Assessing policy efficiency to reduce peak demand in trains

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by

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TU Delft

Preface

This master thesis is the last step to complete my master Transport, Infrastructure and Logistics at TU Delft. To get to this point I made quite a ride.

7 years ago I started my journey at the TU Delft at the faculty of Industrial Design and Engineering. However, after the first two years I knew it wasn't for me. During my minor airport of the future at the faculty of Aerospace Engineering, I discovered my interest in transport and logistics. Therefore, I decided to change my plan and enrolled for the TIL master instead of an Industrial Design master.

After finishing most of my courses, it was time to find a thesis graduation project. However, due to the Covid-19 pandemic this was easier said than done.

In the end I did my thesis research project at the TU Delft, instead of at a company. However, for me it was the best decision at that moment. Working from home on this thesis topic was not always easy. Therefore, I would like to thank my supervisors Bert, Jan Anne and Niels for the support and feedback. Jan Anne, I would like to thank you for your weekly supervision. You always gave good advice during the whole process and you were always willing to help me. I would to thank Niels for his critical eye reviewing my work along the way, providing feedback and helping me to get in contact with field experts. Furthermore, I would like to thank Bert for his enthusiasm about my research and giving me confidence.

Besides my supervisors, I would like to thank all of the 15 students that helped me conducting my focus group meetings. Especially, I would like to thank Carmen and Ramon, who were part of my moderating team during these meetings. Without them I would not have been able to execute those in a proper manner.

Furthermore, I would like to thank Manouschka for always being my LaTEX helpdesk and answering all my LaTEX related questions.

I would like to thank my family for their support, not only during my master thesis, but also during the rest of my studies. Allowing me to make my own choices and feel confident in myself.

Lastly, I would like to thank Anne, he was always willing to help me, by answering my questions and trying to point me in the right direction during my thesis. And most importantly ensuring me it would be fine in the end.

Irene Louise Overkleeft
Delft, 2020

Summary

Trains become more and more crowded during the morning peak hours in the Netherlands. This is the result of the growing Dutch population, higher income, higher number of jobs and more students whom travel by train. These factors all lead to a higher peak hour demand. Because of these factors, growth in traveled kilometers and travelers' numbers is expected in the years post Covid-19. This will lead to increasing pressure on the railway network, in particular for the urban areas such as the Randstad. In the Randstad multiple congested trajectories are expected to appear. However, not all these trajectories were taken into account. This study focused on the trajectory between Rotterdam Central Station and The Hague Central station.

Since, it is expected that the maximum railway capacity will be reached in 2030, this will lead to multiple problems. First, overcrowding will become a bigger problem. Therefore, travelers will not be able to board their preferred train. This is not the only problem caused by overcrowding, also their safety both inside the train and at the platforms is at risk.

Not only travelers are facing the negative effects of crowdedness, also railway operators are facing problems if maximum capacity is reached. Possible solutions that are focused on increasing the capacity are limited, since the option to expand the railway tracks is limited. Furthermore, implementation of more and longer trains is almost impossible in the Randstad, because the train frequency is already at its maximum.

Therefore, new solutions should be found to reduce the peak hour demand in trains. Multiple studies have been done to find a solution to this problem. According to the literature, the solution with the highest potential to reduce peak hour demand in trains is to change the departure time of students.

Although it is known that changing the departure time of students leads to lower peak demand in trains during the morning peak, there is a literature gap regarding which policy measures students prefer regarding the change of their departure time. Furthermore, it is unknown what the costs and benefits are of these students' preferred alternatives, and which of those alternatives are most beneficial to implement compared to the most likely future scenario.

The aim of this research is to develop different alternatives that lead to a reduction in the peak hour demand in trains by changing the departure time of students, which are at the same time attractive for students. The second goal of this research is to give insight in societal benefits and costs of the proposed alternatives compared to the baseline alternative. These objectives led to the following research question:

Which potential policy measures, focused on change in departure time of students traveling by train, are efficient to reduce morning peak demand?

To answer the research question, different steps were performed to generate the input for a Cost-Benefit Analysis (CBA), in order to after that perform the CBA. First, a literature review was performed to map the problem. Then the baseline was defined by using expert knowledge and literature. After that the alternative policies were defined by using focus groups with students. The next step was to identify the effects of the alternative policies compared to the baseline. This was done by using expert knowledge and literature. Lastly, the CBA was performed, including a sensitivity analysis. After that, recommendations could be made about which policy measures have the most potential to be economically and socially beneficial.

The literature review described several travel management factors that lead to a decrease in peak hour demand. For example different peak hour pricing strategies could help to reduce the demand. Furthermore, different passenger's support strategies might help to spread the travelers more even at the platform and in trains. Increasing the railway and train capacity helps to reduce the overcrowding,

however the ability to implement this is limited. Lastly, research showed that the change of departure time of a specific group of railway travelers can lead to a reduction of the peak hour demand. It was concluded that, changing the departure time of students had the most potential to reduce peak hour demand in trains in the Netherlands.

Moreover, an overview of the stakeholders involved in both the baseline alternative and alternative policies were given. This was done so that in a later step the alternative policies' effects of those stakeholders could be compared to the baseline alternative. The stakeholders were mapped by using literature, stakeholder checklists and filling in rainbow diagrams. This process led to the following stakeholders:

Baseline alternative

- Government (National, regional, local)
- Transport providers (NS, ProRail)
- Educational institutions (TU Delft)
- Public transport users

Alternative policies

- Government (National, regional, local)
- Transport providers (NS, ProRail)
- Educational institutions (TU Delft)
- Students
- Teachers

Next, the baseline alternative was defined. This baseline was focused on the trajectory Rotterdam CS - The Hague CS and the city of Delft. To set the baseline expert knowledge, literature and the reasoning of the researcher was used. This led to the following measures taken into account for baseline alternative:

- Emplacement of The Hague CS
- High frequency railway operation between The Hague CS and Rotterdam CS
- Investment in 4 extra Sprinters
- Expansion of the number of railway tracks between Rijswijk and Delft-Campus.
- Change of the track layout between Schiedam and Rotterdam CS
- Free crossing at The Hague HS
- 2500 extra students rooms in Delft
- Investment in TU Delft buildings and faculties

Hereafter, the alternative policies were defined. This was done by using group sessions. Three sessions were held with five students each. The composition of these groups were homogeneous in terms of life stage, familiarity with online education and language. The groups varied in terms of age, study and gender.

During this sessions questions were asked about the students' experience with online education, but also their preference towards policy measures that stimulate the change of their departure time. These sessions led to three potential policy measures to reduce peak hour demand by changing the departure time of the students. However, only two of those met the alternative policy criteria. The alternatives proposed by the students that met these criteria were; online education combined with on-campus education and stimulating living on campus by bringing back the student grant.

After obtaining the preferred alternative policies of the students, the measures needed for these policies were defined. This was done by using focus groups, literature and expert knowledge. This led to the following measures for the alternative policies:

Student grant alternative

- Investment in student grant for all students
- Facilitation of student housing (5,079 to 6,219 rooms)
- No discount on tuition fee for first year students

Blended learning alternative

- Investments on TU Delft buildings to facilitate blended education
- Providing licenses for online tools
- Provide stable Wi-Fi
- Educate teachers for online learning

After defining the baseline alternative and the alternative policies, the effects of the alternative policies compared to the baseline were examined. The aim of the CBA was to conclude whether it is beneficial or not to implement the proposed alternative policies. The alternative policies' effects could be both positive (benefits) and negative (costs) in comparison to the baseline alternative. However, not all types of effects were taken into account during this research, only the direct effects were taken into account. However, indirect and external effects were involved with these policies as well, but these were not taken into account.

For the blended learning alternative the effects were; higher investment costs on online tools, Wi-Fi and teachers' education. Other expected effects were, lower investment costs on the railway infrastructure and trains. And lastly lower numbers of non-facilitated demand was another effect.

The expected effects of the student grant alternative were lower investment costs on railway infrastructure and trains. Furthermore, the exploitation costs of railway infrastructure and non-facilitated demand was expected to be lower compared to the baseline. Higher costs were expected for facilitation of more student rooms and the exploitation of those. Also, higher costs for the government arose by return of the student grant. On the other hand students were expected to earn student grant from the government. Furthermore, the tuition fee discount for first year students is expected to be abolished, which lead to higher costs for students and higher income for the government. Lastly, another effect was that more travel time will saved compared to the baseline, since some of the students do not need to travel by train anymore.

Hereafter, the effects were monetized. This led to costs and benefits of the alternative policies compared to the baseline. To be able to conclude which alternative was beneficial to implement the Net Present Value (NPV) and the Benefit/ Cost (B/C) ratio were calculated. If the NPV is positive and the B/C ratio is bigger than one it is beneficial to implement the policy. To calculate the NPV, the costs were subtracted from the benefits. The B/C ratio was calculated by dividing the benefits by the costs.

Both alternatives showed a B/C ratio bigger than one. However, the B/C ratio of the blended learning alternative showed a more positive outcome than the student grant alternative. The B/C ratio of this alternative was very close to one. Furthermore, the NPV of all alternatives were positive. All the values can be seen in table 1.

After the CBA was conducted, a sensitivity analysis was performed to be able to indicate which effects are most sensitive to changes. For the student grant alternative the effect of the railway exploitation costs was most sensitive to changes. Since the B/C ratio of the student grant alternative was close to one, this alternative is very sensitive to changes. If a the increase of the railway exploitation costs rose by more than 10%, it is possible that the B/C ratio will be lower than one for the student grant alternative, which means the implementation of this alternative was not recommended.

The blended learning alternative's effect that was most sensitive to change was the TU Delft housing costs. However, if the costs increased or decreased by 10% this had less impact on the B/C ratio, since this ratio was not so close to one compared to the student grant alternative.

It could be concluded that both alternatives had a positive outcome compared to the baseline alternative. However, the blended learning alternative showed more potential to be economically feasible. Since, the costs were lower and the benefits higher of this alternative compared to the student grant alternative, which led to a higher NPV and B/C ratio. Furthermore, this alternative was less sensitive to changes, because the B/C ratio was less close to one compared to the student grant alternative.

The alternatives that were proposed in this research were obtained by using focus groups. The outcome of those focus group sessions showed that it is possible to obtain valuable information regarding people's preferences and useful alternative policies. Not only can it be concluded that focus groups can be used to obtain policy alternatives, the CBA also showed that these alternatives have potential to be economically and societal feasible. Therefore, it can be concluded that focus groups can provide useful alternatives as an input for a CBA and be economic and societal feasible to implement.

Although this research showed that it is possible to obtain feasible alternative policies by using focus groups, there are some pros and cons for using focus groups in combination with a CBA. Focus group sessions can lead to high quality information about the participants' preferences and opinions, which lead to very specific alternatives as an input for the CBA. This is a major advantage, since the

biggest drawback of a CBA is that it is hard to take into account stakeholders opinions and preferences. However, it is currently unknown if focus groups can be used to obtain useful alternatives if there are multiple heavily affected stakeholders.

A downside of the combination of using focus groups and CBA is that both methods are time consuming. It takes time to set up the focus groups, find participants and a moderating team, find a suitable date for multiple sessions and process the results. It also takes time to gather the right information and data as an input for the CBA. Therefore, it is not recommended to use both methods if time is very limited.

Furthermore, this research showed that using focus groups to obtain alternative policies as an input for Ex Ante CBA, is an appropriate method. However, it is not researched yet if the combination of focus groups and CBA is useful for already planned policy interventions or Ex Post CBA. To be able to draw a conclusion on this, further research is needed on for which policy types and CBA this combination of methods is useful.

Furthermore, the focus groups sessions of this research only led preferred alternatives by students. However, it can be the case an alternative seen as negative by the participants, will have a positive outcome in the CBA. This can be a negative aspect to the combination of focus group sessions and CBA, that only participants' positive alternatives are taken into account for the CBA, which can lead to a biased outcome.

Besides the pros and cons of using both focus groups and CBA, this research has some limitations if one or both of these alternatives are considered to be implemented in the future. The limitations and recommendations of this research should be taken into account. First, this research was focused at the trajectory between Rotterdam CS and The Hague CS. However, it is unknown if these policies will be the solution for other congested railway sections in the Randstad as well. If a CBA for other trajectories is performed the outcome might not be positive.

Besides, this research took only the most important stakeholders into account. However, if these policies are considered to be implemented all stakeholders should be taken into account, since this can have an effect on the outcome of the CBA. Therefore, for future research all stakeholders must be considered in the CBA.

Furthermore, for future research it is recommended to take all effects into account, because this research was limited to only the direct effects. However, there are also indirect and external effects involved by implementing these policies. Some of the indirect effects that should be considered are a decrease in people's welfare, land use and value reduction of houses. The external effects that might be important are noise hindrance and emissions due to construction. The outcome of the CBA might change if all effects are taken into account.

Table 1: Net present value (in mln) relative to the baseline alternative and benefit/ cost ratio

	Student grant		Blended learning	
	Low growth	*High growth*	*Low growth*	*High growth*
Investment costs				
Emplacement The Hague CS	€ 21.0	€ 18.8	€ 65.0	€ 35.2
High frequency Rijswijk-Rotterdam CS	€ 109.5	€ 98.1	€ 339.0	€ 183.7
Free crossing Hollands Spoor - CS	€ 19.8	€ 17.8	€ 61.4	€ 61.4
Student rooms	€ -96.7	€ -141.1	€ -	€ -
Trains	€ 6.8	€ 6.1	€ 21.2	€ 11.5
Buildings tu delft	€ -	€ -	€ 662.1	€ 395.1
Exploitation costs				
Infrastructure train	€ 25.0	€ 11.1	€ -	€ -
Student rooms	€ -19.9	€ -29.3	€ -	€ -
Housing costs tu delft	€ -	€ -	€ 209.1	€ -
Other impacts				
Exploitation revenue student rooms	€ 93.0	€ 137.3	€ -	€ -
Non-facilitated demand	€ 5.3	€ 5.6	€ 5.6	€ 5.6
Travel time saving	€ 5.1	€ 12.0	€ -	€ -
Tuition fee income government	€ 48.5	€ 48.5	€ -	€ -
Extra tuition fees students	€ -48.5	€ -48.5	€ -	€ -
Student grant government	€ -830.3	€ -830.3	€ -	€ -
Student grant for students	€ 830.3	€ 830.3	€ -	€ -
Online tools	€ -	€ -	€ -168.2	€ -168.2
Teachers' education	€ -	€ -	€ -29.9	€ -29.9
Wifi	€ -	€ -	€ -4.0	€ -4.0
Costs	€ -995.4	€ -1,049.3	€ -202.1	€ -202.1
Benefits	€ 1,164.5	€ 1,185.7	€ 1,363.4	€ 692.5
NPV	**€ 169.1**	**€ 136.3**	**€ 1,161.3**	**€ 490.4**
Benefit/Cost ratio	**1.17**	**1.13**	**6.75**	**3.43**

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1 Introduction

1.1 Context

During the morning peak trains are getting more and more busy in the Netherlands, because of the growth of the Dutch population, number of jobs, income and number of students travelling by train (Loop, Bakker, Savelberg, Kouwenhoven, & Helder, 2018).

Since there is a bigger interest in railway usage, because of improvement in the railway network and connections between trains, growth of traveled kilometers is expected (Loop et al., 2018). Between 2017 and 2023 the estimated growth of traveled kilometers by train is 14% (KiM, 2018b). Besides population growth and more commuters using the railway system, also more students will make use of the public transport network. This is due to the fact that the public transport pass for students is used by students under the age of 18 as well (KiM, 2019).

In the coming years the number of railway passengers is expected to grow. Therefore, the pressure on the network is increasing primarily in the urban areas such as the Randstad (Guis, Banninga, & Verschuren, 2018).

Because of the rising pressure, especially during the morning peak, since both commuters and students travel during the same time period in the morning (CBS, 2016b), overcrowding in trains is becoming a bigger problem. On the long term to prevent overcrowding during peak hour, different solutions are brought up by the Nationale Spoorwegen (NS), namely a higher frequency of trains per hour, longer trains and lastly higher peak prices (Peppels, 2019).

However, the possibility to expand the capacity by increasing length and frequency of trains is finite (Guis et al., 2018). Also, the investment costs of buying new trains, building new infrastructure and expanding platforms are high (Charles & Hale, 2009; Guis et al., 2018).

Furthermore, the maximum rail capacity is expected to be reached in 2030. Multiple different bottlenecks are expected regarding train schedules and railway capacity (ProRail, 2019).

Due to the rising capacity demand in public transport, different complications arise. Not only the ability to transport people might not always be fulfilled, also the safety of the passengers is at stake when maximum capacity is reached, since more accidents occur (B. Wang & Legaspi, 2012). Therefore, railway operators are looking for solutions to lower the demand during the peak hours without expanding the network (IenW, 2017). Because of this, it is important that it is known, which solutions have most potential to solve the railway demand problem.

One solution that has been researched recently is the change of the travel behaviour of students. The education hours of HAN University and Radboud University were changed, which led to a reduction of 19% in peak hour demand. It has been proven to be an effective measure for reducing morning peak demand significantly in public transport in the Nijmegen area (Olde Kalter, Evers, & Timmermans, 2019; Van der Aa & Hodde, 2018).

The outcomes of the studies executed by Olde Kalter et al. (2019); Van der Aa and Hodde (2018) are very relevant, since 20-25% of the train travelers are students in the Netherlands (CBS, 2016a). Furthermore, this group had the biggest growth in rail transport share of all passenger groups between 2005-2016 (Loop et al., 2018).

1.2 Problem statement

In the Netherlands the peak hour demand is getting more crowded, because of the expected growth the capacity limits are expected to be reached in 2030.

Between 7:30 and 8:30 in the morning the transport demand exceeds the capacity, because there are not enough trains available to be able to transport all passengers. Furthermore, extending the infrastructure and increasing the train frequency is almost impossible. While, during the day the demand is much lower and a lot of trains are not in use. Therefore, the NS is looking for policy measures to reduce the peak demand (Guis et al., 2018).

1.3 Research gap

To reduce the overcrowding in trains during the peak hour, various measures are proven to be effective.

Research showed that capacity increase of the existing rail network is an effective measure to reduce peak hour demand, This can be done by, more and longer trains (Charles & Hale, 2009; Vuchic, 2005) and more rails (Dingler, Lai, & Barkan, 2009; Shih, Dick, Sogin, & Barkan, 2014).

Besides capacity increase, other effective measures are flexible education hours and support of students. These measures will help people to change their travel behaviour (Charles & Hale, 2009; Lyons & Chatterjee, 2008).

Multiple recent studies showed, an effective measure to lower peak demand in trains can be established by changing the education hours at universities. The changed education hours of HAN University and Radboud University have been proven to be an effective measure for reducing peak demand significantly in the Nijmegen region (Olde Kalter et al., 2019; Van der Aa & Hodde, 2018).

However, no relevant information was found about the cost efficiency of the policy measures taken to reduce the numbers of students during the morning peak hour. Therefore, it is interesting to take a closer look at this group of railway travelers and study the efficiency of different policy measures changing the departure time of students. Furthermore, it is unknown which policy alternatives are preferred by students regarding the change of their departure time.

Besides, it is unknown what the costs and benefits of these policies might be compared to the current expected policy measures taken to serve the future capacity demand.

This is beneficial to know for both peak hour railway travelers and operators. Since if the policies have a positive outcome the peak hour demand will be reduced. Therefore, trains and train station get less crowded and less investments are expected to be needed on railway infrastructure.

The knowledge gap that has not been filled yet is; information is missing about the students' preferred alternatives that reduce peak hour demand in trains. Furthermore, the comparison between the costs and benefits of those preferred alternatives and the most likely future scenario is not yet been done. Since this comparison is not been made it is unknown which policy measure will be most cost efficient to implement.

Research objective

The aim of this research is to develop alternative policies, by using focus groups, that lead to a reduction of the peak demand by changing the students' departure time and on the other hand were attractive for the students. The second aim of this research is to give insight in the costs and benefits involved in the proposed alternative policies and the societal feasibility of these policies.

1.4 Research questions

For this thesis a main question and several sub-questions are formulated.
The main research question is the following:

Which potential policy measures, focused on change in departure time of students traveling by train, are efficient to reduce morning peak demand?

To be able to answer the main question, the following sub-questions are formulated:

1. Which are the potential policy measures, focused on students, that will be taken into account?

2. What are the impacts/ effects of the specified policies on those affected by it?
3. What are the monetary costs involved with the implementation of the policy measures?

1.5 Scientific and societal relevance

This research will have both scientific and societal relevance. Scientifically this thesis will give an insight on, which policy alternatives are preferred by students, retrieved by focus groups with students, to reduce peak demand in trains during the rush hour. Furthermore, effects of these policy alternatives are compared to the expected future scenario, which will provide insight in the policy with the highest potential to reduce peak demand efficiently. Lastly, it the research shows the economic feasibility of implementing these proposed policies. Current research is mainly focused on which policies are effective to reduce the peak hour demand and not on the efficiency of those policies. However, these are not specifically focused on students.

This research will also have societal relevance, because the outcome of the analysis will provide a recommendation to policy makers, about the most preferred policy to implement. If one of the proposed alternative policies will be considered to be implemented this has an effect on the society, since a lot of stakeholders are involved. On the short term this research is relevant, since the government is planning to implement change lecture hours for students to reduce peak hour demand, this might also have an effect on peak demand in sub-ways, busses and cycle paths.

Besides, this research will provide a recommendation for railway operators which measure is best to reduce the peak hour demand. This is not only relevant for the Netherlands but also for other countries' having problems with peak hour demand.

1.6 Scope

Since the number of train passengers is expected to grow and the maximum capacity in trains is expected to be reached, this thesis will be focused on reducing demand in trains during the morning peak. Therefore, the only transport mode taken into account will be train other modes are not considered.

Many different groups of people travel by train. Among those the biggest groups are commuters and students. The literature research showed that different studies researched that change of departure time of both students and commuters will lead to lower peak demand. However, the decrease in peak demand by shifting the time when students travel appeared to have more impact than the change of time when commuters travel. Therefore, this study is focused on policy measures that will decrease the student's share in the train by changing their departure time. Other groups traveling by train during the morning peak are not taken into account.

However, in the Netherlands there are numerous cities that have a university and therefore students travel at many different trajectories. Therefore, one university location is chosen to focus on during this research. The city focused on is Delft.

Furthermore, it is expected that students studying in Delft travel by train on the trajectory between Rotterdam Central Station and The Hague Central Station, both ways. It is assumed that all students that do not live in Delft travel on this route.

By implementing new policies, that will change the departure time of students, a lot of stakeholders are involved as the literature review shows. However, to limit the amount of stakeholders in this research. The stakeholders included in the baseline alternative are: the government (national, regional, local), transport providers, public transport users and educational institutions. For the alternative policies this list will be complemented by students and teachers. Since changing departure time of students has impact on those groups as well. Since policies are normally implemented over time, it is important that a time horizon for the project is set. Therefore, the project life time for all alternatives is 20 year starting in 2020 until 2040.

1.7 Methodology

To answer the research question, different steps were taken to generate the input for a Cost-Benefit Analysis (CBA), to after that perform the CBA. The steps that were followed were composed by Romijn and Renes (2013) and are shown below. First, a literature review was performed to map the problem. Then the baseline was defined by using expert knowledge and literature. After that the alternative policies were defined by using focus groups with students. The next step was to identify the effects

of the alternative policies compared to the baseline. This was done by using expert knowledge and literature. Lastly, the CBA was performed, including a sensitivity analysis. After that, recommendations could be made about which policy measure has the most potential to reduce peak hour deman in a economical and social beneficial way.

The researcher has chosen to use CBA instead of a multi criteria analysis as a research method, since the CBA is a widely used tool to assess the efficiency of new policies. Furthermore, it easy to understand and it can be used for large scale projects (Beria, Maltese, & Mariotti, 2012).

The basic steps of a cost benefit analysis, given by Romijn and Renes (2013), are:

1. Problem analysis
2. Define the baseline alternative
3. Define alternative policies
4. Identify the effects and benefits
5. Determine the costs
6. Analyse variants and risks
7. Set-up overview of the costs and benefits
8. Present results and make a recommendation

The CBA is divided into two parts. According to Romijn and Renes (2013) the first three steps form the preliminary phase of the CBA and steps four to seven are considered as the main part of the analysis. Step eight gives the insight and outcome of the CBA.

The problem analysis is covered in chapter 1. Then the second and third step will be covered by answering sub-question 1. This is done in chapters 4 and 7. Sub-question 2 will cover step 4 of the CBA. This is done in chapter 8. And the last sub-question covers steps 5, 6 and 7, showed in chapter 9. The last step of the CBA will be covered in the assessment part of this research. A detailed overview of each step of the CBA can be viewed in chapter 2.

Figure 1.2 provides an overview of the approach used to answer the research questions. The methods that are used, are discussed per sub-question.

Which are the potential policy measures, focused on students, that will be taken into account?

This question covers the first step of the CBA, namely the determination of the policy measures.

To be able to answer the first question different methods are used. First, the baseline alternative is defined by using literature and expert knowledge. This is shown in 4. An interview is used to gain knowledge from a NS expert regarding the baseline alternative. This is done by using a semi-structured. To conduct this interview, different steps are followed. First, knowledge about the topic is gained, done by a literature review. Hereafter an interview guide is developed. This guide gave direction to the interview. The in-depth theory of the semi-structured interview can be found in appendix D.

After this, focus group discussions are held with students, to see students' preferences toward measures that change their departure time. During these sessions the moderator gives a clear context about the aim of the session and direction of the discussion. These sessions are used to start a discussion about possible scenarios to change the departure time of students. The focus group is also used to obtain knowledge about, which of the scenarios has the most student support if it would be implemented. The in-depth theory of the focus group sessions can be read in chapter 5 and appendix F.

The scenarios that met the criteria for being an alternative scenario, described in 7, are taken into account for the CBA.

What are the impacts/ effects of the specified policies on those affected by it?

After specification of the baseline alternative and the alternative policies. The third step of the CBA is to determine the effects and benefits.

For this research the effects of departure time change of students are retrieved from literature and index numbers. The standard numbers used for the CBA can be found in appendix 9.1. Also, an interview is done with an expert of student affairs to investigate the effects for the TU Delft. This interview can be found in appendix E.2.

What are the monetary costs involved with the implementation of the policy measures?
This last sub-question covered steps 5, 6 and 7 of the CBA. Implementation of both the base alternative and the alternative policy involves costs. For the calculation of the monetary values of the impacts key figures are used. Those are retrieved from literature. Assuming these figures are applicable for this research. To conclude this question, the outcome of the different variants are analysed. This is the last step of the CBA.

Methodology overview

The detailed methods used in this research are explained per chapter. However, an overview of the different methods used are shown in figure 1.1. Per sub-question the methods that are applied are shown.

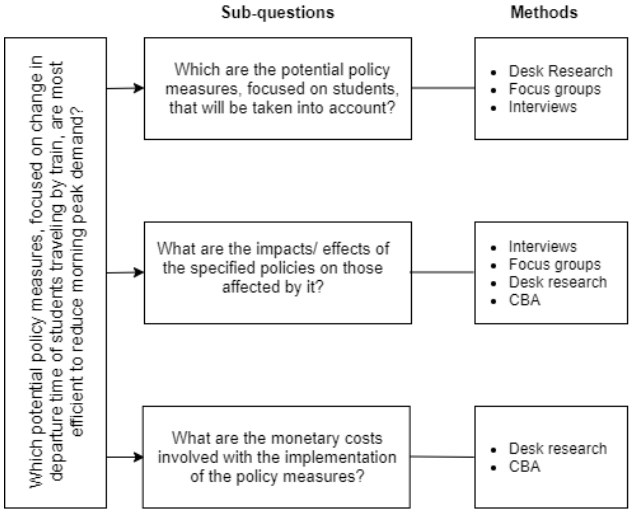

Figure 1.1: Overview thesis methodology

1.8 Thesis approach

The following figure 1.2 shows the outline of the thesis structure, including the chapter numbers. The thesis is structured based on the shown approach.

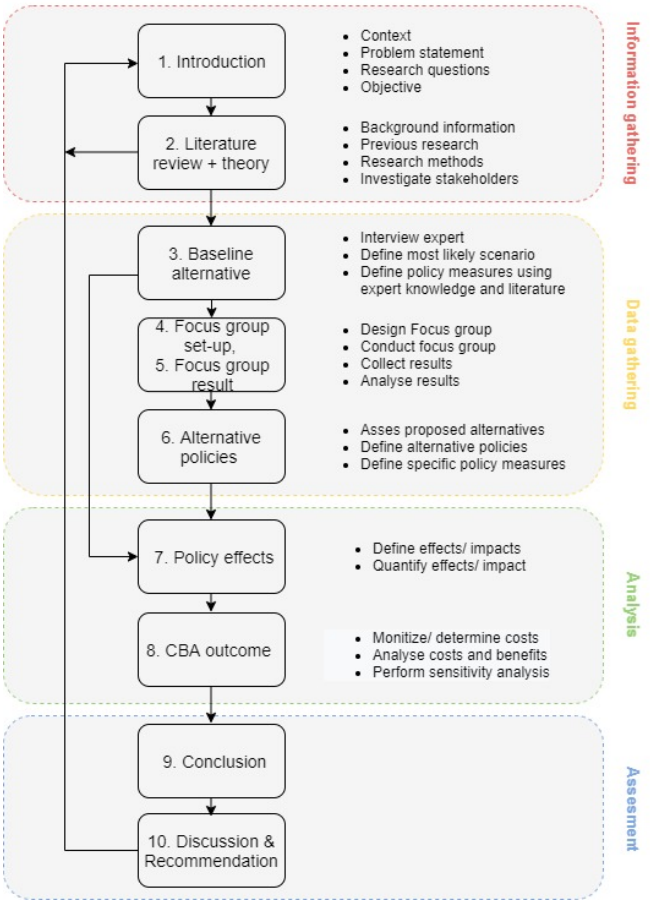

Figure 1.2: Research outline

2

Literature review

In this chapter an overview is given on the existing literature, regarding travel demand management. First, a short introduction to the topic is given in section 2.1. Then the railway travelers and railway statistics are described in section 2.2. In section 2.3 the current travel demand management is described, this includes pricing strategies, support strategies and capacity increase. This section also describes the factors influencing the change of travel time of different travel groups and the effect those measures have on people. Then the stakeholders are given for the described problem in section 2.4. The last section 2.5 of the literature research gives an overall conclusion on the existing literature and the relevant information for this research.

2.1 Introduction to the problem

Overcrowding in public transport during the peak hours has become a bigger problem every year. According to KiM (2018b), the number of travelled kilometers by train is expected to increase with 14% between 2017 and 2023.

It is also known that crowding in public transport can have a negative effect on the travelers' experience, since it leads to discomfort due to not having a seat, personal space or not being able to travel together. Furthermore, it leads to more accident in trains and at the platform (B. Wang & Legaspi, 2012). Because of the expected increase in movements by public transport, it is foreseen that crowding will become a more important factor in transport in the future (Yap, Cats, & van Arem, 2018). The maximum capacity is expected to be reached in 2030 (ProRail, 2019). Furthermore, the ability to increase capacity of trains and railway tracks is limited as well (Guis et al., 2018). Therefore, this literature review shows the current railway situation, including the number of travellers, peak hour pattern and an insight in the (expected) congested railway station. After that research is done at which travel demand management strategies are used and investigated to reduce the peak hour demand.

2.2 Railway travelers and railway statistics

Before being able to identify possible solutions to reduce peak hour demand. Insights are given of the current train travelers composition and railway statistics, but also the expected bottlenecks of the railway network are highlighted.

Railway travelers' composition

In the Netherlands the NS transports over 1.3 million travelers per day (NS, 2019b). Different groups of people travel by train. The two biggest groups are people that must travel and people that travel for pleasure. The people that must travel, travel for work or school related activities. The people that travel for pleasure, do that for leisure activities(van Hagen & Exel, 2014).

During the morning peak the highest number of travelers are people who go to work (commuters) and students. These groups mainly travel between 7:00-9:00 in the morning. People that travel for pleasure will depart from 8:30 in the morning and 18:00 in the afternoon (van Hagen & Exel, 2014). This phenomena can also be seen in figure 2.1.

Furthermore, it can be seen that working people form the largest group during the morning and evening peak, namely more than half of the people traveling in this period belongs to this group. Students and pupils are the second largest group during the peak hours. It can also be concluded that on the Mondays the commuters are best represented, this group travels the least on Friday. For the student group Monday is the least popular day to travel. In general Thursday's morning peak is the busiest (CBS, 2016a).

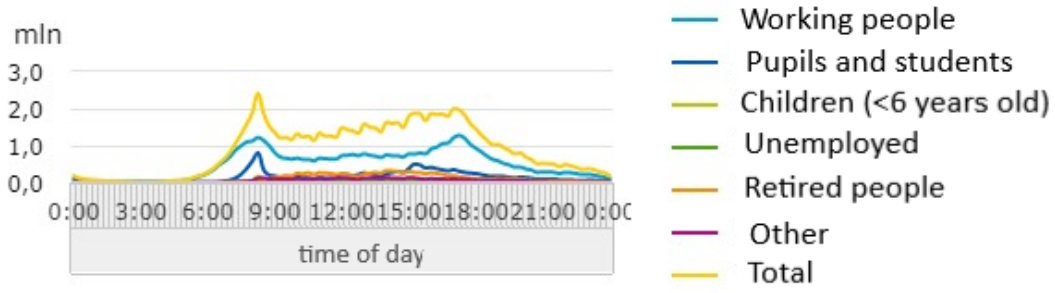

Figure 2.1: Day pattern number of movements on an average workday (CBS, 2016a)

Commuters have an earlier departure time than students in the morning peak. The morning peak for commuters is less concentrated around a specific time window than for students. It can also be seen in figure 2.1, that there is a clear evening peak for the working population, who travel by train (CBS, 2016a). Furthermore, commuters make more use of public transport when living in urban areas (CBS, 2016b).

Furthermore, between 20-25% of the train passengers during peak hours are students currently (CBS, 2016a). This group of passengers had the biggest share in rail transport growth between 2005-2016. This was due to the fact that the number of young adults that were working decreased and the number of students increased in this period (Loop et al., 2018)

Furthermore, since January 2017 the public transport student pass is also used by students under the age of 18. This led to an increase in traveled kilometers by students, between 0.5% and 0.8% (KiM, 2019). Students make use of the train for half of the trips to and from the universities. Lastly, the furthest distances made for study purposes are done by train (CBS, 2016b).

Railway statistics

Because of population growth, mainly in the Randstad, there are several very busy train stations. In the Netherlands there are seven train stations with over 50.000 boarding and alighting passengers at an average work day. Six of these stations are located in the Randstad (van Hagen & Exel, 2014). The following table 2.1 shows the exact boarding information at those stations.

Table 2.1: Number of boarding and alighting passengers per station (NS, 2019a)

Station	**Boarding and alighting**
Amsterdam Central Station	192.178
The Hague Central Station	91.437
Leiden Central Station	79.376
Rotterdam Central Station	96.690
Utrecht Central Station	194.385
Schiphol Airport	92.214

Since an increase in rail travelers is predicted, bottlenecks in the railway network are likely to occur. Different studies are executed to predict which bottlenecks there will be in the railway network in the future. These bottlenecks can be related to railway stations or the railways itself.

First of all, a transfer bottleneck occurs when the available platform width is not sufficient in relation to the number of passengers, the number of objects on the platform and passing trains during the peak hours. From the six train stations shown in table 2.1, four are expected to have one or more (major)

transfer bottlenecks in 2030. These stations are The Hague Central Station, Leiden Central Station, Utrecht Central Station and Schiphol Airport (ProRail, 2017).

Besides the mentioned transfer bottlenecks, it is also predicted that there will be railway track section bottlenecks at different parts of the railway network in the future. These kind of bottlenecks occur when, for example a intercity train cannot pass a sprinter train since there is no extra track. This is the case between Delft-Campus and Schiedam, there are only two tracks so the intercity can not pass the sprinter (Arcadis, 2011).

2.3 Travel demand management

This section shows possible solutions to the capacity demand problem. It highlights the current measures, planned measures and other possible solutions to reduce the capacity demand.

Since a higher number of people is travelling by public transport, multiple problems arise regarding railway capacity and overcrowding. Adding capacity or implementing other measures are needed to deal with the demand. However, adding capacity to be able to handle the increase in demand has turned out to be difficult on the short term (Ma & Koutsopoulos, 2019). This section shows the current and planned travel demand management, but also new researched measures that reduce the peak demand.

Travel demand management (TDM) is the overarching term for all strategies and policy measures that aim to manage congestion of transportation modes and reduce travel demand (SCIS, 2020).

To give a better view of peak demand, the term transport demand will be explained.

Transport demand for public transport is the need for transport expressed in number of people per specific time period and distance (Rodrigue & Notteboom, 2020).

The demand for public transport has a great variation during the day, since most commuters will travel in the same periods of day. This will lead to peak loads during mainly the morning and evening peak (Rantzien & Rude, 2014).

According to the NS the off-peak hours are between 0:00-6:30, 9:00-16:00 and between 18:30-24:00. This means the peak hours are between 6:30-9:00 in the morning and between 16:00-18:30 in the afternoon (NS, n.d.-c).

However, besides peak and off-peak a third period can be distinguished. Namely spike time, this is the peak period within the rush hours. In the Netherlands spike time for train travelers is from 7:30 to 8:30 in the morning. Spike means that within this time window the most people will take the train and the trains are most crowded of the day (Charles & Hale, 2009).

Pricing strategies

Different strategies used to reduce the demand during peak hours. A common practice is to implement peak period pricing to reduce the demand during the morning and evening peak. And spread the load of passengers over the less crowded off-peak hours of the day (Whelan & Johnson, 2004).

However, various different ways of implementing this strategy are reviewed. In Australia the early bird ticket was introduced, this ticket offered people, that travelled by rail before 7:00 in the morning, a free ride. The implementation of the early bird ticket reduced the demand during peak hours. However, when the ticket was introduced there was also higher total demand during peak hours. Therefore, the total effect of the early bird ticket is unclear (Currie, 2010). Furthermore, in the North of England Whelan and Johnson (2004) tested the impact of reduction of off-peak fares and increase of peak fares. It was concluded that the overcrowding reduced significantly. In the Netherlands the NS offers a off-peak subscription for a reduced price (Dal voordeel) to stimulate people to travel off-peak (NS, n.d.-a).

Not only peak pricing of tickets can be an option to reduce the demand, also station specific pricing can help to reduce the demand. By increasing the price of congested train stations and decreasing the price on the less crowded stations, travelers will change to other non-congested stations (Charles & Hale, 2009; S. Wang, Zhang, & Qu, 2018).

Furthermore, strategies to reduce peak demand can be related to station parking pricing, if peak prices are introduced at train stations this can lead to smoothing the peak demand and shift the demand to early peak or late morning peak (Henn, Karpouzis, & Sloan, 2010).

Passenger's support strategies

Besides pricing strategies, also passenger's support strategies can be used to reduce crowdedness. Information on crowdedness inside trains can be helpful to distribute the crowd in public transport more evenly. Since crowding on a train is a criterion to determine the frequency and the number of cars of a train (Kim, Kwon, Wu, & Sohn, 2014), Ingevaldsson and Larsson (2019) researched the effect of real-time crowding information at the platform. The research showed that real-time crowding information is desirable by public transport travelers, for both satisfaction of the traveller and more even distribution of the crowd in the train. The same conclusion can be drawn from the research of Preston, Pritchard, and Waterson (2017). They investigated the effect of real-time crowding information with a stated preference experiment.

Multiple customer information technologies for public transport are reviewed by Miñano et al. (2017). Different concepts of passenger occupancy systems are highlighted, as well as way-finding applications. For example NS implemented the seat finder application (zitplaatszoeker), so that the passengers can see the less crowded cars (NS, 2018). However, the effectiveness and success of these new technologies are depending on the customer experience, legislation and the cost of implementation (Miñano et al., 2017).

Offering better transport services in the off-peak period might help to reduce the number of travelers in the peak period (Chandra & Quadrifoglio, 2013; Potts, Marshall, Crockett, & Washington, 2010). This can be established in different ways, for example better transfer service, less delays and higher frequency of services (Knockaert, Peer, & Verhoef, 2013). The reliability of the transport service in the off-peak should be the same as in the peak period (Consolidated, 2006).

Furthermore, several different researches stated that a mode shift can possibly be established by using promotion (Fujii & Taniguchi, 2006; Henn et al., 2010; Van Acker, Van Cauwenberge, & Witlox, 2013). A Dutch study showed that promotion of bicycle use as access and egress mode lead to an increase in bicycle usage (Martens, 2007). However, to establish the behaviour changes to shift modes, it is recommended to customize the promotion to the target group (Andersson, Hiselius, & Adell, 2018). By doing this the promotion could be a low-cost and effective way to change the traveller's behaviour (Fu, Mundorf, Paiva, & Prochaska, 2012).

Capacity increase

Besides investigation of different pricing and passenger's support strategies, another way to reduce overcrowding in public transport is capacity optimization. Increasing the capacity of train lines can be done in different ways.

Niu and Zhou (2013) studied the optimization of the passenger train schedule in a heavily used train corridors. They constructed a model and algorithm to find the optimal schedule for individual train stations, to minimize waiting times at stations, increase the frequency of trains and reduce overcrowding during peak hour. The model is successfully tested in a real-world case study.

Not only an optimized train schedule during the peak period can help reducing the overcrowding in trains. Another option can be increasing the rolling stock (Charles & Hale, 2009). This means more trains during the busiest hours of the day to increase capacity.

Besides increasing line capacity by using more trains, the capacity of the trains itself can be increased to reduce overcrowding. The capacity of the train itself can be increased by using longer trains or use double-deck trains. Combination of both creates highest capacity without changing the line frequency (Vuchic, 2005).

Furthermore, according to Vuchic (2005) shortening the headway of a train by decreasing the standing time at the station can be solution as well. To upscale the capacity of train lines, it is also possible to expand railway tracks. Expansion of the infrastructure can be done in different ways. For a single track railway line it can be an option to expand the track by implementing sidings. In this way trains can pass each other and the capacity of the line will go up. Another possibility is to expand the line by building a new track (Dingler et al., 2009; Shih et al., 2014).

In the Netherlands several measures are planned to increase the capacity. First, the high frequency railway operation is planned (Programma hoogfrequent spoor) for the country's busiest railway corridors (Movares, 2020). Furthermore, ERTMS is planned to be implemented, if this is done trains can drive closer to each other, a higher frequency of trains per hour is possible and on the long term automatic train driving (IenW, 2020a).

The improvements in operational strategies, such as schedule optimization, are likely to have lower

investment costs than up-scaling the capacity by building new infrastructure. Furthermore, operational changes can be implemented on a shorter period than the expansion of the existing infrastructure (Shih et al., 2014).

Change of departure time

The current TDM is mainly focused on pricing strategies, passenger's support strategies and the increase of capacity to reduce the peak hour demand. However, another possibility to decrease peak hour demand is by changing the departure time of the traveler.

According to Wildervanck and Tertoolen (1998) travel behaviour is habitual behaviour, especially for regular movements. For example the different alternatives of transport modes and departure times are not well considered. The chosen alternative will only change if there is a bad experience with the chosen alternative or if something radical changes in the personal life.

Furthermore, according to Goodwin et al. (2004) the demand for other policies affecting travel behaviour is growing. Different alternatives are sought to reduce travel demand. More attention is brought to the quality of different transport modes and the perception people have of the different modes. It can also help to better inform people about public transport modes and travel plans to reduce the demand.

Multiple studies are done to investigate which measures are effective to reduce peak hour demand targeted at a specific group of people.

First, Van der Aa and Hodde (2018) researched the opportunities to reschedule the lecture hours of the Radboud University, ROC and HAN University to reduce the peak demand. Different scenarios for start times of lecture hours are investigated. It showed that the peak load could be reduced by 19%. Because of this result the Radboud University and HAN University have implemented the changed start time of the lecture hours in 2018. After implementation, it can be concluded that the measures have a positive effect on the peak demand. In the busiest trains there was a decrease of 34% of the number of passengers (Olde Kalter et al., 2019).

Besides rescheduling lecture hours, a research has been conducted regarding shift of school schedules in Groningen. High schools and vocational schools could get financial support when changing the schedule. This was done to spread the load on the public transport. The research' outcome is comparable to Van der Aa and Hodde (2018), the peak demand will be lower and the load will be more distributed (Olde Kalter et al., 2019).

A study of KiM (2018a) showed that new working conditions (Het Nieuwe Werken) can lead to changed mobility patterns and a lower peak demand, by changing the travel behaviour of commuters. Working from home and shift of working hours to avoid peak hours appeared to have a big impact on the development of car and public transport usage as well as on congestion between 2000 and 2016. In this period the number of people that worked from home and avoid peak hour traveling increased. Because of this development, the number over traveled kilometers by car has increased by 3 percent less. The number of traveled kilometers by train has increased by 2 percent less in the period between 2000 and 2016 (KiM, 2018a).

The recent study of IenW (2020e) showed that the Covid-19 pandemic led to an increase in people working from home. The highest growth in people working from home were highly educated, public transport commuters and people having a job suitable to work from home. The increase of people working from home led to a decrease in public transport moves.

Except from implementing new working conditions for commuters and the change of the lecture hours of students, the following measures could also lead to a lower peak hour demand according to Charles and Hale (2009); Lyons and Chatterjee (2008):

- Formal programs for more flexible work hours for commuters.
- Employers allowing employees to participate in flexible working hours.
- Promoting off-peak travelling by rail operators to motivate students use rail in off-peak period.
- Better rail services in off-peak period.

These studies showed, there is potential to changing the departure time of both students and commuters. However, there are many different factors found that are affecting the willingness to change departure time from peak to the off-peak period. The human behaviour needs to be taken into account

by introducing measures aimed to shift the departure time from peak to off-peak periods (Consolidated, 2006).

The first factor that needs to be considered is flexibility of the traveller. This is very important, regarding willingness to travel off-peak. Commuters with a fixed schedule are less likely to travel in another period, due to work or education (Consolidated, 2006; Vuchic, 2005).

Also, family or friend related commitments can lead to rigidity (Liu & Charles, 2013). Besides, not all travelers are able to change departure time, due to obligatory schedules. Others find it hard to change their travel behaviour, since this will affect their sleeping or habitual pattern or their routine commuting pattern (Charles & Hale, 2009; Lyons & Chatterjee, 2008).

The trip length is a factor that has an effect on the travel time variability (Mazloumi, Currie, & Rose, 2010). Furthermore, trip length is affecting the willingness to shift to from peak period to an off-peak period. The longer the trip the less likely the traveler is to switch to a different travel period. Also for those, who have to travel farther, will be less eager to travel earlier (Consolidated, 2006).

Except that there is potential for changing the lecture hours of universities, it will have a great impact on the life of the students as well. Since students have to manage different activities together with their academic demands. A lot of students have extra-curricular activities, such as playing sports, having a paid job, socializing with friends (Çivitci, 2015). Next to those activities, there are multiple different daily activities in the lives of students, such as sleeping, personal care and transport (Richardson, King, Olds, Parfitt, & Chiera, 2019).

For the commuter, there are factors that influence the development of working from home or shift working hours. The most important one is the possibilities that are offered to work from home or work different hours by the employer, for example of flex work offices, access to work documents from home and permission to work at another location. Besides, the opportunities that are provided by the employer, personal circumstances and preferences play an important role as well (KiM, 2018a).

Research has shown that new working conditions can lead to less transport moves. However, there are some potential risks that come with this, since it is harder to balance between private life and work (Jansen, 2015). If the work-family balance is not right, it will lead to lower quality of work and lower satisfaction. Furthermore, the employees will be less involved in their private lives, which can lead to conflicts in relationships, but also less time spend with children or the household (Hill, Hawkins, Ferris, & Weitzman, 2001).

Just like students employees have to balance work and private life, since they have off-job activities as well. These activities include household and child-care activities, leisure activities, such as socializing and sports (Sonnentag & Zijlstra, 2006).

The change of travel time will have effect on the people involved. These changes in behavioural patterns will have impact on people. Those effects can be both negative and positive.

Change of departure time's effects

Nijp (2016) researched the effects on new working conditions (Het Nieuwe Werken) in the Netherlands. The outcome of the research was that there are positive and negative effects. A positive effect of new working conditions is that people are more motivated. Another positive outcome was that people had better access to work from home and higher satisfaction towards work location. Furthermore, it was concluded that the working working hours were still in the same working pattern, so mainly during weekdays and daytime. A negative effect of the new working conditions was that people had a decrease in health. Lastly, it showed that people did work more from home.

Not only the flexible working hours of commuters have been researched. Flexible school hours are studied as well. Some positive effects flexible educations hours are; higher education quality, higher motivation of the students for studying and decrease in dropouts. However, flexible lecture hours come at a high investment, since a different way of teaching is implemented. For example, more personal coaching, more digital tools and less classical teaching are part of flexible education. A direct negative effect for students is the lack of structure when the education is completely flexible (van Casteren, Nooij, van Essen, & Janssen, 2018).

Conclusion change of departure time

As described, different researches are done to investigate the impact of changing departure time of both students and commuters. These showed that the change of the departure time of students has a significant impact on the decrease in number of travelers during the peak. The change of work hours

of commuters will also contribute to lower demand. However, the impact to the peak demand is much smaller. Therefore, the researcher has decided to focus on changing the departure time of student instead of commuters. Furthermore, it must be taken into account that the change of the departure time has both positive and negative effects on those involved.

2.4 Policies' stakeholders

Changing the departure time of students has impact on different stakeholders, besides the students. Therefore, this section shows the stakeholders involved in the change of the departure time of students. In addition, the stakeholders involved in the baseline alternative are mapped.

A definition will be given of stakeholders:

Stakeholders are people or organisations that are affected by a policy measure that is proposed to be implemented (Reed et al., 2009).

To identify the stakeholders, a stakeholder analysis is conducted. The outcome of this analysis is presented here, the full analysis can be viewed in appendix B. First, two lists of stakeholders are made, one for the baseline alternative (scenario that is most likely to happen in the future) and one for the alternative policy (changing the departure time of the students). The stakeholders in these lists are placed into different stakeholder groups. And lastly, a rainbow-diagram is filled in for the different policy alternatives to define which stakeholder groups have the most influence, are the most affected or both. Furthermore, the most important stakeholders for the different policies are defined so that these are used in the CBA later on.

The rainbow-diagram is filled in as follows; in the small circle the stakeholders are placed that are most affected by the policy measure, the middle circle represents moderately affected and the large circle represents the least affected. The left side of the diagram shows the stakeholders with the most influence and the right side shows the ones with the least influence. This gives an overview of stakeholders affected by the policy measure and those affecting the policy measure (Chevalier & Buckles, 2008).

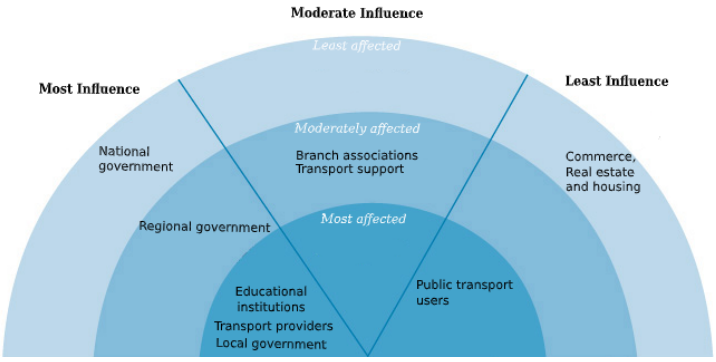

Figure 2.2: Rainbow-diagram baseline alternative

The following figures 2.2 and 2.3 show the placement of all the groups in the diagram. The placement is based on literature and the researchers reasoning.

Not all groups that are shown in the rainbow-diagrams are taken into account for the CBA, since there are time constraints during this research. Therefore, it is decided that only the most affected groups and the groups with the most influence are taken into account. The lists below show the most important stakeholders for both baseline alternatives and alternative policies. These stakeholders are taken into account during this research.

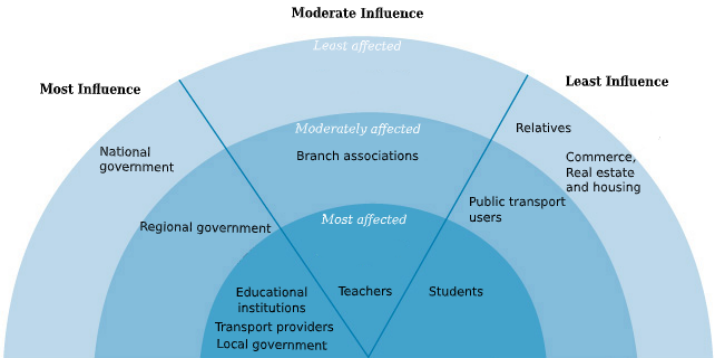

Figure 2.3: Rainbow-diagram alternative policy

Baseline alternative:

- National government (ministries, policy makers)
- Regional government (provinces)
- Local government (municipalities)
- Transport providers (railway operators, train/railway manufacturers, railway owners (ProRAil, transport companies (NS, Arriva, etc.), Railway employees)
- Public transport users (travelers)
- Educational institutions (TU Delft, universities, building management)

Alternative policies:

- National government (ministries, policy makers)
- Regional government (provinces)
- Local government (municipalities)
- Students
- Teachers
- Transport providers (railway operators, train/railway manufacturers, railway owners (ProRAil, transport companies (NS, Arriva, etc.), Railway employees)
- Educational institutions (TU Delft, universities, university employees, educational inspectorate, building management)

2.5 Results from literature review

This chapter has given an insight in the different aspects of peak hour demand of public transport. During the peak hours between 7:00-9:00 in the morning the two biggest groups that are travelling are students and commuters. The growth of the number of passengers traveling by train during rush hour leads to multiple increasing busy train stations in the Randstad.

Besides, the increase in passengers will lead to bottlenecks in the railway system in the future. Both on the platforms and stations as at the railway tracks will occur problems regarding the capacity.

Therefore, different travel demand management strategies are implemented and researched. Research has shown that both pricing strategies and passenger's support strategies can lead to lower demand during peak hour. Another solution can be to optimize the capacity, which can be done in different ways. All the factors that lead to a reduction in peak demand are show in table 2.2.

Multiple studies showed that the change of travel time can also lead to a less travelers during the rush hour. The factors supporting this change are widely researched as well, all the factors are shown in table 2.3.

Research to change travel time of both commuters and students has been conducted. Showing that the change of lecture hours of students has a significant impact on the decrease in number of travelers during the peak. The change of work hours of commuters will also contribute to lower demand. However, the impact to the peak demand is much smaller.

This research will be focused on policies that change the departure time of students, since these policies seem to be more effective according to the research that are done.

When departure time changing policies are implemented, numerous stakeholders are involved,

besides the government and students.

Furthermore, the departure time change also has both positive and negative effects on the people involved. Positive effects are higher satisfaction, higher quality of education and a decrease in dropouts. On the other hand decrease in health and structure a negative aspects. All effects of the change of travel time are shown in table 2.4.

Table 2.2: Travel demand management factors reducing peak demand

Factors	**Author(s)**
Pricing strategies	
Peak period pricing	Whelan and Johnson (2004)
Early bird tickets	Currie (2010)
Off-peak fair reduction	Whelan and Johnson (2004)
Station specific pricing	Charles and Hale (2009),S. Wang et al. (2018)
Station parking pricing	Henn et al. (2010)
Support strategies	
Real-time information	Ingevaldsson and Larsson (2019), Miñano et al. (2017), Preston et al. (2017)
Improved transport services	Chandra and Quadrifoglio (2013), Potts et al. (2010), Knockaert et al. (2013), Consolidated (2006)
Mode promotion	Fujii and Taniguchi (2006), Henn et al. (2010), Van Acker et al. (2013), Martens (2007), Fu et al. (2012), Andersson et al. (2018)
Capacity increase	
Optimized train schedule	Niu and Zhou (2013)
Increase rolling stock	Charles and Hale (2009)
Increase train capacity	Vuchic (2005)
Shortening headway	Vuchic (2005)
Expand railway tracks	Dingler et al. (2009), Shih et al. (2014)

Table 2.3: Factors influencing change of travel time

Factor	**Author(s)**
Flexibility	Consolidated (2006), Vuchic (2005), Charles and Hale (2009), Lyons and Chatterjee (2008)
Schedule/ habbitual pattern	Wildervanck and Tertoolen (1998), Van der Aa and Hodde (2018), Olde Kalter et al. (2019)
Trip length	Mazloumi et al. (2010), Consolidated (2006)
Financial support	Olde Kalter et al. (2019)
Work from home possible	KiM (2018a)

Table 2.4: Effects of change of travel time for commuters/ students

Effects	**Author(s)**
More motivated	Nijp (2016)
Better access to work at home	Nijp (2016)
Higher satisfaction	Nijp (2016)
Health decrease	Nijp (2016)
Higher education quality	van Casteren et al. (2018)
Drop-out decrease	van Casteren et al. (2018)
High investment	van Casteren et al. (2018)
Lack of structure	van Casteren et al. (2018)
Harder to balance work/ school	Jansen (2015), Sonnentag and Zijlstra (2006), Çivitci (2015), Richardson et al. (2019)
More sleep	Dunster et al. (2018)

2.6 Literature review conclusion

The literature review provides the context of this research. It showed that problems on the railway network, regarding the capacity, mainly occur in the Randstad during the morning peak. Several railway stations are expected to be congested in the Randstad in the future. To solve the capacity problem TDM was introduced. Several measures are currently taken to be able to serve the demand. However, the possibility to increase the capacity is limited. Therefore, several studies were done to seek for other solutions to reduce the peak hour demand. This review showed that changing the departure time of specific groups that normally travel by train can lead to a reduction in the peak hour demand. The most promising measure appeared to be the change of the departure time of students.

However, no literature was found on the students' preferred measures, regarding their change of departure time. Furthermore, no assessment has been made on these preferred policies compared to the future scenario, when these measures are not implemented. Lastly, the economic feasibility and societal benefits of those departure time changing measures are not compared to the future scenario yet.

This research will fill this research gap by assessing the students' preferred alternatives regarding change of departure time compared to the most likely future alternative. To gain insight in the knowledge gap, which policies students prefer, focus groups with students will be done. Furthermore, a Cost-Benefit analysis is done to investigate the economic feasibility and the societal benefits of those preferred alternatives compared to the most likely future scenario. The CBA shows costs and benefits of all proposed alternatives.

3

CBA theory

During this research a cost-benefit analysis (CBA) is performed. First, the goal of the CBA will be explained in section 3.1. Then in section 3.2 the steps of the CBA are described. After that section 3.3 the pros and cons of the CBA are explained. Ending with why a CBA is used for this research.

3.1 Goal of the CBA

A CBA can help to make a social decision a more rational decision. A CBA compares the societal benefits of one alternative to another. To see which of the alternatives is most viable to invest in. These new projects or policies will also be compared to the baseline alternative. The baseline alternative is the most likely future scenario if no new policy measures will be implemented (Romijn & Renes, 2013).

For this research the Ex ante CBA was used. This type of CBA is used when a policy or project is considered to be implemented, but it is not yet implemented. This type will help to make the decision whether or not to implement specific policy measures (Romijn & Renes, 2013).

The goal of the CBA is to be able to assess if the proposed alternative policies are a feasible solution to reduce peak hour demand in trains during the morning peak. If the outcome of the CBA is positive for one of the proposed alternative policies a positive recommendation can be given to implement this policy, which in the end reduces the peak hour demand.

3.2 Basic steps of CBA

The basic steps of a cost benefit analysis, given by Romijn and Renes (2013), are:

1. Problem analysis
2. Define the baseline alternative
3. Define alternative policies
4. Identify the effects and benefits
5. Determine the costs
6. Analyse variants and risks
7. Set-up overview of the costs and benefits
8. Present results and make a recommendation

Step 1 problem analysis

The problem analysis describes the problem that occurred and which needs a solution. The analysis shows what caused the problem and how this problem is expected to progress in the future. Furthermore, policy measures are described that might solve the described problem. However, these measures should not be to specific, since this can exclude certain policy measures that solve the problem. Lastly, the problem analysis gives context and scope to the problem (Romijn & Renes, 2013).

Step 2 define the baseline alternative

During the second step of the CBA, the baseline alternative is defined. This baseline alternative is the scenario that is most likely to happen when there is no new policy intervention. However, this baseline alternative describes the current policy and also the measures that are already planned for the future. The alternative policies are compared to the baseline alternative (Romijn & Renes, 2013).

Step 3 define alternative policies

Besides a baseline alternative, different policy alternatives are proposed that are expected to solve the problem (Romijn & Renes, 2013).

For the alternative policy scenarios it is important that those contain the changes that should be made. For this research this means that are measures needed, to be able to serve the future railway demand, by changing the departure time of students. The policies need to be described in detail, including what will be part of the policy and what is out of the scope (Romijn & Renes, 2013).

Furthermore, defining multiple different policy alternatives is advisable to be able to find most suitable solution.

Step 4 identify the effects and benefits

For the fourth step, the impacts or the effects of the policy should be distinguished. Effects can be divided into two categories, namely desirable effects and undesirable effects. The desirable effects are the benefits of the proposed alternatives. The undesirable effects are the costs of the proposed policy measure (OBPR, 2016). The effects of interest are those that affect the main stakeholders, all other effects are out of the scope of the CBA. To be able to identify all impacts of interest, the relevant markets or stakeholders should be known. A distinction needs to be made between direct,indirect and external effects.

After identification of the effects, the effects of the alternative policies should be quantified. This can be done by making a comparison between the baseline alternative and changes that occur because of the alternative policies. However, the ease of quantification of the effects depend on on the availability of information (Romijn & Renes, 2013).

Step 5 determine costs

When the effects are identified and quantified, the next step is to monetize the effects. This means effects have to be translated to monetary costs, thus dollars or euros. For example, each unit of saved travel time has to be monetized. Valuing the different impacts makes it possible to compare the alternatives in terms of costs. However, it might occur that it is not possible to monetize a certain effect. Costs can be occurring once, but also reoccurring. Besides they can be fixed or variable costs (Romijn & Renes, 2013).

Step 6 analyse variants and risks

During the CBA a lot of assumptions are made, therefore it is good to do a sensitivity analysis to show the impact of the different variables to the outcome of the CBA (Boardman, Greenberg, Vining, & Weimer, 2017; Romijn & Renes, 2013). Furthermore, different scenarios within an alternative helps to show uncertainty (Romijn & Renes, 2013).

Step 7 set-up overview of the costs and benefits

The effects of policies can appear on the long term. However, the costs that occur in different years over a longer time period need to be aggregated to be able to take it into account correctly with a CBA. This is done by discounting the future costs and benefits relative to the current ones to get the present values (PV). The PV(B) and PV(C) can be calculated using the following formulas 3.1 and 3.2. Where B_t is benefit and C_t is cost in year t. And lastly s is the social discount rate (Boardman et al., 2017).

$$PV(B) = \sum_{t=1}^{n} \frac{B_t}{(1+s)^t} \tag{3.1}$$

$$PV(C) = \sum_{t=0}^{n} \frac{C_t}{(1+s)^t} \tag{3.2}$$

To compute the net present value (NPV) of each alternative the following formula is used:

$$NPV = PV(B) - PV(C) \tag{3.3}$$

The rule of thumb is that the NPV should be positive in order to implement the policy. So the PV(B) should be greater than PV(C) (Boardman et al., 2017).

Furthermore, all the costs and benefits are put in a summarizing table to be able to see the differences between the different alternative policies.

Step 8 present results and make a recommendation

The last step of the CBA is to make a recommendation to the stakeholders of the project or policy. Normally the policy or project with the largest NPV would be recommended to be implemented.

The above step-by-step plan gives general and concise information about the CBA. However, for a more detailed description of the CBA the reader is referred to Boardman et al. (2017); Romijn and Renes (2013)

3.3 Pros and cons CBA

This section gives the pros and cons of cost-benefit analysis. And why CBA is chosen as a tool of assessment instead of multi-criteria decision making (MCDM).

First, the different tools are explained. Then pros and cons are given for both tools and lastly it is concluded why the researcher chose to use CBA during this research.

CBA is a tool used to evaluate the efficiency of new policies and to support the political decision making regarding policies (Annema, Mouter, & Razaei, 2015; Romijn & Renes, 2013). The CBA monetizes the effects of different policies to be able to compare them (Romijn & Renes, 2013). The tool is mostly used by governments (Annema et al., 2015).

The MCDM is a tool, based on different decision-making methods, which evaluates different policy measures to multiple different criteria (Annema et al., 2015).

The following positive points about the CBA are found. Firstly, the CBA is used worldwide to evaluate policies' efficiency. Therefore, it is understandable to many decision-makers. Furthermore, it is an useful method to use for large scale projects. And CBA translates effects into one single measure, so that a ranking between different alternatives can be made. Because of this 'easy' communication, it helps decision makers to choose between different alternatives (Beria et al., 2012).

According to Mouter (2017), Dutch politicians described some positive points of the CBA, namely that CBA improves planning, makes different policies comparable, it shows all effects and a CBA takes also citizens into account.

Besides pros, CBA analysis has also many cons. First, a lot of data is needed to be able to perform a CBA. This data is not always widely available. Furthermore, it is a time consuming method that is very expensive. And it is almost impossible to assess soft impacts, like personal beliefs and people's attitudes (Beria et al., 2012). It is also hard to monetize factors like environmental impact, as an effect of a certain policy intervention, in the CBA (Barfod & Salling, 2015).

The study of Mouter (2017) showed, besides the pros according to the politicians, also the cons that the politicians described. The most striking was that politicians see CBA as a way to 'kill' the political debate.

In contrast to the CBA, the MCDM can be used on micro-scale, different stakeholders can give their opinion and priorities of the different policies. Furthermore, MCDM can better map the soft effects (Beria et al., 2012), which are not easy to be monetized.

There are also cons for using the MCDM as a method to assess policy measures. Beginning with the lack of clarity regarding to what extent this MCDM is used in real-life (Annema et al., 2015; Beria et al., 2012). Furthermore, the objectiveness of the MCDM is questionable since opinions of many different stakeholders are used (Beria et al., 2012).

According to Annema et al. (2015) the corresponding disadvantage that both methods have found in literature, is the concern about the transparency of the methods.

3.4 Why the CBA is used

The researcher has chosen to use the CBA method over the MCDM method. Since, during this research large scale projects will be compared. Furthermore, the real-life applicability of the MCDM seems questionable according to the researcher. Besides, the CBA is a widely used tool for decision making. The researcher concludes the CBA gives the clearest overview of the policies' performance and is the easiest to understand. However, it should not be forgotten that the CBA also has disadvantages, such as effects that are hard to monetize and it is possible the data needed is hardly available.

As said in the literature review, the maximum railway capacity is expected to be reached in 2030, if no new policy measures are taken. By using a CBA, it is possible to compare alternative policies to the baseline alternative. If the outcome of the CBA for those alternative is positive, it is beneficial to implement those alternatives. The researcher expects that, if the outcome is positive, the peak hour demand will be lower. Therefore, investments on railway infrastructure and trains can be postponed. On the long term this will lead to lower costs.

A positive outcome of the CBA will therefore solve the peak hour demand problem.

4

The baseline alternative

In this chapter the baseline alternative is described, this is the first step of the CBA. The goal of this chapter is to define the baseline alternative for the CBA of this research. First, a definition of a baseline alternative is given. After that, the baseline is defined by using literature, expert knowledge and the reasoning of the researcher, this is done in section 4.1.

The information from the interview used to define the baseline alternative is described in section 4.2. Lastly, the literature used to set-up the baseline is described in section 4.3.

4.1 Defining the baseline alternative

This section first gives the explanation of a baseline alternative. After that, the baseline alternative for this CBA is explained.

The baseline alternative is the scenario that is most likely to happen when there is no (new) policy intervention (Romijn & Renes, 2013)

The baseline alternative of this CBA is focused on serving the future transport demand in trains during peak hour. Besides, the focus on serving demand, the other focus is investment in student facilities in the city of Delft. This baseline alternative is compared to the alternative policies that are proposed in the next chapters. The following documents are used to define the baseline alternative: MIRT and Toekomstbeeld OV. These documents were recommended by the expert of NS. Besides, the annual report was used to define the measures needed for the TU Delft. And the Eindevaluatie studentenhuisvesting in goede banen was used to retrieve the number of student rooms needed.

For the baseline alternative the following measures are defined to be able to serve the future train transport demand at the The Hague CS - Rotterdam CS trajectory and to facilitate all TU Delft students.

- Emplacement of The Hague CS (IenW, 2019b).
- High frequency railway operation between The Hague CS and Rotterdam CS (IenW, 2019b).
- Investment in 4 extra Sprinters (IenW, 2019b).
- Expansion of the number of railway tracks between Rijswijk and Delft-Campus (IenW, 2019b).
- Change of the track layout between Schiedam and Rotterdam CS (IenW, 2019b).
- Free crossing at The Hague HS (Movares, 2019).
- 2500 extra students rooms in Delft (BBN, 2020).
- Investment in TU Delft buildings and faculties (TUD, 2020b).

This list of measures are based on an interview with an expert of NS, literature and the researcher's reasoning.

As described in section 1.1 the demand for travelling by train is expected to grow, because of population growth and more commuters and students traveling by train (KiM, 2019). The growth in traveller's numbers will be between 27% to 45% until 2040 in the Randstad (IenW, 2017). Therefore, the pressure on the railway network will increase (Guis et al., 2018). Due to the Covid-19 pandemic the travelers numbers decreased by 90% in 2020. The demand is expected to be at the same level of 2018 in 2025 (NS, 2020b). However, from 2025 onward the demand is assumed to grow again.

Currently, there are 10 trains per hour at the trajectory Rotterdam CS - The Hague CS. These trains together have a peak hour capacity is 5,514 people per hour (NS, 2017). However, if the measures, explained above, are not implemented the railway demand exceeds the capacity in 2029 for low growth (27%) and in 2030 for high growth (45%) during the peak hour. This can be seen in figure 4.1

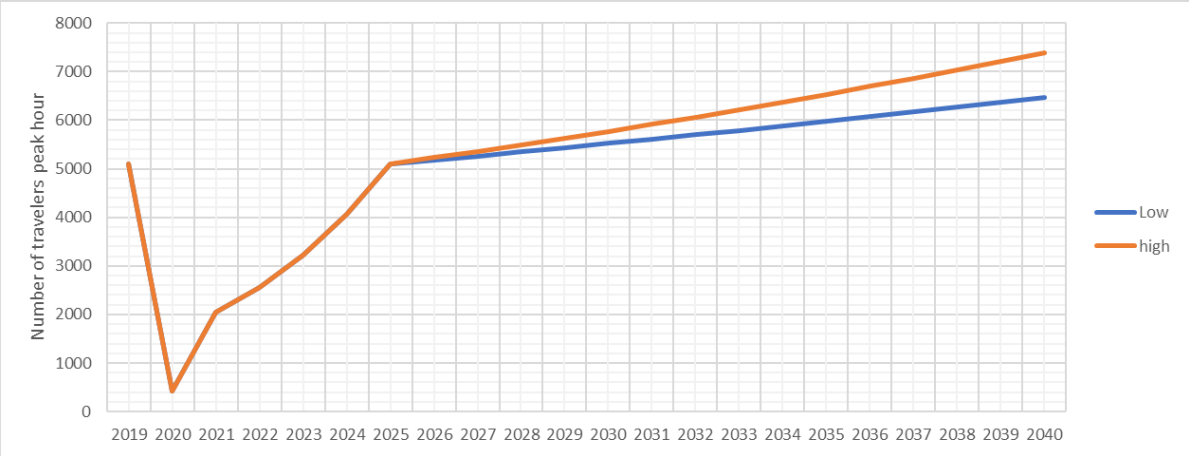

Figure 4.1: Number of travelers during the peak hour on a daily basis

4.2 Interview information used

As said before, an interview with an expert of NS is done about the most likely future scenario for the railway network. The full interview including the interview guide and background information used for the interview can be found in appendix D.

The expert was not able to release any internal documents of NS about the expected future scenario in 'normal' circumstances. However, the expert suggested to use the following studies as a reference, NMCA spoor 2017 (ProRail), MIRT, toekomstbeeld OV and programma hoogfrequent spoor. NMCA shows the expected transport development until 2030 and which measures should be taken. Toekomstbeeld OV shows the plans after 2030. The document hoogfrequent spoor describes which frequency increases are planned and at which locations.

Furthermore, the expert recommended to take the most basic scenarios of the above mentioned documents as a guideline to set up a baseline alternative. Since, the most basic is normally the cheapest option and most likely to be implemented in the future.

It is expected that travelers numbers will increase in the coming years and this will come with higher demand. This leads to the need for more trains. Capacity increase and higher frequency leads to higher costs, however the exact costs are unknown and no key figures can be shared on this topic. Lastly, the expert mentioned that the expansion in capacity increase is finite.

4.3 Literature used

The recommended documents mentioned by the expert are used to set-up the baseline alternative in detail. As said in section 1.6 the trajectory taken into account in this study is between Rotterdam CS and The Hague CS. Therefore, only the investments on this trajectory will be taken into account. Besides investments in the railway network, also investments are needed in educational purposes and students. To define the investments needed on these two point governmental documents and the annual report

of TU Delft are used. Lastly, implementations take place over a time span of 20 years, namely from 2020 until 2040.

Different documents and literature is used to set-up the baseline alternative. The measures of the baseline are explained per document, from which these are retrieved. Starting with the measures that were retrieved from the MIRT document (IenW, 2019b).

First, the emplacement of the Hague CS combined with high frequency railway operation is planned. The Hague CS is rearranged. Two railway tracks, which were used temporarily for RandstadRail, are used for trains again (IenW, 2019b).

Furthermore, the station is rearranged to be able to host more trains and to be more reliable. Besides rearrangement of The Hague CS, high frequency railway operation is implemented between The Hague CS and Rotterdam Central Station (CS). This implementation leads to an increase in Sprinter trains from 4 to 6 between The Hague CS and Rotterdam CS. Therefore, investment in new trains are needed as well. Both the emplacement of the Hague CS and high frequency operation go hand in hand and be implemented between 2023 and 2025 (IenW, 2019b). For this research it is assumed, these measures are implemented in 2024 and investment costs are made in 2020. The more detailed description of these measures can be found at page 225 of the Mirt document.

The next measure retrieved from this document is the expansion of the number of railway tracks between Rijswijk and Delft-Campus. The number of tracks will be doubled from two to four tracks. This is done because this trajectory is part of the high frequency railway operation program, which aims to increase the number of trains per hour. The last measure retrieved from MIRT is, the railway track layout needs to be changed between Schiedam and Rotterdam CS to be able to implement high frequency railway operation. This project is expected to be finished between 2023 and 2025 (IenW, 2019b). Investment costs are expected to be made in advance. For this research it is assumed costs are made in 2020. These measures can be found in the MIRT document at page 244.

The last railway implementation, retrieved from Toekomstbeeld OV document, is the built of a free crossing at The Hague Hollands Spoor (HS). This is needed to serve growing demand in the future. The lay-out of the station needs to be changed and a bridge between The Hague CS and The Hague HS needs to be modified as well. This needs to be build between 2030 and 2040 (Movares, 2019). The measure can be found in the appendix of the Toekomstbeeld OV document page 76.

Besides the measures taken to handle the travel demand in trains, measures are also taken to please the needs of the TU Delft students. This measure is retrieved from Eindevaluatie studenten-huisvesting in goede banen. Currently there is a shortage of student rooms. Therefore, the municipality Delft has decided to build 2500 student rooms until 2025 (BBN, 2020).

Lastly, the annual report of 2019 is used to retrieve information about the investment in the TU Delft for the coming years. Investments in the TU Delft faculties and buildings are needed in the coming 10 years until 2030 to be able to serve the number of students (TUD, 2020b). The numbers can be found at page 70 of the annual report.

The baseline alternative has some drawbacks since the measures focused on railway expansion, have only temporary effects on the decrease in capacity demand. It is expected there will be non-facilitated demand after 2030, due to the increasing numbers of train passengers (ProRail, 2019).

Furthermore, the baseline is based on a limited amount of documents. Therefore, it is possible not all measures are taken into account, but also that there is discrepancy between different documents. Not used documents might give contradictory information regarding measures compared to the measures drawn in this chapter.

5

Design of the focus group

This chapter describes the process of setting up the focus group sessions. The goal of this chapter is to set up a clear focus group interview guide, so that after conducting the focus group meetings, the alternative policies for the CBA can be defined. Which will then answer the first sub-question: *Which are the potential policy measures, focused on students, that will be taken into account?*

Furthermore, these alternative policies will be compared to the baseline alternative, to be then able to conclude if the alternative policies are more beneficial to implement than the baseline.

First, in section 5.1 a description is given of a focus group. This gives insight in what a focus group is and what it can be used for. Then the discussion facilitation is described in section 5.2. Then the goal of the focus group is described in section 5.3. After this the focus group guide questions are described in section 5.4. Then the composition of the groups, the moderating team and the meeting location are shown in section 5.5 The chapter finishes with the conclusion in section 5.6.

5.1 Focus group description

For this study, a focus group discussion is held to gain in depth information about possible policy measures to reduce peak hour demand in trains by changing the departure time of students. And to find out which measures are most attractive for students. Furthermore, knowledge is gathered of the experience of online education and possible improvements.

A focus group is an in-depth discussion about a topic selected by the researcher. The group normally consist of 5-8 people but usually not more than 12 (Robinson, 1999). It is important that the people participating in a focus group are a homogeneous group. Homogeneity within a group means that they have characteristics in common. This can be age, gender familiarity with the topic, life stage or family composition. However, there should be variation in the group composition as well, so that there are different opinions among the participants (Krueger & Casey, 2009).

The moderator specifies the topic and presents the questions to the group. The objective of the focus group is to gain understanding, opinions and views of people in the group about the issues presented by the facilitator(Wilkinson, 1998). By repeating the session with multiple groups using the same set-up, helps to validate the results, since these are not statistical (Glitz, 1997). 3 or 4 sessions are usually enough to reach conversion in the answers (Krueger & Casey, 2009).

5.2 Discussion facilitation

To be able to facilitate a focus group, a detailed plan of how to set-up the discussion is needed to have. This includes the time allocated for the discussion, location, questions used for guidance of the discussion, description of the moderating team and the selection of participants. Furthermore the context, background information and purpose of the focus group needs to be specified.

Moderating team

To be able to moderate the focus group meeting, it is important to set-up and describe the moderating team. For this study the team consisted of a moderator and a moderator's assistant. The main task of the moderator is to lead the discussion and make sure the discussion is flowing. Furthermore, the moderator gives context to the focus group, by explaining the research and the aim (Robinson, 1999).

The assistant takes care of the audio recording and makes notes. Furthermore, the assistant gives a summary of the most important highlights of the conversation (Krueger & Casey, 2009).

The following characteristics can be helpful to moderators to moderate the focus group successfully. First, it is helpful if the moderator has understanding group processes. This can be obtained from working in group projects in the past.

Next the moderator should have interest or curiosity both about the topic and the participants, so that the moderator will come up with appropriate follow-up questions. Communications skills are of great importance as well. The moderator should be able to communicate convenient and rephrase questions to make it understandable for all participants (Krueger, 1997).

The moderator should also be open to new ideas, it is important that the moderator does not take show his or her opinion to the participants (Krueger & Casey, 2009). Lastly, the moderator has to be a good listener and make sure all participants get a share to answer the questions (Krueger, 1997; Krueger & Casey, 2009).

Focus group composition and participant selection process

The composition of the focus groups should be both homogeneous and varied. The focus groups used during this research are homogeneous in terms of life stage. The participants are all students. Furthermore, they all must have had experience with online education, this could be online lectures, project groups and/ or exams. The native language of all participants needed to be Dutch. Lastly, they all should have had at least some experience with travelling by train.

The groups are varied in terms of age, gender, study background and how far along the students are in their studies.

The number of participants in a focus group depends on the purpose of the research. If people are familiar with the topic or have a high level of experience or expertise less participants are needed. The same holds for complex topics. Furthermore, the more questions the fewer people need to be involved. Normally the size of a focus group is between five to eight people (Krueger & Casey, 2009).

For this study five people are used per focus group, since the researcher wanted in-depth information on the topic, which was easier to accomplish with a smaller group. Furthermore, it was expected that the participants had a high level of experience on traveling by train and following online education.

Meeting location

An ideal location to host a focus group meeting is one that makes the participants feel comfortable and that fits the number of people that are invited. Furthermore, it is important that all participants and the moderating team can see each other, this stimulates the interaction. Suitable locations are conference rooms, community rooms or a big living room (Krueger & Casey, 2009).

5.3 Focus group goal

The aim of these focus group sessions was to gain insight on the students' preference regarding policies that change their departure time, since the policy change affect the students the most. And to use these meetings to set up different alternative policies, that are preferred by students. These alternatives proposed by the students were then used to be compared to the baseline alternative in the CBA.

To gain this knowledge a question guide was composed so that student could give their opinion on reducing the peak hour demand by banning students out of the peak hour. Furthermore, students discussed possible alternatives to reduce the numbers of students travelling by train during the peak hours.

5.4 Focus group guide questions

This part shows the questions that were used as a guideline during the focus group discussions by the moderator. The focus group sessions are held in Dutch. However, the guideline in English can be

viewed below, the original version can be found in appendix F.

Question type	Question	Time (min.)
Opening	Can you tell us who you are and what you study currently.	1-2
Introduction	The main topic of this discussion will be lecture hours and schedules change of students to decrease the peak demand. Lately, measures are implemented, so that students can study from home. How did you experience the distance learning?	5
Transition	How is the distance education organised lately, regarding lectures, projects, project groups, exams, etc.?	5
Main	What are the pros and cons for following online education? What are the effects of it on your lives?	5-10
Main	We discussed the university's policy towards distance education. However, the government and the NS have plans to ban students during the peak hour in the train. Suppose students will be banned during peak hours, how do you think this can be done the best? In other words what do you think are ways ban students during peak hours by changes in the education? **Make a list of the mentioned alternatives (Assistant)**	10-15
Main	The following alternatives are proposed (assistant states the alternatives). Can you list the alternatives from most favorite to least favorite)? The three alternatives that are most appealing to you are ... (The assistant state the alternatives). Now we will discuss what is needed to implement these alternatives (per alternative) and what the impact is for you if these alternative are implemented.	10-15
Main	Which measures and implementations are needed for each alternative to make it feasible?	5-10
Main	What influence has the alternative for you and others? What are the pros and cons of this alternative?	5-10
Closing	What would you advice if the government decides to ban students during the peak hours?	5

5.5 Composition of the groups, moderating team and meeting location

This section describes the focus group composition, moderating team and location used.

Group composition

Group 1: The first group consisted of five persons, among which three females and one male participant. The participants aged between 21 years old and 24 years old. Furthermore, all had a different study background. Four out of five where in their master's, only one was doing a bachelor. None of them currently travelled by train to their studies.

Group 2: The second group consisted of three male and two female participants. In this group four master's students participated and only one bachelor's student. The age of the students varied between 22 years old and 27 years old. Again all student have a different study background. Lastly, only one needed to travel by train to study.

Group 3: The third and last group consisted of two male participants and three female participants. The age of the participants ranged from 21 years old to 25 years old. Furthermore, two out of five students had the same study background. And two needed to travel by train to study. Only one student was doing a bachelor's study.

Moderating team

Since money was not available for this research, it has been decided to use a volunteer moderator for the focus group discussion. During two of the three sessions a volunteer fulfilled the role of moderator, one time the researcher did. Two times the researcher fulfilled the role of assistant, one time a volunteer assistant fulfilled this role.

During the focus group session the moderator led the discussion. The participants were allowed to discuss about the question's topic. The moderator could ask follow-up questions to gain more in-depth information or for clarification. The moderator was also allowed to steer the conversation back on topic if it deviates to much. Lastly, the moderator ensured that the discussion stays withing the time limits (Krueger, 1997).

Meeting location

Due to the Covid-19 pandemic it was not possible to host a focus group in real-life. Therefore, the researcher had chosen to host an online focus group via Zoom. The researcher made sure that every participant was familiar with zoom. The checklist described in section F.2 was adjusted to fit an online focus group session. Below the general overview of the focus group session is shown, the complete set-up can be viewed in appendix F.

5.6 Conclusion

This chapter showed the focus group description, discussion facilitation, the focus group composition and the focus group interview guide.

For this research the focus groups were used to gain knowledge about students' preferred alternative measures to change their departure time and their experience with online education. After executing the focus groups the goal was to set up different alternative polices. To be able to gain knowledge the discussion was facilitated by a moderator and an assistant. The moderator led the sessions and the assistant took notes. Furthermore, a question guide was set up which will be used during the meetings as a guideline for the moderator. This question guide consisted of four types of questions, namely opening, introduction, main and closing questions.

For the composition of the focus group it was important to be both homogeneous and varied. The groups were homogeneous in therms of life stage, experience with online education and language. The groups varied in terms of age, study background and gender. Three sessions were held with five students each. Furthermore, due to the Covid-19 pandemic the researcher decided to host those meeting online.

The next chapter shows the outcome of these meetings. Different alternative policies are the outcome of the focus group meetings. Those will be assessed by the criteria of alternative policies. The policies that pass the criteria are taken into account as alternative policies for the CBA.

6 Results focus group meetings

The goal of this chapter is to define different alternative policies to reduce morning peak demand in trains. These alternatives are focused on changing the departure time of students. In the next chapter, the defined policies are assessed by using alternative policy criteria.

In this chapter the analysis method will be described in section 6.1. After this, the summarized results and findings will be explained in section 6.2. Next the limitations and drawbacks of the focus group meetings are discussed in section 6.3 and lastly the conclusion shows the alternative policies defined by the students in section 6.4.

6.1 Analysis method

To analyse the answers given during the focus group meetings a note-based analysis was used. This analysis was based on notes made during the meetings, the debrief with the moderator and summary that is given by the assistant during the sessions. All sessions were tape recorded, however this was mainly to recall specific parts and details of the discussion and not to transcribe the whole session (King et al., 1998).

The notes, made by the moderator's assistant, were used to write a interpretive summary. A interpretive summary of a focus group meeting has the following features, every question has a paragraph which summarizes the answers given and after this some quotes are given to illustrate this. The quotes will give insight in the conversation/ discussion that took place. The last step is to included what the answers meant (King et al., 1998).

6.2 Results and findings

This section shows the summarized results and findings of the three different focus group sessions. The outcomes of the three groups are combined. The detailed transcription of the three focus groups can be read in appendix G.

Since, due to the Covid-19 pandemic all universities were forced to shift from on-campus to online education. During this period, a lot of experience was gained for teaching and learning online. Therefore, all focus group meetings started with a discussion of the current online education situation. Students gave their opinion about the current situation and what could be changed to the current online education. So that it could be a possible solution for the change of the departure time of students. After that, the discussion shifted to other options to change the departure time of students by implementing other option. For example, promoting other transport modes or the shift of lecture hours.

1. How did you experience the distance learning recently?

The most mentioned experiences with the distance learning and not being allowed to go to university, were the lack of social interaction and facing difficulties with projects, motivation and ability to learn.

Because of the lockdown the students experienced less contact with friends and family. Furthermore, due to the lockdown and social distancing the switch to online education was made. However,

the students experienced the implementation of online education as difficult, just as working in groups. Motivation and mental problems are also mentioned as a negative experience of the distance learning.

Comments made by the students:

- Studying together isn't possible at the moment. Socially this is very hard. I dropped exams, because of the lack of motivation and mental issues.
- Due to the circumstances, the threshold is higher to get in touch with peer students, mainly asking help and discussing the project or exercises.
- Group projects were very chaotic.
- Peer students went back to their country of origin. Therefore, I had to deal with different time zones when planning group work. This was very difficult.
- It is very difficult to motivate yourself to study.

Most students had a hard time shifting from on campus education to off campus education and at the same time not seeing their friends and family. Although they understand that this was needed. Some students had a harder time adjusting than others and not all students experienced major problems.

2. How is the education arranged in terms of lectures, projects, exams, etc. recently?

In each group session the following organization changes were mentioned all education shifted from campus to off-campus (online). The lectures were mainly recorded, group projects continued online via Zoom or Skype and exams were shortened in time or changed to oral exams. Teachers were responding via the question options in the online software or answering to e-mails or WhatsApp.

Also mentioned was that education was postponed to the next quarter. Lastly, a change that came up was the inconsistency in monitoring the exams, some where monitored and others weren't. When monitoring happened not all the guidelines where followed, so that the proctoring software indicated that students committed fraud, even when they weren't.

Some comments that were made by the students:

- The availability of the mentor was good, since the Skype-meetings were planned weekly.
- I had one exam that changed from written to an oral exam. The rest of the exams was non-proctored.
- The lectures from the third quarter were cancelled. We had to learn the course by reading the book instead.
- Practical courses needed to be followed online.
- Most lectures were recorded and the exams were replaced by individual exercises.

Most students said to be fine with following lectures online. However, they were not happy about courses being postponed to the next quarter. Therefore, their schedules in the fourth quarter were very challenging. Furthermore, for most students the examination was not ideal. Since the set-up wasn't clear to them or the teacher and there were last minute changes, which were not appreciated.

The proctoring software used during exams was often an issue as well, since students were told to make pictures with their phones even though this wasn't allowed by the software.

The overall experience with the online educations fluctuated. However, the measures taken were more or less the same for all universities and faculties.

3. What are the pros and cons of the distance education?

Both positive and negative points of the primarily online education are brought up. However, the negatives prevailed. The positives, according to the students, were easy reachable teachers and online lectures.

In all the sessions the negatives were dominant. The most mentioned was the lack of social interaction and not being able to study with others. Another struggle of the students was to work in groups. According to them it was hard to work together via Zoom or Skype, because it often was chaotic and badly managed.Furthermore, a lot of students were complaining about motivational problems, due to not having a set schedule.

Lastly, it was hard to not have direct contact with the teachers and being able to ask questions, because the lectures and group meetings were online.

Comments made by students:

- I am missing studying with others.
- A group project with eight people is very difficult. Everyone was frustrated.
- A fixed schedule/ rhythm can help to stay motivated. Change in surroundings can help as well, not only studying in your own room.
- Being able to get in touch with the teacher and ask questions is very important, but this isn't always possible.
- An easy accessible teacher is nice.
- The days are long and slow. Feeling less productive and it is hard to get out of bed. Hard to get motivated.

Most students had the need for a fixed schedule to keep them motivated to study.

Furthermore, there was an urge to keep in touch with peer students and teachers in real-life. They experienced the online environment as acceptable for lectures, but not for doing group work and asking questions to one another and the teacher. However, some students mentioned that some things like organising interviews or meetings with teachers are more convenient.

4. How do you think the numbers of students can be reduced in the train during the peak hours?

In each group session the following alternative measures were mentioned: giving online courses, stimulate living close to the campus, stimulating other transport modes, changing the lecture hours and lastly only practicals on campus.

Within these mentioned alternatives different implementations were given. Some of the students highlighted the e-bike as option for alternative transport. Different ways to change the lecture hours were given as well for example starting at 9:45 instead of 8:45, only afternoon lectures or weekend lectures.

Lastly, an option to reduce the peak hour demand was to stimulate the students to live near the university, this could be done, according to the students, by more student housing and bringing back the student grants.

Possible alternatives mentioned by students:

- Online education
- Evening lectures
- Shifting hours from 9:00-18:00 to 11:00-20:00
- More student housing available
- E-bike for short distances
- Only practicals on campus
- Lectures online

The students gave a lot of possible options to change the education (style), for example study hours could be changed or lectures could be given online. Numerous possibilities were mentioned about stimulating different modes of transport.

Some of the students made very clear that there were alternatives to be disliked, others agreed. A couple of alternatives were not applicable for them. First, the change of the lecture hours to the evening or in weekends. This was not possible for students, since they have side jobs, hobbies and social activities which take place during these hours.

Furthermore, almost all students said online education is an alternative. However, there should be on campus education as well. Since, students have social interaction at the university and it helps to motivate.

Some students were very clear about disliking the idea of banning students during the peak hours. According to them it is most easy to ban them, but there can be other options to reduce peak demand. For example, include measures for businesses. Their feeling was that the students are always the problem and will always be disadvantaged.

5. Which of the listed alternatives do you prefer?

During the three different sessions multiple alternatives were mentioned, some more preferable than others. The students decided which of these alternatives were most preferred to change their departure time. The following alternatives were considered.

- Online education (lectures online)
- Shifting lecture hours (lectures shift from 8:45 to 9:45, shift from 9:00-18:00 to 11:00-20:00, afternoon lectures only, evening lectures, weekend lectures)
- Stimulate to move out (more student rooms available, bringing back student grant)
- Promotion of other transport modes (e-bike, special student transport, busses)
- Combination of online and offline

All three groups agreed on online lectures. However, the combination of online lectures in the morning and practicals or on campus education in the afternoon or large scale education online and practicals offline were most favorite. Two groups also preferred to stimulate to live near the university, by making more rooms available and getting back the student grants.

Last option was to stimulate different modes of transport, to introduce e-bike for short distances instead of the ov-chipcard or student specific transport.

Some students questioned the applicability of some of the alternatives, mostly about the applicability of stimulating living near campus. Since there is already a shortage on student housing and first year students are not always willing to move out. To get people motivated to move out, the students think the student grant needs to be reintroduced, but they are questioning if this is realistic. They also thought it is not realistic to build more student housing on the short term and resistance will occur regarding more students in the city.

6. What is needed to implement the preferred alternatives?

Per preferred alternative, the students of the different focus groups mentioned implementations that are needed for each alternative.

The first discussed alternative was stimulating living near the campus or university. According to the students, the student grant needs to make a come back to make this possible. Furthermore, more student rooms should be available. This could be done by facilitating rooms by the university or building new houses. Another option could be stimulate graduates to move after graduation to make room for new students.

Second discussed alternative was stimulating other modes of transport. For stimulation of using a different transport mode different implementations are mentioned. For example getting cash instead of a student ov-chipcard might help. Another option that came up a couple of times is to facilitate people that live close by with an e-bike, so that they will travel by bike instead of by train. Multiple times special transport for students is mentioned, this can be a dedicated bus or train for students. And lastly an option was to restrict students when they could travel with their student public transport card.

The last alternative discussed was the online education combined with on campus education. Almost all students agreed on that fully online education is not the preferred solution to reduce the peak demand. They thought it is better to combine online lectures with education on campus. To achieve this multiple implementations are needed. The most commented implementation that is needed according to the students is to have a clear structure. It is important that it is clear when online lectures will be given and when it is on campus. To be able to do this the MOOC structure can be used. For students it is also of great importance that the quality of the lectures is good, for this it must be possible to ask questions, have high quality sound and video and improvement of the online social environment. Lastly, it might help if special lecture recording studios are used to optimize the online lectures.

Some comments made by students:

- Facilitate more rooms for students.
- Only student grant for students living on campus, no money for students living at home.
- Clear communication about teaching methods, lectures and when students need to be on campus or not.
- Possibility to have social interaction.
- Be selective about which courses are online and which are on campus.

In all sessions the students had a clear idea about how the online lectures should be set-up, since in all groups the most ideas came up for this alternative. The students were unanimous about the fact that online lectures should be combined with on campus education. Since they thought it is necessary to have social contact, to make friends, ask questions and keep motivated.

Not all students were enthusiastic about promoting alternative transport modes, some liked stimulating e-bike others didn't. This was the same for dedicated student transport.

Getting more students to live near where they study was a favorite of most students. However, some questioned the feasibility of this idea. Although they thought it will lower the peak demand.

7. What are the pros and cons of each alternative?

In each group session pros and cons of the different alternatives, that came up in the previous question, were cited. First, the pros and cons of the online education combined with on campus education was discussed.

The participants mentioned as benefit of online education the ability to watch the lectures when it fits their schedule and being able adapt the education to their needs. The second most commented positive was reducing the travel time since lectures will be online. However, besides the positives the students cited numerous negative aspects of online education. The aspect that was most mentioned during the sessions is the lack of social interaction, because with lectures and projects on campus it is easy to communicate with teachers and friends. The second negative point mentioned was that students find it hard to have the discipline and motivation to study when lectures are online.

Lastly, if the lecture times are at unfavorable times like in the evening, students think they will not attend. Therefore, they think lectures need to be watched at different times and this can be negative effect.

Comments made about online education:

- Less travel time is very pleasant.
- Hard to have discipline to study.
- It is nice to watch lectures whenever I would like to.
- Social interaction is very hard online, so fully online education is not possible.

Most students agreed on the positive effect of online education to reducing the peak demand. However, they think it should be well thought through to be successful. Most preferred was a combination of on and off-campus education. The lecture hours should also not be changed to evening hours. The

best option is to have morning lectures online and give on campus education in the afternoon. This is most suitable for practicals, group work and question hours.

The second alternative discussed is stimulating living on campus. The most mentioned positive outcome of living on campus is higher social satisfaction. Since, all students live close to each other it is easier to hang out and have more social activities in the city where they live. The other positive aspect was, there is less travel time to campus, so students have time to do other things instead.

The students mentioned one major negative of more students near campus, namely the city of Delft is not prepared for higher numbers of students. The residents of the city might not like it and higher population of students in the city.

Some comments made by students:

- Too high number of students in the city.
- Shorter travel time has an impact on study planning.
- High travel time leads to fatigue.

Some students said living on your own helps to get more independent, while others thought it is the other way around. Most students thought residents will not like more students inside the city center and the city is not prepared for more students. The applicability of this alternative was questioned by some students.

Last alternative, was the stimulation of other transport alternatives. Not many pros and cons were mentioned by the students. The most striking point made during these sessions, about stimulation of other transport modes was, most students are not willing to replace their public transport card for an e-bike. And it is a very specific target group that might want to change. No positive aspects were mentioned.

Comments made by the students:

- Very specific target group, only effective for people that leave relatively close to university.

It seemed that the students in all groups did not see the value of stimulating the other transport modes. They thought stimulating living on campus or implementing online education would have a bigger impact on reducing the peak demand.

8. What is your advise if students will be banned during the peak hours?

Some students gave recommendations about reducing peak demand in trains. Multiple students commented that it is undesirable to ban the students, since they feel this is always the group that is disadvantaged, for example the reform the student grants. The students think it is time to meet the students demands.

Instead of reducing number of students, the participants thought it is important to have a closer look at the people travelling and see if their are groups that can work from home more easily, for example people that have an office job.

Lastly, they thought it is needed to build more railway tracks and increase the capacity and frequency of trains. According to them this leads to lower peak during rush hour.

Some comments made:

- Investigate thoroughly who is travelling during the rush hour, so that the focus will not only be on the students.
- Increase the public transport capacity.

6.3 Focus group's advantages, limitations and drawbacks

The focus groups took place via Zoom instead of in real-life. Because of this set-up some drawbacks and limitations occurred. However, also some advantages can be mentioned.

This focus group was mainly used to get information about students' opinion regarding changing their departure time. Furthermore, they prioritized different alternative policies and showed which they

preferred most. One of the major drawbacks of a CBA is, that it is hard to take into account these soft effects and use it on a micro scale. These sessions showed that focus groups can provide opinions and preferences that can be used in combination with the CBA. This is a major advantage of using the focus groups in this research.

Another advantage of this method is that stakeholders can provide their opinion about certain policies. If their opinions are taken into account when designing new policies, they feel less negatively affected.

Besides those advantages, also some disadvantages and limitations occurred. During the first focus group session it was immediately clear that the participants needed to be encouraged to respond to each other. During the second and third focus group session this was clearly explained at the beginning, therefore these two groups needed less encouragement.

Furthermore, people tended to not going in-depth while answering a question. They strictly answered the question, because of this more follow-up questions were needed then expected. Sometimes it was hard to get people into a discussion. Another thing that needs to be said is the students tend to agree on each other very easily, instead of disagreeing on statements.

Since the focus group sessions were held online it was more difficult to see peoples reaction to the questions and each other. Nonverbal communication was almost impossible to catch. This made it sometimes hard to see if the participants were understanding the questions.

The last drawback due to conducting an online focus group was a technical drawback. If someone had an unstable internet connection it happened that participants were not able to hear each other.

During this focus group mainly people participated that were currently living on campus, this might bias the outcome of the sessions. Since, all groups mentioned stimulating people to live on campus as an alternative. There were no participants that still lived at their parents house, so it might happen that the outcome was different if this group of people was included.

Due to time constraints and availability of the moderator, it has been decided to not conduct a test focus group. The first session was used to both test and perform the focus group. However, this could have led to a not well performed session and also flaws in the focus group questions could appear. As said before the biggest problems appeared to keep the time in mind and prioritize most important questions.

6.4 Conclusions

The goal of the focus group meetings was to be able to define policy alternative to reduce peak demand in trains. The policies must be focused on banning students during the peak hour.

During the focus group sessions multiple policy alternatives came up as a solution to reduce peak hour demand in trains. The three alternatives that came up were:

- Online education in combination with on campus practicals and projects. (Blended learning)
- Stimulating living on campus, by bringing back the student grant.
- Promotion of other transport alternatives to students.

The most favourable alternative, according to the students, is the online education in combination with on campus practicals and projects. According to them, the best way to execute this is to have online lectures or self study in the morning and on campus education in the afternoon. This type of education is called blended learning. To implement this, good planning is needed. Furthermore, equipment to record the lectures is a plus and stable WIFI for students is needed as well. Online education tools that are used by students currently are needed for blended learning as well.

According to the students it is not an option to shift the lecture hours to the evening or the weekends, since this interferes with the students' schedules.

Second best was stimulating students to live near campus by bringing back the student grant, so they do not need to travel by train to university. To implement this extra student rooms are needed besides implementation of the student grant itself.

Last option was, to promote other transport alternatives. This can be done by facilitate e-bikes to people that live in cycling distance from the university. The question mark is if this group is large enough to have impact on the peak demand reduction.

In the following chapter, these three alternatives are taken into account as alternative policies. These policies must meet the criteria given in chapter 7. The alternatives that meet the criteria standards are taken into account as alternative policies. And therefore, in the next chapter the first sub question: *Which are the potential policy measures, focused on students, that will be taken into account?* is answered.

7

Alternative policies

The baseline alternative is defined in 4. In chapter 6.2 three alternative policies were proposed. The goal of this chapter is to define which of these proposed alternative policies that are taken into account for the CBA. Then the first step of the CBA is completed.

First, the alternatives proposed by the students of the focus groups are described again in section 7.1. Thereafter, the alternative policy criteria are described in section 7.2. Based on these criteria the feasibility of the proposed alternatives are assessed in section 7.3. This section also shows the measures needed to implement those alternatives.

Lastly, the conclusion is drawn in section 7.4. And the first sub-question can be answered: *Which are the potential policy measures, focused on students, that will be taken into account?*

7.1 Proposed alternative policies

The main goal of the policy alternatives is to reduce the overcrowding in trains by changing the departure time of the students and reduce the demand during the morning peak. The focus of those policies is on the preferred alternatives proposed by the students during the focus groups. The alternative policies are based on students preference only, since this is the most affected group of stakeholders with the least influence, according to the stakeholder analysis shown in section 2.4.

Literature showed that investment in new infrastructure and equipment is mostly seen as a last resort option to reduce mobility problems, because this has both high impact and costs. Furthermore, the investments are made to serve the peak hour demand. The problem with the baseline alternative is that the peak hour demand cannot be served on the long term, even if investments on railway infrastructure and trains are made. For example, in the baseline alternative four more trains are needed to be able to serve the peak hour in the future. However, these trains are only used during the peak hour, which means the rest of the day these trains are unused and are parked the rest of the day. Besides, the maximum capacity is reached even with investments in trains and railway infrastructure. Besides, new trains bring costs, not only cost for investment in new trains, also tracks for parking the trains and maintenance cost money. The other investments on railway infrastructure are also made to serve the peak hour demand. However, these might not be necessary if the demand during the peak hour is lower.

Therefore, it is worth investigating other policy measures that might influence the mobility behaviour and/ or make better use of the existing infrastructure (Devillers, van Dijk, Modijefsky, & Spit, 2011). Furthermore, if the alternative policies reduce the peak hour demand, investments might be postponed or unnecessary, which decreases the costs.

During the focus groups different alternatives came up as a possibility to reduce the peak hour demand by changing the departure time of the student. These different alternative could be implemented in various ways. The different alternatives and their different interpretations are listed below.

- Online education (lectures online)
- Shifting lecture hours (lectures shift from 8:45 to 9:45, shift from 9:00-18:00 to 11:00-20:00, afternoon lectures only, evening lectures, weekend lectures)

- Stimulate to move out (more student rooms available, bringing back student grant)
- Promotion of other transport modes (e-bike, special student transport, busses)
- Combination of online and offline

Not all these possible alternatives and interpretations are taken into account for this CBA. Only the three potential alternative policies, most preferred by the students, that came out of the focus group meetings are considered for the CBA. The following alternatives are taken into consideration:

- Blended learning (Online education in combination with on campus practicals and projects)
- Reintroduction of the student grant (Stimulating living on campus)
- Promotion of other transport alternatives to students

These three alternatives are assessed for being feasible solutions for the problem described in section 1.2.

7.2 Alternative policy criteria

Now the potential policy alternatives are clear, these are assessed for being feasible.

First a definition is given of the alternative policy:

An alternative policy is the smallest possible assembly of measures that are expected to be technically and legally executable and economically feasible. Furthermore, the alternative policy should have a plausible link with the problem (Romijn & Renes, 2013)

This definition also brings criteria, which should be met by the alternative policies. Every criterion is described in detail. The four criteria that are set, are (Romijn & Renes, 2013):

1. Independent alternative
2. Goal oriented
3. Technically and legally feasible
4. Economically feasible

Independent alternative

All the proposed alternative policies should meet the criteria of an alternative policy mentioned before. The different measures can be implemented independently, therefore for each measure independent decisions can be made. Each alternative has its own specific components and plans, so that the different alternatives can be compared. To then see which policy has the most potential (Romijn & Renes, 2013).

Goal oriented

The alternative policies that are included in the CBA should all solve the problem, mentioned in section 1.2 or have the potential to do that (Romijn & Renes, 2013).

Technically and legally feasible

The criterion of being technically and legally feasible needs the judgement of an expert. However, the researcher should check if this criterion is met as well (Romijn & Renes, 2013).

Economically feasible

The alternative policy should be economically feasible. A policy alternative can be left out of the CBA based on the following criteria. First, if it is concluded that the costs are higher than the benefits of the policy alternative. Second, if the alternative performs much worse than the other proposed alternatives. And lastly, an alternative can be left out of the CBA if it is too costly to implement (Romijn & Renes, 2013).

7.3 Feasibility proposed alternative policies

Reintroduction of the student grant

One alternative that came out of the focus group sessions with students, was the reintroduction of the student grant. According to the students this would stimulate students to live on campus instead of at their parents' house.

After the abolition of the student grant and the introduction of the loan system for Dutch students, the number of students that moved out dropped significantly, this can be seen in figures 7.1 and 7.2 (CBS, 2018).

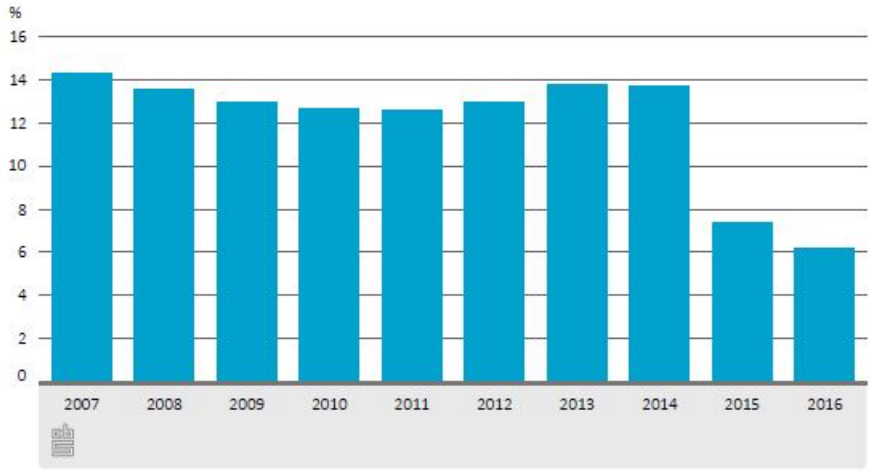

Figure 7.1: Percentage college (HBO) students moved out within 4 months after study start (CBS, 2018)

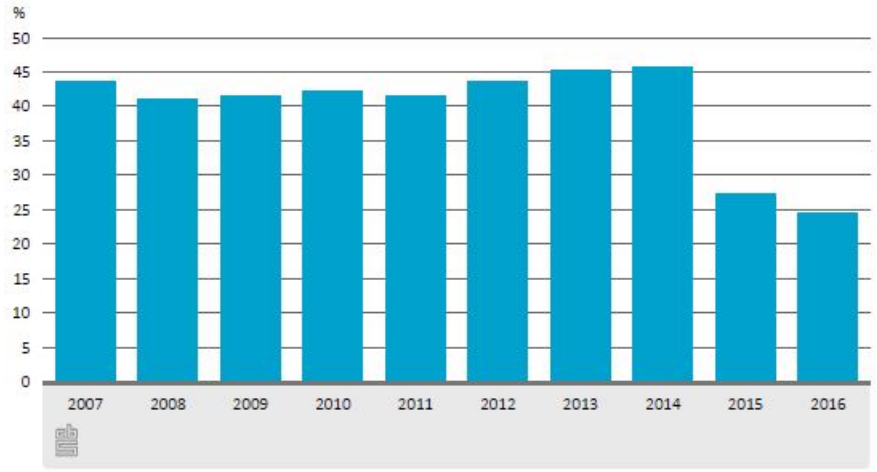

Figure 7.2: Percentage university (WO) students moved out within 4 months after study start (CBS, 2018)

Until the introduction of the student loan system, the number of students that moved out withing 4 months after starting college or university was stable. Before the introduction 12 to 14 percent of the college students and 42 percent of the university students moved out within four months. After introduction only 8 percent of college students and 24 percent of university students moved out within 4 months. This drop in number of students moving out is mainly cause by the increased costs, because students and their parents see it as a way of cost saving. Students that move out regardless of the extra costs, make this decision because of distance to university or having the need to move out (CBS, 2018).

The researcher assumed, the students that don't move out will travel by public transport to go to university or college, it seems this alternative policy fit the goal of reducing peak demand in the trains. If

they live near the education location they don't need to travel as much with public transport. Therefore, the researcher concludes this alternative is goal oriented.

On the long term the researcher assumes this alternative is technically, legally and economically feasible, since before 2014 the student grant was implemented, and after 2014 the student loan system was implemented. Furthermore, multiple political parties are not supporting student loan system, for example CU, PvdA, Groenlinks and CDA (NOS, 2019).

Since, the alternative is passing all the criteria, according to the researcher, the alternative will be taken into account for the CBA.

Measures reintroduction of the student grant

This policy alternative is focused on the return of the student grant. The goal of this policy measure is to stimulate students to live on campus and therefore do not need to use the train to be able to travel to campus. To do this different measures are needed to be implemented, these are retrieved from the focus groups, literature research and an expert interview (E.2).

After the abolition of the student grant in 2015, less students decided to live on campus. 8% to 18% less students moved out after the abolition of the student grant (CBS, 2018). It is expected, by the researcher, that the numbers of students will go up to the same level as before abolition of the student grant, therefore 8% tot 18% less students will travel by train.

Some measures need to be implemented to be able to execute this policy. First, the student grant needs to make a comeback. This means that all students living on their own will get a monthly fee of 300.69 euros during their nominal study duration. For students living at home this fee will be 108 euros (DUO, 2020b).

Besides the reintroduction of the student grant, facilitation of student housing is needed as well. According to DUWO (2019) there is a shortage of 1,330 student houses in Delft in 2019. This number will grow to between 5,079 and 6,219 in the year 2027 (DUWO, 2019). Therefore, between 2500 up to 4000 student rooms are needed on top of the 2500 of the base alternative.

Furthermore, first year students will not get discount on their tuition fee. Therefore, the fee will be the same for all students (HOP, 2019).

Besides implementation of new measures, some planned measures can be reduced or completely left out. For example, lower investments are expected to be needed for the railway infrastructure and equipment. Since the capacity demand is lower, due to less students traveling by train.

The following list shows an overview of measures taken for the student grant alternative.

- Investment in student grant for all students
- Facilitation of student housing (5,079 to 6,219 rooms)
- No discount on tuition fee

Blended learning

The second alternative that came out of the focus group is online education. According to the students it will help to change the lecture style from on campus to online, so that students don't have to travel to attend the lectures. This combined with practicals on campus is most preferred.

The best way to implement blended learning, according to the students, is to implement online lectures in the morning and on campus education in the afternoon to reduce the numbers of students traveling during the morning peak.

This alternative is goal oriented, since if the lectures are only given online, students do not need to travel to the university or college to attend. It is assumed, if blended learning is implemented, that most students prefer to watch the online lectures from home instead of at the university or college. Therefore, the number of students traveling during the peak hour is expected to decrease, since students don't need to be present in the morning. However, the students' schedules have to take into account travel time between the online lectures in the morning and the on campus activities in the afternoon.

This alternative is technically and legally feasible, since due to the Covid-19 pandemic online education was implemented. Furthermore, the universities introduced a combination of online and on-campus education for the academic year 2020/2021 as well. This proves it is possible to combine both online and on-campus education.

Lastly, it is unknown if this option performs better or worse than the first proposed alternative. Therefore, this alternative is assumed as feasible and will be taken into account for the CBA.

Measures blended learning

This second alternative policy is focused on blended learning, which means online lectures during the morning and on-campus education in the afternoon. The online education mainly consists of lectures. The on-campus education is focused on facilitating group projects, one-to-one education, practicals and exams, because these types are most suitable to teach online (Dujardin, 2020).

The goal of the policy is again to lower the peak hour demand in trains by reducing the number of students traveling by train during these hours.

Currently during the morning peak around 25% of the train passengers are students (CBS, 2016b). By implementing blended learning, students do not need to travel in the morning, since their lectures are online. Therefore, the researcher assumes that in this alternative during the peak hour the demand is 25% lower than in the baseline alternative. Because half of the day the education takes place online less lecture halls and faculty buildings are needed to facilitate the same number of students.

According to the TU Delft expert, to implement blended education, investments on the TU Delft's buildings are needed to be able to host both online education and on campus education. Besides, investments on TU Delft buildings, expenses are made for licenses of online tools for example Zoom, MS Teams and Skype for business according to the same expert. These tools need to be available for both students and teachers.

It is also important that stable internet connection is established for all students and teachers (Kamphuys, 2020; Smaling, 2020). This means improving the Wi-Fi connections of students and teachers. The researcher assumes all teachers and students have internet connection, but not necessarily stable Wi-Fi. Therefore, this needs to be provided to all students and teachers.

Furthermore, teachers should also be educated about how to use and give online lectures and education (SURF, 2020). These classes and study material will be provided to all teachers.

However lower costs are expected at the railway side of this alternative, since investments on the infrastructure and equipment will be postponed, due to lower travel demand.

The following list shows an overview of measures taken for the blended learning alternative

- Investments on TU Delft buildings
- Providing licenses for online tools
- Provide stable Wi-Fi connection
- Education of teachers

Stimulating alternative transport mode

The last alternative, proposed by the students, is to stimulate alternative transport modes. Most mentioned alternative mode of transport was (e-)bike.

As discussed in section 2.3 promoting other modes of transport can possibly reduce the peak hour demand. However, to do this customized promotion is needed. For this case the promotion should be targeted to students.

Different experiments are conducted to promote alternative travel passes and transport modes. The experiment Groningen Bereikbaar investigated if student were willing to change their travel behaviour if they got an alternative travel option. In this case they had to change their public transport subscription from travel for free during weekdays to travel for free during the weekends and in addition to their travel card they got an e-bike. Only 46 students participated in this study, the conclusion was that providing an e-bike did not led to lower peak demand. Multiple other experiments showed that some people are willing to change from public transport to using an e-bike. However, this group is very specific (Olde Kalter et al., 2019).

Mobility as a service, were travelers can plan their voyages with different modes didn't help to change the behaviour of people leaving the train and switching to another mode of transport (Olde Kalter et al., 2019).

At the TU Delft a pilot took place, focused on establishing a modal shift from car to more sustainable transport modes. Car users took part in this pilot, in which they tested different transport modes. They

were allowed to choose between e-bike, public transport and working from home. It could be concluded that the participants that tested a specific mode were more positive towards these modes than participants that choose to work from home. This shows that (forced) usage of a certain mode, might positive influence the attitude towards the mode. However, further research was needed to indicate if this positive attitude towards a certain mode leads to a modal shift (Ton, Duives, van Goeverden, Dijk-Koekkoek, & Hoogendoorn, 2019).

Since the impact of the alternative to promote other transport modes will only be attractive for very specific group of student, it is assumed that this measure will not solve the problem. It is expected this measure does not lead to a significant decrease in peak hour demand. Therefore, this measure will not be included in the CBA. Since this measure is not taken into account for the CBA, therefore the measures needed to implement this policy are not researched.

7.4 Conclusion

In this chapter the feasibility of three alternative policies, that came out of the focus groups, was assessed. The three proposed alternatives were blended learning, reintroduction of the student grant and promotion of other transport alternatives to students.

To asses the feasibility alternative policy criteria were used. From that can be concluded that the potential policy measures that are taken into account for the CBA are; blended learning and reintroduction of the student grant. This answers the question: *Which are the potential policy measures, focused on students, that will be taken into account?*

In the next chapter the effects of the alternative policies are presented. And thereafter, these are compared to the baseline. However, the effects are not yet monetized.

8

Effects of the policies

In chapters 4 and 7 the baseline alternative and the alternative policies were defined. Only the effects of those stakeholders, described in section 1.6 are taken into account for the CBA. The aim of this chapter is to execute the fourth step of the CBA, identification of the effects. When the effects are identified, the following sub-question can be answered:

What are the effects of the specified policies on those affected by it?

This chapter starts with an explanation of direct, indirect and external effect in section 8.1. To identify the effects the alternative policies are compared to the baseline alternative. This is done by using a general guideline and standard values. These can be found in 8.2. The effects of the blended learning alternative are compared to the baseline alternative are explained in 8.3, also an overview is given of changes in implementation years and costs compared to the baseline alternative. The same is done for the student grant alternative in section 8.4.

8.1 What are effects?

Effects can be divided into three categories, namely direct, indirect and external effects.

Direct effects: These effects occur in the market were the intervention took place (Romijn & Renes, 2013). For example change in travel time for travelers or costs for construction, exploitation and maintenance (Decisio, 2008).

Indirect effects: Indirect effects are effects that occur as a result of the effect of the direct effects on third parties (ECORYS, 2008; Romijn & Renes, 2013). Examples of indirect effects are welfare, depreciation of houses and land use (Decisio, 2008).

External effects: These effect are mostly unintentional and negative. For example emissions, noise hindrance and social resistance (Decisio, 2008).

Due to time constraints the researcher decided to focus on the direct effects of the CBA. This is done because the researcher expects the direct effects have the most impact on the stakeholders of the policies and the outcome of the CBA. For example if less trains need to be bought, this has an effect on the investment costs, but also the exploitation costs of the trains and the maintenance.

Furthermore, indirect and external effects, such as environmental impact and social resistance, are hard to monetize (Barfod & Salling, 2015). Therefore, these effects are not taken into account. However, the researcher is aware that there are indirect and external effects involved as well and that these can influence the outcome of the study. Besides not taking into account indirect and external effects, also the soft impacts are not taken into account. Soft impacts are effects of personal belief and people's attitude. Since it is almost impossible to monetize these (direct) effects (Beria et al., 2012), these are not considered for the CBA.

8.2 General guidelines

To perform the CBA some general guidelines are used for both alternative policies, to be able to compare effects of these policies to the baseline and to monetize the effects. These guidelines also include

assumptions about monetizing the effects, however these assumptions will be used in the next chapter.

The following general guidelines and assumptions are used for this CBA for all alternatives:

- All effects are valued for the price level of 2020. All prices include tax.
- All effects are in real values by excluding inflation.
- The time horizon of the policies is 2040, a project lifetime of 20 years.
- The discount rate is 5% for all effects (Mouter, n.d.-a).
- The travelers numbers are expected to be the same as in 2019 in 2025. An increase in numbers of train passengers from 2025 onward is expected. Both a low and a high growth scenario are applied for the alternative policies. The low growth scenario expect 27% growth between 2025 and 2040. The high scenario 45% between 2025 and 2040 (NS, 2019c). This is shown in figure 4.1. The baseline alternative uses the high growth scenario.
- 25% of the train travelers during the morning peak is student (CBS, 2016b).
- 20% of the trips is made in the morning peak (NS, 2019b).
- 35% percent of the peak hour travelers travels between 7-8 o'clock and 65% travels between 8-9 o'clock (CBS, 2016b).
- The current peak hour capacity is 4 sprinters and 6 intercity trains with a capacity of transporting 5,512 people per hour. The future capacity (with new sprinters) is 6 sprinters and 6 intercity trains with the ability to transport 6,120 people per hour. An intercity has a capacity of 304 and an intercity of 716 (NS, n.d.-b).
- Investments in railway infrastructure and trains are made 4 years before exceeding the maximum train capacity, since this is also the case in the baseline alternative.
- An increase in student numbers until 2028, a decrease in the numbers after 2029. A growth factor is applied to the base year number of students. Figure 8.1 shows the total number of TU Delft students per year.
- The percentage of first year student is 16.3% based on OSIRIS (2019a) and OSIRIS (2019b).
- The number of TU Delft teachers is 5,421 (TUD, 2020a).
- The number of TU Delft buildings is 37 (TUD, 2020a).

Standard numbers used

To be able to identify the effects of the alternative policies compared to the baseline standard numbers and growth factors are used for the number of railway travelers at the The Hague CS - Rotterdam CS trajectory, room shortage and the number of students at the TU Delft. Hereafter, a example calculation is shown to explain how the growth factors are obtained.

Travelers numbers

This section shows the expected number of travelers at each section of the trajectory between The Hague CS and Rotterdam CS. Between 2019 and 2020 the numbers of traveler dropped significantly, due to the Covid-19 pandemic. It is expected that the numbers of travelers will be at the same level of 2019 in 2025. After that a growth is expected between 27% and 40% until 2040 (NS, 2019c). The travelers numbers are shown in table 8.2. The growth factors can be found in table 8.1.

Table 8.1: Growth of train travelers per year relative to the year before

Year	2020	2021	2022-2025	2025>
Low growth	0.08	4.7	1.26	1.02
High growth	0.08	4.7	1.26	1.03

Table 8.2: Number of travelers per trajectory section in 2019

The Hague CS to Rotterdam CS	# travelers 2019	# travelers 2040 low	# travelers 2040 high
The Hague CS - The Hague HS	11,000	13,970	15,9510
The Hague HS - Moerwijk	38,000	48,260	55,100
Moerwijk - Rijswijk	38,000	48,260	55,100
Rijswijk - Delft	39,000	49,530	56,550
Delft - Delft Campus	37,000	46,990	53,650
Delft Campus - Schiedam	38,000	48,260	55,100
Schiedam - Rotterdam CS	34,000	43,180	49,300
Rotterdam CS to The Hague CS			
Rotterdam CS - Schiedam	33,000	41,910	47,850
Schiedam - Delft Campus	37,000	46,990	53,650
Delft Campus - Delft	37,000	46,990	53,650
Delft - Rijswijk	39,000	49,530	56,550
Rijswijk - Moerwijk	38,000	48,260	55,100
Moerwijk - The Hague HS	38,000	48,260	55,100
The Hague HS - The Hague CS	10,000	12,700	14,500
Total #travelers on averages	33,357	42,364	48,368

Room shortage

As said a room shortage in Delft is expected between 2020 and 2027 (DUWO, 2019). This section shows the predicted room shortages for low and high growth scenario and also the growth factors. These numbers can be found in tables 8.3 and 8.4.

Table 8.3: Room shortage for high and low scenario (BBN, 2020)

Year	2019	2027
Room shortage low	1,330	5,079
Room shortage high	1,330	6,219

Table 8.4: Yearly growth factor room shortage for low and high scenario

Growth factor low	1.18
Growth factor high	1.21

Student numbers

During this research the alternatives are focused on the students. Therefore, it is important the number of TU Delft student per year are known, the numbers are shown in table 8.5. Besides, tables 8.6 and 8.7 show the yearly growth of student numbers.

Table 8.5: Number of students in Delft 2018/ 2019 (Kences, 2019)

			’18/’19	low ’25/’26
Students	Living at home	Within city of study	160	150
		Outside city of study	6,000	7,470
	Living in student housing	Within city of study	9,540	11,070
		Outside city of study	3,360	3,870
	International students	Within city of study	4,090	6,090
		Outside city of study	1,180	1,800

Table 8.6: Growth factors per year relative to previous year until 2026

			Growth factor until 2026
Students	Living at home	Within city of study	0.99
		Outside city of study	1.03
	Living in student housing	Within city of study	1.02
		Outside city of study	1.02
	International students	Within city of study	1.05
		Outside city of study	1.05

Table 8.7: Growth per year compared to previous year (OCW, 2020b)

Year	2026	2027	2028	2029 ≥
Growth factor	1.01	1.01	1.00	0.99

Example calculation

To give insight in the numbers used for this research an example calculation is shown. The example given here, shows how the number of students per year are obtained. However, the number of travelers on the trajectory between the Hague CS and Rotterdam and the student room shortage are calculated using the same method.

The following steps show the calculation of the student number's growth factors and the total amount of student expected per year.

- First, the number of university students in Delft for 2018/ 2019 and 2025/2026 were retrieved from Kences (2019), shown in table 8.5. This document gave a detailed number per type of student.
- Then the yearly growth in student numbers is derived by using the following formula

$$yearlygrowthfactor = \left(\frac{\#students'25/'26}{\#students'18/'19}\right)^{\frac{1}{8}} \tag{8.1}$$

- This leads to the yearly growth factors until 2026 are shown in table 8.6.
- From 2026 until 2040 the growth factors were derived from OCW (2020b), shown in table 8.7.
- To calculate the student numbers per year, the yearly growth factor is applied to the student numbers of the previous year. For example, the student numbers of 2026 are multiplied by the growth factor of 2026 to derive the student numbers of 2027.
- Lastly, the total number of students is calculated. For the years between 2020 and 2026 this is done by making a summation of the type of students. After 2026 the growth factor is for the total amount of students and not per type of student, so here the total is calculated only by using the growth factor on the previous total number of students. The total number of students per year are shown in figure 8.1.

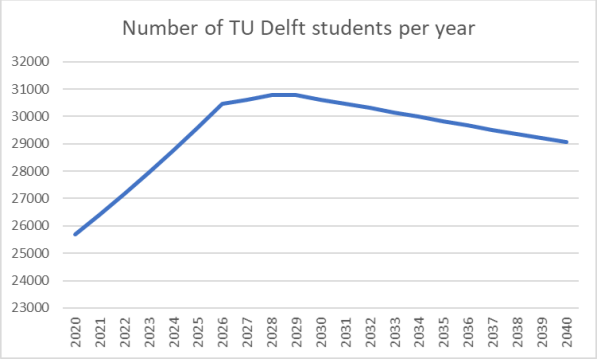

Figure 8.1: Number of TU Delft students per year

8.3 Effects of blended learning alternative compared to baseline

This section shows the effects and costs of the blended learning alternative compared to the baseline alternative. Between the two alternatives there are similarities, but also differences in costs and effects.

The effects are categorized as follows:

- Investment costs
- Exploitation costs
- Other impacts

The investment costs include, the investments in railway infrastructure and trains, TU Delft buildings and student rooms. The researchers decided to take those three into account since big investments and changes are made for those three items. Furthermore, these are expected to have a big impact on the outcome of the CBA.

Firstly, for this alternative lower train travel demand is expected, since students do not travel by train during the peak hours in this alternative, which lead to 25% less travelers during the peak hour. The researcher expects the railway infrastructure investments to be lower, because investments in infrastructure and trains will be postponed. Furthermore, according to the TU Delft expert investments in TU Delft buildings, tools and education of teachers are needed to facilitate blended learning.

Besides the costs of the investments described before, the exploitation costs of railway infrastructure, TU Delft buildings and student rooms are taken into account. Because, changes are made for the blended learning alternative compared to the baseline alternative, the effects on the exploitation costs are taken into account.

Lastly, other impacts, mainly include other investments and changes made in the blended learning alternative compared to the baseline. For this blended learning alternative according to both students from the focus groups and the TU Delft expert tools are needed to facilitate online education. According to them Wi-Fi and online tools are needed. And also teachers' education to educate them how to provide proper online education.

The research of McCutcheon, Lohan, Traynor, and Martin (2015) showed that online learning is not less effective than the traditional education. However, it also stated that there is lack of research showing the implementation of the blended learning approach. Since, not much research is available on the impact of blended learning on the quality of education, this impact is not taken into account.

The effects of the blended learning alternative are compared to baseline alternative. However, if an investment is made later in time, the costs need to be calculated to the base year costs. This is done by a discount rate. Therefore, later investments are cheaper compared to the same investments in the base year. However, no monetary values are given in this chapter. In the next chapter all effects are monetized. The qualitative effect of the discount rate is however taken into account in this chapter.

The next sections explain the effects of implementing the blended learning alternative compared to the baseline alternative.

Investment costs

Investment railway infrastructure and trains

First, the investment costs of the baseline are compared to the blended learning alternative. In the blended learning alternative it the number of traveler during the peak hour is expected to be 25% lower compared to the baseline. The number of travelers for both low and high scenario of the blended learning alternative and the baseline numbers are shown in figure 8.2.

In the baseline alternative investments on the emplacement of The Hague CS, high frequency railway operation between Rijswijk and Rotterdam CS and new trains are made in 2020, four years before implementation. It is decided by the researcher that implementation of new trains is needed when the current capacity of 5,512 is exceeded. For the low train passenger growth scenario of the blended learning alternative this number is not exceeded, so investments are not needed. However, for high growth scenario this number is exceeded in 2040 for the high growth scenario. Therefore, in 2036 (four years in advance) investments are made on the emplacement of The Hague CS, high frequency operation and new trains.

Furthermore, in the baseline alternative 10 years after implementation of the railway changes named earlier, investments are made for a free crossing at The Hague HS. However, for both low and high

growth scenario of the blended learning alternative this investment is not needed, since 2046 is outside the project lifetime.

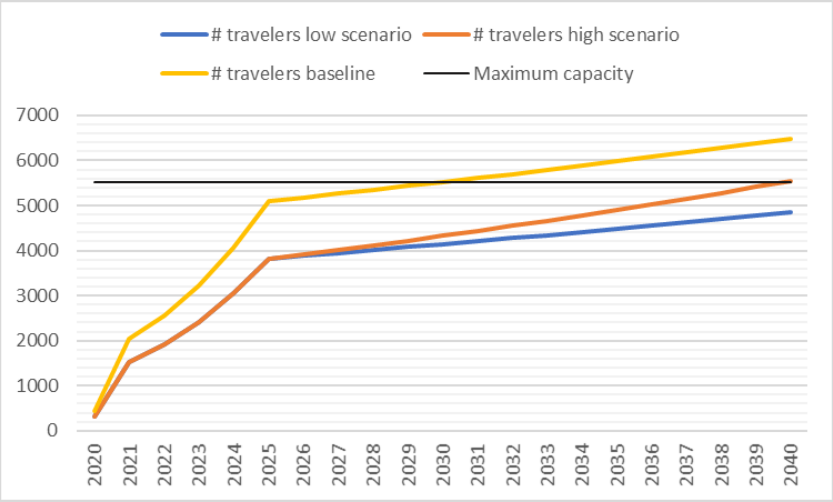

Figure 8.2: Number of travelers for blended learning alternative and the baseline alternative during peak hour

Table 8.8: Investment year of railway implementations baseline alternative and blended learning alternative

Investment	**Baseline alternative**	**Blended learning**	
		low	*high*
Emplacement The Hague CS	2020	not implemented	2036
High frequency Rijswijk-Rotterdam CS	2020	not implemented	2036
Trains	2020	not implemented	2036
Free crossing Hollands Spoor - CS	2030	not implemented	not implemented

Student rooms
Besides investments made on the railway side, also investments are made for student rooms and TU Delft buildings.

First, the investment costs in student rooms are discussed. For the blended learning alternative no changes are made in the numbers of student rooms build compared to the baseline alternative. Therefore, 2500 student rooms are built between 2020 and 2023. The number of rooms built per year are based on the shortages per year. The investment costs of student rooms are the same for both the baseline alternative and the blended learning alternative.

The rooms that are needed to be built per year are calculated as follows:

- In 2020 the shortage is 1,573, these are expected to be build in 2020.
- In 2021 the shortage is 1,859, however in 2020 1,573 rooms are built, which leaves a shortage of 287.
- The number of rooms built are subtracted from the shortage, until the 2,500 room limit is reached. The numbers can be seen in 8.9

Table 8.9: Number of rooms built between 2020 and 2023 for baseline alternative and blended learning alternative

Year	**2020**	**2021**	**2022**	**2023**	**Total**
Room shortage	1,573	1,859	2,198	2,599	**2,599**
Number of rooms built	1,573	287	339	302	**2,500**

Buildings TU Delft
The investment costs on the TU Delft buildings are different for the blended learning alternative compared to the baseline alternative. Since, in the blended learning alternative half of the education takes

place online. The 37 TU Delft buildings have 15,334 study spaces in 2020. This number is retrieved from the education spaces viewer of the TU Delft (TUD, n.d.-c). There is 1 study space available per 1.7 student in 2020. When the blended learning is implemented half of the education is online. Therefore for the low scenario 20 buildings are needed to serve the future student demand. These buildings need transformation to be able to host both online and offline education.

For the high scenario it is assumed by the researcher that all buildings will be used for both online and offline education. Therefore, all 37 buildings need transformation.

Exploitation costs

Infrastructure train

For the blended learning scenario the railway infrastructure exploitation costs are expected to be the same compared to the baseline alternative. Since, the exploitation costs are calculated per traveled passengers kilometers. In the blended learning alternative students travel at a different time, but the travelled kilometers is the same as in the baseline alternative. Exploitation costs are yearly costs between 2020 and 2040.

Student rooms

The exploitation costs of the student rooms are the same for both blended learning alternative and the baseline alternative, since the number of rooms built is the same. It is assumed by the researcher that the student rooms are built in one year and the next year exploitation cost are expected.

Housing costs TU Delft

Lastly, the housing costs of the TU Delft are discussed. The exploitation costs are expected to decrease for the low growth scenario of the blended learning alternative, compared to baseline alternative.

Since, the author assumes after 2030 all 20 buildings are transformed to host both online and on-campus education and after transformation buildings are not be used anymore. Therefore, housing costs only arise for 20 buildings instead of 37.

For the high scenario of the blended learning alternative the housing costs stay the same compared to the baseline alternative. Since, it is assumed the TU Delft will use all 37 buildings.

The housing costs are a yearly costs between 2020 and 2040 for both baseline and blended learning alternative

Other impacts

Exploitation revenue student rooms

Both in the baseline alternative and blended learning alternative the same number of student rooms are expected to be built. Building student rooms brings costs such as building costs and exploitation costs. However, these rooms also bring exploitation revenue for the investors. The exploitation revenues are seen, by the author, as benefits, since it is income for the investors and students are willing to pay the rent. Therefore, the rent is not seen as a cost for the students. These exploitation revenues are earned upward from one year after construction.

Non-facilitated demand

In the baseline alternative after 2030 there will be non-facilitated demand during the peak hour, this can be seen in figure 8.2. This means there are passengers that are not able to board the train. By implementing blended learning all passengers are able to board the train. Because every passenger is served in the blended learning alternative, the costs of the non-facilitated demand in the blended learning equals 0 between 2020 and 2040.

Tuition fee

For the baseline alternative first year students have a discount on their tuition fee compared to the rest of the students. Therefore, they pay less than other students and the government earns less fee from them. This is the same for the blended learning alternative, first year students have a discount on their tuition fee.

Online tools
When blended learning is implemented investments are needed to host online education. Online tools like Zoom and MS teams are needed for all students and teachers. Therefore, higher costs are made for online tools compared to the baseline alternative. The costs for online tools are made between 2020 and 2040.

Teachers' education
Besides, costs made for online tools. Higher costs on teachers' education is made as well. Since more education is given online in the blended learning alternative. It is needed for teacher to be educated to be able to teach online. Therefore, all 5,421 TU Delft teachers need to be educated every year between 2020 and 2040.

Wi-Fi
Lastly, when blended learning is implemented, it is of high importance every student and teacher is connected to proper Wi-Fi. Therefore, higher costs are made to provide good Wi-Fi connection compared to the baseline alternative. The costs are made between 2020 and 2040.

Overview costs and effects blended learning compared to baseline

This section shows an overview of costs and effects of the baseline alternative and the blended learning alternative is given in table 8.10. This table shows when costs are made for the two different alternatives. Table 8.11 shows an overview if the expected costs of the blended learning are higher, lower or the same compared the baseline alternative costs and effects. Costs are lower if the same investments are implemented later in time, for example the emplacement of The Hague CS is implemented in 2020 for the baseline alternative and for the high scenario of the blended learning alternative in 2036. This will be 'cheaper' compared to the baseline since costs are made later in time and these costs are discounted.

Costs can also be lower if less investments are needed. This is the case for the housing costs of the TU Delft.

Table 8.10: Year/ period of costs and effects of baseline alternative and blended learning alternative

	Baseline alternative	**Blended learning alternative**	
		low	*high*
Investment costs			
Emplacement The Hague CS	2020	-	2036
High frequency Rijswijk-Rotterdam CS	2020	-	2036
Free crossing Hollands Spoor - CS	2030	-	-
Student rooms	2020-2023	2020-2023	2020-2023
Trains	2020	-	2036
Buildings TU Delft	2020-2040	2020-2040	2020-2040
Exploitation costs			
Infrastructure train	2020-2040	2020-2040	2020-2040
Student rooms	2021-2040	2021-2040	2021-2040
Housing costs TU Delft	2020-2040	2020-2040	2020-2040
Other impacts			
Exploitation revenue student rooms	2021-2040	2021-2040	2021-2040
Non-facilitated demand	2033-2040	-	-
Tuition fee income government	2020-2040	2020-2040	2020-2040
Tuition fees students	2020-2040	2020-2040	2020-2040
Online tools	-	2020-2040	2020-2040
Teachers' education	-	2020-2040	2020-2040
Wi-Fi	-	2020-2040	2020-2040

Table 8.11: The expected costs of the blended learning alternative compared to the baseline alternative

	Blended learning alternative	
	low	*high*
Investment costs		
Emplacement The Hague CS	Lower	Lower
High frequency Rijswijk-Rotterdam CS	Lower	Lower
Free crossing Hollands Spoor - CS	Lower	Lower
Student rooms	The same	The same
Trains	Lower	Lower
Buildings TU Delft	Lower	Lower
Exploitation costs		
Infrastructure train	Lower	Lower
Student rooms	The same	The same
Housing costs TU Delft	Lower	The same
Other impacts		
Exploitation revenue student rooms	The same	The same
Non-facilitated demand	Lower	Lower
Travel time saving	The same	The same
Tuition fee income government	The same	The same
Tuition fees students	The same	The same
Online tools	Higher	Higher
Teachers' education	Higher	Higher
Wi-Fi	Higher	Higher

8.4 Effects of student grant alternative compared to baseline

In this section the effects and costs of the student grant alternative are compared to the baseline alternative. Again, the alternatives have similarities and differences. And these are described per categorized effect: investment costs, exploitation costs and other impacts.

The investment costs include, the investments in railway infrastructure and trains, TU Delft buildings and student rooms.

According to the researcher this alternative leads to lower train travel demand. Therefore the researcher expects investments to be lower.

For the student grant alternative changes are made in the number of student rooms expected to be built, according to BBN (2020) 2500 rooms are built in the baseline alternative. But the room shortage is bigger (DUWO, 2019). Therefore, in the student grant alternative more rooms are built, which brings higher costs.

Furthermore, the exploitation costs of railway investments and number of student rooms are taken into account. Lower exploitation costs for railway infrastructure and TU Delft buildings are expected to be an effect of this policy according to the researcher. Furthermore, higher student room exploitation costs arise due to higher number of student rooms for this alternative. However, the exploitation revenues of these student rooms is expected to be higher as well, since this alternative has more student rooms compared to the baseline.

Lastly, other impacts, mainly include other investments and changes made in the student grant alternative compared to the baseline. For this alternative according to both students from the focus groups the student grant must return. Furthermore, if the student grant returns, it is likely that the tuition fee discount is abolished (HOP, 2019). Therefore, these two changes are taken into account. And lastly the researcher assumes that travel time is saved for those students that move out to live on campus. Therefore, this effect is taken into account for this alternative.

The investments of the baseline alternative are compared to the investments of the student grant alternatives. However, if an investment is made later in time, the costs need to be calculated to the base year costs. This is done by a discount rate. Therefore, later investments are cheaper compared to the same investments in the base year. However, no monetary values are given in this chapter. In

the next chapter all effects are monetized. The qualitative effect of the discount rate is however taken into account in this chapter.

Investment costs

Investment railway infrastructure and trains

As in the blended learning alternative, investments on railway infrastructure and trains need to be made four years before the maximum capacity (without new sprinters) of 5,514 people per hour is reached. It is assumed by the researcher that 8% less students travel by train during the morning peak for low scenario. For the high scenario 18% less students travel during the morning peak by train. For low scenario this amount is exceeded in 2032 and for the high scenario in 2031, this can be seen in figure 8.3. Therefore, in 2027 and 2028 investments are made on the railway infrastructure and trains. This is 7 years later compared to the baseline alternative. As in the baseline alternative, 10 years later the free crossing is implemented. This means in 2037 costs are made for the free crossing in both low and high scenario the student grant alternative.

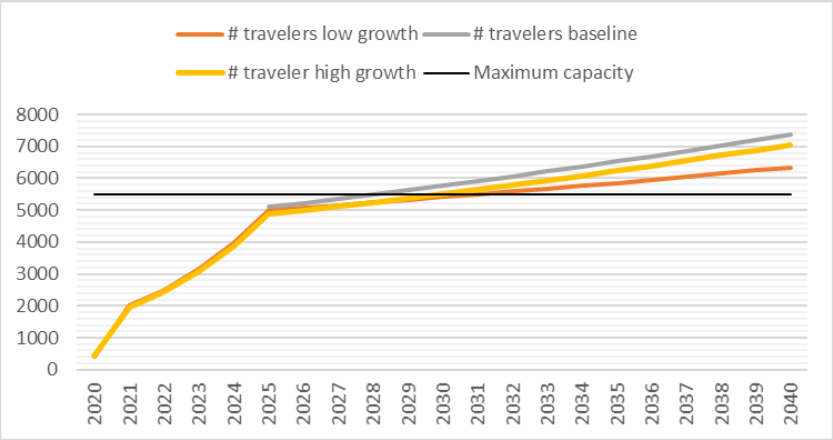

Figure 8.3: Number of travelers of high and low scenario student grant alternative and baseline alternative during peak hour

Student rooms

In the student grant alternative extra rooms are built to decrease the room shortage compared to the baseline alternative. For the low growth scenario 5,079 rooms are built and for the high growth 6,219 rooms are built. These rooms are built between 2020 and 2027. After 2027 the number of students is expected to decrease, therefore hereafter no student rooms are expected to be build.

The investment costs for student rooms are higher for the student grant alternative compared to the baseline alternative, since more rooms are expected to be built. The number of student rooms built per year can be seen in table 8.12.

Table 8.12: Room shortage and number of rooms build per year for low and high scenario of blended learning alternative

Year	2020	2021	2022	2023	2024	2025	2026	2027
Room shortage low	1,573	1,859	2,198	2,599	3,073	3,633	4,296	5,079
Rooms build low	1,573	287	339	401	474	560	662	783
Room shortage high	1,613	1,956	2,372	2,876	3,488	4,229	5,128	6,219
Rooms build high	1,613	343	416	504	612	742	899	1,091

Buildings TU Delft

For the student grant alternative, the investment costs of the TU Delft buildings are the same as in the baseline alternative. Therefore, no change in costs occur.

Exploitation costs

Infrastructure train

Compared to the baseline alternative, less students travel during the morning peak. Since, they moved out to live on campus and therefore do not need to travel by train to campus. The exploitation costs for train infrastructure are calculated travelers kilometers. The higher the traveler kilometers the higher the exploitation costs. Since the travelers kilometer decreases by 2% for the low scenario and 4.5% for the high scenario compared to the baseline alternative, the exploitation costs are lower. The exploitation costs exist over the same time period as for the baseline alternative, namely from 2020 until 2040.

Student rooms

As said before more student rooms will be build for both low and high scenario of the student grant alternative compared to the baseline alternative. Therefore, the exploitation costs for student rooms are higher as well. Again exploitation costs start one year after investment, so from 2021 until 2040 there are exploitation costs for student rooms.

Housing costs TU Delft

The housing costs for the student grant alternative are the same as for the baseline alternative, since no changes are made compared to the baseline. The costs are made between 2020 and 2040.

Other impacts

Exploitation revenue student rooms

For every alternative exploitation revenue of the student rooms are earned by the student room investors. However, in the student grant alternative higher revenues are earned, since more student rooms are built compared to the baseline alternative.

Non-facilitated demand

Since by implementing the student grant alternative less students travel by train during the peak hours, a lower non-facilitated demand occurs. Non-facilitated demand are people that are not able to board the train they would like to, because it is crowded. There still is non-facilitated demand in the student grant alternative, but the non-facilitated demand is lower compared to the baseline alternative, this is shown in figure 8.3. Non-facilitated demand occurs when the demand exceeds the maximum capacity of 6,120 person per hour. The non-facilitated demand is calculated for the busiest section of the trajectory, which is the trajectory between Delft and Rijswijk. The numbers of non-facilitated passengers on a daily basis are shown in table 8.13. However, the researcher is aware that the non-facilitated demand might be higher, because only one section of the trajectory is taken into account. Since the non-facilitated demand is lower in the student grant alternative compared to the baseline the costs of non-facilitated demand are lower. The costs are made for the low scenario of student grant between 2038 and 2040. For the high scenario the costs are made between 2035 and 2040

Table 8.13: Numbers of non-facilitated passengers per day during peak hour

Year	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
Non-facilitated demand baseline	94	350	410	574	742	914	1,090	1,271
Non-facilitated demand student grant low	0	0	0	0	0	25	123	224
Non-facilitated demand student grant high	0	0	116	272	433	597	766	938

Travel time saving

The travel time saving is an effect that occurs for students that changed from living at home to living on campus. These students do not need to travel by train to campus, instead they live close to the university. According to the TU Delft expert, it is assumed students need at least 1 hour to travel to university when the live at home. The researchers assumes that the average travel time of a student living in Delft is 10 minute. Therefore, the researcher expects that those students that move out save 50 minutes travel time one way.

It is expected that between 8% and 18% of the students will not need to travel during the morning peak if this measure is implemented. This leads to a decrease of total travel demand between 2% (low) and 4.5% (high). Figure 8.4 shows the number of students that do not need to travel and therefore save

travel time. This positive effect/ benefit is not existing in the baseline alternative. Therefore, this benefit is higher for the student grant alternative compared to the baseline alternative.

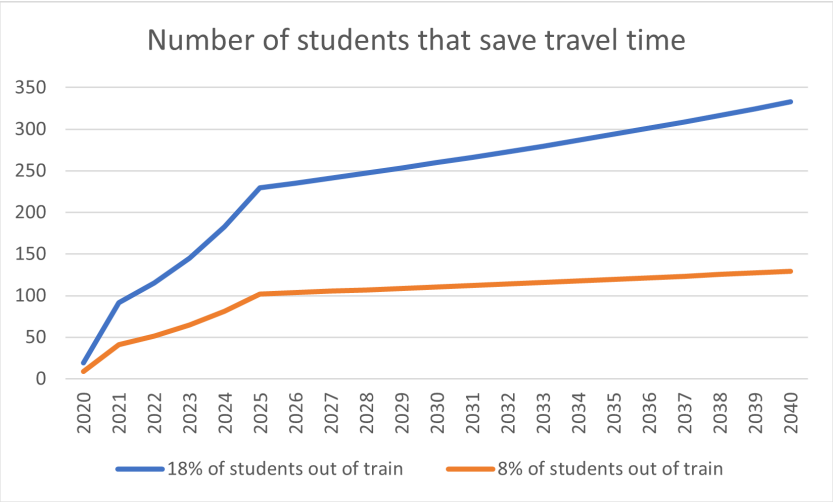

Figure 8.4: Numbers of students that save travel time on a daily basis

Tuition fee
For the student grant alternative it is expected that all students pay full tuition fee, so first year students do not have a discount. Therefore, the fee that is paid by first year students is higher compared to the baseline alternative. Furthermore, the government earns more tuition fee of these students. The costs and effects of the change in tuition fee occur between 2020 and 2040 for the student grant alternative.

Student grant
In the student grant alternative, the government will pay a student grant to all students in their nominal study time. This leads to higher costs compared to the baseline alternative. However, since the student grant is returned, students earn more money compared to the baseline alternative. The money is paid between 2020 and 2040.

Overview costs and effects student grant alternative compared to baseline

This section shows an overview of costs and effects of the baseline alternative and the student grant alternative is given in table 8.14. This table shows when costs are made for the two different alternatives. Table 8.15 shows an overview if the expected costs of the blended learning are higher, lower or the same compared the baseline alternative costs and effects. Costs are lower if the same investments are implemented later in time, for example the emplacement of The Hague CS is implemented in 2020 for the baseline alternative and for the high scenario of the blended learning alternative in 2027. This will be 'cheaper' compared to the baseline since costs are made later in time and these costs are discounted. .

8.5 Conclusion

This chapter compared the effects and costs of the two alternative policies to the baseline alternative. As can be seen in tables 8.10 and 8.14 the years of investment and cost/ benefits appearing are not always the same as in the baseline alternative. The same holds for the level of the costs and benefits. Some costs or benefits are higher compared to the baseline others are lower or the same. This can be seen in tables 8.11 and 8.15. These tables are used in the next chapter to monitize the effects mentioned in this chapter.

Table 8.14: Year/ period of costs and effects of baseline alternative and blended learning alternative

	Baseline alternative	**Student grant alternative**	
		low	*high*
Investment costs			
Emplacement The Hague CS	2020	2027	2028
High frequency Rijswijk-Rotterdam CS	2020	2027	2028
Free crossing Hollands Spoor - CS	2030	2037	2038
Student rooms	2020-2023	2020-2027	2020-2027
Trains	2020	2027	2028
Buildings TU Delft	2020-2040	2020-2040	2020-2040
Exploitation costs			
Infrastructure train	2020-2040	2020-2040	2020-2040
Student rooms	2021-2040	2021-2040	2021-2040
Housing costs TU Delft	2020-2040	2020-2040	2020-2040
Other impacts			
Exploitation revenue student rooms	2021-2040	2021-2040	2021-2040
Non-facilitated demand	2033-2040	2038-2040	2035-2040
Travel time saving	-	2020-2040	2020-2040
Tuition fee income government	2020-2040	2020-2040	2020-2040
Tuition fees students	2020-2040	2020-2040	2020-2040
Student grant government	-	2020-2040	2020-2040
Student grant for students	-	2020-2040	2020-2040

Table 8.15: The expected costs of the student grant alternative compared to the baseline alternative

	Student grant alternative	
	low	*high*
Investment costs		
Emplacement The Hague CS	Lower	Lower
High frequency Rijswijk-Rotterdam CS	Lower	Lower
Free crossing Hollands Spoor - CS	Lower	Lower
Student rooms	Higher	Higher
Trains	Lower	Lower
Buildings TU Delft	The same	The same
Exploitation costs		
Infrastructure train	Lower	Lower
Student rooms	Higher	Higher
Housing costs TU Delft	The same	The same
Other impacts		
Exploitation revenues student rooms	Higher	Higher
Non-facilitated demand	Lower	Lower
Travel time saving	Higher	Higher
Tuition fee income government	Higher	Higher
Tuition fees students	Higher	Higher
Student grant government	Higher	Higher
Student grant for students	Higher	Higher

9 CBA outcome

The goal of this chapter is to show the outcome of the CBA and perform a sensitivity analysis. Since the third step of the CBA is executed, in this chapter steps 4 and 5 are performed. In these steps the effects need to be calculated and monetized for the project life time. This chapter will answer the last sub-question:

What are the monetary costs involved with the implementation of the policy measures?

Then the effects that are taken into account are quantified and monetized in sections 9.2, 9.3 and 9.4. These sections only show the discounted outcome of the calculations. For the complete not discounted calculation of each alternative sections H.2 (baseline alternative), H.3 (blended learning alternative) and H.4 (student grant alternative) in appendix H can be viewed.

Section 9.5 shows the outcome of the CBA in a table. In section 9.6 a sensitivity analysis is performed. Lastly, in section 9.7 the conclusion is given.

Per alternative, the detailed calculation of the costs and effects without discount are shown in appendix H.2, H.3 and H.4.

This chapter only gives an overview of the discounted costs for the different alternatives. For more detailed information, the above specified appendices can be consulted.

9.1 Standard values

To be able to perform the CBA some assumptions and guidelines were made. These were shown in 8.2. However, also some standard numbers were used to be able to monetize the effects of the alternative policies compared to the baseline. The standard values used can be seen in table 9.1. These numbers were used to calculate investment and exploitation costs of student rooms, but also costs made for implementation of online education. A discount of 5% per year is used to calculate all costs in present value.

The discount rate of a specific year is calculated by using the following formula:

$$discount = \frac{1}{1.05^{xthyear}}$$

The costs of a certain year are multiplied by the discount value. The xthyear stands for the year on which the discount needs to be applied. For example 2023 is third year of a certain policy when the policy is implemented in 2020. 1.05 is the discount rate of 5%.

Table 9.1: Standard numbers CBA

	Unit	Value	Reference
Value of time	*euro/hour*	9.76	(IenW, 2020d)
Discount rate	*%*	5	(Mouter, n.d.-a)
Travelers in peak hour	*%*	0.2	(NS, 2019b)
Students in peak hour	*%*	0.25	(CBS, 2016b)
Size student room	*m2*	24	(Scheele-Goedhart, Kromhout, de Wildt, & Wittkämper, 2019)
Costs building student room	*euro/m2*	2,050	(Scheele-Goedhart et al., 2019)
Exploitation cost student room	*room/ year*	1,000	(Scheele-Goedhart et al., 2019)
Exploitation revenue student room	*room/ month*	390	(Scheele-Goedhart et al., 2019)
Student grant living at home	*euros/month*	108	(DUO, 2020a)
Student grant living on campus	*euros/month*	300.69	(DUO, 2020a)
Full tuition fee	*euros/year*	2,060	(OCenW, 2020)
Workdays	*per year*	255	(BZenK, 2018)
Waiting time when not facilitated	*minutes*	5	
Exploitation costs train	*mln euros/year*	41.2	(van Essen & Schroten, 2014)
Number of teachers	*total/year*	5,421	(TUD, n.d.-a)

9.2 Investment costs

Different costs and effect arise by implementation of the baseline alternative, but also for the alternative policies. First, the (avoided) investment costs on the railway infrastructure and equipment will be explained for all alternatives. Then the (avoided) investment costs for the TU Delft buildings and student rooms are explained.

Investment costs railway infrastructure and equipment

This section shows the investment costs on railway infrastructure and equipment for the three alternatives. If investments are made later in time, these are discounted to be able to compare the costs to the base year. Table 9.2 shows the discounted investment costs of the three alternatives. The exact calculations for these investment can be found in H.3.

Baseline alternative

To be able to handle the increase in passenger numbers the NS planned multiple projects to expand the capacity, namely the emplacement of The Hague CS, increase of the number of Sprinter trains and implementation of high frequency railway operation. These projects are planned to be implemented on the short term between 2023 and 2025 (IenW, 2019b). The investment costs are made in 2020.

On a longer term the free crossing will be built between The Hague HS and The Hague CS. The investment for this project is made in 2030 and the project needs to be implemented before 2040 (Movares, 2019). The exact investment costs for these projects were retrieved from IenW (2019b) and Movares (2019), these can be found in table 9.2.

Blended learning

For the blended learning alternative both a high and a low growth scenario is used for the number of train travelers relative to the base alternative.

Furthermore, it is assumed by the researcher that the total share 25% of students during the morning peak will not travel if blended learning is implemented.

For the low growth scenario the maximum capacity in the trains is not exceeded, which means no extra trains are needed to handle the demand and also no investments need to be made on the other planned railway projects.

However for the high growth scenario the maximum capacity of the trains will be exceeded in 2040. The investments on buying new trains and implementing the emplacement of The Hague CS and high frequency railway operation will take place in advance. In the baseline alternative the investments take place four year before the actual implementation. Therefore, the researcher decided that the investments are made four years before the maximum capacity is reached.

Building the free crossing can also be postponed in the high growth scenario.

The postponed investments for the railway infrastructure and equipment lead to lower investment costs, since the costs made later in time are discounted to the base year costs. Therefore, costs are avoided.

Student grant

For the alternative policy of implementing the student grant it is expected more student will move out. CBS (2018) showed that after the abolition of the student grant a decrease of students moving out took place, namely 8% to 18% less students moved out. Therefore, it is assumed by the researcher, a decrease of 8% (low) to 18% (high) of the students travelling by train during the morning peak. Therefore, the maximum capacity in trains will be exceeded in a later point of time then with the baseline alternative.

The investments in trains, emplacement of The Hague HS and the high frequency railway operation need to be made in 2026 for the low decrease in students with high growth of travellers and in 2029 for the high decrease of students with low growth of travellers.

For the low scenario investments are needed in the free crossing in 2036 and for the high scenario in 2039.

Also for this alternative, the investment costs are lower compared to the baseline, since investments can be made later in time. This leads to avoided costs.

Table 9.2: Investment costs on railway infrastructure and equipment (in mln euros)

	Baseline	**Blended learning**		**Student grant**	
	alternative	*Low*	*High*	*Low*	*High*
Emplacement The Hague CS	€ 65.0 -	€ -	€ 29.8 -	€ 44.0 -	€ 46.2 -
High frequency Rijswijk-Rotterdam CS	€ 339.0 -	€ -	€ 155.3 -	€ 229.4 -	€ 240.9 -
Free crossing Hollands Spoor - CS	€ 61.4 -	€ -	€ -	€ 41.5 -	€ 43.6 -
Trains	€ 21.2 -	€ -	€ 9.7 -	€ 14.3 -	€ 15.1 -
Total	**€ 486.6 -**	**€ -**	**€ 194.8 -**	**€ 329.3 -**	**€ 345.8 -**

Investment costs buildings TU Delft and student rooms

This section shows the investment costs on buildings of the TU Delft and investment in student rooms. If investments are made later in time compared to the baseline alternative, costs are lower. These are avoided costs. The overall costs (with discount) for all alternatives can be seen in table 9.3. The exact calculations of the investment costs in Tu Delft buildings without discount can be found in H.6 and H.13. For the calculations of the student room investment tables H.5 and H.18 can be viewed.

Baseline alternative

Besides investments that are needed for the railway infrastructure and equipment, the municipality of Delft and TU Delft are planning to expand the number of student rooms and invest in new buildings for TU Delft. In the coming years between 2020 and 2030 major investments are needed to facilitate the number of students and keep up to date with rule and regulations for education buildings. 650 million euros over these 10 years need to be invested on buildings (TUD, 2020a). Furthermore, there is a shortage of student rooms. Therefore 2500 rooms will be built until 2025, this number does not resolve the problem of student rooms shortage completely.

Blended learning

For the blended learning alternative the investments on the buildings of the TU Delft differ. Since it is expected that half the education will take place online and half of it on campus, less buildings are needed to facilitate the demand. However, changes need to be made in the layout of the buildings to be able to facilitate online education. No new buildings need to be built, but at least half of the buildings need to be made blended learning proof over the coming 10 years. Which means investing in recording studios for lectures and re-purpose of the lecture halls. These costs will be lower than the building of new TU Delft buildings. For low and high student growth the investment will be the same.

No change will be made in the number of student rooms built relative to the baseline alternative. Therefore, no costs are avoided.

Student grant

The alternative policy of implementing the student grant is focused on motivating students to move out. Therefore, it is expected that more students will move out to live on campus. Besides the planned

2500 student rooms that will be built, extra student rooms will be built in this scenario. For the low scenario the shortage is expected to be 5,079 student rooms and in the high scenario 6,219 rooms instead of the 2,500 rooms in the base alternative. The built of extra student rooms leads to higher costs.

Furthermore, no alterations to the baseline alternative planned investments on the campus will be made.

Table 9.3: Investment costs on TU Delft buildings and student rooms (in mln euros)

	Baseline alternative	**Blended learning** *Low*	**Blended learning** *High*	**Student grant** *Low*	**Student grant** *High*
Student Rooms	€ 118.8 -	€ 118.8 -	€ 118.8 -	€ 215.5 -	€ 259.9 -
Buildings TU Delft	€ 976.2 -	€ 314.1 -	€ 581.1 -	€ 976.2 -	€ 976.2 -
Total	**€ 1,095.0 -**	**€ 432.9 -**	**€ 699.9 -**	**€ 1,191.7 -**	**€ 1,236.1 -**

9.3 Exploitation costs

This section the exploitation costs of the three alternatives are explained. The exploitation costs are divided in exploitation of railway infrastructure, student rooms and housing costs of the TU Delft. An overview of the total costs per alternative is given in table 9.4. The non-discounted values of the railway exploitation costs can be found in H.3 and H.20. The exploitation costs of the student rooms are shown in H.8 and H.19. Lastly, the detailed calculation of the TU Delft housing costs can be found in H.9 and H.14.

Baseline alternative

The total expenses on exploitation costs for railway infrastructure is 3.7 billion euros a year. The expenses per trajectory depend on the number of travelers kilometers. Therefore, the expenses for 1 km of rails in the Randstad are higher than for example in Groningen, since more kilometers are traveled in the Randstad compared to Groningen (van Essen & Schroten, 2014). A little over 10 percent of the total traveled kilometers are made on this trajectory. This brings the yearly costs of exploitation 41.2 million euros yearly (van Essen & Schroten, 2014).

In the base alternative 2500 student rooms will be built between 2020 and 2025. After completing the build, there will be exploitation costs for those rooms.

The exploitation costs for housing the TU Delft will increase in comparison to the base year 2020, because two extra buildings are needed to facilitate the number of students. After 2030 the housing costs will stabilize.

Blended learning

There is no difference in exploitation costs of train infrastructure between the base alternative and the blended learning alternative, since the student will travel at another time of day. Therefore, it is expected the travelled kilometers will be the same.

In the blended learning alternative, no difference is made in the number of student rooms compared to the baseline alternative. Therefore, the exploitation costs for the blended learning alternative are the same as the baseline alternative.

The housing costs for TU Delft will be lower in the blended learning alternative compared to the base alternative. Since for the high scenario new buildings are not needed to be built, which leads to lower housing costs. In the low scenario it is expected only 20 buildings are needed to facilitate the demand. Therefore, the exploitation costs are even lower.

Student grant

In comparison to the base alternative, lower exploitation costs for train infrastructure are expected for the student grant alternative. Since a lower number of travelers kilometers will be made, due to the fact less students will travel by train.

Since for this alternative more student rooms are planned to be built higher exploitation costs are expected. In the low scenario 2579 extra rooms will be built and for the high scenario 3719. Therefore, the costs are higher.

Since no changes are be made in TU Delft facilitation compared to the baseline alternative, the exploitation costs are the same as for the baseline.

Table 9.4: Exploitation costs (in mln euros)

	Baseline alternative	**Blended learning** *Low*	*High*	**Student grant** *Low*	*High*
Infrastructure (train)	€ 555.3 -	€ 555.3 -	€ 555.3 -	€ 530.3 -	€ 544.2 -
Student rooms	€ 29.4 -	€ 29.4 -	€ 29.4 -	€ 49.3 -	€ 58.8 -
Housing costs TU Delft	€ 1,160.8 -	€ 951.7 -	€ 1,160.8 -	€ 1,160.8 -	€ 1,160.8 -
Total	**€ € 1,745.5 -**	**€ 1,536.4 -**	**€ 1,745.5 -**	**€ 1,740.4 -**	**€ 1,763.8 -**

9.4 Other impacts

This section shows the other costs and effects that arise because of implementation of the (alternative) policies. Two types of other costs and effects can be distinguished. First, costs/ effects of non-facilitated demand and travel time saving are described. And second, costs/ effect of implementations that are needed for a specific alternative policy (blended learning or the implementation of student grant) are described.

Non-facilitated demand occurs when the maximum capacity is reached and not all people are able to board their preferred train. The effect is that people need to wait for the following train and loose time. This time loss brings costs.

Travel time saving occurs when people do not need to travel or have a shorter travel time. This is the case for the students that move to live on campus. They are expected to have shorter travel time compared to when they lived at home.

Impacts of non-facilitated demand and travel time saving

This section explains per alternative if non-facilitated demand arises and if there is travel time saved for students. The total (avoided) costs can be viewed in table 9.5. The exact calculations of the non-facilitated demand can be found in H.11 and H.22. The exact calculations without discount for saved travel time can be viewed in H.16.

Baseline alternative

In the baseline alternative there is non-facilitated demand in the future. This non-facilitated demand are people that are not able to board the train that they planned. They lose valuable time, therefore this cost is calculated using Value of Time times the time they need to wait for the next train. No travel time savings will appear in this alternative, since there is demand that is not served and no other travel options are applied to provide a faster way to travel.

Blended learning

For blended learning there will not be non-facilitated demand, since students will travel at a different time of day. This leads to a lower peak demand. so in this alternative costs are avoided compared to the baseline alternative. However, these students still need to travel, therefore no travel time savings will appear.

Student grant

Lastly, in the student grant alternative students are more motivated not to travel since they live on campus. Therefore the non facilitated demand will be lower in both high en and low scenario. In the blended learning alternative there will be travel time saving for those students that moved out and that therefore don't need to travel.

Impacts of implementing alternative policies

This section highlights the impacts of implementing the alternative policies. For the blended learning alternative, online tools, teachers' education and Wi-Fi are provided. These bring higher costs compared to the baseline. The exact calculation of these effects can be found in H.3.

Table 9.5: Impacts of non-facilitated demand and travel time saving (in mln euros)

	Baseline alternative	**Blended learning**		**Student grant**	
		Low	*High*	*Low*	*High*
Non-facilitated demand	€ 5.6 -	€ -	€ -	€ 0.0	€ 0.3 -
Travel time saving	€ -	€ -	€ -	€ 5.1 +	€ 12.0 +
Total	€ 5.6 -	€ 0	€ 0	€ 5.1 +	€ 11.8 +

For the student grant alternative, the student grant's return brings higher costs for the government and benefits for the students. Furthermore, the tuition fee discount for first year students is abolished, this brings also costs and benefits. And lastly more student rooms are built compared to the baseline, therefore higher exploitation revenue for student rooms is expected. The exact calculations for these effects can be found in H.4.

Table 9.6 shows an overview of the costs that arise by implementation of the alternative policies.

Baseline alternative

Since, the abolition of the student grant, the tuition fee for first years students is halved. It is assumed that for the baseline alternative this will be the case. Furthermore, no extra investments on online education tools, teacher's education and Wi-Fi for students need to be made. However, since 2500 student rooms are built the exploitation revenue is higher.

Blended learning

In the blended learning alternative the tuition fee will be the same as in the baseline alternative. However, investments in online tools, like MS team and zoom need to be made and also WIFI should be provided for students. Therefore the costs on these posts are higher than in the baseline alternative.

Student grant

With the return of the student grant, the tuition fee discount for first year students will be abolished. Therefore, the fee is the same for every student, also for the first year's. The tuition fee will be higher compared to the baseline. This brings as a benefit that the government earns more money from students. Furthermore, more student rooms are built compared to the baseline alternative. Therefore, the exploitation revenues of those rooms is expected to be higher.

As in the baseline alternative no extra investments are needed in online tool, teacher's education or providing Wi-Fi for students and teachers.

Table 9.6: Costs and effects of implementing alternative policies (in mln)

	Baseline alternative	**Blended learning**		**Student grant**	
		Low	*High*	*Low*	*High*
Exploitation revenue student rooms	€ 137.7 +	€ 137.7 +	€ 137.7 +	€ 230.7 +	€ 275.1 +
Tuition fee income government	€ 48.5 +	€ 48.5 +	€ 48.5 +	€ 97.1 +	€ 97.1 +
Extra tuition fee students	€ 48.5 -	€ 48.5 -	€ 48.5 -	€ 97.1 -	€ 97.1 -
Student grant government	€ -	€ -	€ -	€ 830.3 -	€ 830.3 -
Student grant for students	€ -	€ -	€ -	€ 830.3 +	€ 830.3 +
Online tools	€ -	€ 168.2 -	€ 168.2 -	€ -	€ -
Teachers' education	€ -	€ 29.9 -	€ 29.9 -	€ -	€ -
Wi-Fi	€ -	€ 4.1 -	€ 4.1 -	€ -	€ -
Total	**€ 137.7+**	**€ 64.4 -**	**€ 64.4 -**	**€ 230.7 +**	**€ 275.1 +**

9.5 CBA outcome

In this section the monetary costs of the CBA is presented and explained in a summarizing table 9.7. The values of the different costs and benefits are presented in Net Present Value, this means a weighted summation over the time horizon of the CBA. Thus these are not yearly expenses or outcomes. The table shows investment costs, exploitation costs and other costs. Furthermore, the table shows the total costs and benefits and the benefit/ cost ratio (B/C ratio) is presented. If the B/C ratio is equal or bigger than one, the benefits are higher than the costs. Therefore, the presented policy has a positive societal effect and it is beneficial to implement the policy. If the B/C ratio is smaller than one the policy does not increase societal prosperity (Romijn & Renes, 2013). Therefore, it is not advisable to implement the policy measure.

In table 9.7 can be seen that both the student grant and the blended learning alternatives have a positive NPV. Furthermore, for all alternatives the B/C ratio is bigger or equal to one. This means that the policy increases prosperity.

However, the blended learning alternative is more efficient than the student grant alternative. This can be said, because both the NPV and the B/C ratio are higher.

This can be concluded, since the B/C ratios of student grant are just above 1. Compared to the baseline alternative, there are reductions in people traveling by train and less investments need to be made. However, there still is non-facilitated demand. Furthermore, higher costs are made regarding building and exploitation of student rooms. Since the B/C ratio is close to 1 it is advisable to investigate different variants of the student grant alternative, with slightly different measures. Another option that could be investigated is adding some of the measures defined in the student grant alternative to the baseline alternative to see if this improves the baseline alternative.

The table also shows that the outcome of the blended learning is positive. This is mainly due to the fact that the investment costs on TU Delft buildings and housing are lower, because less buildings are needed to facilitate the same number of students. Higher costs are made for online tools and teacher's education. This alternative facilitates for both low and high scenario the demand. This alternative has the most potential to reduce morning peak demand efficiently, since it has the highest NPV and B/C ratio.

Since the B/C ratio for the student grant alternative is close to 1 a sensitivity analysis is done to see what happens if the variables are increased and decrease in costs. This will also be done for the blended learning alternative.

Table 9.7: Net present value (in mln) relative to the baseline alternative and benefit/ cost ratio

	Student grant		Blended learning	
	Low growth	*High growth*	*Low growth*	*High growth*
Investment costs				
Emplacement The Hague CS	€ 21.0	€ 18.8	€ 65.0	€ 35.2
High frequency Rijswijk-Rotterdam CS	€ 109.5	€ 98.1	€ 339.0	€ 183.7
Free crossing Hollands Spoor - CS	€ 19.8	€ 17.8	€ 61.4	€ 61.4
Student rooms	€ -96.7	€ -141.1	€ -	€ -
Trains	€ 6.8	€ 6.1	€ 21.2	€ 11.5
Buildings tu delft	€ -	€ -	€ 662.1	€ 395.1
Exploitation costs				
Infrastructure train	€ 25.0	€ 11.1	€ -	€ -
Student rooms	€ -19.9	€ -29.3	€ -	€ -
Housing costs tu delft	€ -	€ -	€ 209.1	€ -
Other impacts				
Exploitation revenue student rooms	€ 93.0	€ 137.3	€ -	€ -
Non-facilitated demand	€ 5.3	€ 5.6	€ 5.6	€ 5.6
Travel time saving	€ 5.1	€ 12.0	€ -	€ -
Tuition fee income government	€ 48.5	€ 48.5	€ -	€ -
Extra tuition fees students	€ -48.5	€ -48.5	€ -	€ -
Student grant government	€ -830.3	€ -830.3	€ -	€ -
Student grant for students	€ 830.3	€ 830.3	€ -	€ -
Online tools	€ -	€ -	€ -168.2	€ -168.2
Teachers' education	€ -	€ -	€ -29.9	€ -29.9
Wifi	€ -	€ -	€ -4.0	€ -4.0
Costs	€ -995.4	€ -1,049.3	€ -202.1	€ -202.1
Benefits	€ 1,164.5	€ 1,185.7	€ 1,363.4	€ 692.5
NPV	**€ 169.1**	**€ 136.3**	**€ 1,161.3**	**€ 490.4**
Benefit/Cost ratio	**1.17**	**1.13**	**6.75**	**3.43**

9.6 Sensitivity analysis

The previous section showed the costs and benefits of the alternative policies compared to the baseline alternative. However, to be able to indicate the reliability of the CBA a sensitivity analysis is performed. The method used for the sensitivity analysis is the tornado chart.

A tornado chart is a bar chart with horizontal instead of vertical bars. The bars show impact of increase or decrease in costs/ benefits per variable compared to the initial state shown in the previous chapter. The change of a variable is expressed in the delta NPV. This value can be obtained by subtracting the initial state value of the new state value For this analysis a 10% increase and decrease are applied on the costs and benefits. The variables are changed one by one, while the other variables stay untouched. The variable that is most sensitive to the 10% increase or decrease is shown at the top of the chart. The least affected variable is shown at the bottom. The aim of the tornado chart is to determine the most critical variables to the problem and which have the most impact (F1F9, 2019).

For this analysis a 10% increase and decrease of the costs per year are used, since this is assumed to be the standard value. Furthermore, not all variables are changed, only those that are assumed being key variables. Lastly, some of the variables are combined to asses the sensitivity since investments take place at the same time.

The following sections give a detailed description of the variables taken into account per alternative and the outcome of the sensitivity analysis.

Sensitivity analysis of student grant alternative

As said not all variables are taken into account for the sensitivity analysis. For the sensitivity analysis of the student grant alternative all costs and benefits are taken into account that differ from the base

case. This means those effects are not equal 0 in table 9.7. Furthermore, the costs and effects of the tuition fee and student grant, have both a positive and negative value. However, these are dependent so if one of either values changes the other changes as well. Since in the sensitivity analysis only one variable change at the time can be taken into account, this effect is not considered because of their dependency. Furthermore, the emplacement of The Hague CS, high frequency railway operation and train investments are seen as one variable as well. Since they are implemented at the same time, and therefore can not be taken into account independently.

The following costs and benefits are taken into account for the sensitivity analysis of the student grant alternative:

- Railway investment (Emplacement The Hague CS, High frequency Rijswijk - Rotterdam CS, Trains)
- Free crossing Hollands Spoor - The Hague CS
- Investment in student rooms
- Exploitation railway infrastructure
- Exploitation costs student rooms
- Exploitation revenue student rooms
- Non-facilitated demand
- Travel time saving

Tables 9.8 and 9.9 show the initial state of each variable taken into account. Furthermore, it shows the value when the cost/ benefit is increased or decreased by 10%. This increase or decrease of the variable has an impact on the NPV of the CBA. Figures 9.1 and 9.2 show the delta NPV of each variable compared to the initial state. In these figures can also be seen that the railway exploitation costs are the most sensitive to an increase or decrease of 10%. Therefore, the NPV will change the most if this variable changes. The non-facilitated demand has the least influence on the NPV. Furthermore, this variable has the biggest impact on the change of the B/C ratio. For this variable the B/C ratio's changes are shown in table 9.10.

This table shows that by the increase or decrease of 10% the B/C ratio increases or decreases as well. It also shows that the B/C ratio stays bigger than 1, which means it is advisable to implement the alternative. However, it must be said that during this research a lot of assumptions are made regarding the costs. If these are valued incorrectly it is possible that the costs are higher and therefore the B/C ratio is smaller than shown here. Furthermore, if there is higher uncertainty the variables can be increased or decreased by a larger percentage for example 20%. If this is the case it might also be possible that the B/C becomes smaller than 1.

Concluding the B/C ratio of this alternative is very close to 1 it is possible, therefore if costs/ benefits increase or decrease by a higher percentage percentage or values are incorrectly valued, the ratio can become lower than one. This must be taken into account if this alternative is considered to be implemented.

Table 9.8: The initial state of low student grant alternative's the costs and benefits (in mln) and the increased and decreased values

	Initial state	**-10%**	**+10%**
Railway investment	€ 287.70	€ 258.93	€ 316.47
Free crossing investment	€ 41.55	€ 37.40	€ 45.71
Student room investment	€ 215.46	€ 193.91	€ 237.00
Infrastructure exploitation	€ 530.31	€ 477.28	€ 583.34
Student room exploitation	€ 49.30	€ 44.37	€ 54.23
Non-facilitated demand	€ 0.03	€ 0.03	€ 0.03
Travel time saved	€ 5.09	€ 4.58	€ 5.60
Exploitation revenue rooms	€ 230.72	€ 207.65	€ 253.79

Table 9.9: The initial state of high student grant alternative's the costs and benefits (in mln) and the increased and decrease values

	Initial state	-10%	+10%
Railway investment	€ 302.20	€ 271.98	€ 332.42
Free crossing investment	€ 43.63	€ 39.27	€ 47.99
Student room investment	€ 259.91	€ 233.91	€ 285.90
Infrastructure exploitation	€ 544.19	€ 489.77	€ 598.61
Student room exploitation	€ 58.77	€ 52.90	€ 64.65
Non-facilitated demand	€ 0.25	€ 0.24	€ 0.29
Travel time saved	€ 12.05	€ 10.84	€ 13.25
Exploitation revenue rooms	€ 275.07	€ 247.56	€ 302.57

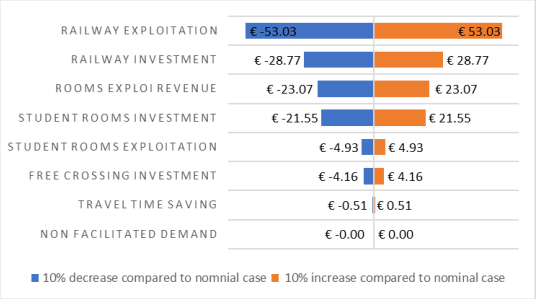

Figure 9.1: Δ NPV (in mln euros) per effect/ cost low scenario

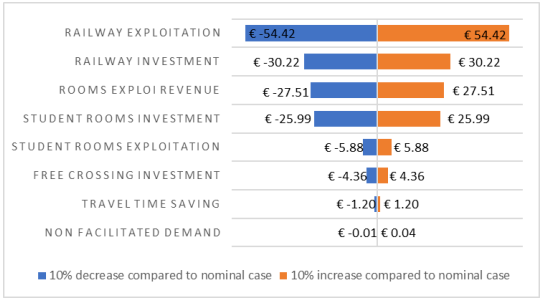

Figure 9.2: Δ NPV (in mln euros) per effect/ cost high scenario

Table 9.10: B/C ratio for increased and decreased railway exploitation costs of the student grant alternative

Sensitivity change	Low scenario (B/C ratio)	High scenario (B/C ratio)
90% (10% decrease)	1.20	1.17
100% (nominal)	1.15	1.13
110% (10% increase)	1.1	1.07

Sensitivity analysis of blended learning alternative

For the sensitivity analysis of the blended learning alternative again all costs and benefits are taken into account that differ from the baseline alternative. This means all variable that are not equal to 0. Furthermore, also for this alternative the emplacement of The Hague CS, high frequency railway operation and investment in trains are taken into account as one variable. However, only costs for this variable are made in the high scenario. Therefore these are not shown in the figure for the low scenario of the blended learning alternative. Although both positive and negative values of the tuition fee and student grant are different than those of the baseline alternative, these variables are again not taken into account. Because these values are dependent, if either of those negative/ positive values changes the other one changes as well. Together these values equal 0.

The costs and benefits taken into account in the sensitivity analysis of the blended learning alternative are the following:

- Railway investment (Emplacement The Hague CS, High frequency Rijswijk - Rotterdam CS, Trains)
- Free crossing Hollands Spoor - The Hague CS
- Investment TU Delft buildings
- Exploitation TU Delft buildings
- Investment online tools
- Investment teachers' education
- Investment Wi-Fi

Tables 9.11 and 9.12 show the initial state of each variable taken into account for the sensitivity analysis of the blended learning alternative. Furthermore, these tables show the values when the cost/

benefit is increased or decreased by 10%. This increase or decrease of the variable has an impact on the NPV of the CBA. Figures 9.3 and 9.4 show the delta NPV of each variable compared to the initial state. These figures show that the blended learning alternative is most sensitive to changes in the TU Delft housing (exploitation) costs. It is least sensitive to change is costs for Wi-Fi.

For the variable that has most impact on the NPV change, the B/C ratios are shown in 9.13. If the housing costs change by 10% the B/C ratio will increase or decrease as well. However, the B/C ratio of the blended learning alternative is not so close to 1 as the student grant alternative. Therefore, it is less likely for this alternative that the B/C ratio becomes smaller than 1. Therefore, this alternative is less sensitive to changes in costs and benefits than the student grant alternative.

Table 9.11: The initial state of low blended learning alternative the costs and benefits and the increased and decrease values

	Initial state	-10%	+10%
Railway investment	0	0	0
Free crossing investment	0	0	0
Housing costs TU Delft	€ 951.70	€ 856.53	€ 1,046.87
Investment TU Delft buildings	€ 314.12	€ 282.71	€ 345.53
Investment online tools	€ 168.17	€ 151.35	€ 184.98
Investment teachers' education	€ 29.92	€ 26.93	€ 32.91
Investment Wi-Fi	€ 4.04	€ 3.64	€ 4.45

Table 9.12: The initial state of high blended learning alternative the costs and benefits (in mln) and the increased and decrease values

	Initial state	-10%	+10%
Railway investment	€ 194.79	€ 175.31	€ 214.26
Free crossing investment	0	0	0
Housing costs TU Delft	€ 1,160.8	1044.728	1276.89
Investment TU Delft buildings	€ 581.12	€ 523.01	€ 639.23
Investment online tools	€ 168.17	€ 151.35	€ 184.98
Investment teachers' education	€ 29.92	€ 26.93	€ 32.91
Investment Wi-Fi	€ 4.04	€ 3.64	€ 4.45

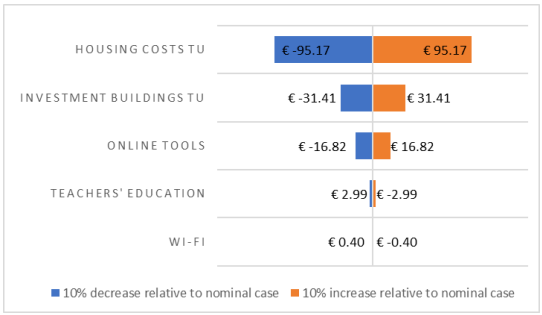

Figure 9.3: Δ NPV (in mln euros) per effect/ cost low scenario

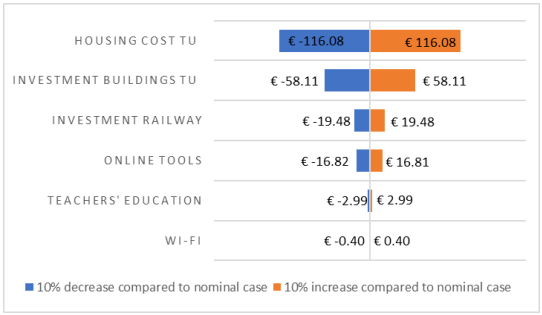

Figure 9.4: Δ NPV (in mln euros) per effect/ cost high scenario

Table 9.13: B/C ratio for low and high scenario of the blended learning alternative

Sensitivity change	Low scenario (B/C ratio)	High scenario (B/C ratio)
90% (10% decrease)	7.22	4.00
100% (nominal)	6.75	3.43
110% (10% increase)	6.27	2.85

9.7 Conclusion

This chapter showed the investment costs, exploitation costs and other costs of all the alternatives. Furthermore, the monetary values of the CBA were shown in table 9.7. And also this led to the NPV and B/C ratio.

It can be said that the NPV is positive for all alternatives. Furthermore, it showed that the B/C ratio for all alternatives was equal or bigger than one, which means it is useful to implement the alternatives. However, section 9.6 showed that both alternatives are sensitive to changes of specific variables. Since the B/C ratio of the student grant alternative is very close to one, this alternative is more sensitive to changes of the variables than the blended learning alternative. And therefore, if the variables are uncertain, this student grant alternative is more likely to have a B/C ratio below 1. Then it is not advisable to implement the specific alternative.

Therefore, it can be concluded that the blended learning alternative has most potential to reduce the peak hour demand efficiently, since it has the highest NPV and B/C ratio. Furthermore, this alternative is less sensitive to effect changes. It is recommended to implement this policy. However, more research must be done the get a more detailed outcome.

Chapter 10 will therefore discuss the limitations of this research and give recommendations for future research. In the next chapter the conclusions are drawn.

10

Conclusion, discussion & recommendations

In this chapter, the overall conclusions are drawn in section 10.1. The next section 10.2 shows the discussion, in which the limitations of the research are drawn and the outcome of the research is reflected. Lastly, section 10.3 shows the recommendations for future research as well as recommendations for practice.

10.1 Conclusion

Due to population growth, more jobs and more students traveling by train in the morning peak, trains are getting more crowded. In the coming years post Covid-19 it is expected these numbers will rise. Therefore, the pressure on the railway network increases during the morning peak, especially in the urban areas such as the Randstad multiple congested trajectories appear. Because of the growth in travelers traveling by train, it is expected the maximum railway capacity will be reached in 2030.

Therefore, new solutions should be found to reduce the morning peak demand in the Netherlands. Although some studies show the potential of changing the departure time of students to reduce the morning peak demand, literature lacks the information about which alternatives students prefer regarding the change of their departure time and that will at the same time lead to a reduction in capacity demand during the morning peak. Besides, at the time of this research it was unknown what the costs and benefits are, if students change their departure time.

The aim of this research was first to develop alternative policies that led to a reduction of the peak demand by changing the students' departure time and on the other hand were attractive for the students. The second aim of this research was to give insight in the costs and benefits involved in the proposed alternative policies and the societal feasibility of these policies.
To fill this gap and to be able to give insight in alternative policies that have the most potential the following research question was formulated:

Which potential policy measures, focused on change in departure time of students traveling by train, are efficient to reduce morning peak demand?

To answer this question, it was needed to define alternative policies that have the potential to reduce the peak hour demand compared to the baseline. Secondly, a CBA was performed to compare the costs and benefits of those alternatives to the baseline and conclude which of the proposed alternatives was efficient.

During this research focus groups with students were used to obtain alternatives used as an input for the CBA. These sessions led to two potential alternatives, namely implementation of the student grant and the blended learning alternative.

Furthermore, the outcome of the CBA showed that both alternatives appeared to be beneficial for society to be implemented, since the benefits were higher than the costs. However, the blended

learning alternative was more efficient from an economic point of view. Because the costs were lower and the benefits were higher for this alternative, which led to a high B/C ratio and NPV.

A sensitivity analysis was performed to indicate which effects are most sensitive to change. Housing costs and railway exploitation cost appeared to be most sensitive. Besides, the student grant alternative was most sensitive to change in general since its B/C ratio was close to 1.

This research showed that focus groups can be used to obtain alternative policies as an input for a CBA, because the focus group meetings used in this research generated two useful alternatives. Besides, the CBA's outcome also showed that the proposed alternatives of this research were also economically feasible and beneficial to society to be implemented, so it is also possible to obtain economic and societal beneficial policies by the use of focus groups. However, this research did not elaborate for which types of policy interventions the focus groups can be used to obtain useful policies. It only can be said these focus groups can be used to obtain most preferred alternatives for heavily affected stakeholders for a specific policy measure. Therefore, further research is needed to investigate for which types of policy interventions focus groups can be used.

Compared to literature research used to obtain alternative policies, focus groups give more insight in people's preferences and opinions. This leads to more specific and detailed alternatives. However, it might be questioned if the generated alternatives are as objective as when only literature is used, since the number of participants is limited and the researcher needs to interpret the focus group outcome.

Although this research showed that both alternative policies are efficient regarding costs and benefits, these alternative include high investment costs. Therefore, it might be worthwhile to investigate if partial implementation of one or both of these policies solves the peak hour demand problem as well. In this way the investment costs and risks coming with that are lower.

This researched showed that implementing the policies that change the departure time of students are efficient to reduce the peak hour demand in trains. However, the literature research showed that besides students, commuters have a big share during the morning peak as well. Changing the departure time of the commuters might also solve the problem, but this is not researched yet.

Lastly, it must be said that this outcome must be handled with care. If it is decided to consider to implement one or both of these policies or partially implement the policies, further research is needed on several aspects and the limitations of this research should be taken into account as well. Besides, it is unknown if these policies provide the solution to other congested railway trajectories as well, because this research only focused on the trajectory Rotterdam CS - The Hague CS. The outcome of the CBA focused on another trajectories in the Netherlands might not be positive.

The next sections describe the limitations of this research as well as the recommendations for future research and for practice.

10.2 Discussion

During this research focus groups were held and a CBA was performed. However, to be able to do this multiple different steps are taken in advance to generate the input for the CBA. For example defining the different alternatives, defining the effects of the policies and determining the stakeholders. and multiple assumptions and choices were made. Therefore, in this section the most critical assumptions are discussed and the limitations of this research are explained.

Scope

This thesis started with defining the problem, which occurred to be the capacity demand problem in trains in the Netherlands during the morning peak. Since there were time constraints during this thesis research, only one busy trajectory in the Randstad was chosen to do the research on, namely the trajectory between Rotterdam CS and The Hague CS. However, there are more congested railway trajectories in the Randstad expected, for example Schiphol - Amsterdam, Amsterdam - Almere and The Hague - Gouda (Arcadis, 2011). While, the outcome of the CBA for both alternative policies is positive, it might not be the case for other trajectories. Therefore, it is advisable to perform a new CBA for other trajectories to see the different outcomes and to be able to determine if these policies solve the problem at other trajectories as well.

During this research it was decided to focus on banning students during the peak hours in the train. However, as the literature research showed, another group that has a large share in using the train during peak hours are commuters. However, this group is not taken into account during the CBA. The researcher expects, if policies are implemented to change the travel behaviour of the commuters, this can be a solution to the peak hour demand problem.

Furthermore, the literature research showed that the morning peak is busiest on Thursday, other days such as Friday are less busy. However, this research focused on the morning peak in general. It might be possible that the policies are only needed on the most busy days to reduce peak hour demand and that this solves the peak hour capacity problem as well.

To be able to perform a CBA, it is needed that the stakeholders of the different policy alternatives are known of both baseline alternative and alternative policies. For this research the step presented by Chevalier and Buckles (2008) are followed to perform the stakeholder analysis. This included an individual brainstorm, stakeholder checklists and rainbow diagrams are used to define and select the stakeholders. However, it is known to the researcher other methods can be used as well, for example the methods presented by Reed et al. (2009). However, the researcher expects no differences in the most important stakeholders defined.

Besides different methods that can be used to identify the stakeholders, it is also possible that there are more stakeholders involved besides the ones presented in the rainbow diagrams, figures 2.2 and 2.3. The researcher assumes the most important stakeholders are defined and taken into account for this research. Therefore, if more stakeholders are involved it will not have influence on the outcome of this research.

If besides the most important stakeholders, the government (national, regional and local), railway operators, TU Delft University and students, the other defined stakeholders are taken into account as well. The outcome of the CBA can change, since more costs and benefits are involved. If all stakeholders are taken into account this gives a more realistic view of the impact of the alternative policies on society. Since, the impact of implementing the alternative policies has a bigger impact on society than what is shown in this research, because of the limited amount of stakeholders taken into account. It is therefore valuable to take all stakeholders into account to see the outcome change, the NPV might be negative or less positive compared to the presented outcome of this research.

Policy alternatives

After defining the scope and the stakeholders, the baseline alternative and the alternative polices were set. This was done by using literature, expert knowledge and focus groups. However, also here limitations occurred and these are reflected.

Baseline alternative

The baseline alternative is the scenario that is most likely to happen without extra policy interventions. To be able to define the baseline alternative, used during the CBA of this research, an interview, literature and the researcher's reasoning are used.

However, only one interview took place with an expert of the NS. The expect suggested to used specific literature and documents to define the baseline, which are after that used by the researcher to do so. Since, the baseline is based on one interview and documents suggested by the expert. It is possible that some assumptions on the implementations of the baseline alternative differ if other documents are used. Furthermore, since only the knowledge of one expert is used this could biased the information that the researcher has used. If more experts are interviewed, it is possible more documents are suggested to use as a reference for the baseline alternative. It is most obvious that other implementations and effects occur if more documents are used to define the baseline. This leads to a more defined baseline alternative compared to the baseline set for this research.

Another possibility, if more than one expert are interviewed, is that multiple experts mention the same documents. If this is the case this will lead to a more convincing baseline, since more than one expert suggest a specific document to use for defining the baseline alternative.

Besides, using expert knowledge and literature to set a baseline alternative. An even stronger future scenario (baseline alternative) could be generated by using the three phases to generate the baseline, proposed by Börjeson, Höjer, Dreborg, Ekvall, and Finnveden (2006). The three phases mentioned, are generating, integrating and checking consistency. Each phase includes different methods and techniques, which together will lead to a plausible future scenario. However, it was not possible to use this method during this thesis, because of time constraints.

For the baseline alternative an assumption was made about the growth of number of railway passengers during the project lifetime. It is assumed that the grow will be between between 27% and 45% from 2025 to 2040. The measures of the baseline alternative are based on this assumption. However, as we know now, there is a high uncertainty about the growth in the number of railway passengers in the future. If there are no Covid-19 measures in the future, it is still possible these measures could lead to behaviour changes. Because people are used to working from home and video calls, it can be the case there is less demand for work related travels. Furthermore, it is possible that people will minimize the amount of trips made by public transport to avoid contact with others. According to IenW (2020c) 10% of the people expects to travel less by train in the future, on the other hand a comparable share expects to travel more by train in the future. Furthermore, van Hagen and Ton (2020) found out that the sustainable mobility gained importance due to Covid-19. This led to a more positive view towards public transport and bike transport and a more negative view towards traveling by car. It can be concluded that it is possible that the growth is higher than the assumed growth. If this is the case it is expected the maximum capacity will be reached sooner. This leads to higher investment costs, since measures need to be implemented earlier in time. If the growth is lower than expected. It is the other way around, costs will be lower since measures can be implemented later in time.

Alternative policies

To obtain the alternative policies, focus group meetings with students are used, because it was assumed this group is most affected by changing their departure time. Three focus groups were used to define the preferences of the students regarding the change of their departure time. This led to the two alternative policies, blended learning and the reintroduction of the student grant.

However, there are several limitations regarding the execution of the focus groups. First, it must be said that none of the students was currently living at home. Therefore the preferred alternative of reintroduction of the student grant to stimulate people to live on-campus, might be biased.

Furthermore, no first year students participated during these focus groups. Therefore, their opinion could be under-represented.

To increase reliability of the focus groups' outcome, first year students and students living at home must be included. If this is done, more types of students must be included, which will give a better view of the students' preferences. And this might lead to more preferable alternatives according to the students.

The alternatives that came out of the held focus groups, were blended learning and stimulating living on campus by bringing back the student grant. The specific measures, that are needed to implement blended learning, are mainly based on literature, also one interview with a TU Delft expert took place. Due to time constraints only one interview is done to see which implementations are needed on the side of the university. Furthermore, the researcher made choices regarding which implementations were necessary to execute this alternative.

For the student grant alternative only desk research is done, regarding implementations needed for this alternative. The researcher tried to identify most important implementations for this alternative as well.

However, it is possible that when a more in-depth research is done on the implementations needed for both alternatives, more measures are found that will contribute to the execution of the alternatives. For example, a more in depth research can be done by interviewing more experts to gain knowledge on what is needed for reintroduction of the student grant.

As said the focus group meetings with students led to alternative policies that are preferred by students. Non-preferable alternatives for students are not taken into account during this research.

However, these non-preferred alternatives might be a solution to the problem as well and have a positive outcome in the CBA.

For example, the NS and national government have introduced measures to ban students during the peak hours in the train in the past (Voermans & Nieuwenhuis, 2016), but also recently due to Covid-19 (van Veldhoven Van der Meer, 2020). Then more lecture halls and study facilities are needed, to host all students in a shorter or different period of time. These measures are not popular with students (HOP, 2020; van Zwienen, 2016), while these will solve the problem. This example shows that students, NS and the government not always agree on the most preferable measure to reduce peak demand in trains. Since, during this research only students are asked about their preferences, these non-preferred alternatives were not mentioned, while these might solve the problem.

There are many more stakeholders involved than students alone by reducing the peak hour demand in trains. These stakeholders, such as NS, the government or educational institutions might have a different vision of preferred alternatives to reduce the peak demand in trains. Therefore, it is advisable to take these stakeholders into account as well.

Therefore, it is valuable to host focus groups with all of the different stakeholders at the same time to be able to come to good (compromised) alternatives for all parties involved. It is expected that the alternative defined during these sessions have less negative impacts for all stakeholders, since the alternatives are a compromise for all stakeholders. For the same reason the benefits will be lower, there different stakeholders have lower benefits since the alternative is a compromise. The researcher also expects that these sessions will lead to more realistic alternatives for all stakeholders involved, not only for students.

Policy effects

For the CBA different effects were identified for the stakeholders mentioned in the research scope. However, during this research only direct effects are taken into account. While, there are also external and indirect effects involved in the implementation of the different policy alternatives. Furthermore, other costs and effects might occur for the stakeholders outside the scope of this research.

Indirect effects, for example depreciation of houses and land, might occur when new student rooms are built or when TU Delft buildings are transformed. Furthermore, also external effects, like noise hindrance, could occur by implementing the explained policies. However, for all alternatives indirect and external effects are not taken into account for the CBA, while these will exist in real-life.

Besides, the external and indirect effects that are not taken into account, also the direct effects taken into account are limited. The effects taken into account are: investment costs divided in costs of railway infrastructure, TU Delft buildings and student rooms. Exploitation costs divided in the same categories as mentioned before. And other costs and effects, these are costs and effects occurring by implementing the alternative policies.

In this research the NPV and B/C ratio of this CBA are both positive. However, if indirect, external and more direct effects are taken into account this might not be the case. If these effects are taken into account have high costs, the NPV and B/C ratio might be negative. Or if these effects have high benefits the NPV and B/C ratio can become even bigger.

Besides limitations on the effects taken into account, numerous assumptions are made by the researcher to be able to calculate the effects of the different policies. For example assumptions are made for growth factors of number of railway travelers and students, but also assumptions are made for implementations on railway infrastructure, number of student rooms and TU Delft buildings. If the effects are not valued correctly this has an influence on the CBA outcome as well. It might be useful to check the values used with an expert to be more certain about the values used.

A risk that might occur when performing a CBA is double count of effects. This means an effect is counted more than once, which is not intended for a CBA (Mouter, n.d.-b). The researcher assumed no effects are double counted in the CBA. However, if the same effects are counted multiple times this can lead to higher/ lower costs or higher/ lower benefits. And this will effect the outcome of the CBA in a negative way.

Results

Although this research showed that focus groups can be used to obtain both useful and feasible alternative policies. However, there are both positive and negative aspects of using focus groups in combination with CBA. The focus groups sessions in this research led to clear preferred alternatives by the participants, but also it gave information about people's feelings and opinions. Furthermore, the different sessions provided more or less the same outcome. If this method is used in the future, the researcher expects that multiple focus group sessions, about a certain topic, will generate the same outcome as well. And that these outcomes can be relatively easy taken into account as an input for the CBA, like during this research.

Furthermore, for this research the alternatives proposed by the participants are chosen in agreement with each other. If multiple stakeholders are involved in the focus groups, it is expected that they will also come to a compromised alternatives. This will have a positive effect on all of the stakeholders, since it is expected that the outcome of the CBA will not be very positive for one group and very negative for another group of stakeholders, but more nuanced for all stakeholders.

As said before, for this research only the students' preferred alternatives were taken into account. However, it is possible that an alternative negatively valued by students, will have a positive outcome of the CBA. The participants of the focus groups will not vote for an alternative that is negative according to them. This is one of the drawback of using focus groups in combination with a CBA.

Another downside of the combination of using focus groups and CBA is that both methods are time consuming. It takes time to set up the focus groups, find participants and a moderating team, find a suitable date for multiple sessions and process the results. It also takes time to gather the right information and data as an input for the CBA. If time is too limited the set-up of the focus group might be not thought trough, which might lead wrongly interpreted questions and to 'wrong' outcomes. Therefore, it is not recommended to use both methods if time is very limited.

During this research the focus groups were used to obtain useful alternative policies as an input for the CBA. It showed that this combination is useful to use for Ex Ante CBA. However, it is not known if it is also useful for Ex Post CBA or for already planned policy interventions. Furthermore, it can be said that it is useful to use for policies that heavily affect one specific group of stakeholders. Although, this research showed the combination is useful if there is one heavily affected stakeholder, it is currently unknown if it is also useful when there are multiple affected stakeholders. Therefore, it should be researched if this combination is also applicable when there are multiple affected stakeholders involved.

One of the main negative aspects of the CBA is, it is hard to assess and monetize soft impacts, like personal beliefs, attitude and environmental impact. For the CBA the effects needed to be monetized. To do so, a lot of assumptions are made regarding the costs involved. The sensitivity analysis showed that the exploitation costs and investment costs have a big influence on the outcome of the CBA.

Furthermore, these costs are sensitive for change. If the researcher incorrectly validated these costs, it is possible that the outcome of the CBA is negative for both alternatives instead of the current positive outcome.

Besides, estimations are made to monetize the effects. The researcher assumed the discount rate to be 5%. However, if the discount rate is lower the costs will be higher later in time. The outcome of the CBA will be lower. If the discount rate is higher than the assumed 5%, the costs in the future are lower. This leads in the end to a higher NPV.

Furthermore, the summarizing table of the CBA showed that the C/B ratio of the student grant alternative is very close to 1, which means that if the costs increase it is possible that the B/C ratio drops below 1. Since, a lot of assumptions are made it is possible that for the real-life situation the B/C ratio will be below 1 and the NPV will be negative.

Lastly, the outcome of the CBA is positive for both alternatives, blended learning and the student grant alternative. However, this CBA was focused on the trajectory The Hague CS - Rotterdam CS. It is not possible to translate this outcome one to one with another trajectory in the Netherlands. If these alternative are considered as a solution for reducing peak hour demand in other parts of the Netherlands, a new CBA must be performed. When this is done it can be said if the proposed alternatives of this research will be also a solution for other trajectories.

10.3 Recommendations

This research was executed in limited amount of time. Therefore, assumptions are made and some limitations occurred. This section shows the recommendations for future research as well as for practice.

Recommendation for future research

- The baseline alternative is based on an interview with an expert of NS and literature. However, to be more complete regarding future implementations for the baseline alternative, more experts can be interviewed and a more in depth literature research can be done.
- The research showed that the focus groups can be used to obtain alternative policies for Ex Ante CBA. However, it is currently unknown if this combination of CBA and focus groups can also be used to validate planned measures, or when Ex post CBA is used. Therefore, further research is needed to indicate for which CBA types this combination of methods can be used.
- Focus groups can be used to obtain preferred policy alternatives of one specific stakeholder that is most affected by the policy measure. However, it must be researched if focus groups can be used when there are multiple heavily affected stakeholders.
- It is unknown for which types of policy interventions the focus group can be used to obtain the alternative policy as an input for the CBA. Therefore, more research is needed to investigate for which policy types the combination of focus groups and CBA are valuable.
- As said in the discussion only the direct effects for (some of) the stakeholders are taken into account. To get a more complete view of the effects of the policies on the stakeholders. It is recommended to research indirect and external effects as well in the future. Besides, the effects on all stakeholders, shown in the rainbow diagrams, should be taken into account not only the effects for the stakeholders described in the scope of this research should be investigated.
- It is also advisable to extent the research for the direct effects taken into account. For this research only investment costs, exploitation costs and other costs and effects that occur by implementing the policies are taken into account.
- For this research a discount rate of 5% was used. To see what the impact of this discount rate is on the B/C ratio and the NPV it is recommended to investigate the effect when this rate is varied.
- Due to the Covid-19 pandemic there is a lot of uncertainty regarding the numbers of railway passengers in the future and the passengers behaviour in the future. However, the number of train travelers were of great importance during this research, since the policies are based on this. Therefore, if the Covid-19 pandemic is over, the number of railway passengers might be less uncertain, because the travelers' behaviour is less unknown. It might be the case that more precise growth ratios can be used, which leads to a less uncertain outcome of the CBA. Therefore, it is recommended to investigate if the CBA outcome will change in the future, with more certain travelers numbers.

Recommendation for practice

- This thesis showed that the proposed alternative policies have potential to reduce the peak hour demand in trains, by changing the travel behaviour of the students. Since, the trajectory, that is researched, is not the only congested trajectory in the Netherlands, the proposed policies might be a solution for other regions as well. However, it is unknown for which of these trajectories these policy alternatives are applicable. Therefore, if these policies are considered to be implemented in other trajectories, it is needed to execute a new CBA to see if the policies are a solution to the problem.
- Before implementing, one or both of the proposed alternatives, it is recommended to execute a more in-depth research regarding effects, stakeholders, policy alternatives and trajectories. Since the scope of the research was limited at these points. More precise measures should be established. This can be done by using more experts, literature and measures that were used for similar projects.

- This research focused on the change of travel behaviour of the students. However, literature research showed that another large group, that uses the train during the morning peak, are commuters. It is advised to investigate policy measures that help to reduce peak demand focusing on the change of departure time of commuters.
- As said, the alternative policies are determined by using three focus group meetings with students. However, if it is decided to implement the students' preferred alternatives, these focus groups must be extended. Since, none of the students lived at home and none of the students was a first year student. In future research these two types of students could be included in the focus group sessions to see if the outcome of it is the same. If this is done the outcomes is more reliable.
- Besides the potential alternatives presented, it is also recommended to investigate the effect of adding some of the measures presented in the alternative policies. Since, this solution will be less rigorous compared to the proposed alternatives and it might still solve the problem.
- During this research the project lifetime was limited to 20 years, meaning the implementations and measures between 2020 and 2040 are taken into account. However, for most CBAs the time horizon of the project is infinite. Since, an infinite time horizon is not feasible, it is mostly chosen to set one or two time horizons in the far future. So that the effects have reached the structural level (Romijn & Renes, 2013). Since it is expected that the lifetime of a project in real-life is more or less infinite, it is recommended to extent the project's lifetime to see the effects on a longer term.
- This research was focused on the morning peak hour demand in trains. However, the literature review showed that for some days the morning peak is higher than for other days. Therefore, it is recommended if one or both of these policies are implemented, to focus on the days for which the peak hour demand is problematic and implement measures for those days.

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A

Scientific Paper

Assessing policy efficiency to reduce peak demand in trains

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Abstract -

Since the trains are getting more crowded during the morning peak hour in the Netherlands, multiple problems arise for both railway travelers and railway operators. Therefore, new solutions are needed to be found, to reduce the peak hour demand in trains during the morning peak in The Netherlands. A possible solution appeared to be changing the departure time of students. The aim of this research is to propose alternative policies that lead to a lower peak demand and are at the same time attractive for students. First, the baseline alternative is set using literature research and expert knowledge. Then the alternative policies are defined by using focus groups. After that, the effects of the proposed alternatives are compared to the baseline and these effects are then monetized. Lastly, a sensitivity analysis is performed by using tornado charts. It can be concluded from this research, that both blended learning and implementation of the student grant have potential to be economically feasible and to have societal benefits. However, these alternatives are not proven to be the solution for all congested railway trajectories in The Netherlands. Therefore, if these policies are considered for other trajectories to be implemented, research needs to be done for the specific trajectories.

Keywords: Cost-Benefit Analysis, Focus groups, Effects, Baseline alternative, Alternative policies

1 Introduction

Trains are getting more and more crowded in The Netherlands during the peak hour. This is caused by population growth, higher income, more jobs and bigger number of students traveling by train [1]. Besides, students and working people are traveling at the same time period during the morning peak [2]. Furthermore, it is expected that the numbers of railway travelers will increase post Covid-19. Therefore, during the morning peak the pressure on the network will rise. The urban areas such as the Randstad are primarily affected by the increasing numbers [3]. Because of the expected growth both in traveled kilometers by train and number of railway travelers, it is expected that the maximum railway capacity is reached in 2030 [4].

Multiple problems arise when the maximum railway capacity is reached. Not only are railway travelers not be able to board the train they preferred, their safety inside the trains and at the stations is at risk as well, due to overcrowding [5]. Besides the travelers facing negative aspects of overcrowding, the railway operators face obstacles as well if the maximum capacity is reached.

On the long term overcrowding becomes a bigger problem in transport by train as well. To solve this problem multiple solutions are suggested, for example more trains per hour, longer trains and higher prices during the morning peak [6].

However, the ability to expand the railway tracks is limited and increasing number of trains during the morning peak is almost impossible in the Randstad, since the train frequency is already at is maximum [3]. Furthermore, expanding the railway network, building new infrastructure and investment in new trains comes with high costs [3, 7].

Since investments in the railway infrastructure and trains will not solve the crowding problem on the long therm, new solutions should be found. Multiple studies are done to research which policy alternatives have potential to reduce the peak hour demand in trains. The most promising alternative according to the literature was to change the departure time of students to reduce the morning peak demand in trains. Changing the departure time of student can lead to a lower demand [8, 9].

However, literature lacks the information about which alternatives students prefer regarding the change of their departure time and that will at the same time lead to a reduction in capacity demand during the morning peak. Besides, at the time of this research it was unknown what the costs and benefits are, if students change their departure time.

This research had two aims. The first aim was to define alternative policies, focused on the students' departure time change, that have the potential to reduce the peak hour demand and are at the same time attractive for students. The second goal of this research was to gain insights in costs and benefits involved in the alternative policies proposed by students and the economic and social feasibility of these policies. This research gap will be filled by answering the following research question:

Which potential policy measures, focused on change in departure time of students traveling by train, are efficient to reduce morning peak demand?

This study focused on the trajectory between Rotterdam Central Station and The Hague Central Station, the TU Delft and the TU Delft students. Since, it is assumed

to be impossible to do a research on all congested railway trajectories in the Randstad and to take all University cities into account as well.

2 Research methodology

To answer this research question, a cost-benefit analysis was performed. However, to be able to do this the input for the CBA needed to be generated. This was done by using different methods and using the steps defined by Romijn and Renes [10] as a guideline .

2.1 Defining baseline

The first step in the process was to define the baseline alternative of the CBA.

The baseline alternative is the most likely future scenario, if no (new) policy measure are introduced [10].

Based on expert knowledge and the following documents, NMCA Spoor 2017, MIRT, Toekomstbeeld OV and Programma Hoogfrequent Spoor, the baseline alternative was defined.

This baseline was focused on being able to serve the future train transport demand during the morning peak. Furthermore, it focused on the facilitation of education and student housing for student in Delft.

The following measures were proposed to be needed for the baseline alternative, to be able to facilitate the future demand at the trajectory between Rotterdam CS and The Hague CS and the future number of students:

- The emplacement of The Hague CS [11].
- Implementation of high frequency railway operation at the Rotterdam CS - The Hague CS trajectory [11].
- Implementation of 4 new sprinter trains [11].
- Expanding the number of railway tracks between Rijswijk and Delft-Campus from two to four tracks [11].
- Railway track layout change between Schiedam and Rotterdam CS [11].
- The built of a free crossing at The Hague HS [12].
- Investment in 2500 new students rooms in Delft [13].
- Investment in TU Delft buildings and faculties [14].

The baseline alternative presented here, was compared to the proposed alternative policies during the CBA.

2.2 Defining alternative policies

The next step was to define the alternative policies used for the CBA. This study used focus group sessions to define alternative policies that both reduce the peak hour demand in trains by changing the departure time of the students and are at the same time are preferred by the students. Besides, during these sessions information was gathered about the student experience with online education and possible improvements that could be made.

A detailed plan was set up to be able to host these sessions properly. To do this the time, location, moderating team and questions used for the focus group were defined.

During this research 3 focus groups with 5 students were held via Zoom. 15 participants were selected. The age, gender and type of study varied between the participants. However, their life stage and experience with online education were similar.

The moderating team used for this research consisted of a focus group moderator and an assistant. The moderator led the discussion and explained the context and aim of the sessions [15]. The assistant took care of recording and making notes during these sessions [16].

A question guide was used to gain the right information from the students, this guide is shown in Table 1.

These focus groups led to two alternative policies that were taken into account for the CBA. The two proposed alternatives taken into account for this research were the combination of online and offline learning (Blended learning alternative) and the return of the student grant to stimulate students living on campus (Student grant alternative).

Several measures were needed for both of these alternatives. To define the measures needed expert knowledge and literature research were used.

The following list shows an overview of measures taken for the student grant alternative.

- Facilitation of a monthly study fee of 300.69 euros all students living on campus and 108 euros for students living at home in their nominal study time [17]
- Investment in 5,079 to 6,219 student rooms [18]
- Abolishing of the tuition fee discount for first year students [19].

The following list shows an overview of measures taken for the blended learning alternative

- Investment in facilitation of online education at the TU Delft buildings [20].
- Investment in licenses for online tools for both students and teachers [20].
- Providing a stable Wi-Fi connection for students [21, 22].
- Educate teachers for online teaching [23].

2.3 Defining and monetizing effects

To define the impacts and effects an interview with educational expert and literature were used. Furthermore, it was decided, by the researcher, to apply a low and high growth scenario on both alternative policies.

Not all types of effects were taken into account during this research, only the monetizable direct effects, were

Question type	Question
Opening	Can you tell us who you are and what you study currently.
Introduction	The main topic of this discussion will be lecture hours and schedules change of students to decrease the peak demand. Lately, measures are implemented, so that students can study from home. How did you experience the distance learning?
Transition	How is the distance education organised lately, regarding lectures, projects, project groups, exams, etc.?
Main	What are the pros and cons for following online education? What are the effects of it on your lives?
Main	We discussed the university's policy towards distance education. However, the government and the NS have plans to ban students during the peak hour in the train. Suppose students will be banned during peak hours, how do you think this can be done the best? In other words what do you think are ways ban students during peak hours by changes in the education? **Make a list of the mentioned alternatives (Assistant)**
Main	The following alternatives are proposed (assistant states the alternatives). Can you list the alternatives from most favorite to least favorite)? The three alternatives that are most appealing to you are ... (The assistant state the alternatives). Now we will discuss what is needed to implement these alternatives (per alternative) and what the impact is for you if these alternative are implemented.
Main	Which measures and implementations are needed for each alternative to make it feasible?
Main	What influence has the alternative for you and others? What are the pros and cons of this alternative?
Closing	What would you advice if the government decides to ban students during the peak hours?

Table 1. Focus group question guide

taken into account. However, indirect and external effects were involved with these policies as well, but these were not taken into account.

The effects that were considered for the student grant alternative were investment costs, exploitation costs and other impacts. Investment costs include, costs for railway infrastructure and trains, TU Delft buildings and student rooms. The exploitation costs include railway and student room exploitation, and housing of the TU Delft. Other impacts include changes that need to be made compared to the baseline, these effects are mainly return of the student grant, abolishment of tuition fee discount, exploitation revenue of the student rooms, saved travel time by students and non-facilitated demand.

The effects that were considered for the blended learning alternative were investment costs, exploitation costs and other impacts. The investment costs include, the investments in railway infrastructure and trains, TU Delft buildings and student rooms. The exploitation costs include the exploitation costs of railway infrastructure, TU Delft buildings and student rooms. Lastly, the other impacts take into account costs made to facilitate blended learning, investment in licenses and online tools, facilitation of Wi-Fi, education of teachers and non-facilitated demand.

Effects of the policy alternatives appear both on short and long term. These effects that occur over longer period of time need to be translated to current prices to be able to take those into account in the CBA. To do this future costs (C) and benefits (B) were discounted to the present value (PV). The present values of the costs and benefits were calculated by using the following equations. Where B_t is benefit and C_t is cost in year t. And lastly s is the social discount rate [24]. The discount rate that was used for this research was 5%.

$$PV(B) = \sum_{t=1}^{n} \frac{B_t}{(1+s)^t} \tag{1}$$

$$PV(C) = \sum_{t=0}^{n} \frac{C_t}{(1+s)^t} \tag{2}$$

To compute the net present value (NPV) of each alternative the following formula is used:

$$NPV = PV(B) - PV(C) \tag{3}$$

If the outcome of the NPV was positive, it was advised to implement the alternative policy. The rule of thumb was that the benefits should be greater than the costs [24].

Furthermore, the benefits were divided by the costs to calculate the Benefit/ Cost (B/C) ratio. If the B/C bigger or equal to 1 the policy is economically feasible and beneficial to society [10].

All the costs and benefits were put in a summarizing table to give an overview of all costs and benefits of the proposed alternative policies.

2.4 Sensitivity analysis

Lastly, a sensitivity analysis was performed using tornado charts. This was done to verify the reliability of the CBA. A tornado bar chart uses horizontal instead of vertical bars. The larger the bar the more sensitive a specific variable is to change. The variables are changed independently, one at the time. By increasing or decreasing the variable the NPV and Benefit/ Cost ratio changes. The variable that is most affected by the change compared to the initial state is shown at the top of the tornado chart. The lower on the chart, the less sensitive a certain variable is. The goal of the sensitivity analysis is to determine the variables most sensitive to change and which have the most impact [25].

During this research a 10% increase and decrease of the yearly costs is applied. Not all variables were changed, only those with the highest impact (cost or benefit) were taken into account.

3 Results

The CBA was performed using these three policies. The effects of the alternative policies were defined by comparing the baseline alternative with the alternative policies. The goal of the CBA was to be able to conclude whether or not it is beneficial to implement one of the alternative policies. The effects of the alternative policies could be both positive (benefits) and negative (costs) compared to the baseline alternative. For this research only the direct effects were taken into account.

Different effects were identified for both alternative policies and compared to the baseline. First, for the blended learning alternative, lower investment on railway infrastructure and trains were expected to be needed. Furthermore, the investments on TU Delft buildings should be lower, since less students needed to be facilitated in this alternative compared to the baseline. Housing costs of the TU Delft should be lower as well, since not all building were expected to be needed. Another effect is that non-facilitated demand was lower, since less students travel by train during the morning peak. Besides beneficial effects, there were some effects that led to higher costs, namely investments in facilitation online education. Lastly, higher costs were expected to provide stable Wi-Fi, online tools and teachers education for online teaching.

For the other alternative policy, implementation of the student grant, there were also effects expected to occur compared to the baseline alternative. First, lower investment costs were expected on railway infrastructure and trains for this alternative as well compared to the baseline. Furthermore, the exploitation costs for the railway infrastructure should be lower, since less traveled kilometers are expected. Also, travel time was saved for those students that moved out to live near the campus. And by implementing the student grant, students get money from the government every month. Lastly, an effect for the government was the abolition of the tuition fee discount, which led to higher tuition fee income for the government.

However, besides the beneficial effects of this student grant alternative, some effects brought extra costs. First, since this alternative was focused on stimulating students to move out, extra student rooms were expected to be needed to facilitate all students compared to the baseline. Therefore, higher investment costs on student rooms were expected. This also went hand in hand with higher exploitation costs of the student rooms. Other costs were made by students paying extra tuition fee to the government and the government paying the student grant to students.

The effects of these two alternatives were monetized, which led to benefits and costs shown in table 2. To determine if it is beneficial to implement those alternatives the NPV and B/C ratio were calculated.

For both alternatives the B/C ratio was bigger or equal than one. However, the B/C ratio of the student grant alternative is close to 1, while the blended learning alternative showed a more positive B/C ratio. This meant, that both alternative policies had positive societal impact compared to the baseline alternative.

Furthermore, the NPV was positive for all alternatives. The NPVs of both alternatives can be seen in table 2 .

The sensitivity analysis showed that some effects were more sensitive to change than others. For the student grant alternative the railway exploitation costs appeared to be most sensitive to change. Since the B/C ratio of this alternative was close to 1, this alternative is very sensitive to effects' changes. The B/C ratio could become lower than 1 if effects were valued incorrectly. This should be taken into account, if this policy alternative is considered to be implemented. The tornado charts of low and high scenario of the student grant alternative can be seen in figures 1 and 2. The blue bars show a reduction in costs compared to the initial state and the orange bars show an increase in costs compared to the initial state.

For the blended learning alternative, the effect most sensitive to change appeared to be the TU Delft housing costs. However, if this effect was valued incorrectly the B/C ratio was not expected to change as drastic, since the ratio was not so close to 1. This means the B/C ratio could change, however it was less likely for this alternative that the ratio becomes lower than one. The tornado charts of both low and high blended learning alternative can be seen in figures 3 and 4. The blue bars show a reduction in costs

	Student grant		Blended learning	
	Low growth	*High growth*	*Low growth*	*High growth*
Investment costs				
Emplacement The Hague CS	€ 21.0	€ 18.8	€ 65.0	€ 35.2
High frequency Rijswijk-Rotterdam CS	€ 109.5	€ 98.1	€ 339.0	€ 183.7
Free crossing Hollands Spoor - CS	€ 19.8	€ 17.8	€ 61.4	€ 61.4
Student rooms	€ -96.7	€ -141.1	€ -	€ -
Trains	€ 6.8	€ 6.1	€ 21.2	€ 11.5
Buildings tu delft	€ -	€ -	€ 662.1	€ 395.1
Exploitation costs				
Infrastructure train	€ 25.0	€ 11.1	€ -	€ -
Student rooms	€ -19.9	€ -29.3	€ -	€ -
Housing costs tu delft	€ -	€ -	€ 209.1	€ -
Other impacts				
Exploitation revenue student rooms	€ 93.0	€ 137.3	€ -	€ -
Non-facilitated demand	€ 5.3	€ 5.6	€ 5.6	€ 5.6
Travel time saving	€ 5.1	€ 12.0	€ -	€ -
Tuition fee income government	€ 48.5	€ 48.5	€ -	€ -
Extra tuition fees students	€ -48.5	€ -48.5	€ -	€ -
Student grant government	€ -830.3	€ -830.3	€ -	€ -
Student grant for students	€ 830.3	€ 830.3	€ -	€ -
Online tools	€ -	€ -	€ -168.2	€ -168.2
Teachers' education	€ -	€ -	€ -29.9	€ -29.9
Wifi	€ -	€ -	€ -4.0	€ -4.0
Costs	€ -995.4	€ -1,049.3	€ -202.1	€ -202.1
Benefits	€ 1,164.5	€ 1,185.7	€ 1,363.4	€ 692.5
NPV	**€ 169.1**	**€ 136.3**	**€ 1,161.3**	**€ 490.4**
Benefit/Cost ratio	**1.17**	**1.13**	**6.75**	**3.43**

Table 2. Net present value (in mln) relative to the baseline alternative and benefit/ cost ratio

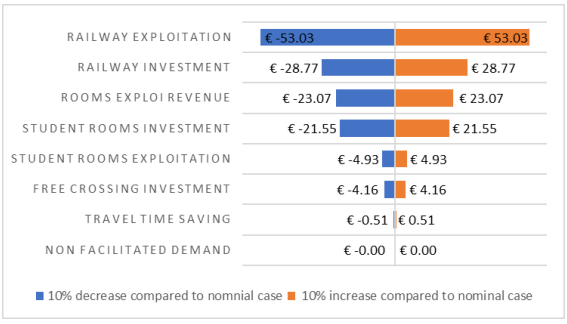

Figure 1. Δ NPV (in mln euros) per variable low scenario student grant

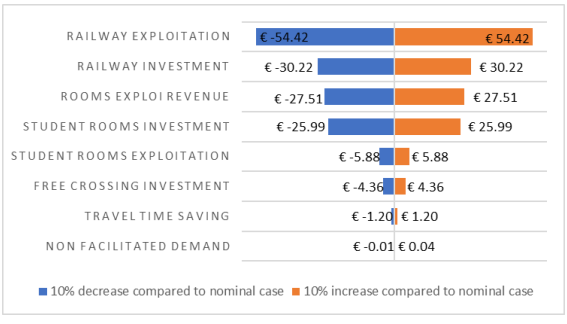

Figure 2. Δ NPV (in mln euros) per variable high scenario student grant

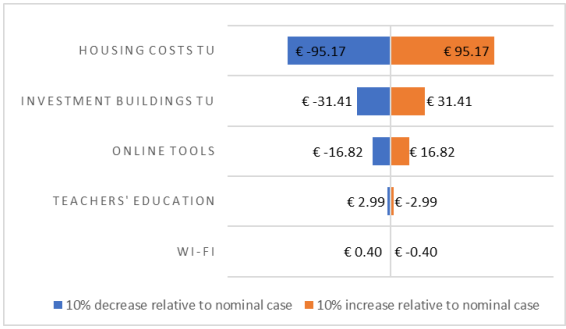

Figure 3. Δ NPV (in mln euros) per variable low scenario blended learning

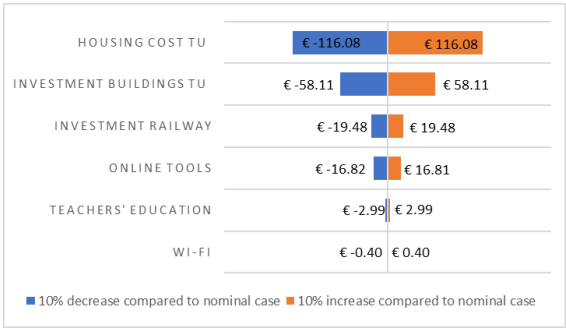

Figure 4. Δ NPV (in mln euros) per variable high scenario blended learning

compared to the initial state and the orange bars show an increase in costs compared to the initial state.

4 Discussion

For this research a CBA was executed. However, to be able to do so multiple assumptions are made. The most critical limitations of the research are therefore discussed in this part.

This study focused on the trajectory between Rotterdam Cs and The Hague CS, however the literature research showed that there are multiple congested trajectories in the Randstad. While this research showed that implementing the proposed alternatives to reduce peak hour demand can be both socially and economically beneficial, this might not be the case for different trajectories.

For the focus groups held during this research only students were included, since it was assumed this group is most affected. The students preferred alternatives that were most attractive for them, while it is possible that non-preferred might also lead to positive outcome of the CBA. By including other stakeholders in the focus groups the sessions might lead to different proposed alternatives.

Another limitation of this research is that only the monetizable direct effects were taken into account. However, also indirect and external effects are involved when one or both of these policies are considered to be implemented. For example noise hindrance and emissions can be effects that occur during construction of railway infrastructure of student housing. These effects have impact on the outcome of the CBA, this can lead to a less positive outcome. Therefore, these factors should be considered to be taken into account.

One of the biggest limitations of the Cost-Benefit Analysis is it is hard to monetize soft impacts, such as personal opinions, people's attitude environmental impact. However, to perform a CBA all effects should be monetized. Therefore, these soft impacts were not taken into account, while in reality they have an impact on the CBA outcome.

Furthermore, during this research many assumptions are made regarding the effects and costs involved with these policies. The sensitivity analysis showed that the exploitation costs and investment costs have a big influence on the outcome of the CBA. However, it is possible that these effects are incorrectly valued, if so the outcome might change if other values are given to those effects. This might lead to a higher or lower NPV and B/C ratio, which has an impact on the consideration to implement one or both of these proposed alternative policies.

Lastly, this research used a combination of focus groups and a CBA. The combination of these methods were effective to set up alternative policies that could be used for Ex Ante CBA and showed to have potential to reduce the peak hour demand. However, this research didn't show if these methods could be used for Ex Post CBA as well or if there is no clear negative affected stakeholder. If these methods are used in the future this knowledge gap should be considered.

5 Conclusion & Recommendations

The goal of this research was to set up alternative policies that led to a reduction of peak hour demand by changing the departure time of the students and that were at the same time attractive for students. Furthermore the aim was to give insight in which of the proposed alternative policies had the potential to be both economic and societal feasible to be implemented.

It could be concluded that the proposed alternative policies, blended learning and implementation of the student grant, appeared to be beneficial to implement, because the benefits were higher than the costs.

Furthermore, from this research could be concluded that focus groups can be used as an appropriate method to set up alternatives for Ex Ante CBA. Besides, the CBA showed that these alternatives were a feasible solution to the problem, so it also can be concluded that it is possible to obtain economically feasible and societal beneficial solutions by using focus groups.

Lastly, from the CBA outcome can be concluded that the blended learning alternative appeared to be more efficient regarding costs compared to the student grant alternative. For this blended learning alternative the costs were lower and the benefits were higher.

This research concluded that it is possible to use focus groups to set up alternative policies for the Ex Ante CBA. However, it is currently unknown if focus groups can also be used for already planned policies or Ex Ante CBA. Therefore, it is recommended to research for which CBA types this method combination can be used. Besides, it is currently unknown for which policy measures focus groups can be used to generate policy alternatives for a CBA. More research is needed to indicate for which interventions the combination of CBA and focus groups can be used.

During this research only the direct effects are taken into account, However, since in reality also indirect and external effects are involved, it is recommended to take all those effects into account if implementation of these policies is considered.

If focus groups are considered to be used to generate alternative policies, it is recommended to use groups including multiple stakeholders or to set up different sessions with different stakeholders. So that more nuanced and compromised alternatives are also considered for the CBA.

Lastly, if the proposed alternative are considered to be implemented on other trajectories, it should be investigated

if these policies solve the peak hour demand problem for those as well. Since this research only showed that the proposed alternatives have potential to solve the demand problem at the Rotterdam CS - The Hague CS trajectory.

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B

Stakeholder analysis

The aim of this chapter is to identify the main stakeholders that are involved in the different policy interventions and to determine which will be taken into account for the CBA. To be able to identify these stakeholders, a stakeholder analysis is performed.

The identification of the stakeholders is a iterative process. Therefore, the different steps,that need to be executed, are explained. The steps composed by (Chevalier & Buckles, 2008) are used as a guideline to identify, group and visualize the stakeholders.

First, an individual brainstorm is done. After that, literature research is conducted on stakeholders involved in the policy measures. A stakeholder checklist is used to check if there are any missing stakeholders. After that the next step is to categorize the identified stakeholders in groups. This is done in section B.4.

Next all the identified stakeholders will be placed in a rainbow diagram shown in figure B.1 to find out which have the most influence and which are most affected, this is described in section B.5. Furthermore, a decision was made which of the stakeholders will be taken into account for the CBA.

The conclusions and findings are drawn in section B.7.

B.1 Individual brainstorm

First, an individual brainstorm session is executed to get a first idea of which stakeholders are involved. Two separate lists of stakeholders are formed one for the baseline alternative and one for the policies involving the change of departure time.

The researcher identified the following stakeholders:

Baseline alternative:

- Railway operators
- Railway employees
- Transport planners
- Pt travelers
- Construction companies
- Government
- Provinces
- Municipalities
- Residents (around railway)
- Train/ rail manufacturers

Alternative policies

- Students
- Teachers
- TU Delft/ Universities
- Employees
- Railway operators
- Bus and tram operators
- Residents Delft
- Student associations
- Family/ roommates
- Municipality Delft
- Construction companies
- Peak hour pt travelers

B.2 Literature research

The following subsections show the literature research on stakeholders involved with the different policies. After this research the stakeholders are listed.

Capacity increase

Since the Dutch government is shareholder of the NS this is one of the most important stakeholders, especially the ministry of Infrastructure, but also the ministry of Finance.

Furthermore, the goal for NS is to deliver door-to-door transport. However, the NS is not able to provide the service alone. Therefore, also other regional and city transport companies have to be aligned with the NS. Examples of these companies are Arriva, Conexxion and RET. Next to these companies, municipalities and branch associations also play a role in alignment of the regional transport. Some examples of branch associations are Transport4Randstad and Coöperatie TLS. Lastly, ProRail is the rail infrastructure manager in the Netherlands, therefore this company is also a stakeholder in this project (NS, 2017).

Besides transport companies, other services are important to NS if expansion is planned. These services are station facilities and material maintenance. Stations facilities are mainly commercial businesses, such as shops or restaurants (NS, 2017).

According to Stein (2015) the stakeholders of changing railway networks can be divided into three groups, namely transport providers (bus and rail services), landowners (private owners and municipalities) and urban planning authorities. Not only these are involved in the change of the railway network other stakeholders can be civil and network engineers and policy makers.

Change of departure time of students

In the region of Nijmegen a study has been executed to reduce the peak demand. To be able to implement the policy measure, changing lecture hours, a project group of stakeholders has been composed. This project group consisted of the Ministry of Infrastructure and Water Management (I&W), province of Gelderland, municipality of Nijmegen, HAN University, Radboud-UMC, Radboud University, ROC, Breng, Arriva, NS and the student union AKKU (Van der Aa & Hodde, 2018). Other stakeholders of this project were company management, councilors and building management. The target groups of this study were students, employees and visitors of the Hospital and universities (Buise, 2018).

For the province of Groningen a similar study has been done. The most important stakeholders for this project were (regional) governments, ministry of Infrastructure and Water management, ministry of Education, culture and Science, infrastructure managers and educational institutions (Doornbos-Schoonveld, 2017; IenW, n.d.). Another stakeholder that should not be forgotten is educational inspectorate. The target groups in this study were again students, but also high school students (IenW, n.d.).

Literature shows that students have a lot of extra-curricular activities, such as having a job or playing sports (Çivitci, 2015). Because of this, student associations and students' employers will be affected if the lecture hours are changed.

All the relevant stakeholders found in literature listed below.

Baseline alternative:

- Ministries of Infrastructure and finance (NS, 2017)
- Transport providers (Stein, 2015)
- Landowners (Stein, 2015)
- Policy makers (Stein, 2015)
- Civil and network engineers (Stein, 2015)
- Branch associations (Transport sector) (NS, 2017)
- Maintenance companies NS (2017)
- Commercial businesses at station NS (2017)

Alternative policies:

- Municipality councilors (Buise, 2018)
- Ministries of Infrastructure, finance and education (IenW, n.d.; Van der Aa & Hodde, 2018)
- Building management (TU Delft) (Buise, 2018)
- Infrastructure managers (Doornbos-Schoonveld, 2017; IenW, n.d.)
- Educational inspectorate (IenW, n.d.)
- Student's employers (Çivitci, 2015)

B.3 Stakeholder checklist

A stakeholder checklist is used to check if there are any missing stakeholders. The two stakeholder identification checklists of Chevalier and Buckles (2008) are used in this research, those can be found in appendix C. The missing stakeholders, identified by using the checklist, are shown below. Only stakeholders are added to the list departure time change stakeholders.

Alternative policies

- Land owners
- Teacher/ university employee associations
- Student parties (Oras and Lijst Beta)
- Food truck/ restaurant owners Campus Delft

Complete list of stakeholders

This section shows an overview of all stakeholders, for both the baseline alternative and alternative policies, identified during the stakeholder identification process. It is assumed that the stakeholders for the two alternative policies will be the same. Therefore, these are treated as one. The stakeholders identified for the base alternatives and alternative policies are shown in the two columns below. The left column shows the stakeholders of the baseline alternative and the right column shows the alternative policies' stakeholders.

Baseline alternative:

- Railway operators
- Bus and tram operators
- Railway employees
- Transport planners
- Pt travelers
- Construction companies
- Government (ministries of infrastructure and finance)
- Provinces
- Municipalities
- Residents (around railway)
- Train/ rail manufacturers
- Railway owner (ProRail)
- Transport companies
- Landowners
- Policy makers
- Civil and network engineers
- Branch associations (transport sector)
- Maintenance companies
- Commercial businesses at station
- Building management (TU Delft)
- TU Delft/ Universities

Alternative policies:

- Students
- Teachers
- TU Delft/ Universities
- Employees
- Railway operators
- Bus and tram operators
- Residents Delft
- Student associations
- Family/ roommates
- Municipality Delft (councilors)
- Construction companies
- Public transport travelers
- Government (ministries of infrastructure, finance and education)
- Building management (TU Delft)
- Educational inspectorate
- Student's employers
- Land owners
- Teacher/ university employee associations
- Student parties (Oras and Lijst Beta)
- Food truck/ restaurant owners Campus Delft

B.4 Stakeholder groups

Since the compiled list of stakeholders of section before is very extensive. The different stakeholders are placed into overarching groups to minimize the number of stakeholders. The different groups are listed below, between brackets it can be seen which stakeholders fall into the specific groups.

Baseline alternative:

- National government (ministries, policy makers)
- Regional government (provinces)
- Local government (municipalities)
- Transport providers (railway operators, train/ railway manufacturers, railway owners (ProRail), transport companies (NS, Arriva, etc.), railway employees)
- Transport support (maintenance companies, transport planners, civil & network engineers)
- Public transport users (travelers,)
- Commerce, real estate and housing (land owners, commercial businesses and shops, residents)
- Branch associations/ travelers organizations (OVNL)
- Educational institutions (TU Delft, universities, building management)

Alternative policies:

- Students
- Teachers
- National government (ministries, policy makers)
- Regional government (provinces)
- Local government (municipalities)
- Transport providers (railway operators, train/ railway manufacturers, railway owners (ProRail), transport companies (NS, Arriva, etc.), railway employees)
- Educational institutions (TU Delft, universities, university employees, educational inspectorate, building management)
- Branch associations (Student associations, employee associations, student parties (Oras, Lijst Beta))
- Public transport users (travelers)
- Commerce, real estate and housing (land owners, commercial businesses and shops, residents, construction companies, student's employers)
- Relatives (family, partners, roommates)

B.5 Rainbow-diagram

A rainbow-diagram is filled in for the different policy alternatives to define which stakeholder groups have the most influence, are the most affected or both. Furthermore, the most important stakeholders for the different policies are defined so that these are used in the CBA later on.

Figure B.1 shows the blank rainbow-diagram.

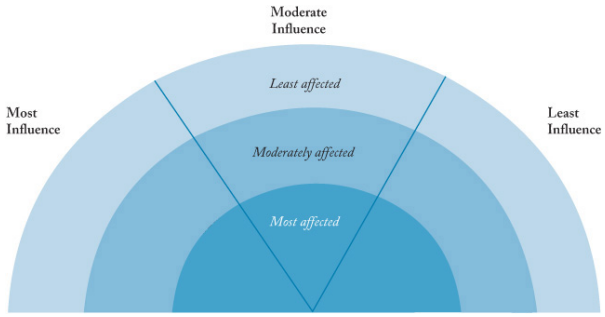

Figure B.1: Rainbow diagram stakeholders (Chevalier & Buckles, 2008)

B.6 Outcome stakeholder analysis

After identification of the stakeholders and the stakeholder groups. The different groups are placed into the rainbow-diagram. The aim of using this diagram is to be able to identify the most important groups of stakeholders and eliminate those that are less important.

The following figures B.2 and B.3 show the placement of all the groups in the diagram. The placement is based on the interview outcome and literature.

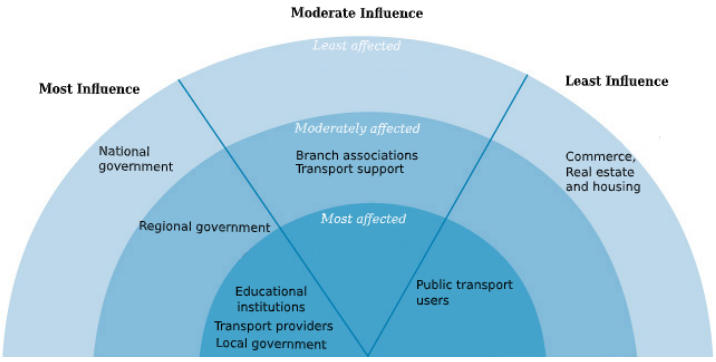

Figure B.2: Rainbow-diagram baseline alternative

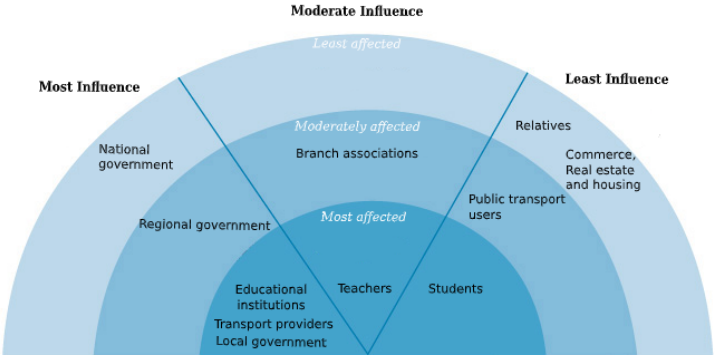

Figure B.3: Rainbow-diagram alternative policies

Not all groups that are shown in the rainbow-diagrams are taken into account for the CBA, since there are time constraints during this research. Therefore, it is decided that only the most affected groups and the groups with the most influence are taken into account. The lists below show the most important stakeholders for both baseline alternatives and alternative policies.

Baseline alternative:

- National government (ministries, policy makers)
- Regional government (provinces)
- Local government (municipalities)
- Transport providers (railway operators, train/railway manufacturers, railway owners (ProRAil, transport companies (NS, Arriva, etc.), Railway employees)
- Public transport users (travelers)
- Educational institutions (TU Delft, universities, building management)

Alternative policies:

- National government (ministries, policy makers)
- Regional government (provinces)
- Local government (municipalities)
- Students
- Teachers
- Transport providers (railway operators, train/railway manufacturers, railway owners (ProRAil, transport companies (NS, Arriva, etc.), Railway employees)

- Educational institutions (TU Delft, universities, university employees, educational inspectorate, building management)

B.7 Conclusion and discussion

The aim of this chapter was to identify the stakeholders, rank them by most influence, most affected or both. And to identify which stakeholders need to be taken into account for the CBA.

Concluding, the stakeholders with the most influence on the base alternatives are the government (national, regional, local), transport providers and educational institutes. The most affected stakeholders of this policy are the transport providers, local government and public transport users.

The outcome of the most affected and affecting stakeholders of the alternative policies is different, namely the most affecting groups are government (national, regional, local), transport providers and educational institutions. The most affected groups are students, teachers, local government, transport providers and educational institutions.

C

Stakeholder checklists

The checklists used for identification are retrieved from (Chevalier & Buckles, 2008) and these are shown below.

C.1 Checklist for Stakeholder Identification

1. Individuals (such as company owners)
2. Families and households (such as long-term local residents)
3. Traditional groups (such as clans)
4. Community-based groups (such as self-interest organizations of resource users, neighborhood associations, gender or age-based associations)
5. Local traditional authorities (such as a village council of elders, a traditional chief)
6. Political authorities recognized by national laws (such as elected representatives at the village or district levels)
7. Non-governmental bodies that link different communities (such as a council of village representatives, a district-level association of fishermen)
8. Local governance structures (administration, police, the judicial system)
9. Agencies with legal jurisdiction over natural resources (such as a state park agency)
10. Local governmental services in the area of education, health, forestry and agriculture, etc.
11. Relevant non-governmental organizations at the local, national or international levels
12. Political party structures (at various levels)
13. Religious bodies (at various levels)
14. National interest organizations (such as a workers' union—also called people's associations)
15. National service organizations (such as the Lions Club)
16. Cultural and voluntary associations (such as a club for the study of unique national landscapes, an association of tourists)
17. Businesses and commercial enterprises (from local cooperatives to international corporations)
18. Universities and research organizations
19. Local banks and credit institutions

20. Government authorities at the district and regional levels
21. National governments
22. Foreign aid agencies
23. Staff and consultants of relevant projects and programs
24. International government bodies (such as UNICEF, FAO, UNEP)
25. International unions (such as IUCN)

C.2 Checklist of Questions for Stakeholder Identification

1. Are there communities, groups or individuals who may be affected by the management decisions? Are there historic occupants (such as indigenous communities or nomads) or traditional resource users with customary rights of ownership or use of the lands? Are there recent arrivals? Non-resident users of resources? Absentee landlords? Major secondary users of local resources (such as buyers of products or tourists)? Are there local non-profit organizations concerned with natural resources? Are there business people or industries that might be negatively affected by natural resource management decisions? Are there research, development or conservation projects in the area? How many employees (national and international) live in the area because of such projects? Are these people active in natural resource management?
2. Who are the main traditional authorities in the area? Are there government agencies officially responsible for the resources at stake? Are there respected institutions that people rely on in the area?
3. Who has access to the land, area or resources at stake? Who is using the natural resources now? In what ways? Has this changed over time?
4. Which communities, groups and individuals are most dependent on the resources? Is this because of livelihood or economic advantage? Can these resources be replaced by others that are less ecologically valuable or fragile?
5. Who is responsible for claims, including customary rights and legal jurisdiction, in the territory or area where the resources are located? Are there communities with historic and/or other types of acquired rights? Are various government sectors and ministry departments involved? Are there national and/or international bodies involved because of specific laws or treaties?
6. Which communities, groups or individuals are most knowledgeable about, and capable of dealing with, the territories or resources? So far, who has a direct experience in managing them?
7. How does use of the resources change depending on the seasons, the geography and the interests of the users? Are there seasonal migration patterns? Are there major events or trends (such as development projects, land reforms, migration, natural increase or decrease in the population) affecting local communities and other interested parties?
8. Are there other co-management projects in the region? If so, to what extent are they succeeding? Who are their main partners?

D

Interviews

This chapter describes the interview method that is used and the purpose of conducting interviews. First, the different types of interviews are described in section D.1. After determination of the type of interview that is used, background knowledge on the research topic is gained, this is described in section D.4. Then the interview guide in section D.5 shows the questions used as a guideline during the interview. Section D.6 the outcome of the interview is summarized. Lastly, in section the conclusion is given of this chapter.

D.1 Type of interview

The type of interview that is used during this research is a semi-structured interview. A semi-structured interview is useful to gain insight on people's opinion relative to the research topic. A semi-structured interview has as main advantage that it allows the interviewer to improvise on follow-up questions based on the participant's answer, therefore it is decided this type of interview will be used.

To perform a semi-structured interview, the questions are prepared in advance and formulated in a interview guide. The interview guide contains the key topics and questions of the interview. Although the guide will give direction to the interview it is not necessary to follow it strictly.

To conduct a semi-structured interview five steps need to be followed (Kallio, Pietilä, Johnson, & Kangasniemi, 2016; Turner III, 2010):

1. Gain knowledge of the interview topic.
2. Develop interview guide.
3. Pilot testing.
4. Conducting interview
5. Interpreting data/ results.

These steps will be described in detail in the following sections. Before following the steps. The goal and purpose of the interview needs to be clear. Furthermore, the participant criteria should be set, so that it is clear who to interview.

D.2 Interview goal

Before setting up the interview, the goal and purpose of conducting the interview is determined. The goal of the interview is to gain knowledge about the baseline alternative that will be used for the CBA. This is the scenario that is most likely to happen in the future. The knowledge to be gained is about the measures that this policy bring.

The outcome of the interview is used to be able to set up the baseline alternative for the CBA.

D.3 Participant selection

For the interview a sample must be drawn. This is a subset of the target group for the interview, since it is not necessary to interview everyone from the target group (Oishi, 2002). For this interview it is important that the participant has knowledge of the current policy at the NS and the future policies that will be implemented. Furthermore, they need to be familiar with the Covid-19 circumstances at the NS. Age and gender are not of any importance during the selection. Experts in different fields of the transport sector can be interviewed. For example a transport modeller at the NS, a policy manager or researchers.

D.4 Background information

Before setting up the interview questions. Background information of the interview is needed. The first step for the interview guide is to do background research on the specified topic. For the interview the topic is the current (Covid-19) and future expected situation of the railway network in the Randstad. Therefore, information is gained about the scenarios in which the passengers transport demand is expected to grow and the measures that will be taken to be able to serve this demand in the future. Besides the expected future situation, the current Covid-19 situation needs to be researched as well. This research includes current measures to reduce peak demand and implementations that are needed.

According to IenW (2019a) the public transport and bicycle are the main transport modes in urban areas. In the urban areas the mobility growth is expected to be the biggest until 2030, namely a growth between 27 to 45 percent compared to 2014 (NS, 2019c). In these urban areas the capacity and quality limits of the public transport system will be reached, mainly during the peak hours. To tackle this problem the NS will mainly focus on enlarging the capacity on the network. Customization of the frequency, number of stops and speed on the different trajectories in the Randstad are needed (IenW, 2019a).

The reliability and the capacity of the current infrastructure needs to be increased. To do this investments are on the long run. On a shorter period of time investments are needed for longer platforms, track switches, energy supply and noise measures. From 2020 on there will be a shortage of holding capacity for trains (NS, 2019c).

To enlarge the change for traveller to have a seat, the NS will increase the number of seats, optimize the current seats and influence the demand for a seat. This will be done by the inflow of new and rebuild equipment, increase in the number of trains (more trains and higher frequency), schedule equipment to reach the demand for a seat and execute the time schedule according to plan (NS, 2019a).

Northern Randstad In the Northern Randstad capacity increase is needed namely around Amsterdam. Upscaling the network is needed for both regional and urban level to decrease the pressure on the bottlenecks in the system. The bottlenecks in Amsterdam are Amsterdam Zuid, Centraal, Bijlmer and Schiphol. Solutions can be increasing rail track capacity and capacity of the urban and regional network (IenW, 2019a). On the Gouda-Amsterdam Bijlmer trains will be added as well ass on the Amsterdam-Utrecht corridor (APPM, Movares, & Coffeng, 2019).

Southern Randstad In the Southern Randstad capacity increase is needed at both urban as regional level, to be able to solve bottlenecks and facilitate urban growth. In Rotterdam the capacity increase of public transport is mainly focused on the subway. For the Den Haag region urban public transport needs to be optimized. Furthermore, to reduce the demand on the Rotterdam subway system, increasing the frequency at the Oude Lijn and building new railway stations between Dordrecht and Den Haag can be a solution (IenW, 2019a).

Covid-19 measures The measures that are yet taken because of Covid-19 are (NS, 2020a):

- People are only allowed to sit on the seats with a green sticker.
- Inside the trains it is mandatory to wear face mask.
- Keep distance during alighting and boarding the train.
- Touch as little as possible.
- Travel only if necessary.

Furthermore, the government, NS and ProRail agreed on keeping students out of the public transport during the peak hours. This means that schools and universities need to plan their lectures and education between 11:00 and 15:00 and after 20:00. In this way most of the students don't need to travel during peak hours. However, students are allowed to travel during peak hours (DUO, 2020a).

D.5 Interview guide

Introduction research topic

For the interview it is important to give an introduction. This is done by explaining the topic of the research (Baumbusch, 2010), the purpose, the format and the duration of the interview (Turner III, 2010).

Research topic

The topic of my research is to conduct a CBA to gain knowledge on which policy measure is most cost efficient regarding reducing the peak demand in trains. The base alternative is focused on the train capacity scenario that is most likely to be implemented in the future. As alternatives policies blended learning and bringing back student grant are be investigated. The baseline alternatives are compared to the different policy alternatives. Then a conclusion is drawn which policy has most potential to be implemented.

Het onderwerp van mijn onderzoek is om uit te zoeken welke beleidsvoering het meest kosten efficient is om piekbelasting te reduceren. Dit zal ik gaan onderzoeken aan de hand van een kosten baten analyse. Hiervoor zal ik verschillende scenario's opstellen. Allereerst zal ik een nulalternatief voor de korte en de lange termijn opstellen. Voor de korte termijn zal deze Corona gerelateerd zijn, denk hierbij aan welk beleid wordt er gevoerd om te zorgen dat de treinen niet te druk zijn. Voor de lange termijn wordt er gekeken naar welk scenario het meest voor de hand liggend is voor de toekomst.

De alternatieve beleidsvoeringen zullen gericht zijn op het verschuiven/ veranderen van de college uren, zodat de studenten niet in de spits hoeven te reizen.

Purpose of the interview

The purpose of this interview is to gain knowledge about the most likely scenario regarding passenger transport capacity, capacity increase and investments. Also the interviewer wants to retrieve information about reducing the peak demand during Covid-19 times.

Het doel van het interview is om inzicht te krijgen in de beleidsvoering van de NS tijdens corona. Welke maatregelen er getroffen worden om de belasting op het netwerk zo lag mogelijk te houden. Verder is het interessant om inzicht te krijgen in wat voor beleid er gevoerd zal worden in de toekomst tot 2030. Bovendien, is het doel om de nulalternatieven op te kunnen stellen voor dit onderzoek en inzicht te krijgen in de kosten die deze alternatieven met zich mee brengen.

Format

First, I will ask some questions about the Covid-19 scenario, which measures are already taken and what measures are planned. After that some questions will be asked about the future scenario of the NS, namely regarding reduction of the peak hour demand and what measures will be implemented. This interview will be semi-structured, which means that I prepared the main questions however there will be room to go in depth and ask other questions as well. Furthermore, I would like to record the interview, so that I can analyse it later on. Are you ok with that?

If you would like to stay informed you can leave your contact details. Lastly are there any questions from your side before starting the interview?

Ik zal eerst ingaan op het corona scenario. Welke maatregelen er genomen zijn en gepland staan. Daarna zal ik vragen stellen over het toekomst beeld van de NS, met name gericht op het reduceren van de piekbelasting. Het interview zal semi-gestructureerd zijn wat betekend dat ik de hoofdlijn van het interview heb uitgewerkt, maar dat er ruimte is voor vervolg vragen. Verder zal het interview opgenomen worden, zodat ik dit later kan analyseren. Vind u dat goed? Als u het interessant vind om op de hoogte te blijven van mijn onderzoek dan is dat mogelijk. U kunt dat achteraf aangeven. Zijn er verder nog vragen vanuit uw kant?

Vragen mbt Corona scenario

Er is op het moment natuurlijk corona en er zijn verschillende maatregelen getroffen om veilig gebruik te kunnen maken van het OV. Maar ook om de piek druk te verlagen. Daarom de vraag:

- *Welke maatregelen zijn er op het moment getroffen om de piek drukte te verlagen?*
- *Welke maatregelen staan er nog op de planning?* Hoe en wanneer zullen deze worden ingevoerd en hoelang zal dit naar verwachting duren?
- *Wat zijn de kosten die het implementeren met zich mee brengt?* Voor wat voor dingen worden extra kosten gemaakt?(zijn er kosten voor infra, dienstregeling, schoonmaak etc.)
- *Hoe lang wordt er gestuurd op Corona beleid bij de NS? Tijdspanne van hoeveel maanden, jaren?*
- *Wat zijn de verwachte effecten van deze maatregelen (op de piek drukte tijdens de spits)?* (denk aan meer comfort, minder mensen die niet in de trein passen, betrouwbaarheid) (hoe denken jullie dat te bereiken)
- *Wat zijn de belanghebbenden van deze maatregelen* (wie worden er getroffen, wie zijn de stakeholders, wie is hier het belangrijkst, wie hebben er baat bij)
- *Hoeveel mensen denken jullie hiermee uit de trein te krijgen (hoeveel procent?)?* (hoeveel belanghebbenden zijn er)
- *Hoeveel vraag/ mensen denken jullie nu niet te kunnen faciliterend door deze crisis?*

Vragen mbt toekomstige scenario

De volgende vragen zullen betrekking hebben op het meest voor de handliggende scenario voor de toekomst tot 2030. Hiermee bedoel ik welke maatregelen zouden er getroffen worden om aan de capaciteitsvraag te voldoen, zonder dat er innovatieve maatregelen zoals ERTMS worden geimplementeerd. Ook bedoel ik met de toekomst dat deze weer 'normaal' zal zijn, dus zonder dat er Corona maatregelen van kracht zijn.

- *Welke maatregelen zijn er gepland over de komende 10 jaar (qua spoor uitbreiding, treinaankoop, verbouwing) om capaciteit te vergroten* Op welke plekken in de randstad staat dit gepland? (wat staat er gepland? Hoeveel trein hoeveel spoor etc.
- *Hoe ziet de beleidsvoeing eruit/ hoe wordt deze ingericht?* Wat wordt wanneer geimplementeerd in de randstad en hoelang duurt dit? Met wie moet er rekening gehouden worden of worden overlegd?
- *Op hoeveel mensen heeft deze beleidsvoering invloed/ hoeveel procent?*
- Ik heb in het document Netwerkuitwerking Lange Termijn Toekomstbeeld OV opgestel door goudappel coffeng. Hierin stonden verschillende netwerkalternatieven, namelijk benutting, basis, markt en aanbod.*Zou u wellicht meer inzicht kunnen geven in deze alternatieven? Wat is het verschil tussen alternatief benutting en basis?* Zo ja welke is het meest voor de hand liggend. In het Benuttingsalternatief is het uitgangspunt dat de kleinere vervoersknelpunten uit de NMCA kunnen worden opgelost door de inzet van beleidsknoppen. In het Basisalternatief wordt voor alle vervoerknelpunten uit de NMCA een oplossing voorgesteld in de vorm van andere lijnvoering en/of meer treinen. Dit leidt tot een structuurwijziging in de dienstregelingopzet.
- *Welke kosten brengen de maatregelen/ beleidsvoering met zich mee?*
- *Welke investeringen zijn er nodig om de capaciteit uit te breiden (infra, trein etc.)?*
- *Hoeveel uitbreiding is er nodig (hoeveel trein, rails, etc.)?*
- *Wat zijn de verwachte effecten van deze maatregelen?* (zelf heb ik deze effecten opgesteld welke zou u het belangrijkste achtten?)
- *Wie hebben er baat bij en wie zullen negatieve effecten ervaren?*

- *Hoeveel mensen zullen er tov nu (voor Corona) meer vervoerd worden?* Hoeveel mensen zullen er niet vervoerd kunnen worden?

- *Beschikken jullie over feiten en cijfers waar ik inzicht in zou mogen hebben en die wellicht van toegevoegde waarde zijn voor mijn onderzoek?*

- *Zijn er wellicht nog suggesties vanuit uw kant? Wellicht suggesties voor mensen die ik kan interviewen?*

- *Heeft u zelf nog vragen of opmerkingen voor mij?*

Ik wil u bedanken voor uw tijd en bijdrage aan dit interview. Zou ik u wellicht opnieuw mogen benaderen als ik meer informatie nodig heb over bepaalde onderwerpen?

D.6 Outcome interview

The main conclusions that can bee drawn from the interview are highlighted here. The complete summary of the interview can be found in appendix E.

Corona scenario

During the Covid-19 pandemic the NS is only able to run at 40% of their normal maximum capacity. Normally 1.3 million trips a day are made. At the time of the interview the demand was only at 10%. However, when the demand rises the above 40% of the normal capacity it is not possible to keep distance between the passengers at all time since it is impossible to implement more trains into schedules. This is both because there is no extra equipment and the maximum frequency is reached.

To keep travelers aware to keep distance between them and other passengers, stickers are installed inside trains and on the platforms. Green stickers inside the trains are placed at seats where people are allowed to sit down. At the train stations stickers are place to remind people to wear a mask and to keep 1.5 meters distance. It is unknown for what time these measures are needed. These measures due to Covid-19 bring extra costs, also other expenses will stay the same, such as equipment costs and wages.

The biggest problem with the demand occurs during the morning peaks since both commuters and students travel at the same time. Students are 25% of the morning peak share. The evening peak is less of a problem. Therefore, it is preferable to change lecture hours to keep students out of the morning peak.

The main stakeholders, according to the interviewee, to have a say in the change of lecture hours and also in measures taken to reduce the are governments (ministry of infrastructure and water management, ministry of finance, ministry of education), branch associations, traveler organizations, other public transport operators and universities.

Future scenario

To be able to set up the expected future scenario in 'normal' circumstances, no internal documents can be released. However, the interviewee suggested to use the following studies as a reference, NMCA spoor 2017 (ProRail), MIRT, toekomst beeld OV and programma hoogfrequent spoor. NMCA show the expected transport development until 2030 and which measures should be taken. Toekomst beeld OV shows the plans after 2030. Furthermore, the document hoogfrequent spoor describes which frequency increases are planned and at which locations.

To set up a base alternative for the future it is advisable to take the most basic scenario showed in the highlighted documents. Since, the most basic is normally the cheapest option and most likely to be implemented in the future.

Furthermore, it is expected that travelers numbers will increase and this comes with higher demand. This will lead to the need for more trains. Capacity increase and higher frequency will lead to higher costs, however the exact costs are unknown and no key figures can be shared on this topic.

The most important stakeholders for the future 'normal' scenario are NS, ProRail and governments (ministry of infrastructure and water management, provinces and municipalities),

D.7 Conclusion and discussion

During the interview questions are asked to gain knowledge about Covid-19 measures taken at the NS. Furthermore, insight is given about the most likely scenario for the future. The gained knowledge is used to set-up a baseline alternative for the expected future scenario.

However, since the difficulties with recruiting participants willing to participate only one subject is interviewed. This limits the outcome of the interview in terms of the view expected future scenario. Therefore, other methods are needed to determine the base alternatives. Other limitations that appeared where the answers to the question if there are key figures that could be used for the CBA. Most documents are confidential. Therefore, only open source documents will be used. ‘

E

Interview summary

E.1 Interview baseline alternative

Menno de bruijn heeft econometrie gestudeerd. Is vanaf 1998 werkzaam bij ns. Vooral bezig met het analyseren en modeleren van reizigers gedrag. Vervoerstromen nu en in de toekomst hoe ziet dat er dan uit. Daarnaast onderzoekn naar reizigers gedrag door enquetes en van waar naar waar klanten reizen hier maakt hij ook modellen van. Ook gekeken gedragsveranderingen door corona.

Corona deel Piekdrukte verlagen in treinen tijdens corona. 40% van de normale capaciteit. Aantal reizigers was 10% van normaal. Nu meer richting 20 procent. Meer vraag weggevallen dan dat er aanbod is weggevalen. Als het weer meer in lijn komt, kan je weer de normale drukte verwachten. Dit past niet in de treinen. In de treinen is bestikkering aangebracht. Welke plaatsen wel en niet bezet mogen worden. Er wordt gekeken naar soort aanmeldingssysteem voor de reizen die ze maken. NS zal kijken of het dan past. Daar wordt een pilot mee gedaan met 10.000 mensen.

Er wordt gekeken of die 40% kan worden opgerekt. Normaal rond de 1,3 miljoen reizen per dag. 25% is het aantal studenten tijdens de spits. De ochtend spits is vooral lastig. Fijn als de studenten niet tijdens ochtend spits reizen.

Universiteiten moeten college tijden aanpassen. Als gevolg daarvan reizen studenten buiten de spits. Forenzen werken nu vooral thuis. Dat wordt geleidelijk weer meer. Een rol hierin spelen de kinderdagverblijven en de scholen. Zodat ouders weer aan het werk kunnen. Groot deel werkt nog steeds thuis.

Hoe lang gelden dezen maatregelen? Geen idee, hier gaat de ns niet over. De bedrijven beslissen of werknemers thuis werken. Wel wordt er gekeken met overheid welke sectoren wanneer opschalen. Als ns merkt dat het heel druk wordt dan zal ns in gesprek gaan met bedrijven en overheid om te zorgen dat het minder druk wordt. Als het drukker wordt dan kan alleen de 40% van de bezette stoelen omhoog gedaan worden. Er is geen extra materiaal. En het spoor is vol. Ns heeft vooral minder opbrengsten. 4,7 miljard verlies verwacht. Normaal 2,5 miljard opbrengst per jaar. De kosten worden niet minder tijdens corona, evenveel personeel evenveel materiaal. Grootste kostenposten zijn materieel en mensen.

Kosten die erbij komen door corona, opzet van aanmeld systeem, aanpassen van treinen en stations. Kosten die minder zijn zijn minder treinen die rijden. Ns hoeft tijdelijk minder consessie om treinen te mogen rijden. Ook de concessie voor de rails bij prorail is tijdelijk lager.

Er werken meer mensen thuis (effect). Normaal spits veel drukker dan de rest van de dag. Nu meer mensen over de hele dag verspreid. Materieel afgestemd op de spits. Maar het materieel is ook beschikbaar tijdens de rest van de dag maar word niet gebruikt. De spits vlakt meer af.

Mensen moeten met mondkapjes in de trein. In de spits is de wegval van mensen groter dan buiten de spits komt doordat mensen meer thuiswerken.

Stakeholders zijn: ministerie infra, minister van financien, branch organisaties, reizigersorga, andere openbaarvervoerders. Ook universiteiten en ministerie van onderwijs. Het belangrijkste zijn financien en infra, outbreak management team.

Normale deel Wat voor cap uitbreidingen gepland? Verwijs naar studies die uitgevoerd zijn. Interne stukken kunnen niet gedeeld worden. Extern zijn handig: NMCA spoor te lezen van 2017 document

prorail. Verwachte vervoersontwikkeling tot 2030 en 2040. Hierin staan ook maatregelen die genomen zouden moeten worden. Kijk ook naar MIRT. Voor termijn na 2030 toekomst beeld ov. Hierin staan plannen voor lange termijn. Frequentie verhogingen wel gepland. Deze staan uitgelegd in rapportage hoogfrequent spoor. Tussen Amsterdam naar Eindhoven is al verhoogd. In 2022 tussen Rotterdam Schiphol Arnhem gepland. Er zijn plannen amsterdam alkmaar te verhogen. En Schiphol Lelystad. Met hogere frequentie moet er gekeken worden naar de dienstregeling. En hoeveel mensen er moeten worden vervoerd en hoeveel treinen heirvoor nodig zijn. Geen idee hoeveel extra treinen nodig zijn. Wel bekend dat er steeds meer treinen nodig zijn omdat er veel meer reizigers zijn en hogere frequentie.

Ga uit van de basis variant die je genoemd hebt. Basis is meest waarschijnlijk en dan zijn er een aantal variaties. Die waarschijnlijk het meer geld kosten dat niet per se per direct beschikbaar is. Daarom is het slim om vanuit de basis variant uit te gaan.

Belangrijkste stakeholders: partijen anders dan bij corona, vooral ns prorail, i&W, gemeentes en provincies. Rijden van meer treinen ns beleidsbeslissing. Als at niet past op infra wat er ligt ook in gesprek met prorail. Perronverlengen is ook niet van ns maar van Prorail. Treinen kunnen niet langer zijn dan het korste perron waar ze rijden.

Kosten die capaciteit uitbreiding met zich mee brengt. Hier kan geen inzicht in gegeven worden. Misschien kjiken naar openbare document van i&w voor infra. Voor het ns deel kijken in het financieel jaarverslag, geen idee of dit inzicht geeft. Of jaarverslag van prorail.

Verandering van lestijden heeft niet alleen op ns effect. Maar ook op studenten en de capaciteit op de tu. Maar ook de bijbaantjes. Kamerprijzen. Uitwonende studenten. Vervoerstromen op andere tijden etc.

E.2 Interview departure time change

A second interview is done with an educational expert of TU Delft, namely Marinke Sussenbach of the TPM Faculty.

Introduction

Hallo, Allereerst wil ik u bedanken dat u mee wilt doen aan dit interview. Ik zal eerst mijzelf voorstellen en het doel en onderwerp van het interview.

Mijn naam is Irene Overkleeft. Ik ben een master student Transport, Infrastructuur en Logistiek aan de TU Delft. En voor mijn thesis doe ik onderzoek naar beleidsvoering om piek drukte in de trein te verlagen, met als focus studenten te weren. Ik zal verschillende beleidsmaatregelen wegen in een kosten baten analyse. Via focus group sessies met studenten kwam ik erachter dat zij het meest zien in een hybride vorm van onderwijs om niet in de spits te hoeven reizen of om een terug keer van de stufi te zien om zo meer mensen op kamers te krijgen. Om even toe te lichten wat ik versta onder hybride onderwijs: De combinatie tussen online les en fysiek op de campus.

De hybride vorm van onderwijs zal het onderwerp zijn van dit interview, gezien de TU Delft nu ervaring heeft met lesgeven zowel op de campus als online. Het doel van dit interview is om inzicht te krijgen in wat voor investeringen en maatregelen getroffen moeten worden bij de TU Delft. Maar ook wat misschien baten zullen zijn van deze vorm van onderwijs. Dit zal ik verwerken in mijn kosten baten analyse.

Heeft u zelf nog vragen? Heeft u liever dat ik u of jij zeg?

Interview

Zou u uzelf kunnen voorstellen?

- Naam
- Werk (functie) wat doe je binnen de tu
- Hoe lang werkt u bij de tu

- Marinke Sussenbach. Hoofd onderwijs zaken delft. Proces onderwijs zo soepel mogelijk maken. Beleidsmaker

Openingsvraag Ik heb zelf weinig ervaring met online onderwijs en ook met de combinatie van online onderwijs en les op de campus. Blended onderwijs zoals dat genoemd wordt.

Kunt u mij vertellen welke rol u heeft in het inrichten van het (blended) onderwijs? Hoe wordt het nu ingericht?

20% van het onderwijs is nu op de campus, dus er moet heel selectief gekeken worden naar wat wel en niet kan op de campus. Met name projectgroepen, want op tbm is maar plek voor 28 man in de collegezaal. Wel sneller problemen met de maatregelen als je project groepen doet. Sneller kom je binnen de anderhalve meter. De meeste colleges zijn online dat gaat prima. Er is een taskforce om het onderwijs zo goed mogelijk in te richten.

Hoofdvragen: *Als er in de toekomst geen corona meer is en er dus geen restricties meer zijn m.b.t. tot afstand houden en capaciteit. Hoe zou het onderwijs in hybride vorm dan ingericht moeten zijn om dit goed uitvoerbaar te maken?*

Er zijn minder college zalen nodig als het naar online en fysiek onderwijs gecombineerd gaat. Ook minder gebouwen. Er moet meer geïnvesteerd worden in werkgroepen. De roostering hiervan is complexer, want er moet rekening gehouden worden met de reistijd. Voor de reistijd wordt een uur tot 1,5 uur aangenomen zodat iedereen wel bij de fysieke onderdelen aanwezig kan zijn. Goede wifi en studieplekken zijn van groot belang. Practicums zijn niet te doen online. Dus dit moet fysiek.

Wat is hiervoor nodig (om in de toekomst blended onderwijs te kunnen aanbieden)?

Onderwijs ondersteuning is erg belangrijk. Voor studenten zodat ze zich niet geïsoleerd voelen, maar ook cursussen voor docenten. Reserveringssysteem nodig voor studie plekken zodat er zekerheid is voor een plek om te studeren. Zodat er geen stress is. Zaken moeten ingericht worden voor het blended/ hybride onderwijs. Er is al teaching lab en new media center voor opnames. De behoefte neemt toe voor zulke ruimtes. Goede thuisvoorzieningen zijn nodig. Zoals wifi. Maar ook dat je normaal dingen kan opnemen.

- Opname ruimtes
- Software (Zoom, skype, online tools voor bs.)
- Trainingen voor docenten
- Aanpassingen op de campus (studieplekken)
- Aanpassingen voor goede thuisvoorzieningen voor studenten en docenten (Wi-Fi).

Wat voor kosten brengt dit met zich mee?

Geen kosten efficiënte maatregel. Er moet tooling komen/ assesment tools dit kost geld. Virtual classrooms, zoom, skype etc. licenties. Personeelsscholing voor online lesgeven. Opname apparatuur moet aangeschaft worden/ voor docenten. Meer student-assistenten nodig om de chat bij te houden en filmpjes op te nemen. Het lesmateriaal moet zo ingericht worden dat het online ook bruikbaar is. Collegerama is echt als archief om dingen even terug te kunnen kijken en niet om online college te volgen. Het is voor veel docenten toch lastig om de groep geboeid te houden dan is online wel een uitkomst. Maar alle investeringen zijn nu al gedaan. Dus de drempel zijn we al over.

Wat zijn de voordelen?

Flexibiliteit. Grotere groepen mogelijk om les aan te geven. Online onderwijs kan waarde toevoegen, door extra lesmateriaal Het is makkelijker om studenten te tracken of ze bij de les blijven of niet. In een grote zaal met volgzalen is het lastig te zien of mensen naar huis gaan. Online kan van alles bijgehouden worden. Ook kan er gezien worden wat voor soort filmpjes en video's aan slaan en hoe lang deze kunnen duren. Extra materiaal kan online ook makkelijker bij gehouden worden. Nu zien we dat dezelfde hoeveelheid studenten de BSA gehaald hebben. Maar er is ook meer druk als alles online is. Lagere kosten voor gebouwen en gebouwbeheer. Omdat er minder zalen nodig zijn, er kan geld in andere dingen worden geïnvesteerd.

Wat zijn de nadelen?

Belasting voor docenten hoger, omdat er steeds geswitcht moet worden tussen online en fysiek dat maakt het lastig. Voor de eerstejaars zijn de ervaringen heel belangrijk, dus het leggen van contacten. Maar ook de structuur. Hiervoor is de huidige introductie en opzet van het onderwijs waarschijnlijk wel het meest passend.

Ook de sfeer/ houding van een college of werkgroep/ universiteit is heel lastig te pijlen via een zoom of skype meeting. Sommige dingen zijn erg slecht af te lezen van een scherm en daarvoor is fysiek onderwijs erg belangrijk.

De drempel is hoger online om alles te delen en mensen dingen toe te vertrouwen. Een gesprek met de studieadviseur is daarom liever op de campus dan online. Dit geldt ook voor begeleiding. Dat is beter als het op de campus plaats vind.

Denkt u dat er toekomst zit in het combineren van online en fysiek onderwijs?

Ja hier zit zeker toekomst in we weten nu wat er kan en niet kan. Ik zie het niet snel terug gaan naar hoorcolleges met 800 mensen. Dit is iets wat makkelijk verplaatst kan worden naar online.

Hoe zou u het onderwijs in de toekomst het liefst ingericht zien ?

Blended learning is het onderwijs van de toekomst. Hiervoor is het belangrijk dat de colleges online zijn en niet meer in grote volgzalen daarvan zie ik het nut niet meer. Werkgroepen moeten op de campus. Flexibiliteit van het onderwijs is ook echt een must. Geld moet geïnvesteerd worden in iets anders dan de stenen van de gebouwen dit kost gewoon heel veel geld. Liever investeren in het onderwijs.

Goede begeleiding is nodig voor studenten zodat je weet waar ze mee zitten en dat ze met hun problemen terecht kunnen. Maar ook ondersteuning voor docenten zodat ze weten hoe ze online moeten omgaan met hoe de systemen werken.

Voor eerstejaars is het toch het belangrijkst dat er veel indien niet alles op de campus plaats vind zodat ze vrienden kunnen maken en structuur hebben in hun studie tijd dit is minder belangrijk voor oudere jaars. En overall neemt het minder plaats in als er minder fysiek les wordt gegeven.

Zijn er nog dingen die u zou willen toevoegen waarvan u denkt dat dat wellicht waardevol is voor mijn onderzoek?

Al het onderwijs is gericht op fysiek, ook het krijgen van geld van de overheid en de Europese overheden. Als je het onderwijs anders inricht moet je ook op een andere manier geld werven. Ook voor de rankings van de TU zal anders gekeken moeten worden als er overgegaan wordt naar blended learning. De accreditatie is anders dan voorheen.

Als er meer online onderwijs is, is er meer plek over voor fysieke vormen van onderwijs. Maar ook kunnen er makkelijker extra vakken gevolgd worden op andere universiteiten als je niet fysiek aanwezig hoeft te zijn. Dit kan meer zekerheid brengen voor studenten omdat ze een vollediger cv hebben met aangevulde vakken, wat erg waardevol kan zijn.

Er moet wel een balans zijn tussen live college en niet live college. Ook moet gedrag van studenten online gemonitord worden of ze wel goed in hun vel zitten of dat ze vakken volgen en geen drop out worden . Dat kan leiden tot dat studenten zich minder gedistantieerd voelen van anderen en blijven ze zich beter inzetten voor hun studie.

F

Focus set-up

This appendix shows the set-up of the focus group, the checklists used and the complete focus group sessions including, some background on the participants and all statements made. In total 15 participants, both male and female participated in these focus group sessions. During these sessions the researcher twice made use of a volunteer moderator and once of a volunteer assistant.

F.1 Focus group set-up

The set-up of the focus group discussion is the following, first the participants are welcomed, then an introduction to the thesis will be given as well as the goal of the focus group meeting. The rules of the meeting will be then explained. After that the first question can be asked.

The focus group discussion has five different types of questions, namely opening, introduction, transition, key and ending questions (Morgan, Krueger, & King, 1998).

The discussion starts with the opening, participants are asked to answer a simple question about who they are and what they currently study. This opening questions is to make the participants feel comfortable and should be easy to answer quickly. The opening question is not used to gain usable information for the research (Morgan et al., 1998).

When the opening question is answered by all the participants the moderator will transition to the introduction question. This introduction question is used to introduce the general topic of the discussion and to steer towards the focus of the discussion's topic. This question can also be used to gain knowledge about the overall experience of the participants with the topic. The participants' answers can lead to follow-up questions as well (Krueger, 1997).

After the introduction question the moderator will move to transition questions. These questions help to create a broader scope for the participants about the topic and a link between the introduction questions and the key questions of the discussion (Krueger, 1997).

When the transition questions are finished, the moderator transition to the key questions of the discussion. These questions are the main part of the discussion and are used to get in-depth information about the topic. On average two to five key questions are composed. Each of this questions take about 10 to 15 minutes to answer.

To end the discussion ending questions will be asked. These questions are used to reflect and summarize the discussion and it allows the moderator to answer existing questions of the participants. It also gives the participants the opportunity to give their final opinion on the topic (Morgan et al., 1998).

F.2 Focus group interview guide

This section is used as a guide for the moderator during the focus group discussions. The guide consists of the context of the study, ground rules and questions as well as what is needed to be able to conduct the discussion successfully.

Introduction

Welkom allemaal, bedankt dat jullie willen meewerken aan deze focus group meeting voor mijn afstuderen. Ik zal allereerst wat over mijzelf vertellen en over mijn afstuderen. Daarna zal ik het doel van deze focus groep geven en het onderwerp. Nadat ik mijn thesis onderwerp heb toegelicht zal ik het woord geven aan de moderator. De moderator zal de discussie leiden en ik zal verder niet deel nemen aan de discussie. Hij/zij zal de regels uitleggen die gehanteerd worden tijdens deze meeting. Hierna hebben jullie nog de mogelijkheid om vragen te stellen. Vervolgens zullen we starten met de daadwerkelijke discussie. Deze sessie zal opgenomen worden zodat ik later alle antwoorden kan analyseren. Maar jullie hoeven niet bang te zijn dat jullie naam ergens genoemd zal worden, het zal volledig anoniem zijn.

Ik ben Irene Overkleeft. Ik studeer transport, infrastructuur en logistiek. En ik ben momenteel bezig met mijn master thesis. Tijdens mijn master thesis zal ik een kosten baten analyse uitvoeren om zo een vergelijking te kunnen maken tussen verschillende beleidsvoeringen om piek drukte in de trein te verlagen. Vandaag zullen we doormiddel van deze focus groep gaan kijken welke mogelijkheden er daadwerkelijk zijn voor het verlagen van de piekdruk door studenten te weren in de spit, voor welke alternatieven er draagvlak is en wat ervoor nodig is om deze daadwerkelijk te implementeren. De scenario's die tijdens deze sessie bedacht worden zullen worden meegenomen in de kosten baten analyse. Jullie zijn uitgenodigd, omdat jullie allemaal te maken hebben of hebben gehad met de situatie van online lessen volgen en omdat jullie allemaal wel eens met de trein reizen en studeren.

Dan geef ik nu het woord aan de moderator. De moderator zal zichzelf kort voorstellen.

Allereest zullen de volgende regels van kracht zijn tijdens deze sessie:

1. Er zijn geen foute antwoorden, ik ben zowel geinteresseerd in positieve als negatieve antwoorden. Wees niet bang als je een andere mening hebt dan iemand anders, laat dit vooral horen.
2. Iedereen heeft een naamkaartje zodat jullie elkaar bij de naam kunnen noemen. Het is toegestaan om door te gaan op een antwoord van een ander. Maar het is niet de bedoeling dat er door elkaar heen gepraat wordt.
3. Als er bepaalde mensen veel aan het woord zijn kan je gevraagd worden om andere de ruimte te geven om ook hun mening te laten horen.
4. Verder zal deze meeting opgenomen worden, zodat er geen opmerken gemist worden. Jullie namen zullen niet in het verslag worden genoemd. Jullie opmerkingen zijn vertrouwelijk.
5. Als je je telefoon op geluid hebt staan zou ik je willen vragen deze op stil te zetten.
6. Verder is het toegestaan te eten en drinken tijdens deze sessie.
7. Ik zal de discussie leiden maar niet deelnemen aan de discussie.

Questions

This part shows the question that are used as a guide during the focus group discussion by the moderator. The questions are in Dutch since the participants of the group are Dutch.

Type vraag	Vraag	Duur (min.)
Opening	Vertel ons wie je bent en wat je momenteel studeert.	1-2
Introductie	Deze discussie zal vooral gaan over de verandering van college tijden en roosters voor studenten om de spits druk te verlagen. De afgelopen tijd zijn er noodgedwongen maatregelen getroffen, zodat studenten vanuit huis konden studeren. Hoe hebben jullie het afstand onderwijs ervaren de afgelopen tijd?	5
Transitie	Hoe is het onderwijs de afgelopen tijd ingericht qua colleges, projecten, werkgroepen, tentamens, etc.?	5
Hoofd	Wat vinden jullie de voor en nadelen van het volgen van online onderwijs? Met andere woorden wat zijn de gevolgen voor jullie?	5-10
Hoofd	We hebben het beleid van de universiteit besproken, hoe het afstandsonderwijs is ingericht. Maar er zijn ook plannen van het kabinet en de NS om studenten te weren in de spits door lestijden en dergelijke te veranderen. Stel studenten worden geweerd tijdens de spits. Hoe denken jullie dan dat dat het beste gedaan kan worden? (ook huidige beleid mag genoemd worden). Hoe denken jullie dan dat dat het beste gedaan kan worden op de lange termijn? In andere woorden wat zijn volgens jullie manieren om studenten uit de spits te krijgen door middel van het doorvoeren van veranderingen in het onderwijs?	10-15
	Maak een lijst van de genoemde alternatieven (Assistant)	
Hoofd	De volgende alternatieven zijn voorgesteld (assisent noemt opsomming van de alternatieven). Zouden jullie deze opties kunnen rangschikken van meest geschikt naar minst geschikt (doe dit als groep)? De 3 alternatieven die jullie het meest aanspreken zijn (De assistent noemt de alternatieven). Van deze alternatieven zullen we bespreken welke maatregelen/ implementaties er nodig zijn om dit daadwerkelijk uit te kunnen voeren. En wat voor invloed het alternatief heeft op jullie. Beiden punten zullen we eerst voor alternatief 1 bespreken dan 2 dan 3.	10-15
Hoofd	Wat is er volgens jullie nodig om alternatief 1/2/3 (omschrijf alt. 1/2/3) uitvoerbaar te maken?	5-10
Hoofd	wat zijn de voor en nadelen van dit alternatief voor jullie? Of wat zijn de gevolgen voor jullie?	5-10
Afsluiting	Wat zouden jullie adviseren als er overgegaan wordt tot het weren van student uit de spits?	5

Moderator's assistant checklist

The following checklist is used to make sure the assistant is able to perform well. This list is retrieved from Krueger and Casey (2009).

1. Make sure all listed equipment is available:
    - List of participants
    - Question guide
    - Laptop
    - Audio recorder
    - Microphone(s)
    - Note block
    - Pens/ pencils
    - Correct names in Zoom
    - Present for participants
    - Contact information
2. Zoom set-up, availability of a waiting room.
3. Test if the equipment is working properly (record function).
4. Welcome the participants when they arrive, letting them in the Zoom meeting.
5. Take notes during the discussion.
6. Monitor the recording equipment during the session.
7. Make sure everyone uses their microphone and camera properly.
8. Give a summary of the most important views of the discussion.
9. Arrange meetings to hand out the presents for the participants and thank them for their attendance.
10. Debrief with the moderator.

G

Full focus group meetings

G.1 Focus group 1

The first focus group took place on July 21st from 4 pm to 6 pm. For the first group 5 participants are selected, both male and female. The moderator during this focus group was a volunteer and the assistant's role was full filled by the researcher. After the session a debriefing took place.

Participants

Participant 1

- Male
- 21 years old
- Living in Delft
- Studying Civil Engineering (BSC) at TU Delft

Participant 2

- Female
- 24 years old
- Living in Amsterdam
- Studying linguistics (MA) at UVA
- Travelled daily to university by train during her bachelors.

Participant 3

- Female
- 24 years old
- Living in Delft
- Studying IDE (MSC) at TU Delft

Participant 4

- Female
- 24 years old
- Living in Delft

- Studying TIL (MSC) at TU Delft
- Travelled daily to university by train during her bachelors

Participant 5

- Female
- 24 years old
- Living in Delft
- Studying Aerospace Engineering (MSC) at TU Delft

Note based transcription

How did you experience the distance learning?

Studying is going slow, because of the circumstances. Especially the projects are going much slower, since all communication is going via Skype or Zoom. Furthermore, I study at the same spot every day of the week for the entire day. Because of this I am feeling the walls are closing in. I am not very happy with the entire situation.

Practical courses needed to be followed online, however this was not really working for me. From the third quarter on we had to work from home, this was doable. However, most courses were not thought through yet, since exercises were not explained instead we had to learn the course by reading the book. This caused me to failing the course and not being allowed to finish my bachelor thesis because I did not have enough credits. Furthermore, I was planning to do my minor abroad, however due to Covid-19 this was cancelled.

I live on my own in Delft and my roommate returned to her parents. I experienced the living alone as boring. Therefore, I returned to live with my parents again. Furthermore, I was doing an internship, which I had to finish from home as well and meetings took place via phone. The solution worked for me. I missed the social interaction, also studying together was not possible. Lastly, I dropped exams since I lacked motivation and didn't feel well.

How is the education arranged in terms of lectures, projects, exams, etc. recently?

Courses were postponed from third to fourth quarter and exams were online. The way of examining was OK, for this Maple TA and Cos were used. The online learning environment was known for the students. However, the questioning differed from the previous exams. For example, you only get credits for the final answer instead of all steps. However, for me the exams worked fine.

I had one exam that changed from a three hours written exam to half an hour oral exam. This was only changed a week ahead. I experienced this as horrible. During the oral exam you didn't get the change to answer the question at a later point in time. This led to much stress for me. At another exam I needed to use proctoring software. However, this was very weird, since I had to break the rules to hand in my exam. I had to make a picture with my cellphone and send it to the teacher by mail. This was very weird. I also had to scan my room before starting my exam and it took a long time until I got my grade.

I also heard people had trouble handing in their exams and had to redo the exam during the re-sit. If the system fails you have to do it again.

I was afraid my graduation project would be cancelled, this luckily didn't happen. I have the possibility to go to my graduation company twice a week.

At the 3ME faculty half of the exams were fraudulent, because the students needed to take pictures of the exercises. Therefore, all students were allowed to do the re-sit.

For my non-proctored exams the code of honour had to be signed. So it was very easy to crib, however I didn't do that. For the Python course I teach, a plagiarism test was used to see if there was fraud. It turned out two couples handed in the same results.

Lectures from third quarter are cancelled we had to learn from the book.

What are the pros and cons of the distance education?

Teacher are bothered by the fact they cannot see if students understood the topics. Usually the last 10 minute of the lectures is used to chat with the teacher, to gain insight how the lecture went. It is feedback for the teacher.

Students will not go to a teacher with their problems, therefore the problems are hard to solve.

I followed two pre-master courses, no online lectures that was hard. I only needed to hand in exercises. I never saw the teacher, I experienced this as a disadvantage. Following lectures and knowledge transfer from teacher to student is better and more motivating on campus. A lot of information is lost when a teacher is not giving lectures and you have to study the course yourself.

I don't have an reference material, since I have no contact with other students about the courses. It is hard to deal with your own mind, because you give yourself a high target.

Stay at home is hard for everyone. To get the right rhythm is hard, this is easier to do together. The days are long and passing by very slow. I am also feeling less productive. It is hard to get up on time and when I started working it is hard to take a break. When I take a break it i hard to start working again. I think a schedule can help to stay motivated.

A change in the environment will help to keep motivated, not only being in your room but also at the library or university. The same place will get you bored and the concentration is bad. Braking the same rhythm every day is also useful.

Disadvantage of online education is that you will miss a lot.

How do you think the number of students can be reduced in the train during the peak hour?

- Less lectures in general
- More online education with better support
- Following the lectures live online (at home)
- Using an E-bike instead of public transport (mainly useful for short distances).
- Stimulating living on campus.
- Group projects not in the morning.
- 11:00-20:00 instead of 9:00-18:00 (I think this is not a good solution, since students have a social life too).
- Only practicals on campus
- More on campus education for freshmen, less for the rest of the students.
- No individual projects.

Which of the listed alternatives do you prefer?

- More online education with better support: 2 votes
- Stimulating living on campus: 5 votes
- Following the lectures live online (at home): 4 votes
- Using an E-bike instead of public transport (mainly useful for short distances): 2 votes
- Only practicals on campus: 1 vote

What is needed to implement the preferred alternatives?
Online education (with better support)

Students should be able to ask questions and get answers. It should not take ages to get answers.

The quality of the lectures and education should be good, this means the sound, video is good. And there should be no problems with online education in general.

The structure of a MOOC is very nice. With weekly tasks and exercises. It will help students to keep motivated and have a schedule. It has a good structure and exercises are available, as well as questionnaires.

The use of a discussion form will be helpful for students, so that students can easily ask questions.

It should be possible to ask questions one to one. Just as in the normal situation students should be able to go to the teacher and ask questions, instead of only using the chat function of Zoom or e-mail the teacher.

Compensation is needed to have human contact, not only with teachers but students want social interaction with each other as well.

Stimulating on campus

I think it is hard to accomplish this, since a lot of investment is needed in housing.

Houses should be build and facilitated. The university should help students to find appropriate student housing.

The student grant should make a comeback, so that students have the money to live on their own. Right now they have to take a student loan or parents who can afford to giving money to their child. So that they can live in the city they study.

It is needed that students who graduated move to new houses, so that they make room for new students. For example all students should move within half a year after graduation, even if they don't live in social student housing.

Maybe it is an idea to build housing especially for first year students, then they have everything at the same place.

Using e-bike

Stimulating people, who live relatively close to campus, to buy an e-bike. They should not travel by train.

Money needs to be available to subsidize investment in an e-bike.

It also can help to change the free public transport card to cash. This is not an option at the moment.

Specific zip codes are not allowed to have a student public transport card. Or a mandatory swap from public transport to bike.

What are the pros and cons of each alternative?
Online education

- It is possible to learn at own pace.
- It is very hard to have social interaction with online education. So it is not fully replaceable.
- It is possible to watch back lecture whenever it fits your schedule.
- Lectures on demand are very chill.
- It is nice to follow lectures together, that is not possible when everything takes place online.

Stimulate living on campus

- This alternative can lead to too many students in the city center. The city will decrease if this is implemented, because more buildings need to be build.
- Students might have more interaction with the student associations.
- A benefit is that friends live nearby and they will therefore have more social interaction than when they live with their parents.
- Less students will travel by train.
- It will stimulate interaction between students.

Using e-bike

- It is a very specific target group if people that live close to campus need to change to using an e-bike.
- I wonder how many students will change from using public transport to cycling to university.

What is your advise if students will be banned during the peak hours?
Due to time constraints this question was not asked during the first focus group session.

Debriefing

During the debriefing a couple points of improvement came up. First, to much time was spent to the first couple of questions. This caused that the some of the main questions were rushed and there was no time left to discuss the last question. The first to question were discussed in depth, while this was not planned since this were introductory and transition questions. For the following groups the time schedule will be handled differently, so that most time is spent to the most important questions.

During this first group, it was hard for the assistant to see the transition between the first and second question, because the moderator blended them together. A clearer transition is easier for the assistant to transcribe.

Another thing that was very noticeable, was that the participants needed encouragement to talk. The moderator had to name each participant to get the answers. It might that is wasn't clear participants could react to each other's comments. For the next focus groups the participants will be made clear this is allowed.

The summary given by the assistant at the end of the session didn't seem to add much to the discussion. Since, partial summaries were given along the session. Therefore, this will be left out in the other sessions.

Last, the moderator forgot to discuss the e-bike alternative in the first place. Therefore, this alternative is briefly discussed later on. However, this led to no in depth answers.

During the session it was easy to communicate and steer the moderator, since the private chat was used during the discussion. The size of the group was also manageable online.

G.2 Focus group 2

The second focus group took place on July 22nd from 4pm to 5.30 pm. This group consisted of five participants, both male and female. The moderator during this focus group was a volunteer and the assistant's role was full filled by the researcher.

Participants

Participant 1

- Male
- 24 years old
- Living in Delft
- Studying Aerospace Engineering (BSC) at TU Delft
- Travelled by train to university in his first year.

Participant 2

- Male
- 23 years old
- Living in Delft
- Studying Maritime Engineering (MSC) at TU Delft
- Studied abroad during Covid-19 but finished the program in the Netherlands.

Participant 3

- Male
- 27 years old
- Living in Delft
- Studying TIL (MSC) at TU Delft

Participant 4

- Female
- 22 years old
- Living in Delft
- Studying Technical Medicine (MSC) at TU Delft
- Has to travel to different universities by train

Participant 5

- Female
- 23 years old
- Living in Delft
- Studying Building Technology (MSC) at TU Delft

Note based transcription

How did you experience the distance learning?

Besides following lectures, I am a teacher. It is very hard to teach online, it is challenging to get students attention and it is hard to estimate the students' level. However, in terms of social activity not much changed for me, since I live with friends on the same floor.

During this whole situation the response time of teacher was very long and they didn't respond as much as they used to.

The measures due to Covid-19 struck during a major project. Doing the project at the company was therefore impossible. We had to Skype with the supervisors and work online. When everyone was settled, it worked fine. However, the coordination of the project was still a struggle, because not everyone was prepared to work fully online.

Courses that need interaction are hard to do, but smaller courses with small groups is doable.

During the third quarter all courses were cancelled. In the fourth quarter the courses were resumed. After the restart of the courses it went OK, because teacher were willing to answer questions and this was well prepared.

How is the education arranged in terms of lectures, projects, exams, etc. recently?

The teacher were easily accessible. In the third quarter Skype meetings were planned ahead. Therefore, it worked very well. Furthermore, I didn't have any exams only group projects. The group project I did consisted of 8 people. This made it very hard to do the project. Everybody got frustrated. The presentation was online instead of at the faculty.

It is harder for teacher to get feedback from students, so teachers are not really able to estimate the level of the students. Furthermore, it is hard for the teachers to see if they are going to slow or to fast.

I did a group project with five people, this went well. The teacher organised two question hours a week.

My written exam changed from written to oral. The examination took place via Zoom without monitoring.

I had some exams with proctoring. One of my exams had the same amount of questions, while the time to finish the exam was half the time. This caused that nobody was able to finish it in time. I also did some exams without proctoring, with these you were allowed to keep your notes aside.

During the online courses we could reach teachers via e-mail or WhatsApp.

What are the pros and cons of the distance education?

I am missing the studying with peer students. The balance between studying and private life is gone, since it takes place at the same location and there is no reason to leave the house. Therefore, it is hard when it is work time or private time.

Discussing technical content of courses is very hard if you cannot do that in real life.

It is hard to work together with people of different faculties, since I had a group project with people I didn't know before. This causes that discussion is harder and going in depth almost never happens.

The project are of lower quality, because it is harder to tell the truth if something is wrong to people you don't really know. It is also very hard to get to know people via Zoom.

When a project is very intensive and long it is possible to get to know people.

If projects take the whole day it is as fun as normal. However, if you only need to discuss a couple of thing the meeting is more formal.

I think it is nice that the teachers are very accessible.

How do you think the number of students can be reduced in the train during the peak hour?

- Change the lecture hours
- Stimulate to travel shorter distance (living closer to university)
- Stimulate living on campus
- E-bike for short distance
- Less lectures
- Evening lectures instead of morning lectures
- Classes of the first year students in the afternoon (look at which groups travel at what time.)
- Plan courses online if possible (lectures for example), plan contact hours during the afternoon. (change the contact hours)
- Watching lectures live at home
- Record lectures and ask questions afterwards
- Place certain groups (zip codes) in different time slots, so that people are spread.
- Let the teacher travel to were the students are
- Spread the load over more transport alternatives
- Special student transport (busses)
- Change the lectures from 8:45 to 9:45
- Skip the breaks
- More flexible teaching hours
- Reform the free public transport during peak hours
- Education during the weekend.

Which of the listed alternatives do you prefer?

- Classes of the first year students in the afternoon: 1 vote
- Online education in the morning: 3 votes
- Contact hours in the afternoon: 3 votes
- Watching lecture live at home: 1 vote
- More flexible hours: 1 vote
- Special student transport: 1 vote

What is needed to implement the preferred alternatives?
Online education

Preparation videos that are posted online, so that student can prepare for the course in advance. Then these videos can be discussed in class.

Discipline is difficult for first year students. They might not do the preparation at home, because they don't feel the urge.

It is important to find out which courses are most suitable for online education, so that the quality loss is the least.

The exercises that can be done at home, should be done at home.

It might help if less classes will be taught in a shorter period to keep students motivated. Or another possibility is to only have larger courses (more ECTS), so that less courses need to be followed. It is easier to have an overview of all courses.

Contact hours in the afternoon

It is needed to work more efficient if there are less courses on campus. For example clear explanation is needed.

If no lectures are followed in the morning, these need to be followed later. This can lead to unfavorable hours. When the starting time of lectures moves to a later time, it is possible that students will not study before this.

The only option I see for shifting hour is to shift all lectures to the afternoon.

Some people like to start later, namely if you have to get up really early. It might be a possibility to change the lecture hours on the basis of zip codes.

Online education methods are not needed.

Classes of first year students to afternoon

It would be nice if universities discuss when certain groups will attend lectures on campus.

A dialogue is needed to determine, which groups go to university and at what time.

Maybe more infrastructure is needed, when everybody is coming at the same time, for example bicycle lanes.

What are pros and cons of each alternative?
Online education

- It is an easy way out for the NS.
- Socializing is harder online, this is a big disadvantage.
- Easy contact with the teacher is lost.
- Flexibility is needed if everything is online.
- It is hard to have the discipline to study from home.

Contact hours in the afternoon

- Inefficient times are not nice, because it messes with your schedule if one day the lecture is at 9 in the morning and the other lecture is at 11 in the morning.
- It is nice to start later during the day.

- Unused morning hours will lead to slacking during the morning.
- The morning hours which are not used for education need to be made up at another time.

Classes of first year students to afternoon

- Disadvantage is that it is harder to make friends and having a social life if you are only allowed to follow lectures in the afternoon.
- To much responsibility for first year students if they are only allowed in the afternoon.
- To much freedom is very hard for new students.

What is your advise if students will be banned during peak hours?
It is not fair that the students are the cause of everything according to the government. It would be nice if a research is done to find out which people travel when.

Debriefing

During the second focus group it was more clear for the participants that they were allowed to discuss on topics. This led both to participants agreeing and disagreeing on each other's statements.

The time distribution on the second focus group went well. Less time was spent to the first questions. The most time was spent at the main questions.

G.3 Focus group 3

The third and last focus group took place on July 29th from 4:30 pm to 6:00 pm. The group consisted of 5 participants both male and female. During this session the researcher herself was the moderator, the assistant role was full fulled by a volunteer.

Participant 1

- Male
- 23 years old
- Living in Delft
- Studying Civil Engineering (MSC) at TU Delft

Participant 2

- Female
- 21 years old
- Living in Delft
- Studying Industrial Design Engineering (BSC) at TU Delft

Participant 3

- Female
- 25 years old
- Living in Delft
- Studying Econometrics (MSC) at Erasmus University Rotterdam
- Has to travel to university by train

Participant 4

- Female

- 23 years old
- Living in Delft
- Studying Urbanism (MSC) at TU Delft

Participant 5

- Male
- 24 years old
- Living in Delft
- Studying Econometrics (MSC) at Erasmus University Rotterdam
- Has to travel to university by train

Note based transcription

How did you experience the distance learning?

I had to do my bachelor thesis from home. The threshold is much higher to get in touch with peer students, namely to discuss the project. Furthermore, it is hard to get motivated and to keep motivated.

Working in groups was hard, since I had to deal with group members that returned to their country of origin. This caused I had to deal with different time zones of different people. Planning group work was therefore very difficult.

The outcome of the project work was not what I would liked, because it was of lower quality.

How is the education arranged in terms of lectures, projects, exams, etc. recently?

The lectures are mainly recorded, so that the student can watch those from home. The question option could be used to ask questions during the lectures.

Many exams were replaced by individual exercises. The combination with online lectures worked well for me.

I had to conduct interviews, this was very easy since I was able to do this online. It took less time doing this online instead of at the location. Furthermore, people are more willing to help if you plan an interview online than when it is conducted in real-life.

Normally it is possible to go to the teacher's office to ask questions. Currently this is not possible. So if a teacher will not answer your question via email there is no possibility go to the office.

The most contact with the teachers take place via email. The importance of email is underestimated by the teachers. That is a shame.

The exams were shortened, normally an exam is 3 hours. Now the maximum length was only 90 minutes. However, many exams stayed the same as before online education took place.

What are the pros and cons of the distance education?

During the exams we had to make photographs of our answers. The way that this was organized was very inconvenient. I had to make a picture and send an email with my phone to hand it in.

The online education has an negative effect on the grades.

I think it is very important to be able to get in touch with the teachers. However, not all seem to feel the urge and therefore it is not always possible.

Following lectures online worked fine. Once a week I had the possibility to ask questions via Zoom. This work well.

The organisation of group work was very chaotic. Since it moved from campus to online, the set-up was not clear yet in the beginning.

The exams were not always organized very well and practical.

Online education leads to fun and creative ways to present the course content to students. It is not only taught through lectures, but short videos and exercises are used as well.

It is harder to individually ask questions to teachers, however teacher are looking for good alternatives to serve the students' needs.

Some of the exams change from being a written exam to an oral exam. Oral exams are as easy as the normal exams, since it can be done via online platforms like Zoom and Skype. No travel time for everyone, this is way more efficient.

To be able to have a good experience with online education, it is needed to have a stable internet connection. I had the problem that everyone in my building was home and therefore, I had sometime very poor connection. This led to having switched off my camera and sound so that I was at least able to watch the conversation. This wasn't ideal.

I am missing the interaction with peer students and also social contacts with other people.

Because of not seeing friends and peer students and as well as having to follow online lectures I ended up being unmotivated and in a dark place.

Sometimes the threshold to go study is lower instead. Since, your not allowed to do anything else like social interaction or go to parties.

Procrastination is right around the corner when it comes to watching lectures, because everything is recorded I don't feel the urge to watch it live.

How do you think the number of students can be reduced in the train during the peak hour?

- Introduce student grants, so that student have the money to live on campus.
- Make more student rooms available.
- Change the lecture hours, for example start the first lecture at 11 am instead of 8:45 am.
- Large scale education has to take place online and small scale education has to take place on campus. A combination between online and offline.
- Plan studies with few contact hours in an efficient way, so that these hours will take place of peak.
- Expand the free public transport and also include bike and car sharing systems, to spread the load over different modes.
- Subsidize e-bikes to stimulate alternative modes of transport.
- Implement e-bikes of Swapfiets.
- Implement different fares instead of infinite free travelling for students, in this way they might be more willing to travel off-peak.
- Stimulate other modes in combination with fare reduction for tram and bus.
- Dedicated student transport, for example a wagon especially for students.

Which of the listed alternatives do you prefer?

- Introduce student grants (student is able live on campus): 4 votes
- Make more student rooms available: 2 votes
- Large scale education online and small scale on campus: 5 votes
- Efficient planning of online and offline education: 1 vote
- Expand free public transport: 1 vote
- Subsidize e-bikes: 1 vote
- Implementation of different fares: 1 vote

What is needed to implement the preferred alternatives? During this session two preferred alternatives are combined, since they were so similar. The participants of the session were not able to see the difference. The two alternatives that are merged are introduce student grants (so that students is able live on campus) and make more student rooms available. According to the students one cannot go without the other.

Large scale education online and small scale on campus

It is needed that the quality of the sound and video recordings is high, so that student are not bothered with technical issues.

Clear communication about the way of education is needed. A schedule is needed for students, so that they know when they have to be at university or have to follow the lectures online.

it is important to place students into groups, for example zip code related, so that it is easier to schedule on campus education. The students in Delft can follow lectures in the morning since they don't need to travel.

The safety of online education software needs to be checked, so that no personal information will be leaked.

A media training will help teachers to handle the online education environment. So that they know how to present during lectures but also answer questions etc.

Maybe recording studios are needed to ensure the lectures are of the highest quality and make it more easy to record.

An improvement of the online social interaction will help students as well. Because the social interaction is very important for students.

Introduce student grants/ stimulate living on campus

If we want more students living on campus, more student rooms are needed.

It helps if only people living on their own get money and no money is available for people that live at home with their parents.

Stimulating alternative modes of transport to get from home to the campus, for example take the bus, tram or subway.

It might help to restrain travelling by public transport.

What are pros and cons of each alternative?

Large scale education online and small scale on campus

- The social interaction is missing, when all education will be online. The social interaction is especially important for new students, for example first year student and international students. They make friends at university, this is way more difficult to establish in a online environment. It might also help to organise non-education related event for those groups
- A big advantage of online education is the reduction of travel time.
- I think it is nice to be able to eat breakfast during the first morning lecture, which takes place online.

Introduce student grants/ stimulate living on campus

- Living on your own helps for self-development and to be independent.
- Some people cannot take care of themselves.
- The city center is not able to manage a large increase in student numbers.
- Residents don't like more students in the city center.
- More rooms are needed, this leads to more construction work, which is bad for the environment.
- Decrease of people that pass the BSA, because of lack of authority.
- Less time spent to travelling.
- Being able to study more since less travel time.

What is your advice if students will be banned during peak hours?

I think a more in depth research is needed to see which groups travel at what time. This needed to see which student groups are travelling, so that very specific measures can be implemented. And also look at for which people it is easy to work from home.

I think not all the focus should be always on the students but also other groups of people can be looked at.

From a political point of view the students are always disadvantaged, I think it is time to meet the student needs instead of taking things away.

I think the solution to the problem is to increase capacity and build more tracks and invest on trains. The maximum capacity is not reached.

Debriefing

During this last session the roles of assistant and moderator are switched, so that a volunteer made notes and the researcher was the moderator. Therefore, it was much harder to take notes of the most important things. Some statements are lost in this way.

During this session the participants agreed on much of each other's statements, so not much discussion took place. However, they went in depth on some of the topics.

H

CBA tables

This appendix shows the numbers and values used for all alternatives, but also alternative specific values. The standard values used for all alternatives are shown in tables, 8.1, 8.5, 8.6 and 9.1. The alternative specific values are shown of the different alternatives.

Then the costs and effects are shown per alternative. Starting with the baseline alternative in section H.2. Then the in section H.3 explains the costs and effects of the blended learning alternative. Lastly, H.4 shows the calculations for the student grant alternative.

H.1 Standard values

For the alternative policies (implementing student grant and blended learning) a low and high growth factor is used on the number of students and for the number of passengers over the project lifetime from 2020 until 2040.

For the calculation of the number of train travelers a high and low scenario are used. The base year of the passengers is 2019, due to the Covid-19 pandemic the number of travelers in 2020 decreased significant and are therefore not representative for the 'normal' circumstances. It is expected that in 2025 the number of passengers are the same as in 2019 and from then on will grow until 2040. The low scenario assumes a total growth of 27% until 2040 takes place. The high scenario assumes 45% growth between 2025 and 2040 (NS, 2019c). The yearly growth factors are shown in table H.1. Table H.2 shows the number of travelers per section in 2019. It can be seen that the section between Rijswijk and Delft is most busy. The maximum capacity on this section is reached the fasted. Therefore, this section is taken as a reference for the number of travellers during the peak hour. 35% percent of the peak hour travelers travels between 7-8 o'clock and 65% travels between 8-9 o'clock (CBS, 2016b). The non-facilitated demand is calculated for this section in specific. However, it is possible that other stations have capacity problems as well.

Table H.1: Growth of train travelers per year relative to the year before

Year	2020	2021	2022-2025	2025>
Low growth	0.084615	4.726	1.257433	1.016062
High growth	0.084615	4.726	1.257433	1.02508

Table 8.5 show the number of students in the year 2018/ 2019. A high and a low growth factor is applied to these numbers until 2026. These growth factors can be found in table 8.6. After 2026, the average growth per education type is taken. There were no numbers available for low and high growth after 2026, therefore only one growth factor is used (OCW, 2020b).

Table H.2: Number of travelers per trajectory section in 2019

The Hague CS to Rotterdam CS	**# travelers 2019**
The hague CS - The Hague Hs	11000
The Hague HS - Moerwijk	38000
Moerwijk - Rijswijk	38000
Rijswijk- Delft	39000
Delft- Delft Campus	37000
Delft Campus -Schiedam	38000
Schiedam - Rotterdam CS	34000
Rotterdam CS to The hague CS	
Rotterdam cs- Schiedam	33000
Schiedam - Delft Campus	37000
Delft Campus- Delft	37000
Delft - Rijswijk	39000
Rijswijk - Moerwijk	38000
Moerwijk - The Hague HS	38000
The Hague HS - The hague CS	10000
Number of travelers on averages at total trajectory	33357

H.2 Baseline alternative

This section shows the different costs and effects of the baseline alternative. The costs are based on a high growth of train passengers. Table H.3 shows the total costs and effects without discount.

Table H.3: Total investment costs and exploitation costs without discount (in mln euros)

Investment	**Year/ period of costs**	**Total costs in euros**
Emplacement The Hague CS	2020	€ 65.0
High frequency Rijswijk-Rotterdam CS	2020	€ 339.0
Free crossing Hollands Spoor - CS	2030	€ 100.0
Student rooms	2020-2023	€ 123.0
Trains	2020	€ 21.2
Buildings TU delft	2020-2040	€ 1,485.0
Exploitation		
Student rooms	2021-2040	€ 48.1
Railway infrastructure	2020-2040	€ 866.2
TU Delft	2020-2040	€ 1,805.9
Other impacts		
Exploitation revenue student rooms	2021-2040	€ 225.2
Tuition fee government	2020-2040	€ 76.1
Tuition fee students	2020-2040	€ 76.1
Non facilitated demand	2033-2040	€ 13.3

Investment costs

Railway investment

For the baseline alternative, it is assumed that the maximum train capacity is 5,512 people per hour between 2020 and 2024. After 2024, the new trains are implemented and the capacity will increase to 6,120 persons per hour. According to IenW (2019b) and Movares (2019) investments in trains and railway infrastructure are made four years before the maximum capacity is reached. The exact investment costs for the railway infrastructure are retrieved from those documents.

Furthermore, 4 new sprinter trains are bought in this alternative. The costs are calculated as follows.

- 302 sprinter wagons costs 400 billion euros (Treinreiziger.nl, 2018).
- 1 wagon costs 1.3 million euros.
- 1 sprinter consists of 4 wagons, which brings 1 sprinter to a cost of approximately 5.3 million

- The total costs of 4 new sprinter is 21.2 million euros.

Student room investment

Table H.4 shows the number of rooms built per year, after 2023 no rooms will be built. It is assumed that the investment costs are made in the year of building the student rooms. The investment costs are calculated by investment cost per m2 times average room size times total rooms built per year. The investment costs can be seen in table H.5.

- Investment costs per m2: 2,050 euros (Scheele-Goedhart et al., 2019)
- Average room size: 24 (Scheele-Goedhart et al., 2019)

Table H.4: Number of rooms built between 2020 and 2023

Year	**2020**	**2021**	**2022**	**2023**	**Total**
Number of rooms built	1573	287	339	302	**2500**

Table H.5: Investment costs student rooms

Year	**2020**	**2021**	**2022**	**2023**
Investment student rooms	€ 77,367,322	€ 14,106,829	€ 16,679,008	€ 14,846,841

Building costs TU Delft

TUD (2020b) expects the investment costs are 650 million euros in the next ten years. This means at least 65 million euros on a yearly basis between 2020 and 2030. The researcher assumes that for the baseline alternative the investment after 2030 will be 65 million euros yearly as well, since no other values are available. Therefore over the whole project lifetime the investment costs per year for the TU Delft are 65 million euros. However, in this expectation the growth of student numbers is not taken into account. To take this into account 2 extra buildings need to be built in 2023 and 2024. Costs of this is 120 million euros in total, this number is based on the fact that the TU Delft spent 60 million euros more on buildings when TNW Zuid was built (TUD, 2020b). The investment costs can be seen in H.6.

Table H.6: Investment costs on tu delft buildings

Year	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025>**
Investment TU Delft	€ 65,000,000	€ 65,000,000	€ 65,000,000	€ 65,000,000	€ 125,000,000	€ 125,000,000	€ 65,000,000

Exploitation costs

This section shows the exploitation costs of the student housing, the train infrastructure and the TU Delft buildings.

Exploitation costs student rooms

For the exploitation costs of the student rooms, it is assumed the rooms are built in one year and the following year after built exploitation costs are expected. The exploitation costs can be calculated by multiplying the exploitation costs per room by the number of rooms exploited per year. The exploitation costs are 1,000 euros per year per room. The number of exploited rooms can be found in H.7. From 2021 the costs increase until 2024. After 2024 the exploitation costs will be the same since no more rooms are built. The exploitation costs can be seen in H.8. The total costs can be found by summing the early costs.

Table H.7: Number of rooms exploited per year

Year	**2021**	**2022**	**2023**	**2024**	**2024>**
Number of rooms built	1,573	1,860	2,196	2500	2500

Exploitation costs train infrastructure

Table H.8: Exploitation costs student rooms

Year	2021	2022	2023	2024>
Exploitation costs	€ 1,572,507	€ 1,859,231	€ 2,198,235	€ 2,500,000

To calculate the exploitation costs of the trajectory between the Hague CS and Rotterdam CS the following formula is used.

$$Exploitation_{trajectory} = \left(\frac{rkm_{trajectory}}{rkm_{NLtotal}}\right) * totalinfracosts$$

Rkm trajectory is the traveled kilometers of the travelers on the trajectory, the value of this is 211 million kilometers. Rkm total is the total traveled kilometer by train in the Netherlands, this value equals 19 billion (KiM, 2018a). And the total infra costs are the total exploitation costs spent in the Netherlands, these equal 3,7 billion euros (van Essen & Schroten, 2014). The calculated yearly exploitation costs are 41.2 million euros.

Exploitation cost TU Delft

The housing costs of the TU Delft are retrieved from TUD (2020b). The costs from 2019 until 2024 are known. After 2024, it is expected that the costs of housing will decrease until 2030, the housing cost of 2030 are also known (TUD, 2020b). The growth factor between 2025 and 2030 is calculated by using the example calculation in section 8.2. The yearly growth factor between 2025 and 2030 is 0.992. The researcher assumes after 2030 that the costs for the baseline alternative will be stable, because other numbers are unknown. The exact housing costs of the TU Delft can be found in table H.9.

Table H.9: Housing costs TU Delft

Year	2020	2021	2022	2023	2024	2030>
Housing costs	€ 81,000,000	€ 87,000,000	€ 91,000,000	€ 88,000,000	€ 89,000,000	€ 85,000,000

Other impacts

The other impacts in the baseline alternative are, exploitation revenue of student rooms, tuition fee and non-facilitated demand.

Exploitation revenue student rooms The monthly fee of 1 student room is assumed to be 390 euros per month. The exploitation revenue is calculated by multiplying the yearly fee per student room time the number of rooms exploited. Table H.10 shows the exact exploitation revenue of the student rooms.

Table H.10: Exploitation revenue student rooms baseline alternative

Year	2021	2022	2023	2024≥
Exploitation revenue	€ 7,359,331	€ 8,701,200	€ 10,287,739	€ 11,700,000

Tuition fee

For the baseline alternative first year students have a discount on their tuition fee. Therefore, they pay less than other students and the government earns less fee from them. The costs are calculated by the number of first year students multiplied by their tuition fee. The number of WO first year is 16.3% of the total (OCW, 2020a), shown in figure 8.1. The tuition fee for first year students is 1030 euros per year.

Non-facilitated demand

As can be seen in figures 8.2 and 8.3 from 2030 there is non facilitated demand. This means not all passengers are able to board their preferred train and need to wait for the next train. This occurs when the new maximum capacity 0f 6,120 is exceeded. The numbers of passengers not served and the costs of it can be found in H.11. The costs of non-facilitated demand is calculated as follows:

- Average waiting time is 5 minutes if person is not facilitated.
- Number of passengers is multiplied by waiting time per person.

- Yearly waiting time is calculated by multiplying by number of workdays (255) (IenW, 2020d)
- Monetized by value of time of 9.76 euros/hour (IenW, 2020b)

Table H.11: Numbers of non facilitated passengers per year and costs of non-facilitated demand in mln euros

Year	2033	2034	2035	2036	2037	2038	2039	2040
Non-facilitated demand baseline	94	350	410	574	742	914	1,090	1,271
Costs non-facilitated demand	23,992	63,749	104,503	146,279	189,103	233,001	278,000	324,128

H.3 Blended learning alternative

Table H.12 shows the costs made for the blended learning alternative.

Table H.12: Total investment, exploitation and other costs (in mln euros) including year/ period of the costs

	Year/ period low	Year/ period high	Costs low	Costs high
Investment costs				
Emplacement The Hague CS	not implemented	2036	0	65
High frequency Rijswijk-Rotterdam CS	not implemented	2036	0	339 -
Free crossing Hollands Spoor - CS	not implemented	not implemented	0	0
Student rooms	2020-2023	2020-2023	123 -	123 -
Trains	not implemented	2036	0	21.2 -
Buildings tu delft	2020-2040	2020-2040	490.0 -	906.5 -
Exploitation costs				
Student rooms	2021-2040	2021-2040	48.1 -	48.1 -
Railway infrastructure	2020-2040	2020-2040	866.2 -	866.2 -
TU Delft	2020-2040	2020-2040	1295.3 -	1805.9 -
Other impacts				
Exploitation revenue student rooms	2020-2040	2020-2040	225.2 +	225.2 +
Tuition Fee government	2020-2040	2020-2040	76.1 +	76.1 +
Tuition Fee students	2020-2040	2020-2040	76.1 -	76.1 -
Online tools	2020-2040	2020-2040	262.7 -	262.7 -
Teachers' education	2020-2040	2020-2040	46.7 -	46.7 -
Wi-Fi	2020-2040	2020-2040	6.0 -	6.0 -

Investment costs

Railway investment

The investments made for the railway infrastructure and trains are made if the demand exceeds the current maximum capacity of 5,512 people per hour. As can be seen in figure 8.2, this number is in low growth scenario not exceeded therefore no investments are needed. In the high growth scenario that number is exceeded in 2040. The investments are made 4 years in advance. The same investment costs are expected for the implementations compared to the baseline. However, the free crossing will be built 10 years after the other railway implementations. This would be in 2046, however this is outside the lifetime of the project and therefore is not taken into account. Furthermore, all costs are discounted to be able to express these as current values. These values can be seen in chapter 9.5.

Investment costs student rooms

The investment costs in student rooms are the same for both low and high blended learning alternative compared to the baseline alternative, since no changes are made. Therefore, the costs are expected to be the same. Investment costs of student rooms are the same as in the baseline scenario, the exact numbers can be viewed in H.4, H.5.

Investment costs TU Delft

The investment costs in TU Delft buildings are lower for both low and high scenario of the blended learning alternative. Since it is expected half of the education is hosted online less buildings are needed.

For the low scenario it is calculated that 20 of the 37 buildings need to be transformed for online education the other buildings are not transformed. In the high scenario all buildings are transformed to be able to host both online and on-campus education. Transforming a faculty building cost around 11.7 million euros. This is based on the transformation costs of the civil engineering build of TU Delft (TUD, 2020b). Since the investments in the baseline alternative are made over a time period of 10 years, it is assumed that the buildings are transformed over a period of 10 years. For the low scenario this means 20 buildings in 10 years time. For the high scenario this means 37 buildings in 10 years. The total costs of transforming the buidlings in ten years are shown in table H.13. This table also shows the yearly investment costs between 2020 and 2040.

Furthermore, no extra faculties or buildings have to be build in the future.

Table H.13: Investment costs (in mln euros) for TU Delft buildings for low and high scenario

	Low	**High**
Investment costs over 10 years	233.3	431.7
Investment costs buildings TU Delft (yearly)	23.3	43.2

Exploitation costs

Student rooms

Exploitation costs of student rooms are the same as in the baseline scenario, because no changes are made in the number of student rooms built. The exact numbers can be found in H.8.

Railway infrastructure

It is assumed that the exploitation costs will be the same for both low and high scenario as the baseline alternative, because the students will still travel only they will travel at a different time. Therefore, the traveled kilometers are the same compared to the baseline.

TU Delft buildings

The TU Delft housing costs for the low growth scenario are the same as the baseline alternative until 2030. After that, it is assumed all 20 buildings are transformed and the remaining 17 buildings are not needed for education anymore. Therefore, the housing costs are only for 20 buildings from 2030 onward.

For the exploitation of the 20 buildings, the total exploitation costs of TU Delft buildings in 2030 are divided by 37. This number is multiplied by 20 to obtain the exploitation costs for the low blended learning scenario shown in table H.14.

The housing costs of the high growth scenario for blended learning is the same as the baseline alternative, the numbers can be viewed in H.6.

Table H.14: Housing costs low growth scenario (in mln euros)

Year	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030>**
Housing costs	81	87	91	88	89	88	88	87	86	86	46

Other impacts

Besides investment and exploitation costs, other impact are involved for this alternative as well.

Exploitation revenue student rooms

The exploitation revenue of the student rooms is the same for this alternative compared to the baseline since the same number of student rooms are exploited.

Tuition fee

The tuition fee is the same as in the baseline alternative, since nothing is changed compared to the baseline. The specific calculations of these costs can be found in H.2.

Online tools

Investments are needed to host online education. The tools needed that are taken into account are Zoom and MS teams. The TU Delft already has a license to facilitate Skype. These three are assumed most needed, according to the TU Delft expert. The costs are calculated for the total amount of licenses needed over the year for both students and teachers multiplied by the costs for a license. Zoom licenses are only available to teachers. The exact student numbers can be found in figure 8.1. The number of teachers can be found in table 9.1.

Table H.15: License costs in euros per year

License	For	Yearly cost per license
MS Teams	Student	85.7 (Microsoft, n.d.)
	Teacher	114.0 (Microsoft, n.d.)
Zoom	Teacher	1674.6 (Zoom, n.d.)

Teachers' education

Besides online tools, teacher need to get education for online lecturing. Costs are 410 euros per year per teacher (TUD, n.d.-b). This comes to a total cost of 2.2 million euros yearly.

Wi-Fi

Lastly, it is assumed every student and teacher has access to internet. However, not all have a good Wi-Fi connection according to the students from the focus group meetings. Therefore, it is needed that Wi-Fi amplifiers are provided to both students and teachers. The cost of one amplifier is 24 euros (bol.com, n.d.). Total costs are calculated by number of students in their first year from 2021 to 2040. For the year 2020 all students are taken into account assuming that nobody has an amplifier yet. The costs of the amplifier for teachers is calculated by using total number of employees at TU Delft, namely 5,421 (TUD, n.d.-a). Since no numbers are know about how many new teachers there are on a yearly basis. Every year 5,421 new amplifiers are bought.

H.4 Student grant alternative

In table H.16 the effects for the low and high growth scenario of the student grant alternative are shown. Compared to the baseline alternative some costs are the same and some differ. This section will explain all similarities and differences between the two alternatives.

Table H.16: Total investment, exploitation and other costs (in mln euros) including year/ period of the costs for student grant alternative

	Year/ period low	Year/ period high	Costs low	Costs high
Investment costs				
Emplacement The Hague CS	2028	2027	65 -	65 -
High frequency Rijswijk-Rotterdam CS	2028	2027	339 -	339 -
Free crossing Hollands Spoor - CS	2038	2037	100 -	100 -
Student rooms	2020-2027	2020-2027	249.9 -	306.0 -
Trains	2028	2027	21.2 -	21.2 -
Buildings tu delft	2020-2040	2020-2040	1,485.0 -	1,485.0 -
Exploitation costs				
Student rooms	2021-2040	2021-2040	85.3 -	102.5 -
Railway infrastructure	2020-2040	2020-2040	827.2 -	848.9 -
TU Delft	2020-2040	2020-2040	1,805.9 -	1,805.9 -
Other impacts				
Exploitation revenue student rooms	2021-2040	2021-2040	399.0 +	479.7 +
Tuition Fee government	2020-2040	2020-2040	152.2 +	152.2 +
Tuition Fee student	2020-2040	2020-2040	152.2 +	152.2 +
Student grant for student	2020-2040	2020-2040	1,301.4+	1,301.4+
Student grant government	2020-2040	2020-2040	1,301.4 -	1,301.4 -
Non-facilitated demand	2038-2040	2035-2040	0.08 -	0.6 -
Travel time saving	2020-2040	2020-2040	8.7 +	20.8 +

Investment costs

Railway investment

As in the blended learning alternative, investments on railway infrastructure and trains need to be made 4 years before the maximum capacity of 5,512 people per hour is reached. For both low scenario this amount is exceeded in 2032 and for the high scenario in 2031. Therefore, in 2027 and 2028 investments are made on the railway infrastructure and trains. 10 years after implementation of the infrastructure changes the free crossing is built. The investment costs are the same compared to the baseline. However, it must be taken into account that these values need to be discounted.

Student room investment

In the student grant alternative investments are made on the student room shortage. Therefore, more rooms are built. The shortage is expected to rise until 2027, since after that the number of students decreases (OCW, 2020b). In both scenarios total amount of rooms shortage is built, so that there is no shortage after 2027. Table H.17 shows the shortage of student rooms and the amount built per year.

The investment costs for the student rooms are assumed to be made in the year of building. These costs can be seen in table H.18. After 2027 no investment costs are made. The investment costs and the average room size are shown below.

- Investment costs per m2: 2,050 euros (Scheele-Goedhart et al., 2019)
- Average room size: 24 (Scheele-Goedhart et al., 2019)

Table H.17: Room shortage and number of rooms built per year

Year	2020	2021	2022	2023	2024	2025	2026	2027
Room shortage low	1,573	1,859	2,198	2,599	3,073	3,633	4,296	5,079
Rooms to build low	1573	287	339	401	474	560	662	783
Room shortage high	1,613	1,956	2,372	2,876	3,488	4,229	5,128	6,219
Room to build high	1,613	343	416	504	612	742	899	1,091

Table H.18: Investment costs (in mln) student rooms for low and high scenarios

Year	2020	2021	2022	2023	2024	2025	2026	2027
Investment rooms low	€ 77.4	€ 14.1	€ 16.7	€ 19.7	€ 23.3	€ 27.6	€ 32.6	€ 38.5
investment rooms high	€ 77.3	€ 13.4	€ 15.1	€ 17.0	€ 19.2	€ 21.6	€ 24.3	€ 27.4

Investment costs TU Delft

In this student grant alternative nothing is changed regarding investments in TU Delft buildings compared to the baseline alternative. Therefore, the costs are the same as in the baseline alternative. The exact calculations can be found in table H.6

Exploitation costs

Student rooms

For this student grant alternative more rooms are built compared to the baseline. Therefore the exploitation costs of these rooms will be higher. The yearly exploitation costs for one student room is 1,000 euros. The exploitation costs start one year after building, so there are exploitation costs for student rooms from 2021 until 2040. The exploitation costs are stable from 2028 onward, this can be seen in table H.19.

Table H.19: Exploitation costs of student rooms for low and high scenario (in mln euros)

Year	2021	2022	2023	2024	2025	2026	2027	2028>
Exploitation costs low	€ 1.6	€ 1.9	€ 2.2	€ 2.6	€ 3.1	€ 3.6	€ 4.3	€ 5.1
Exploitation costs high	€ 1.6	€ 2.0	€ 2.4	€ 2.9	€ 3.5	€ 4.2	€ 5.1	€ 6.2

Railway infrastructure

The exploitation costs for train infrastructure decreases for both low and high scenario of the student grant alternative, because less students travel by train. And the exploitation costs are calculated per traveled kilometer. The researcher assumed that 25% of the railway travelers is student and that between 8% to 18% will leave the train when this alternative is implemented. Therefore, the number of traveler decreases by 2% to 4.5%. This also lead to a decrease of 2% to 4.5% in traveled kilometers. The exploitation costs of the railway infrastructure are calculated the same way as shown in the baseline. Table H.20 shows the exploitation costs for the low and high scenario of the student grant alternative.

Table H.20: Yearly railway exploitation costs baseline and student grant alternative (in mln euros)

	Yearly costs
Baseline alternative	41.2
Student grant low (98% of baseline)	40.4
Student grant high (95.5% of baseline)	39.4

TU Delft buildings

In this student grant alternative nothing is changed regarding exploitation costs of the TU Delft compared to the baseline alternative. Therefore, the costs are the same as in the baseline alternative. The exact calculations can be found in table H.9.

Other impacts

Other impacts in the student grant alternative are, exploitation revenue of student room, tuition fee and non-facilitated demand. An effect is travel time saving of student that travel less since living on-campus.

Exploitation revenue student rooms

As explained in the baseline alternative, exploitation revenues are earned from exploiting student rooms. However, in the student grant alternative more student rooms are built. Therefore, the exploitation revenues are higher compared to the baseline. Table H.19 shows the exploitation costs for both high and low growth. The costs are obtained in the same way as in the baseline alternative.

Table H.21: Exploitation revenue student rooms (in mln euros) student grant alternative

	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2028>**
Exploitation revenue low	€ 7.4	€ 8.7	€ 10.3	€ 12.2	€ 14.4	€ 17.0	€ 20.1	€ 23.8	€ 23.8
Exploitation revenue high	€ 7.5	€ 9.2	€ 11.1	€ 13.5	€ 16.3	€ 19.8	€ 24.0	€ 29.1	€ 29.1

Tuition fee

In this alternative all students pay full tuition fee, which is 2060 euros per year instead of 1030 euros a year (OCenW, 2020). Therefore, the paid tuition fee of first year students is doubled compared to the baseline alternative. The government earns twice the amount as well.

Student grant

In this alternative every student in their nominal study time earns a student grant from the government. For students living at home this monthly fee is 108 euros. For students living on campus this is a monthly fee of 300.69 euros (DUO, 2020b). The total costs per year are calculated by multiplying the number of students living at home/ on campus by their fee.

Non-facilitated demand

For this scenario low and high percentage that is expected to move out to live on campus is taken into account. The low scenario is 8% less students students will travel by train. High scenario is 18%. This leads to lower non-facilitated demand. And higher percentage of students that save travel time. However, for both high and low scenarios there is non-facilitated demand. This can be seen in table H.22.

Table H.22: Non-facilitated demand per day and costs of non-facilitated demand per year

Year	2035	2036	2037	2038	2039	2040
Non-facilitated demand high	116	272	433	597	766	938
Cost non-facilitated demand high	€ 24,031	€ 56,480	€ 89,743	€ 123,840	€ 158,792	€ 194,621
Non-facilitated demand low	-	-	-	25	123	224
cost non-facilitated demand low	-	-	-	€ 5,126	€ 25,604	€ 46,410

Travel time saving

The travel time savings is calculated by the number of students that now do not need to travel by train, because they live on campus. Between 8% and 18% of the students that travel by train save time. It is expected they save 50 minutes traveling to and from the campus compared to the baseline alternative. VoT is used for calculating the effect.