and progressive improvement in the quality of rail services were not secured. There has been a need for continuous subsidies after rail regulation (Welsby & Nichols, 1999). The subsidies from the Network Rail have artificially inflated the profits of these private rail companies, and make it look like these companies are operating at a profit when in reality it's just an illusion. This enables supporters of privatization to claim that private rail operators are a net gain for the British taxpayer (Bowman, 2015). This is supported by McCartney & Stittle (2017). They find evidence that suggests rail privatization in Great Britain has been a major public policy error. No clear evidence that supports the idea of increased competition leading to increased efficiency has been found.

In the UK, Railtrack, the privatized and vertically separated company, had to be bought back by the UK government following an accident (Hatfield derailment in 2000) that disrupted the entire system, increased costs per unit. Railtrack also did not invest enough in physical assets (Glass, 2011). Sir Roy McNulty finds that the UK needs to reduce the efficiency gap compared to France, the Netherlands, Sweden and Switzerland to realize its potential. These aforementioned countries all use competitive tendering (McNulty, 2011). McNulty further recommends evolution rather than revolution in UK railway, meaning it's better to adapt existing structures and that large amount of changes, although necessary, needs to be planned carefully and should be phased over a period of time, aiming to have almost all of the benefits delivered within five to seven years.

The rail assets and services in New Zealand and the states of Victoria and Tasmania in Australia were also taken back into public ownership after earlier privatizations (Abbott & Cohen, 2016). They find that the main challenge is that rail infrastructure exhibits substantial economies of scale such that the operator cannot recover their initial investment without a high level of subsidies. This is especially the case for smaller countries. The private companies under-invested in track maintenance in the short term, because of the lack of incentives and over the long term these companies tended to exit the industry. The reluctance on the part of private companies to make the necessary levels of investment in track maintenance and upgrading resulted in two brief periods of separation in Tasmania and New Zealand, leading eventually to the government takeover of both track and freight operations. A separate track company could not recover sufficient revenues for ongoing operations given the scale of investment needed to maintain the system as required by the government.

2.5 Competitive tendering

In 2015, the Norwegian government approved the proposals for a reform in the rail sector (Minsitry of Transport, 2015). The purpose of the reform was to create more competition in domestic rail transport and by making it more efficient, thus providing a better offer and service to passengers, whilst keeping the subsidies to a minimum. Norway used competitive tendering to award licenses to operate domestic passenger services (Minsitry of Transport, 2020). The aim of competitive tendering is to create competition for the market and hence exploit the benefits that competition can bring in terms of lower costs, higher efficiency, greater quality, and innovation. The effectiveness of competitive tendering is determined by the bidding competition: the most economically efficient enterprises winning the competition and ensuring that this efficiency is passed on to the government. In general, competitive tendering is an effective instrument for identifying the most efficient company that would serve a market, this doesn't necessarily apply to the rail sector. A government can't allow a rail service operator to go bankrupt, thus when these companies face difficult commercial challenges it would be more profitable for them to default on its obligation instead of fulfilling them. These challenges could arise because the operating costs proved to be higher than calculated, demand lower than forecast or other events, such as a pandemic. The governments face complicated decisions when they are awarding licenses (OECD, 2013).

In an empirically study by Laabsch and Sanner (2012), they find that ownership separation tends to weaken rail instead of strengthening it. They argued that full ownership separation may contradict the declared goal of the European Union, which is to increase the market share of rail. Econometric evidence suggests that vertical separation increases costs at a higher density in traffic, while it appears to reduce them at lower densities. There doesn't appear to be any evidence that suggests vertical separation in being the best solution regarding cost-benefit terms, nor does it increase competition (van de Velde, et al., 2012). They recommend that countries should be free to choose the structural option that best suits their circumstances, thus allowing competition between different organizational models.

However, many countries have recently introduced competition in railway markets by vertical separation, meaning they have separated the responsibility for infrastructure from the railway services for freight and passengers. This type of developments have been further stimulated by the European legislation European Commission (EC, 2001; EC, 2012), the Fourth Railway Package (2016). A part of the fourth railway package, the legislation *Regulation (EU) 2016/2338 of the European Parliament and of the Council was legalized 14 December 2016 amending Regulation (EC) No 1370/2007 concerning the opening of the market for domestic passenger transport services by rail* was passed (EC, 2016). This was confirmed by the Norwegian government on 29.05.2018 (Ministry of Transport, 2018). The main purpose of deregulation of the rail industry, thus privatizing, is to create a high service quality and productive efficiency (and therefore reduce rail subsidies). This is achieved by creating greater competition, thus resulting in a more efficient rail network.

3.0 Empirical strategy

Privatization of rail were meant to increase competition, and reduce the need for governmental funding, with the hope that this would decrease the prices of train tickets. This thinking is based on the supply-and-demand model, where more suppliers usually push down the price. However, there are evidence in the literature that suggests that this model doesn’t necessarily applies to the rail sector and competitive tendering.

3.1 Generalized travel costs

What can the Norwegian government do to increase travels by rail? I will attempt to find the total costs of a rail travel, by including all relevant costs. This is the generalized travel cost; also known in short as travel cost.

Cost-benefit analysis (CBA) is a policy instrument that quantifies, in monetary terms, the value of all consequences of a policy to all members of society. CBA applies to policies, programs, projects, regulations, and other government interventions (Boardman, et al., 2011). Benefits are measured as willingness to pay and costs are measured by opportunity costs (the value of what a resource would have in the best alternative way). The focus in thesis will be on generalized cost (GC), one of the components of CBA.

The generalized cost is equivalent to the price of the good in supply-and-demand framework, meaning the demand for travels can be related to the generalized cost of those travels. In general, as prices increases, the demand will decrease – regardless of transport mode. The theory is that rational consumers should always choose the cheapest option between two similar products. Travelling by air and by rail are not similar, because of the difference in time. In this thesis I will attempt to find out the total value of air and rail travels by assigning time a value, and then compare the two different travels costs. There are two types of costs in GC: monetary costs and non-monetary costs. Ticket prices are an example of monetary costs and time is an example of non-monetary costs. The value of time is measured differently and depends on the person, the purpose of the travel, and whether it is travel or waiting time – this includes weighted waiting time, meaning where you wait and what the occasion is.

A general formula for generalized costs can be defined as:

$$GC = M + \alpha_1 TT + \alpha_2 WT + \alpha_3 FT \quad (1)$$

where *M* is the monetary costs, such as price of the ticket(s); *TT* is the travel time while inside the vehicle; *WT* is the waiting time; *FT* is the feeder time (to and from stop/station/terminal); $\alpha_1 - \alpha_3$ are value of different kinds of time.

There is good empirical evidence for using a higher time value for waiting time than for travel time on the vehicle (Grøvdal & Hjelle, 1998). This statement is also supported by findings from Ramjerdi et. al (2010) and Østli et. al (2015) where they have calculated and suggested the value for waiting time and travel time of an average person, respectively. The various values waiting times are also weighted differently based on what transport mode you are waiting for, how long you are waiting, distance of the travel and how long the travel takes in time.

3.2 Generalized costs calculations of air and rail travels

In total, this thesis will calculate the total value of ten different travels in the five most populated cities in Norway. One air travel and one rail travel will be shown in this section. The example used in this section will be a travel between the campuses of the two largest cities in Norway: Oslo Metropolitan University (OsloMet) and University of Bergen (UiB).

By using equation (1) as the base and expanding it to the needs of these travels gives us the following formula for generalized costs for air travel, and can be defined as:

$$GC_{Air} = \sum_{i=1}^{4} (M_i + \alpha_i TT_i) + (\alpha_2 WT_1 + \alpha_3 WT_2 + \alpha_4 WT_3) \quad (2)$$

where M_1 is the price of the bus ticket from OsloMet to Oslo train station (Oslo S); M_2 is the price of the train ticket from Oslo S to Oslo Airport (OSL); M_3 is the price of the airline ticket from OSL to Bergen Airport (BGO); M_4 is price of the tram ticket from BGO to UiB; TT_1 is the travel time on the bus from OsloMet to Oslo S; TT_2 is the travel time on the train from Oslo S to OSL; TT_3 is the travel time on the aircraft from OSL to BGO; TT_4 is the travel time on the tram from BGO to UiB; WT_1 is the weighted waiting time at Oslo S waiting for the local train, in minutes; WT_2 is the weighted waiting time at OSL waiting for the aircraft, in minutes; WT_3 is the weighted waiting time at BGO waiting for the tram, in minutes; α_1 is the value of travel time for tram, in hours; α_2 is the value of travel time for local train, in hours; α_3 is the value of travel time for aircraft, in hours; α_4 is the value of travel time for tram, in hours. *FT* has been omitted since it is part of *TT* in the expanded equation.

By using equation (1) as the base and expanding it to the needs of these travels gives us the following formula for generalized costs for rail travel, can be defined as:

$$GC_{Rail} = \sum_{i=1}^{3} (M_i + \alpha_i TT_i) + (\alpha_2 WT_1 + \alpha_3 WT_2) \quad (3)$$

where M_1 is the price of the bus ticket from OsloMet to Oslo S; M_2 is the price of the train ticket from Oslo S to Bergen train station (Bergen S); M_3 is the price of the bus ticket from Bergen S to UiB; TT_1 is the travel time on the bus from OsloMet to Oslo S; TT_2 is the travel time on the train from Oslo S to Bergen S; TT_3 is the travel time on the bus from Bergen S to UiB; WT_1 is the weighted waiting time at Oslo S waiting for the local train, in minutes; WT_2 is the weighted waiting time at Bergen S waiting for the bus, in minutes; α_1 is the value of travel time for tram, in hours; α_2 is the value of travel time for rail as the main transport mode, in hours; α_3 is the value of travel time for bus, in hours. *FT* has been omitted since it is part of *TT* in the expanded equation.

The other nine travels will be calculated using similar methods and presented in a table in section 5.0. The GC-equation for all ten travels will be similar with slight variations. This is needed since some of the cities don’t have direct flights / rail from some of the other cities, thus needing layovers (aircraft) and connections (rail) to visit.

Since travelling by rail is in general more environmentally friendly than by air, the government should incentivize passengers in choosing rail. In most cases the ticket price of air is more expensive than the equivalent train ticket, but the value of time has not been factored in. In order to examine this relation, I check the following condition:

$$GC_{Rail} < GC_{Air} \tag{4}$$

Assuming that people are rational, the difference in costs determines how the passengers will travel. If: $GC_{Rail} < GC_{Air}$, then passengers will travel by rail. If: $GC_{Rail} > GC_{Air}$, then passengers will travel by air. This means the government must take action to ensure that travelling by rail costs less than travelling by air.

4.0 Methodology

The methods used in this thesis are qualitative data for document collection, by analyzing, comparing, and discussing the various relevant topics regarding privatization, efficiency, environment, emissions, economic, productivity and more. For the calculation, quantitative data had to be found from previous research and prices were collected directly from the transport companies.

4.1 Document collection

The document collection has exclusively been from written public documents such as textbooks, research papers, journals, news pages and statistics from sites such as SSB (Statistics Norway). Documents have been found by internet search for relevant words, and combinations of words, related to the subject, and by navigating through web pages of the government and the different ministries of the government. The majority of academic papers have been found by using the google scholar search engine (made specifically for scientific purposes), Science Direct and Research Gate. In order to develop empirical knowledge and understanding of the subject the documents have been examined and interpreted as thorough as possible with limited time.

4.2 Data collection

The data collection for ticket prices has been collected directly by the transport companies: Norwegian, SAS and Wizzair for air and Vy for rail. The ticket prices for local transport have been collected directly from the local bus / tram / metro companies: Ruter (Oslo), Skyss (Bergen), AtB (Trondheim), Kolumbus (Stavanger) and AKT (Kristiansand). The sources for travel time are also collected directly from the transport companies. The value of travel time is based on findings from Institute of Transport Economics – Norwegian Centre for Transport Research (Østli, et al., 2015). The weighted weighting factors for travel time components is also based on findings from Institute of Transport Economics

(Ramjerdi, et al., 2010). Institute of Transport Economics (TØI) is one of Norway's most prominent research institutions for research and development.

4.3 Data

In order to examine the hypothesis, data had to be collected directly from the companies that provides the services for air, rail and local transport (local train, bus and tram). The value of travel time is measured in currency NOK from 2016 and are based on findings from Østli et. al (2015). The findings are shown in Table 1, Table 2, and Table 3.

Table 1: Time values for car, rail, bus and aircraft for travels over 200 km

Reisehensikt	Lett bil (kr/persontime)	Tog (kr/persontime)	Buss (kr/persontime)	Fly (kr/persontime)
Tjenestereise	449	449	449	526
Til og fra arbeid	217	197	94	340
Fritid	169	96	97	213

Table 2: Time values for car, rail, and bus for travels between 70 km and 200 km

Reisehensikt	Lett bil (kr/persontime)	Tog (kr/persontime)	Buss (kr/persontime)
Tjenestereise	449	449	449
Til og fra arbeid	217	197	94
Fritid	169	125	79

Table 3: Time values for walking, biking, car, local train/tram/metro and bus for travels under 70 km

Reisehensikt	Gående (kr/persontime)	Syklende (kr/persontime)	Lett bil (kr/persontime)	Buss/Bane/trikk (kr/persontime)
Tjenestereise	172	154	449	449
Til og fra arbeid	172	154	100	70
Fritid	172	154	85	64

Adjusted for inflation, which was 11% from 2016 to April 2021 (SSB, 2021), the following updated values based on the three tables above are shown in Table 4, Table 5, and Table 6.

Table 4: Time values for car, rail, buss and aircraft for travels over 200 km, adjusted for inflation.

Purpose	Car NOK / hour	Rail NOK / hour	Bus NOK / hour	Aircraft NOK / hour
Business travel	498	498	498	584
Work	241	219	104	377
Leisure	188	107	108	236

Table 5: Time values for car, rail, and buss for travels between 70 km and 200 km, adjusted for inflation

Purpose	Car NOK / hour	Rail NOK / hour	Bus NOK / hour
Business travel	498	498	498
Work	241	219	104
Leisure	188	139	88

Table 6: Time values for walking, biking, car, local train/tram/metro and bus for travels under 70 km, adjusted for inflation

Purpose	Walk NOK / hour	Bike NOK / hour	Car NOK / hour	Bus/Metro/Tram NOK / hour
Business travel	191	171	498	498
Work	191	171	111	78
Leisure	191	171	94	71

The calculation of waiting times and feeder times in between transport has been accounted for and are based on findings from Ramjerdi et. al (2010). The waiting times are weighted.

Weighted air travels are not mentioned. However, it makes sense to group it together with the “long public travel” section. The weighted values are shown in Table 7.

Table 7: Weighting factors for travel time components

	Korte kollektivreiser		Lange kollektivreiser (buss, tog, hurtigbåt)		
		Vekt			Vekt
Tilbringertid		1,00	Tilbringertid		1,36
Ventetid	0-5 min	2,30	Ventetid	0-30 min	1,04
	6-15 min	1,88			
	16-30 min	0,92			
	31-60 min	0,56		31-240 min	0,54
	>60 min	0,28		>240 min	0,4
Omstigning		2-10 min	Omstigning		10 min

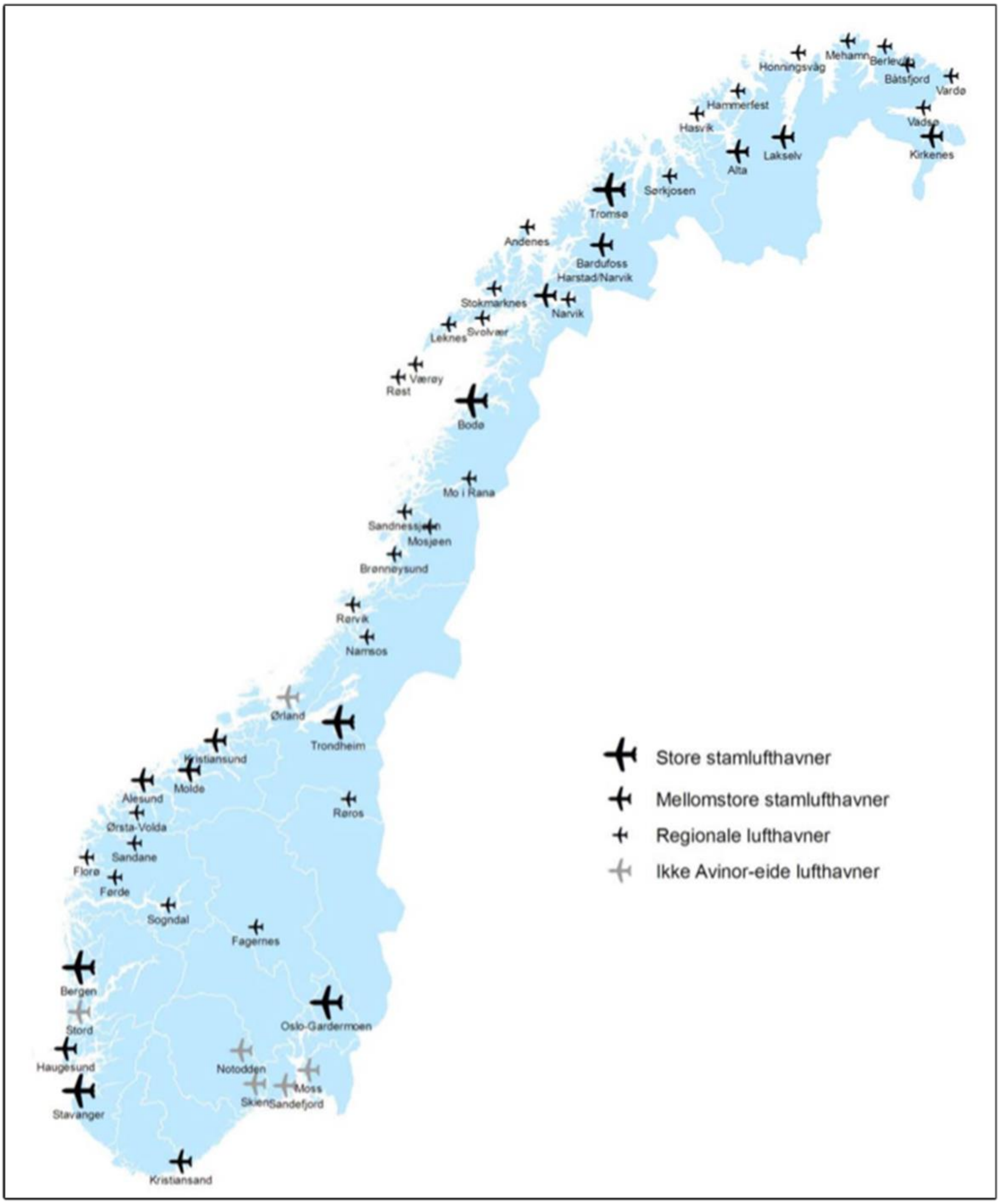
The size of the airport affects the waiting time. According to Avinor the amount of travelling passengers in 2019 for OSL, BGO, TRD, SVG and KRS were 28.6, 6.5, 4.4, 4.3, and 1.1 million, respectively (Avinor, 2021). Institute of Transport Economics (TØI) have in their findings measured the average waiting times for the various airport in Norway. Passengers travelling on business travels usually arrives later than passengers travelling on leisure travels for Oslo and other large airports. One reason might be that they are more accustomed to the airport procedures because of their frequent travels. For various reasons, some passengers arrive very early at the airport, and this increases the measured average waiting time. Using the median waiting time gives a better picture of the “normal” passenger. The median waiting time is significantly lower than the average waiting time (Denstadli & Rideng, 2010). The data is shown in Table 8.

Table 8: Average passenger arrival time in minutes before departure by type of airport. 2003, 2007 and 2009. Number in minutes. TØI rapport 1073/2021

	Alle reiser			Arbeidsbetingede reiser			Fritidsreiser		
Lufthavn	2009	2007	2003	2009	2007	2003	2009	2007	2003
Oslo	106	96	81	93	84	71	118	110	92
Store lufthavner	78	69	65	75	65	62	82	73	68
Mellomstore lufthavner	65	63	59	66	62	56	63	64	63
Regionale lufthavner	51	50	40	53	51	40	49	49	40
Gjennomsnitt alle lufthavner	90	84	75	82	75	67	99	94	84
Median alle lufthavner	65	60	60	60	60	60	75	70	60

Figure 3 shows the different sized airports in Norway. In our calculations, the waiting times for air have been set to 60 minutes for Oslo airport, 60 minutes for large airport: Bergen, Trondheim and Stavanger, and 45 minutes for medium-sized airports: Kristiansand. The base for this reasoning is that the median numbers are being used, but also because the numbers are of older information, and that are perceived as still too high. There is no newer information from TØI regarding waiting times, and the information obtained from 2009 is the most up to date.

Figure 3: Norwegian airports in 2009. TØI rapport 1073/2010



Boarding times for long public transports (in this case: rail as the main transport mode) are 10 minutes, based on finding from Ramjerdi et. al (2010). Feeder times for local train, tram and bus are half of the headway (the average interval of time between vehicles moving in the same direction on the same route) which varies from 3 to 8 minutes in the calculations.

The walking costs at the start and end of the route has been omitted from all travels. Most of the campus has a bus or tram stop close by, so this value will be similar for all travels. The total value will be slightly lower, but the main objective of these calculations is to compare the total value between the respective air and rail travels.

Potential cancellation and waiting times due to strikes, delays, accidents, pandemics, etc has not been accounted for. The data for ticket prices and transport times has been collected directly from the websites of the rail companies and airlines. Note that the tickets prices can and will change depending on several factors such as high and low seasons, time of the day, purchase date close to departure date etc.

Flight distances are based on Great Circle Distance (GCD). GCD refers to the shortest distance between two points on the earth's surface. A lengthening factor of 14.3% has been applied on the GCD to all flight routes as recommended by Dobruszkes & Peeters (2019). The five largest Norwegian cities based on population has been chosen as destinations.

I want to find out the total cost of travelling. I will travel one-way only, and each calculation will start at different school campus and end at a different school campus. This gives us the following routes: OsloMet to UiB (Oslo to Bergen); OsloMet to NTNU (Oslo to Trondheim); OsloMet to UiS (Oslo to Stavanger); OsloMet to UiA (Oslo to Kristiansand); UiB to NTNU (Bergen to Trondheim); UiB to UiS (Bergen to Stavanger); UiB to UiA (Bergen to Kristiansand); NTNU to UiS (Trondheim to Stavanger); NTNU to UiA (Trondheim to Kristiansand); UiS to UiA (Stavanger to Kristiansand).

I will be travelling these routes as a leisure travel and as a business travel. For leisure travels, I will be travelling later in the week and will be choosing the cheapest tickets (main transport mode). For business travels, I will be travelling early in the week and will be choosing the earliest tickets (main transport mode), most of the time this will be the tickets that suits me the best regardless of price. The feeder vessel (local train, trams and bus) will be the same, since the main objective is to compare rail and air as main transport modes. Otherwise, the comparisons would be skewed if I only used taxi, an expensive form for transport, as the feeder vessel when travelling for business.

5.0 Results and analysis

In this section I'm going to present the generalized travel costs for the Oslo-to-Bergen travel when travelling by air and by rail, as leisure and business travel. I will then present the generalized travel costs for all ten leisure and all ten business travels.

5.1 Calculating the generalized costs

Generalized travel costs are the sum of all the costs passengers face when they take the decision to travel. It will include time costs, fuel costs, tolls, bus ticket, ferry ticket, etc.

The whole route of OsloMet to University in Bergen by aircraft as main transport mode will be:

1. OsloMet to Oslo train station by tram (13 minutes), with the ticket price being NOK 37;
2. Waiting (headway) at Oslo train station (15 minutes);
3. Oslo train station to Oslo Airport by local rail (24 minutes), with the ticket price being NOK 110;
4. Waiting at Oslo Airport, check in and security control (60 minutes);
5. Oslo Airport to Bergen Airport by aircraft (55 minutes), with the ticket price being NOK 285 for leisure travel and NOK 869 for business travel;
6. Waiting at Bergen Airport (5 minutes);
7. Bergen Airport to UiB by bus (59 minutes), with the ticket price being NOK 39.

Inserting values into equation (2) gives me the following:

$$GC_{Air} = \sum_{i=1}^{4} (M_i + \alpha_i TT_i) + (\alpha_2 WT_1 + \alpha_3 WT_2 + \alpha_4 WT_3)$$

$$GC_{Air,Leisure} = 37 + 110 + 285 + 39 + \frac{71 * 13}{60} + \frac{71 * 24}{60} + \frac{236 * 55}{60} + \frac{71 * 59}{60} + \frac{71 * 15 * 1,88}{60} + \frac{236 * 60 * 0,54}{60} + \frac{71 * 5 * 2,30}{60}$$

$$GC_{Air,Leisure} = 975{,}35$$

$$GC_{Air,Business} = 37 + 110 + 869 + 39 + \frac{498 * 13}{60} + \frac{498 * 24}{60} + \frac{584 * 55}{60} + \frac{498 * 59}{60} + \frac{498 * 15 * 1{,}88}{60} + \frac{584 * 60 * 0{,}54}{60} + \frac{498 * 5 * 2{,}30}{60}$$

$$GC_{Air,Business} = 3\ 032{,}00$$

The generalized travel costs for the route OsloMet – UiB by aircraft as main mode of transport is NOK 975 for leisure travel and NOK 3 032 for business travel. The travel costs are very different.

The whole route of OsloMet to University in Bergen by rail as main transport mode will be:

1. OsloMet to Oslo train station by tram (13 minutes), with the ticket price being NOK 37;
2. Be early at the train station (10 minutes);
3. Oslo train station to Bergen train station by rail (411 minutes), with the ticket price being NOK 479 for leisure travel and NOK 689 for leisure travel;
4. Waiting at Bergen train station (3 minutes);
5. Bergen train station to UiB by bus (9 minutes), with the ticket price being NOK 39.

Inserting values into equation (3) gives me the following:

$$GC_{Rail} = \sum_{i=1}^{3} (M_i + \alpha_i TT_i) + (\alpha_2 WT_1 + \alpha_3 WT_2)$$

$$GC_{Rail,Leisure} = 37 + 479 + 39 + \frac{71 * 13}{60} + \frac{107 * 411}{60} + \frac{71 * 9}{60} + \frac{107 * 10 * 1{,}04}{60} + \frac{71 * 3 * 2{,}30}{60}$$

$$GC_{Rail,Leisure} = 1\ 340{,}70$$

$$GC_{Rail,Business} = 37 + 689 + 39 + \frac{498 * 13}{60} + \frac{498 * 411}{60} + \frac{498 * 9}{60} + \frac{498 * 10 * 1,04}{60} + \frac{498 * 3 * 2,30}{60}$$

$$GC_{Rail,Business} = 4\ 502,49$$

The generalized travel costs for the route OsloMet – UiB by rail as main mode of transport is NOK 1 341 for leisure travel and NOK 4 502 for business travel. The travel costs are very different.

Table 9 below presents the results for the hypothesis, which is that the travel cost of an airline ticket is higher than the travel cost of an equivalent train ticket. The calculations are for all ten travels and presents the generalized travel costs from campus to campus (door-to-door).

For both leisure and business travels, five of the rail travels didn’t have a direct railway, so they needed a connection to arrive at the final destination: Bergen to Trondheim via Oslo; Bergen to Stavanger via Drammen; Bergen to Kristiansand via Kongsberg; Trondheim to Stavanger via Oslo; Trondheim to Kristiansand via Oslo; and three of the air travels needed a layover to arrive at the final destination: Bergen to Kristiansand; Trondheim to Kristiansand; Stavanger to Kristiansand; all via Oslo airport.

These layover and connections increase the travel cost of the travel. This is because the ticket price is more expensive and also because of the time factor. From Table 9, every travel that needs a layover or connection costs significantly more than travel that doesn’t need connection – this is especially true for business travel travelled by rail. This is because the value of time for business travel is high and the travel time is long.

Table 9: Total value for leisure and business travels

	Total value, leisure travels			Total value, business travels		
Routing	Rail	Aircraft	Difference	Rail	Aircraft	Difference
OsloMet - UiB	NOK 1 341	NOK 975	NOK 365	NOK 4 502	NOK 3 032	NOK 1 470
OsloMet - NTNU	NOK 1 233	NOK 964	NOK 269	NOK 4 062	NOK 3 181	NOK 881
OsloMet - UiS	NOK 1 556	NOK 1 018	NOK 539	NOK 5 116	NOK 2 798	NOK 2 319
OsloMet - UiA	NOK 1 144	NOK 1 514	-NOK 370	NOK 3 249	NOK 2 841	NOK 408
UiB - NTNU	NOK 2 434**	NOK 1 555	NOK 879	NOK 8 786**	NOK 3 136	NOK 5 650
UiB - UiS	NOK 2 416**	NOK 1 380	NOK 1 035	NOK 9 160**	NOK 2 597	NOK 6 562
UiB - UiA	NOK 1 926**	NOK 2 448*	-NOK 522	NOK 6 118**	NOK 4 601*	NOK 1 517
NTNU - UiS	NOK 2 797**	NOK 1 525	NOK 1 272	NOK 9 448**	NOK 2 957	NOK 6 490
NTNU - UiA	NOK 2 353**	NOK 2 656*	-NOK 303	NOK 7 654**	NOK 4 385*	NOK 3 269
UiS - UiA	NOK 990	NOK 2 060*	-NOK 1 070	NOK 2 629	NOK 4 612*	-NOK 1 983

*includes layover
** includes connection by rail

See Table 10 – 19 in Appendix 9.1 for full calculation and data.

In table 9, the difference in price when it's positive means that the total value of the rail travel is higher, and when the difference is negative, it means that the total value of the air travel is higher. For business travels the costs with rail is substantial higher than air, while the difference for leisure is smaller.

For leisure travels, four of the travels are more expensive when travelling by air: Oslo to Kristiansand; Bergen to Kristiansand; Trondheim to Kristiansand; Stavanger to Kristiansand. Three of these travels are more expensive, because airline tickets with layovers costs more than train tickets with rail connections. The most notable is the Stavanger to Kristiansand travel with a difference of NOK 1 070. This is because there are no direct flights from Stavanger to Kristiansand, while direct rail track exists. The opposite can also be seen in the Trondheim to Stavanger travel, where travelling by rail costs NOK 1 272 more than by air travel, because there is a direct flight, but travelling by rail needs to go via Oslo. The travelling costs and waiting time costs for the Oslo to Kristiansand leisure travel are similar: NOK 465 for air and NOK 54 for rail (see table 13 in Appendix A), and the difference are in the prices for the tickets: NOK 1 049 for air and NOK 599 for rail. In general, the airline tickets to Kristiansand are more expensive than the other cities. If the city of Kristiansand can be considered an outlier because of layovers and rail connections, then it’s cheaper to travel by air by a small amount when the travel includes both a direct air and a direct rail travel, but it’s much cheaper to travel by air when the equivalent rail travel needs a connection and needs to go via a different city.

For business travel, only one travel is more expensive when travelling by air: Stavanger to Kristiansand. As mentioned, this is because there are no direct flights from Stavanger to Kristiansand, while direct rail track exists. This is also the only route where travelling by air (347 minutes) take more time than travelling by rail (258 minutes). The travel costs are similar, NOK 2 177 for rail versus NOK 2 610 for air, but the difference in ticket price is higher, NOK 452 for rail versus NOK 2 002 for air. The travel Oslo to Kristiansand has similar travel costs. The travel Oslo to Trondheim has similar travel costs, NOK 4 062 for rail versus NOK 3 181 for air, but the difference, NOK 881, is higher than the combined price of the train, tram and bus tickets, which is NOK 416. The difference in cost for business travels where the rail travel needs connections and the equivalent air travel doesn’t need a layover is very significant, and the differences varies from NOK 5 650 to NOK 6 562. The difference in total value for leisure travels varies from small to significant. The difference in total value for business travels varies from significant to very significant.

The air travel between Bergen and Stavanger is less than 200km. The calculation for this travel uses data from Table 4, because these values are the best estimated value available for this travel. Similarly, the rail travel from Bergen to Kristiansand has a rail connection in Kongsberg S, and it’s 195 km from Kongsberg S to Kristiansand S. Still, the values from Table 4 have been used in the calculation, because the whole travel is over 200 km. Note that the business values for rail between Table 4 and Table 5 is the same. The difference would be in leisure travel. If the values from Table 5 are being used in the calculation instead, then the travel costs for leisure would increase by NOK 98. The leisure travel by rail from Stavanger S to Kristiansand is only 160 km, therefore the travel values are from Table 5.

5.2 Limitation

There are limitations in the analysis and the result that has been presented. The analysis only compares rail travel against air travel. Travelling by bus, tram and personal vehicles has not been included, and the potential effect of this has not been reflected in the results, e.g. an more expensive airline ticket might increase the amount of travelers by personal vehicle instead of rail travel (the intended target).

The price of tickets was checked approximately thirty days before departure. The prices can and will fluctuate based on low and high seasons. The whole transport sector has been affected by the pandemic, and it's not given the prices will be similar to the prices we've obtained for this thesis. The analysis only accounts for Norway and the value of time is based on Norwegian citizens. Norway is one of the most expensive countries in the world, so under most circumstances, the value of time for a Norwegian traveler will be worth more than a traveler from a low-cost country. There are also uncertainties and weaknesses when measuring the value of time. The stated values are for an average person, while in real life only the traveler (or the company they are working for) will know how they value their time. A rich person doesn't necessarily value their time more than a poor person value theirs. This analysis can be generalized, but the results will be different and vary from country to country.

This analysis also only accounts for the five largest cities in Norway, but there are other important destinations in Norway, such as Bodø and Tromsø in Northern Norway. Tromsø doesn't have a train station as of today, but the Norwegian government are planning to build a railway in the future. Without having primary data for travel times and costs for something that doesn't exists, it's not possible for this analysis to present a result that reflects the travel costs for an imaginary travel, i.e. Kristiansand to Tromsø by rail, even though it's most likely the travel costs of a rail travel to Tromsø to be very high, because of the distance and time it would take.

6.0 Discussions

According to the results, the travel cost of a rail travel is in most cases higher than the travel cost of an equivalent air travel. If the outlier city Kristiansand is omitted, then it's cheaper to travel by air for all the travels – regardless of if they are business or leisure.

The difference in travel costs for business travel is significant – for eight of the business travels, the difference in travel costs is higher than the tickets for tram, bus, and train (monetary costs). This means that even if the tickets (tram, rail, bus) were free, the rail travel would still cost more than the equivalent air travel. In terms of monetary value only, there's no reason for business passengers to travel by rail, unless it's from Stavanger to Kristiansand. If looking at the other routes, it's cheaper for business travellers to travel by air – even if the train ticket is free. In some cases, they could get a paid to travel by rail, and if it's lower than the calculated difference, they still would opt for air travel. For the business travels by rail for Bergen to Trondheim; Bergen to Stavanger; Trondheim to Stavanger, the rail companies would need to pay the traveller (or the company the traveller is working for) NOK 4 275, NOK 5 395, and NOK 5 236, respectively (waiting cost for rail minus travel cost for air), for them to consider travelling by rail instead of travelling by air. There were 80.4 million rail passengers in Norway in 2019 (SSB, 2020) and if they were subsidised with NOK 1 000 per travel, then the Norwegian government would need to subsidise NOK 80.4 billion per year. This is a significant cost considering the budget for the whole rail sector is NOK 33.3 billion per year (Ministry of Transport, 2021).

The passengers travelling leisurely should travel by air if they are not travelling to Kristiansand. The generalized travel costs travelling to Kristiansand leisurely are lower. The two leisure travels where the rail waiting costs exceed the travel costs of the equivalent air travel is Bergen to Stavanger, by NOK 189 and Trondheim to Stavanger, by NOK 131. This means the passenger would need to be paid this amount on average to consider travelling these two travels by rail instead of by air. However, this average only applies if the passengers value their time exactly as the standard values in Norway. The travel costs are at best correct as an average. From the results and analysis, the findings suggest that a leisure travel by rail with direct track on a shorter distance (around 250 km) costs less than the equivalent air travel. The findings suggest that a business travel by rail will always cost more than the equivalent air travel – with the only exception being when the traveller can travel by rail that has direct track on a shorter distance, while the equivalent air travel needs a layover.

There are three solutions that the Norwegian government can do to increase travels by rail: make the train tickets cheaper, make the airline tickets more expensive or a combination of both. It's possible to investigate these solutions in detail. It's important to know the socio-economic ramifications of frequent flying. It's too cheap to fly when considering how the externalities are impacting the environment. These externalities are not reflected in the airline ticket price. One of the choices is to increase taxes for air travel, where the increased tax amount equals the environmental cost (damage) inflicted on society. This is the principle of Pigouvian tax, also known as internalizing an externality. However, this externality is quite low, so even by correcting the prices for the externality, it will not be enough to make rail transport an attractive choice. A better solution is to increase taxes for air travel, where the increased tax amounts to the difference in generalized travel costs. The difficulty in setting this tax is to tax the correct amount, as we've already seen from the calculated results: the amount is an average at best and people value their times differently. There is also the problem that the difference in generalized travel costs between leisure and business is very high. The politicians that makes the decisions know it's not popular to increase taxes. It's much easier to subsidize the rail sector, so they can keep the ticket prices low. This is the popular decision, but not the optimal solution. It's also possible to increase the price of fuel, as this is a significant driver in turning consumers towards electric transportation (Diamond, 2009). However, this has the side-effect in turning consumers towards electric vehicles, which would lower the environmental impact of rail as fewer people would be rail passengers. As shown in the results, the politicians can make leisure travels more attractive, because the travel costs of a rail travel are close to the travel costs of an air travel. This means they can subsidize the rail sector or increase the air travel tax a small amount and still achieve results. However, this is not possible regarding business travels, because the travel costs of a rail travel are much higher than the travel costs of an air travel. There is no point in subsidizing unless the rail companies are subsidized so much that they can pay a traveller several thousand Norwegian kroner to travel with them. Increasing the air travel tax with several thousand Norwegian kroner is a solution to make business travellers consider rail as an option but would effectively be a ban on leisure air travels.

If passengers are willing to pay more to become environmentally friendly, then the value of time must be researched again and be amended. However, if passengers aren't willing to pay more to be more environmentally friendly, then the Norwegian government need to consider if they should introduce larger subsidies for the rail sector. This could be answered in a cost benefit analysis where all the costs and benefits are accounted for.

7.0 Conclusion

In this thesis, I was to analyze what the Norwegian government could do to make more people travel by rail and the implications this would have on the environment. The literature suggests that deregulation of rail is not efficient and possibly a policy mistake. The key findings in this thesis are that travelling by rail is much more expensive than it first appears compared to travelling by air. Even if travelers were offered a free rail ticket, most of them still might choose to travel by air. In some situations, the travelers would choose to travel by air even if they got paid to travel by rail. The ticket prices for air travel are usually higher, but when accounting for the value of time (waiting time and travel time), then it’s much more expensive than air travel.

To close the gap between the generalized travel costs, the optimal solution is to increase taxes for the aircraft industry and increase the tax on fuel. A stated, taxes are not popular among the populations, and few politicians are willing to implement the optimal solution. Based on the results, this thesis suggests increasing the air travel tax an amount, then increase more gradually. By implementing this change slowly, it will be easier for passengers to accept this necessary change. To better understand the optimal amount of taxes to increase, further studies could address this by measuring willingness to pay for more expensive, but environmentally friendly choices.

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9.0 Appendices

9.1 Generalized travel cost for all ten travels

Table 10: OsloMet to University of Bergen

			Leisure			Business		
Main transport Aircraft	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
OsloMet to Oslo S	Tram		13	NOK 15	NOK 37	13	NOK 108	NOK 37
Waiting	-		15	NOK 33		15	NOK 234	
Oslo S to OSL Airport	Rail		24	NOK 28	NOK 110	24	NOK 199	NOK 110
Check-in, security control	-		60	NOK 127		60	NOK 315	
OSL Airport to BGO Airport	Aircraft	372 km	55	NOK 216	NOK 285	55	NOK 535	NOK 869
Waiting	-		5	NOK 14		5	NOK 95	
BGO Airport to UiB	Bus		59	NOK 70	NOK 39	59	NOK 490	NOK 39
	Sum		231	NOK 504	NOK 471	231	NOK 1 977	NOK 1 055
	Total value (waiting costs + price)			**NOK 975**			**NOK 3 032**	
			Leisure			Business		
Main transport Rail	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
OsloMet to Oslo S	Tram		13	NOK 15	NOK 37	13	NOK 108	NOK 37
Arrive early for rail	-		10	NOK 19		10	NOK 86	
Oslo S to Bergen S	Rail	463 km	411	NOK 733	NOK 479	411	NOK 3 411	NOK 689
Waiting	-		3	NOK 8		3	NOK 57	
Bergen S to UiB	Bus		9	NOK 11	NOK 39	9	NOK 75	NOK 39
	Sum		446	NOK 786	NOK 555	446	NOK 3 737	NOK 765
	Total value (waiting costs + price)			**NOK 1 341**			**NOK 4 502**	

Table 11: OsloMet to Norwegian University of Science and Technology

			Leisure			Business		
Main transport Aircraft	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
OsloMet to Oslo S	Tram		13	NOK 15	NOK 37	13	NOK 108	NOK 37
Waiting	-		15	NOK 33		15	NOK 234	
Oslo S to OSL Airport	Rail		24	NOK 28	NOK 110	24	NOK 199	NOK 110
Check-in, security control	-		60	NOK 127		60	NOK 315	
OSL Airport to TRD Airport	Aircraft	416 km	55	NOK 216	NOK 249	55	NOK 535	NOK 849
Waiting	-		10	NOK 22		10	NOK 156	
TRD Airport to NTNU	Bus		72	NOK 85	NOK 40	72	NOK 598	NOK 40
	Sum		249	NOK 528	NOK 436	249	NOK 2 145	NOK 1 036
	Total value (waiting costs + price)			**NOK 964**			**NOK 3 181**	
			Leisure			Business		
Main transport Rail	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
OsloMet to Oslo S	Tram		13	NOK 15	NOK 37	13	NOK 108	NOK 37
Arrive early for rail	-		10	NOK 19		10	NOK 86	
Oslo S to Trondheim S	Rail	495 km	458	NOK 817	NOK 277	392	NOK 3 254	NOK 339
Waiting	-		3	NOK 8		3	NOK 57	
Trondheim S to NTNU	Bus		17	NOK 20	NOK 40	17	NOK 141	NOK 40
	Sum		501	NOK 879	NOK 354	435	NOK 3 646	NOK 416
	Total value (waiting costs + price)			**NOK 1 233**			**NOK 4 062**	

Table 12: OsloMet to University of Stavanger

			Leisure			Business		
Main transport Aircraft	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
OsloMet to Oslo S	Tram		13	NOK 15	NOK 37	13	NOK 108	NOK 37
Waiting	-		15	NOK 33		15	NOK 234	
Oslo S to OSL Airport	Rail		24	NOK 28	NOK 110	24	NOK 199	NOK 110
Check-in, security control	-		60	NOK 127		60	NOK 315	
OSL Airport to SVG Airport	Aircraft	391 km	60	NOK 236	NOK 319	50	NOK 487	NOK 769
Waiting	-		8	NOK 18		8	NOK 125	
SVG Airport to UiS	Bus		45	NOK 53	NOK 40	45	NOK 374	NOK 40
	Sum		225	NOK 512	NOK 506	215	NOK 1 842	NOK 956
	Total value (waiting costs + price)			**NOK 1 018**			**NOK 2 798**	
			Leisure			Business		
Main transport Rail	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
OsloMet to Oslo S	Tram		13	NOK 15	NOK 37	13	NOK 108	NOK 37
Arrive early for rail	-		10	NOK 19		10	NOK 86	
Oslo S to Stavanger S	Rail	555 km	535	NOK 954	NOK 449	460	NOK 3 818	NOK 729
Waiting	-		3	NOK 8		3	NOK 57	
Stavanger S to UiS	Bus		29	NOK 34	NOK 40	29	NOK 241	NOK 40
	Sum		590	NOK 1 030	NOK 526	515	NOK 4 310	NOK 806
	Total value (waiting costs + price)			**NOK 1 556**			**NOK 5 116**	

Table 13: OsloMet to University of Agder

			Leisure			Business		
Main transport Aircraft	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
OsloMet to Oslo S	Tram		13	NOK 15	NOK 37	13	NOK 108	NOK 37
Waiting	-		15	NOK 33		15	NOK 234	
Oslo S to OSL Airport	Rail		24	NOK 28	NOK 110	24	NOK 199	NOK 110
Check-in, security control	-		60	NOK 127		60	NOK 315	
OSL Airport to KRS Airport	Aircraft	321 km	50	NOK 197	NOK 869	50	NOK 487	NOK 869
Waiting	-		8	NOK 18		8	NOK 125	
KRS Airport to UiA	Bus		39	NOK 46	NOK 33	39	NOK 324	NOK 33
	Sum		209	NOK 465	NOK 1 049	209	NOK 1 792	NOK 1 049
	Total value (waiting costs + price)			**NOK 1 514**			**NOK 2 841**	
			Leisure			Business		
Main transport Rail	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
OsloMet to Oslo S	Tram		13	NOK 15	NOK 37	13	NOK 108	NOK 37
Arrive early for rail	-		10	NOK 19		10	NOK 86	
Oslo S to Kristiansand S	Rail	321 km	268	NOK 478	NOK 529	268	NOK 2 224	NOK 529
Waiting	-		3	NOK 8		3	NOK 57	
Kristiansand S to UiA	Bus		21	NOK 25	NOK 33	21	NOK 174	NOK 33
	Sum		315	NOK 545	NOK 599	315	NOK 2 650	NOK 599
	Total value (waiting costs + price)			**NOK 1 144**			**NOK 3 249**	

Table 14: University of Bergen to Norwegian University of Science and Technology

			Leisure			Business		
Main transport Aircraft	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
UiB to BGO Airport	Bus		56	NOK 66	NOK 39	56	NOK 465	NOK 39
Check-in, security control	-		60	NOK 127		60	NOK 315	
BGO Airport to TRD Airport	Aircraft	529 km	60	NOK 236	NOK 899	60	NOK 584	NOK 899
Waiting	-		10	NOK 22		10	NOK 156	
TRD Airport to NTNU	Bus		72	NOK 85	NOK 80	72	NOK 598	NOK 80
	Sum		258	NOK 537	NOK 1 018	258	NOK 2 118	NOK 1 018
	Total value (waiting costs + price)			**NOK 1 555**			**NOK 3 136**	
			Leisure			Business		
Main transport Rail	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
UiB to Bergen S	Bus		10	NOK 12	NOK 39	10	NOK 83	NOK 39
Arrive early for rail	-		10	NOK 19		10	NOK 86	
Bergen S to Oslo S	Rail	463 km	390	NOK 696	NOK 756	387	NOK 3 212	NOK 1 296
Waiting	-		23	NOK 28		101	NOK 453	
Oslo S to Trondheim S	Rail	495 km	458	NOK 817		407	NOK 3 378	
Waiting	-		3	NOK 8		3	NOK 57	
Trondheim S to NTNU	Bus		17	NOK 20	NOK 40	17	NOK 141	NOK 40
	Sum		911	NOK 1 599	NOK 835	935	NOK 7 411	NOK 1 375
	Total value (waiting costs + price)			**NOK 2 434**			**NOK 8 786**	

Table 15: University of Bergen to University of Stavanger

			Leisure			Business		
Main transport Aircraft	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
UiB to BGO Airport	Bus		56	NOK 66	NOK 39	56	NOK 465	NOK 39
Check-in, security control	-		60	NOK 127		60	NOK 315	
BGO Airport to SVG Airport	Aircraft	182 km	35	NOK 138	NOK 899	35	NOK 341	NOK 899
Waiting	-		8	NOK 18		8	NOK 125	
SVG airport to UiS	Bus		45	NOK 53	NOK 40	45	NOK 374	NOK 40
	Sum		204	NOK 402	NOK 978	204	NOK 1 619	NOK 978
	Total value (waiting costs + price)			**NOK 1 380**			**NOK 2 597**	
			Leisure			Business		
Main transport Rail	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
UiB to Bergen S	Bus		10	NOK 12	NOK 39	10	NOK 83	NOK 39
Arrive early for rail	-		10	NOK 19		10	NOK 86	
Bergen S to Drammen S	Rail	281 km	355	NOK 633	NOK 768	412	NOK 3 420	NOK 1 088
Waiting	-		68	NOK 185		129	NOK 578	
Drammen S to Stavanger S	Rail	269 km	380	NOK 678		425	NOK 3 528	
Waiting	-		3	NOK 8		3	NOK 57	
Stavanger S to UiS	Bus		29	NOK 34	NOK 40	29	NOK 241	NOK 40
	Sum		855	NOK 1 569	NOK 847	1018	NOK 7 993	NOK 1 167
	Total value (waiting costs + price)			**NOK 2 416**			**NOK 9 160**	

Table 16: University of Bergen to University of Agder

			Leisure			Business		
Main transport Aircraft	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
UiB to BGO Airport	Bus		56	NOK 66	NOK 39	56	NOK 465	NOK 39
Check-in, security control	-		60	NOK 127		60	NOK 315	
BGO Airport to OSL Airport	Aircraft	372 km	55	NOK 216	NOK 1 578	50	NOK 487	NOK 1 929
Waiting	-		60	NOK 127		85	NOK 447	
OSL Airport to KRS Airport	Aircraft	321 km	50	NOK 197		45	NOK 438	
Waiting	-		8	NOK 18		8	NOK 125	
KRS airport to UiA	Bus		39	NOK 46	NOK 33	39	NOK 324	NOK 33
	Sum		328	NOK 798	NOK 1 650	343	NOK 2 600	NOK 2 001
	Total value (waiting costs + price)			**NOK 2 448**			**NOK 4 601**	
			Leisure			Business		
Main transport Rail	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
UiB to Bergen S	Bus		10	NOK 12	NOK 39	10	NOK 83	NOK 39
Arrive early for rail	-		10	NOK 19		10	NOK 86	
Bergen S to Kongsberg S	Rail	253 km	355	NOK 633	NOK 638	391	NOK 3 245	NOK 678
Waiting	-		68	NOK 43		11	NOK 95	
Kongsberg S to Kristiansand S	Rail	195 km	267	NOK 476		196	NOK 1 627	
Waiting	-		3	NOK 8		3	NOK 57	
Kristiansand S to UiA	Bus		21	NOK 25	NOK 33	21	NOK 174	NOK 33
	Sum		734	NOK 1 216	NOK 710	642	NOK 5 368	NOK 750
	Total value (waiting costs + price)			**NOK 1 926**			**NOK 6 118**	

Table 17: Norwegian University of Science and Technology to University of Stavanger

			Leisure			Business		
Main transport Aircraft	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
NTNU to TRD airport	Bus		72	NOK 85	NOK 80	72	NOK 598	NOK 80
Check-in, security control	-		60	NOK 127		60	NOK 315	
TRD Airport to SVG Airport	Aircraft	668 km	60	NOK 236	NOK 899	60	NOK 584	NOK 899
Waiting	-		8	NOK 18		8	NOK 125	
SVG airport to UiS	Bus		39	NOK 46	NOK 33	39	NOK 324	NOK 33
	Sum		239	NOK 513	NOK 1 012	239	NOK 1 945	NOK 1 012
	Total value (waiting costs + price)			**NOK 1 525**			**NOK 2 957**	
			Leisure			Business		
Main transport Rail	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
NTNU to Trondheim S	Bus		17	NOK 20	NOK 40	17	NOK 141	NOK 40
Arrive early for rail	-		10	NOK 19		10	NOK 86	
Trondheim S to Oslo S	Rail	495 km	405	NOK 722	NOK 1 068	453	NOK 3 760	NOK 1 181
Waiting	-		22	NOK 27		35	NOK 157	
Oslo S to Stavanger S	Rail	555 km	468	NOK 835		460	NOK 3 818	
Waiting	-		3	NOK 8		3	NOK 57	
Kristiansand S to UiS	Bus		21	NOK 25	NOK 33	21	NOK 174	NOK 33
	Sum		946	NOK 1 656	NOK 1 141	999	NOK 8 194	NOK 1 254
	Total value (waiting costs + price)			**NOK 2 797**			**NOK 9 448**	

Table 18: Norwegian University of Science and Technology to University of Agder

			Leisure			Business		
Main transport Aircraft	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
NTNU to TRD Airport	Bus		72	NOK 85	NOK 80	72	NOK 598	NOK 80
Check-in, security control	-		60	NOK 127		60	NOK 315	
TRD Airport to OSL Airport	Aircraft	416 km	55	NOK 216	NOK 1 629	55	NOK 535	NOK 1 678
Waiting	-		115	NOK 244		40	NOK 210	
OSL Airport to KRS Airport	Aircraft	321 km	45	NOK 177		50	NOK 487	
Waiting	-		8	NOK 18		8	NOK 125	
KRS airport to UiA	Bus		39	NOK 46	NOK 33	39	NOK 324	NOK 33
	Sum		394	NOK 914	NOK 1 742	324	NOK 2 594	NOK 1 791
	Total value (waiting costs + price)			**NOK 2 656**			**NOK 4 385**	
			Leisure			Business		
Main transport Rail	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
NTNU to Trondheim S	Bus		17	NOK 20	NOK 40	17	NOK 141	NOK 40
Arrive early for rail	-		10	NOK 19		10	NOK 86	
Trondheim S to Oslo S	Rail	495 km	435	NOK 776	NOK 868	453	NOK 3 760	NOK 981
Waiting	-		22	NOK 60		35	NOK 157	
Oslo S to Kristiansand S	Rail	321 km	283	NOK 505		268	NOK 2 224	
Waiting	-		3	NOK 8		3	NOK 57	
Kristiansand S to UiA	Bus		21	NOK 25	NOK 33	21	NOK 174	NOK 33
	Sum		791	NOK 1 412	NOK 941	807	NOK 6 600	NOK 1 054
	Total value (waiting costs + price)			**NOK 2 353**			**NOK 7 654**	

Table 19: University of Stavanger to University of Agder

			Leisure			Business		
Main transport Aircraft	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
UiS to SVG Airport	Bus		45	NOK 53	NOK 40	45	NOK 374	NOK 40
Check-in, security control	-		60	NOK 127		60	NOK 315	
SVG Airport to OSL Airport	Aircraft	391 km	55	NOK 216	NOK 1 179	55	NOK 535	NOK 1 929
Waiting	-		80	NOK 170		95	NOK 499	
OSL Airport to KRS Airport	Aircraft	321 km	45	NOK 177		45	NOK 438	
Waiting	-		8	NOK 18		8	NOK 125	
KRS airport to UiA	Bus		39	NOK 46	NOK 33	39	NOK 324	NOK 33
	Sum		332	NOK 808	NOK 1 252	347	NOK 2 610	NOK 2 002
	Total value (waiting costs + price)			**NOK 2 060**			**NOK 4 612**	
			Leisure			Business		
Main transport Rail	Transport mode	Distance	Time	Travel cost	Ticket price	Time	Travel cost	Ticket price
UiS to Stavanger S	Bus		29	34	40	29	241	40
Arrive early for rail	-		10	19		10	86	
Stavanger S to Kristiansand S	Rail	160 km	195	452	379	195	1619	379
Waiting	-		3	8		3	57	
Kristiansand S to UiA	Bus		21	25	33	21	174	33
	Sum		258	538	452	258	2177	452
	Total value (waiting costs + price)			**NOK 990**			**NOK 2 629**	