



WHAT FIRST?

PUBLIC TRANSPORT OR HOUSES?

A study on the development timing of public transport in a residential area

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A study on the development timing of public transport in a residential area.

by

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PREFACE

Several years ago I travelled from Pijnacker to Rotterdam using the metro. Staring out the window I noticed several stops at places that seemed to be in the middle of nowhere. At that moment I wondered why the metro would stop there. This small moment of puzzlement was the seed for this research several years later: a study on the development timing of public transport in a residential area.

This thesis is the last step in obtaining my master's degree in Transport, Infrastructure and Logistics and concludes my education at the TU Delft. This study has inspired me to pursue a career in sustainable mobility, to contribute to a healthy and sustainable environment for us all.

I want to thank Royal HaskoningDHV for the opportunity and freedom to conduct a study on a subject of my own choice. A special thanks goes to my supervisor, Wilco Bos, who guided me through our weekly meetings and introduced me to a lot of interesting people in the field of public transportation. I also want to thank my TU Delft supervisors, whose enthusiasm, ideas and criticism helped me shape and improve my research. Furthermore, I wish to thank all of the interviewees, without whose cooperation I would not have been able to conduct my analyses.

Lastly, a big thank you goes to my boyfriend for critically reading my thesis numerous times and listening to my struggles during the process. I would also like to thank my friends and family for their support and distraction, not only during this process, but throughout my whole academic career.

Merel Slangewal
Rotterdam, March 2022

SUMMARY

Modern cities are seeking possibilities to create healthy, sustainable and liveable urban environments. Yet these endeavours should not come at the expense of the accessibility of the city. Therefore, many cities try to promote the use of sustainable modes of transportation within their legislative bounds. A concept that has become increasingly popular in this endeavour is Transit-Oriented Development (TOD) (Ibraeva et al., 2020). The reason for this interest is the influence both the public transport quality as well as the spatial layout of an area can have on travel behaviour. High quality public transport in a built environment with a spatial layout tailored to the use of sustainable modes of transportation can namely encourage the use of them, hereby serving as a replacement for the car (Faber et al., 2021).

One of the ongoing debates in the development of transit-oriented neighbourhoods, is the right development timing of a public transport connection relative to the development of the residential area it serves (Puylaert, 2021). Even though it is generally assumed that early provision of public transport is favourable, the significance of this notion has not yet been studied, and the considerations of the different parties involved in the decision making process in practice are unclear. Therefore, the aim of this research is to explore what development strategy of public transport in a residential area results in high ridership levels while still being feasible for the different parties involved:

"What development strategy of public transport in a residential area results in high ridership levels while still being feasible for the different parties involved?"

This research focuses on the development strategy of public transport in residential areas located in the Netherlands. The residential areas studied and the stakeholders involved are both studied in relation to the urban context.

METHODOLOGY

The answer to the research question requires insight in both the influence of development timing on travel behaviour and the development process in practice. To determine the influence of development timing on travel behaviour, two methods are applied: a literature review and case studies. The literature review is used to create a conceptual framework on the different mechanisms that influence travel behaviour in relation to development timing. This conceptual framework forms the basis of a hypothesis on the influence of development timing on travel behaviour. This hypothesis is tested with the aid of case studies, in which the effects of three different development timelines on travel behaviour are studied. The information received from both the literature and the interviews is used to draw conclusions on the influence of development timing on travel behaviour.

The second part of the research aims to provide insights in the different stakeholders involved in the process and their perspective on the development strategy. This part starts with desk research to obtain an in-depth understanding of the process and the stakeholders involved in it. The knowledge gained is validated and extended with the aid of interviews with stakeholders involved in the process. These interviews also serve to determine the view of the interviewees on the development strategy and the decision making factors they use to determine this. The answers on this subject are compared to identify the similarities and differences between them. In a second interview round, the results from the first round of interviews are presented to the interviewees to ascertain whether or not they agree with each other. From this round, conclusions are drawn on the decision making factors utilised and the development timelines resulting from them.

FINDINGS

The findings in this research can be attributed to two categories: findings on the influence of development timing on travel behaviour and findings on the development process in practice.



Influence of development timing on travel behaviour

The studied literature revealed that people who live in an area with a built environment tailored to sustainable modes of transportation, are more likely to use these sustainable modes than people who live in car-oriented neighbourhoods. Considering that habitual behaviour and life events both influence travel behaviour, there is a certain window of opportunity that people are more susceptible to a change in travel behaviour. Thus, when the built environment is optimised for the use of public transport and when people are subjected to this environment during the window of opportunity, theoretically, the chance is greater that they will use the provided services. On the contrary, when people are subjected to good public transport after they have lived at a location for a while, habitual behaviour can reduce the chance of them using public transport. This suggests that public transport should be provided as early as possible.

Based on this literature review, the following hypothesis was formulated:



"If the public transport connection is developed late, people will have developed other travel habits and the chance that they use public transport when it is provided, will diminish."

This hypothesis was tested using case studies of the Vinex neighbourhoods IJburg, Leidsche Rijn and Ypenburg, in which the effect of different development timelines on travel behaviour was evaluated. These case studies suggest that the early development of public transport results in less car usage in a newly developed residential area. However, they also show that the quality of public transport and the built environment play a role in this as well. The case studies namely revealed that people who move to a neighbourhood without (high-quality) public transport, often feel obliged to own a car to get around and that people who do have access to high-quality public transport own a car less often. Furthermore, the case studies also show that the provision of high-quality public transport in a later stage does not necessarily mean that it is doomed to fail, as average car-ownership levels can slowly decrease in the years after public transport is provided. Nevertheless, the hypothesis that late provision leads to a decreased chance in people using public transport, can be accepted.



Development process in practice

The desk research and interviews reveal that the stakeholders involved in the development process belong to two categories: governmental institutions and market parties. The governmental institutions involved are the national and regional governments, transport authorities and municipalities. The market parties involved are public transport providers, developers and consultants. The main players in the process are the municipalities and the governing transport authority. Together they make decisions on the development vision for the area. From the market parties, the party with the largest interest are the public transport providers.

Interviews with stakeholders from each of those three parties revealed the following the decision making factors: costs, benefits, location and assurance. The costs and benefits are weighed in a costs and benefits analysis. Governmental institutions use social cost-benefit analyses, while public transport providers base their decisions on the financial costs and benefits, as their goal is to make a profit from the service they offer. The preconditions of the location influence how early the public transport connection can and must be provided. The last decision making factor, assurance, relates to the need of mutual assurance between the different parties involved, to start with the development in the first place. This shows that the stakeholders themselves can be of influence as well.

Regarding the development strategies, all interviewees agreed that these differ per situation, and a tailor-made solution is required for each development. The interviews also revealed that the approach to provide public transport as early as possible, is a transition from basic to higher quality public transport as more and more inhabitants start to live in the area. With this approach, the type and frequency of public transport can be tuned to the specific situation. The interviewees also argued that it is important that people know when the public transport will be provided, as this might influence their decision to seek alternative transport options.

CONCLUSION

The literature, case studies and interviews reveal that there is no unequivocal answer to the question: "What development strategy should be followed to achieve high ridership levels while still being feasible for the different parties involved?"

The literature suggests that public transport should be provided as early as possible, as there is a certain window of opportunity in which people are more susceptible to a change in travel behaviour. This window of opportunity is the result of the interplay between life events and habitual behaviour. Where habitual behaviour keeps people from changing their travel habits, life events, such as moving, are a trigger to change them. This, together with the effect of the built environment on travel behaviour, suggests that the chance that people will use public transport, is greater when they are subjected to it during this window of opportunity, than when they are subjected to it later. The case studies provide a more nuanced view. They do suggest that the early development of public transport results in less car usage in a newly developed residential area, but they also show that the public transport quality and the built environment play a role in this as well. Furthermore, the case studies show that the provision of high-quality public transport in a later stage does not necessarily mean that it is doomed to fail, as car-ownership levels can slowly decrease in the years after public transport is provided.

The interviewed stakeholders argue that provision from day one is not feasible, as the revenues during early implementation are low and the budget available to subsidise public transportation is limited. They stated that a tailor-made solution is required for each location, as the feasibility of the development strategy and the need for early provision highly depend on the location. These tailor-made solutions are often devised using the same approach, being a transition from a basic to the final quality public transport connection as the development of the area progresses. This way, the first inhabitants do have access to public transportation, but the expenses do not skyrocket.

In short, the development strategy needs to be tailored to the specific development, as the feasibility of a development strategy and the need for early provision are highly dependent on the location.

DISCUSSION & RECOMMENDATIONS

This study has contributed to a better understanding of the influence of development timing on travel behaviour, and clarification of the challenges of providing public transport in an early stage. Where previous research focused on either the influence of the built environment on travel behaviour, or the moments in time that people are most susceptible for a change in travel behaviour, this research combined the two topics to explore if development timing can influence travel behaviour as well. The research shows promising results of early implementation for a reduction in car ownership levels and increase in public transport usage. This implies that policy measures aimed at the early provision of public transport can increase the use of public transport. The research also identified the different points of view of the stakeholders and unveiled factors that hinder the early provision of public transport.

There are, however, two main limitations to this research. The first is that the case studies might not portray the causal effect of development timing, as the differences between the case studies can also be caused by other factors than a varying development timeline. This, a limited sample size and missing data all mean that the exact effect of early implementation on the ridership levels remains unclear. Future research could address this limitation by applying a longitudinal research design to evaluate the ridership levels over time. The second limitation concerns the areas and stakeholders studied in the research. The stakeholders considered in this research did not include the national government or parties related to heavy-rail transport, but only stakeholders involved in the development and operation of urban public transport such as bus, tram and metro. The inclusion of these parties will result in another set of stakeholders with their own influence on and interest in the development timing, which might result in different or additional opportunities and obstacles for early implementation of public transport.

Furthermore, future research is recommended to determine if the early provision of any type of public transport is beneficial, or if the quality of public transport plays a major role in this as well. Additionally, this topic also relates to a recommendation for practice: careful attention should be paid to the quality of public transport provided from the start, to ensure that people are persuaded to leave their car at home, or better still, at their dealership.

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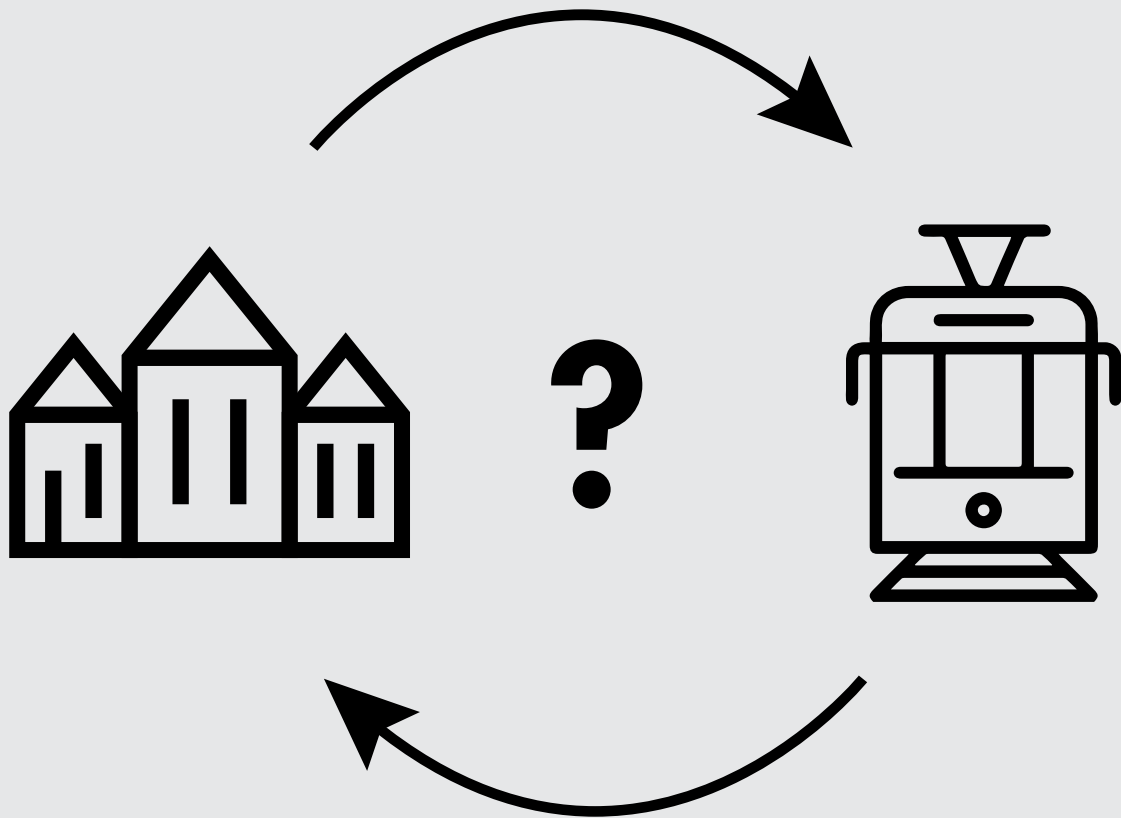
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INTRODUCTION

An introduction to the research

1

INTRODUCTION

What first? Public transport or houses? A question that sounds a lot like the chicken or egg dilemma. This chapter describes the background of this dilemma and argues why the question is deemed important. It also discusses the research questions that will be used to explore how this dilemma can be tackled and defines the scope and limitations of the research.

1.1. Background

The Netherlands is undergoing a population growth that is projected to continue for the coming 50 years (CBS, 2020b). This growth is expected to be the strongest in cities and their surrounding suburbs (see Figure 1.1), which leads to emerging issues such as congestion and environmental pollution experienced by growing cities all around the world (Pan et al., 2017). Therefore, more and more cities are seeking possibilities to solve these issues and create healthy, sustainable and liveable urban environments for today and tomorrow (Ibraeva et al., 2020).

Unregulated growth of urban areas will result in a growing number of cars in and around cities. Not only will this lead to more congestion, but it will also contribute to greenhouse emissions (Kuiken, 2016). Therefore, many cities try to promote the use of sustainable modes of transportation within their legislative bounds (Ibraeva et al., 2020). But how does one get people to use sustainable modes of transportation instead of their car?

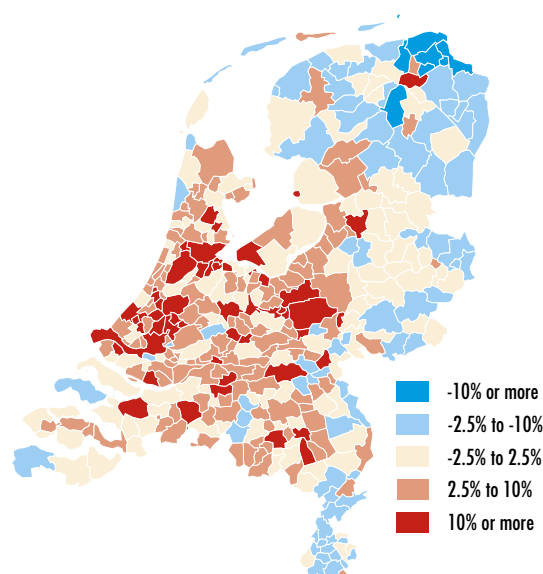


Figure 1.1: Population growth per municipality (CBS, 2019b).

A concept that has become increasingly popular in this endeavour is Transit-Oriented Development (TOD). The amount of research conducted on the subject has grown enormously since the 1990s (Ibraeva et al., 2020) and the concept has spread all over the world as an attractive way to make cities more sustainable. The reason for this interest is the influence both the public transport quality as well as the spatial layout of an area can have on travel behaviour. High quality public transport in a built environment with a spatial layout tailored to the use of sustainable modes of transportation can namely encourage the use of them, hereby serving as a replacement for the car (Faber et al., 2021).

Transit-oriented development is a planning concept that does exactly that. Its key characteristics being high housing densities in areas adjacent to high-quality public transport, a spatial layout in which walking and cycling infrastructure are prioritised and mixed land-use to provide activities closer to home (Ibraeva et al., 2020; Kamruzzaman et al., 2015). Figure 1.2 gives an overview of these characteristics.

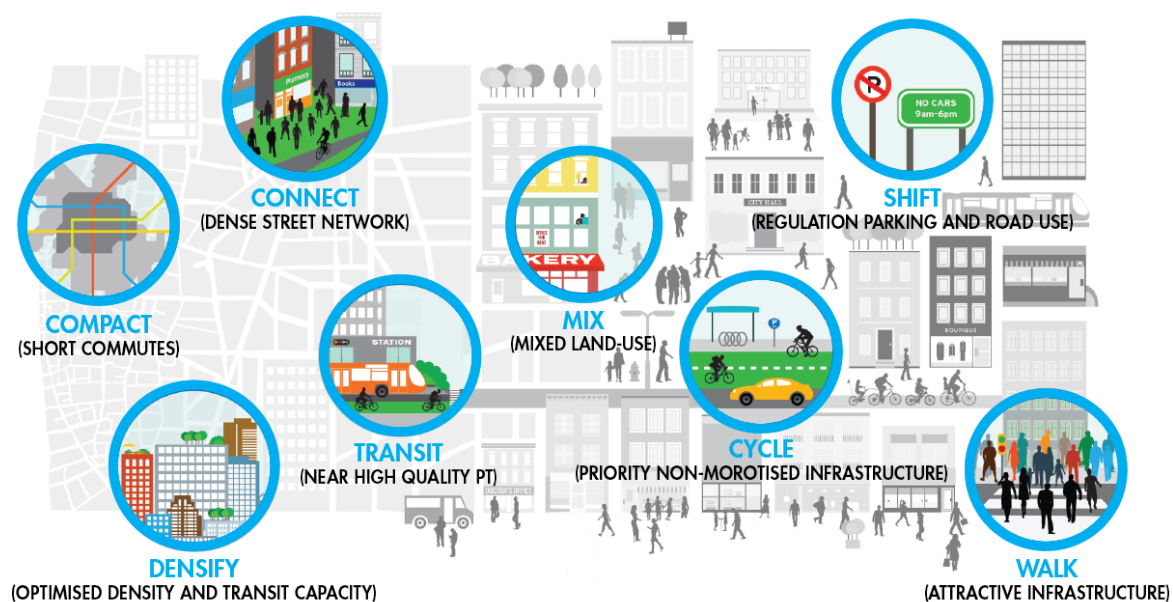


Figure 1.2: Design principles for transit-oriented built environments (image adapted from ITDP (2018)).

According to Ibraeva et al. (2020), who did a literature review on the subject, it can be concluded that residents living in these transit-oriented neighbourhoods are less inclined to use the car, as opposed to more traditional neighbourhoods, where the spatial layout is optimised for car-use and where the only function is living.

1.2. Problem definition

The development of transit-oriented neighbourhoods requires the integration of land-use and transport planning (Ibraeva et al., 2020; Deboosere et al., 2018). In practice, this means a collaboration between different institutions, who all have their own interests and priorities. Mismatches in these interests and priorities lead to debates in the decision making process, which make the process arduous and often results in trade-offs that do not give the desired outcome.

One of the ongoing debates in the development of transit-oriented neighbourhoods, is the right development timing of a public transport connection relative to the development of the residential area it serves (Puylaert, 2021). If the public transport connection is provided early, this will result in low ridership levels in the first years of the development, as not all of the intended users live there yet. These low ridership levels are a significant expense for the public transport provider, considering that they need to pay the operating costs even though they ride empty. However, this early provision also has advantages, as residents are more likely to use the offered transit connection when it is provided from the moment they start to live there (Thomas et al., 2016). The reason for this is that people are more likely to change their habits after life events such as moving. Late development on the other hand, might result in the formation of other travel habits such as car travel. As those habits do not easily change (Haggart et al., 2019), the risk may exist that people will not start to use the connection when it is provided in a later stage.

To resolve this dilemma, insights are needed in both the influence of development timing on travel behaviour and the decision making process around this development timing as followed in practice. This leads to the knowledge gaps for this research.



Need for insights in the influence of development timing on travel behaviour

To achieve the highest public transport usage, insights are needed in the influence of development timing on the travel behaviour. Current studies related to the subject focus either on the influence of the built environment on travel behaviour or on the moments in time that people are most susceptible for a change in travel behaviour. While both aspects are considered to be of influence, no study as of yet has investigated if the right timing of the development of a public transport connection, relative to the development of the built environment, influences travel behaviour as well.



Need for insights in the decision making process

Even though most stakeholders agree that the timely development of public transport in relation to the residential area it serves is crucial for the ridership levels, they all have different priorities with regards to the subject (Puylaert, 2021). What is a good solution for one party, may not work for another. To determine the development strategy that is feasible for all stakeholders involved in the process, there is a need for insights in the decision making process. Identification of the different views and main issues in the decision making process might help to align the views of the different parties and might help to improve the decision making process in the future.

1.3. Research aim and objectives

As mentioned in the previous section, there is an ongoing debate on the right development timing of public transport relative to the residential area it serves. Even though it is generally assumed that early provision of public transport is favourable, the significance of this notion has not yet been studied, and the considerations of the different parties involved in the decision making process in practice are unclear. Therefore, **the aim of this research is to explore what development strategy of public transport in a residential area results in high ridership levels while still being feasible for the different parties involved.** This is done through an evaluation of both the influence of development timing on travel behaviour and the decision making process around this development timing.

The research objective is split into two parts. The first objective is to determine the influence of development timing on travel behaviour, which is done through a literature review on the theoretical influence and case studies to substantiate this. The second objective is to gain insight in the decision making process around the development timeline. This is done through an evaluation of the process itself, the stakeholders involved, the decision making factors they use and their view on the development strategy to follow.

1.4. Research questions

To reach the goal as stated in the previous section, the following research questions need to be answered:

"What development strategy of public transport in a residential area results in high ridership levels while still being feasible for the different parties involved?"

Sub-questions:

1. What is the theoretical influence of development timing on travel behaviour?
2. What lessons can be learned from past development timelines?
3. What stakeholders are involved in the development process and what is their role?
4. What are the decision making factors used by the different stakeholders?
5. What is the 'ideal' development strategy according to the stakeholders?

1.5. Scope

This research focuses on the development strategy of public transport in residential areas located in the Netherlands. The residential areas studied and the stakeholders involved are both studied in relation to the urban context. An elaboration on this is given below.



Built environments

For the evaluation of past development strategies, Vinex neighbourhoods are scrutinised. These neighbourhoods, originating from the 1990's, are new-town greenfield locations located near existing city centres. The Vinex neighbourhoods selected for the research specifically aimed to discourage car usage and promote the use of sustainable modes of transportation. These neighbourhoods come closest to transit-oriented neighbourhoods as defined in international literature.



Stakeholders

The stakeholders considered in this research do not include parties involved in the development and operation of heavy-rail transport, but only the stakeholders involved in the development and operation of urban public transport such as bus, tram and metro.

1.6. Relevance

This thesis has both scientific and societal relevance, which will be discussed in this section.



Societal relevance

Insights in the decision making process around the development timeline can help to improve the decision making process in the future. If stakeholders can align their priorities and agree on responsibilities, this might result in a more effective transit-oriented development. That is, it might help to create development strategies that persuade more people to use sustainable modes of transportation over the car. Not only is this a win for different institutions involved in the planning process, the community also benefits from a more healthy, sustainable and liveable urban environment.



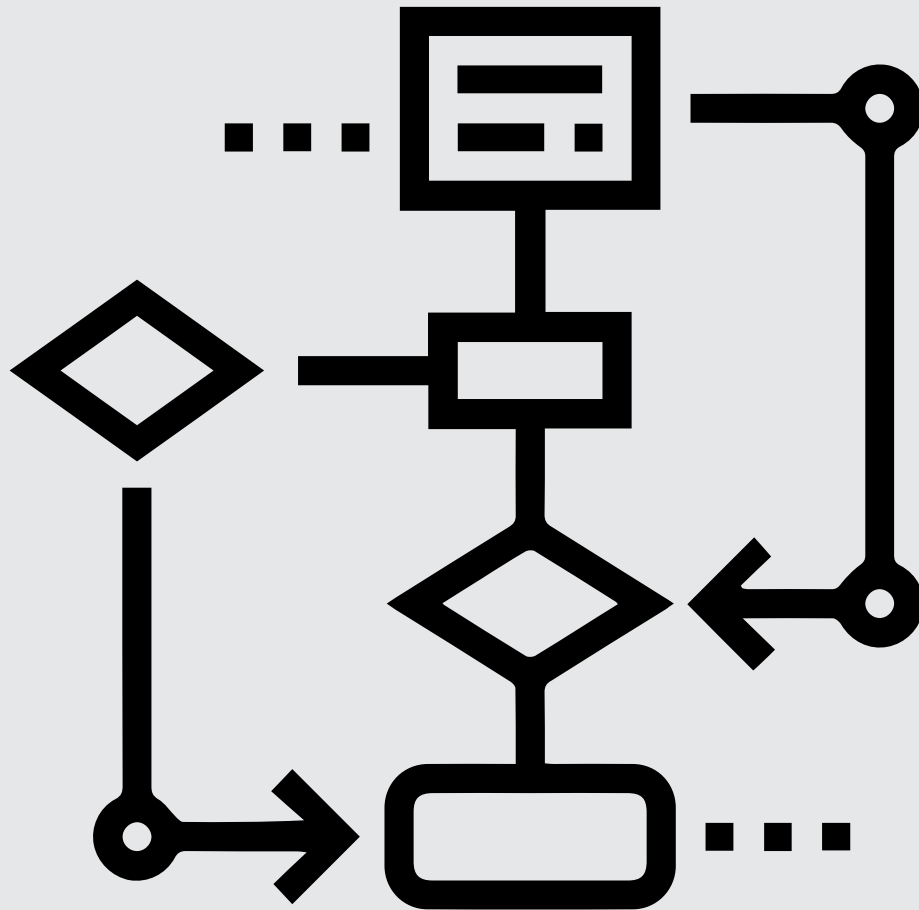
Scientific relevance

There is a lack of scientific knowledge to answer the question what development timing achieves the most public transport users while still being feasible for the different parties involved. This Master's thesis looks into the question, providing insights in both the influence of development timing on travel behaviour and the considerations of the different parties involved in the decision making process. Hereby, the study contributes to the clarification of the different aspects that need to be taken into account to answer the question.

1.7. Thesis outline

In this chapter, the aim and relevance of this research were identified and the research questions to reach the goal were formulated. Chapter 2 will discuss the research approach and methodology suggested to answer these research questions. It will elaborate on the type of research and the motivation for the proposed methods. The next chapter (chapter 3) presents the literature review on the relation between development timing and travel behaviour, in which a conceptual model on the mechanisms influencing travel behaviour in relation to the development timeline is established. Based on this conceptual framework, a hypothesis is formed on the influence of development timing on travel behaviour. This hypothesis is tested using case studies of past developments in chapter 4.

The development process and stakeholders involved in it will be introduced in chapter 5, after which the first round of interviews is discussed in chapter 6. The results from this round of interviews are presented to the interviewees in a second round of interviews, which is elaborated on in chapter 7. The conclusions on the decision making factors and development strategies resulting from these two rounds of interviews are elaborated on in chapter 8. The thesis ends with a conclusion on development strategy that results in high ridership levels while still being feasible for the different parties involved, a discussion on the insights obtained in this research and recommendations for further research and future development processes.



METHODOLOGY

Research methods and approach

2

METHODOLOGY

This chapter describes the research approach and methodology used to answer the research questions stated in chapter 1. The chapter is divided into two sections. The first section describes the research framework that is used to answer the research questions. The second elaborates on the use of the research methods and gives a motivation for the choice of them.

2.1. Research approach & design

The aim of this research is to explore what development strategy of public transport in a residential area results in high ridership levels while still being feasible for the different parties involved. This requires knowledge on the influence of development timing on travel behaviour and knowledge on the different stakeholders involved in the process and their perspective on the development strategy. To acquire this knowledge, the research approach as given in Figure 2.1 is used.

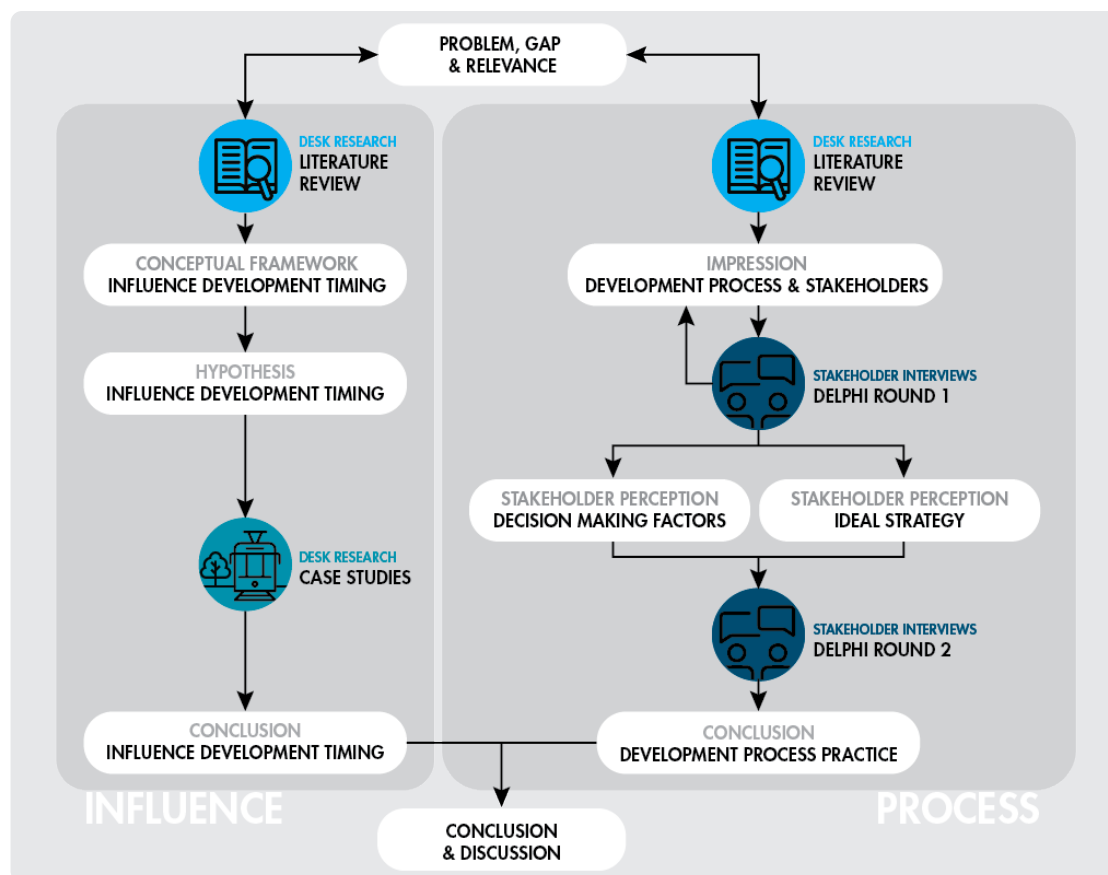


Figure 2.1: Research framework.

The research is split in two main parts: A part on the influence of development timing on travel behaviour and a part on the development process in practice. To determine the influence of development timing on travel behaviour two methods are applied, namely a literature review and case studies. The literature review is used to create a conceptual framework on the different mechanisms that influence travel behaviour in relation to development timing. This conceptual framework forms the basis of a hypothesis on the influence of development timing on travel behaviour. This hypothesis is tested with the help of case studies, in which the effects of three different development timelines on travel behaviour are studied. The information received from both the literature and the interviews is used to draw conclusions on the influence of development timing on travel behaviour.

The second part of the research aims to provide insights on the different stakeholders involved in the process and their perspective on the development strategy. This part starts with desk research to get an in-depth understanding of process and the stakeholders involved in it. The knowledge obtained is validated and extended with the help of interviews with stakeholders involved in the process. These interviews also serve to determine the view of the interviewees on the 'ideal' development strategy and the decision making factors they use to determine this. The answers on this subject are compared to determine the similarities and differences between them. In a second interview round, the results from the first round of interviews are presented to the interviewees to determine if they agree with each other or not. From this conclusions are drawn on the decision making factors used in practice and the development timelines resulting from it. The research ends with a conclusion and discussion on the development strategy that leads to high ridership levels while still being feasible for the different parties involved.

The relation between research questions and the methods used to answer them is given below:

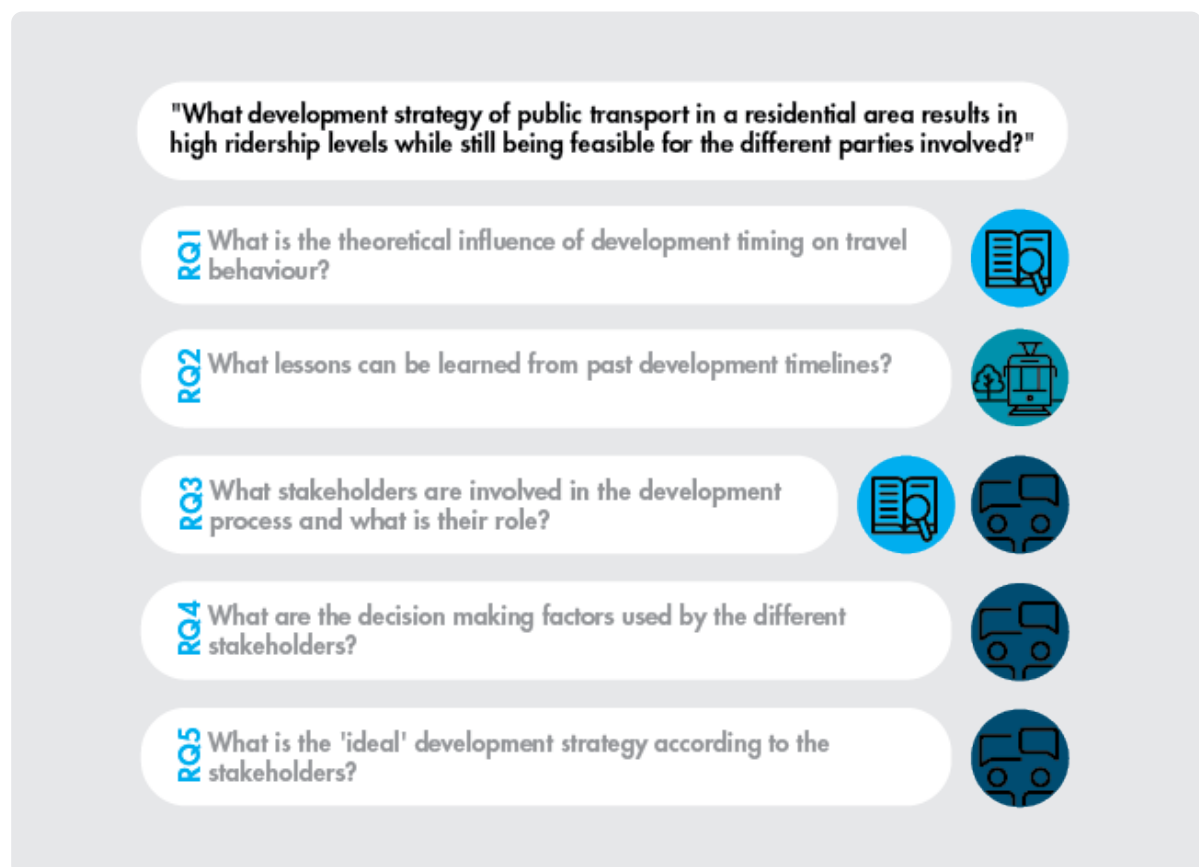


Figure 2.2: Relation between methods and research questions.

2.2. Methods

This section will discuss the different methods used in the research, as represented by the coloured circles in Figure 2.1 and Figure 2.2. It gives insight in the steps taken, a motivation for the choice of the method and the advantages and disadvantages of it. First, the literature review is discussed, after which the case studies are elaborated on. Lastly, the interview method is discussed.



DESK RESEARCH

2.2.1. Literature review

A literature review is conducted to get an in depth understanding of the subject. The research topics for the literature review are:

- The identification of the problem and research gap
- Definition of a methodology to answer the research questions
- Influence of development timing on travel behaviour (sub-research question 1)
- The identification of the different stages of the development process
- The identification of the stakeholders

Search method

The literature used for the literature review is found using search engines such as 'Scopus', 'Google scholar' and 'Science Direct'. These search engines provide journal articles, conference papers and reports using keywords. An overview of the keywords used in this research is given in Table 2.2. The keywords are matched in different ways to find the articles. The relevance of each of the articles is assessed by checking the title, type of article and publishing year. When a relevant article is found, forward and backward snowballing are used to check the references used for that article to see if they are relevant as well.

Next to scientific articles, grey literature such as newspaper articles and reports written by consultants, knowledge institutes and government agencies are used as well. These types of publications are used to determine the steps in the development process and to determine the stakeholders involved in it. The articles are found using the Google search engine. The relevance of the articles is assessed by checking the title, publisher and year of the publication. The information obtained is validated and supplemented with expert knowledge during the interviews.

Table 2.1: Keywords used for literature search.

Research topic	Keywords
Problem definition and research gap	'travel behaviour', 'built environment', 'residential location', 'transit-oriented development', 'life events', 'habit', 'mode choice'.
Methodology	'qualitative research', 'qualitative analysis', 'travel behaviour', 'delphi method', 'semi-structured interview', 'encoding scheme'.
Relevance research	'travel behaviour', 'built environment', 'life events', 'habitual behaviour', 'travel attitude', 'residential self-selection', 'mode choice', 'area development', 'public transport'.
Stakeholder identification	'policy', 'planning', 'stakeholders', 'transit-oriented development', 'Netherlands', 'Decision making process'.
Stages development process	'area development', 'planning', 'stages', 'Netherlands'.



DESK RESEARCH

2.2.2. Case studies

To test the hypothesis on the influence of development timing on travel behaviour case studies are executed. These case studies focus on the development timelines of neighbourhoods that have already been completed, to determine how different development timelines influenced the public transport ridership levels and car ownership in the neighbourhood.

Selection of developments to study

The areas selected for the case studies are Vinex neighbourhoods. Vinex is a policy briefing note from the Dutch government that aimed to tackle two themes: catching up on housing construction and reducing travel movements to relieve the environment. The neighbourhoods were built near existing city centres and the provision of high-quality public transport was important in the development plans (Snellen et al., 2005). These neighbourhoods are chosen, because they are designed to promote public transport usage and are built following the same vision, which makes them suitable to be compared.

The three cases that are selected vary from places where the public transport connection was developed way before the residents started to live there, to a fully developed neighbourhood that obtained access to public transport years later. These three cases together offer insight in the acceptance of residents and the effect of early development of public transport on the one side and late development on the other.

Method

The cases are compared both in terms of ridership levels (in relation to the amount of houses built) as well as the car ownership levels. Ridership levels give an indication of the popularity and feasibility of the provided public transport connection. Statistics on car-ownership show the other side, namely how many households still rely on one or more cars to get around. This gives an impression of the effect of different development timelines had on the travel behaviour of the residents.

Data gathering

To determine the success of development timelines according to the method as described above three different types of data are required, namely:

- The ridership levels of the public transport connection over the years;
- The amount of houses built over the years;
- The car-ownership levels.

This data is gathered using government documents, ridership levels published by public transport providers, newspaper articles and evaluations of neighbourhoods.



INTERVIEWS

2.2.3. Delphi method

To gain insight in the development process as followed in practice, interviews are held with stakeholders involved in this process. These interviews are used to:

- Validate and extend the knowledge on the process and the stakeholders involved in the process;
- Determine the decision making factors used;
- Determine the ideal development strategy according to stakeholders.

As there are many stakeholders involved in the decision making process and the views of those different stakeholders on the development strategy might not align, the Delphi method is applied.

Method

The Delphi method is an iterative feedback technique that has been specifically designed to achieve a consensus from a group of experts (Okoli and Pawlowski, 2004). It uses several rounds of interviews, in which each of the participants is asked to respond to the (anonymous) statements of the other participants until a group consensus is reached (Schmalz et al., 2021). For this research, the technique is applied to explore if there is a consensus on the development strategy that has to be followed. This is done through two round of interviews.

In the first round, the interviewees are asked to give their view on the 'ideal' development strategy and the decision making factors they use to determine this. Furthermore, the participants are asked to validate the identified stakeholders and to state the influence of each of the stakeholders per development phase. The results from this round are analysed and potential issues and point of debate are highlighted. In the second round, the results from the first round of interviews are presented to the interviewees, so they can react to the response of the other interviewees and potentially change their own response. Hereby, the points of debate are accentuated, while the differences in responses due to misinterpretation are eliminated.

Advantages, disadvantages and considerations

The Delphi method has the advantage that the views of a group of experts can be aggregated without the need of a group meeting (Twin, 2021). Furthermore, individuals can express their own opinions in stead of group thinking. However, this also has its disadvantages, as group thinking might help to resolve the points of debate during the discussion. Another disadvantage is that the method can be time consuming and the interviewees need to make a commitment.

Considering that the goal is to identify if there are differences in opinion on the development strategy, it is useful that the views of the different stakeholders are collected separately. By collecting the opinions separately, the opinions of all stakeholders are heard and there are no persons dominating the discussion. Furthermore, a group discussion could also result in a focus on a specific topic, while other topics are neglected. The differences in opinion that are normally discussed in a group session are instead presented to the participants in the second round. This gives them the opportunity to reconsider their answer based on the opinions of others, while they are not under pressure in the heat of a discussion. As a result, all opinions are heard and the points of debate become clear.

Justification amount of rounds

In this research, only two rounds of interviews are conducted, as the time available for the research is limited. The consequence of this choice is a smaller possibility that a group consensus will be reached than when more rounds would be executed. The method does still offer an advantage over just one round of interviews, as the opinions offered by the different experts will not just be interpreted by the facilitator, but by the other experts as well. Additionally, the two rounds do also minimise the chance of dropouts in between the two interview rounds. All in all, the two rounds of interviews offer a good balance between thoroughness and time.

Interview protocol

The interview method that will be used for the two rounds of interviews, is the semi-structured interview. This interview method is chosen, because these types of interviews allow for open-ended responses within the interview structure (Kallio et al., 2016). Hereby, each interviewee can give their own view on the process, but the different results can still be compared. The interview protocol used to set-up, conduct and analyse the interviews is shown in Figure 2.3. It is based on different steps of the methodology as recommended by Wilson (2014).

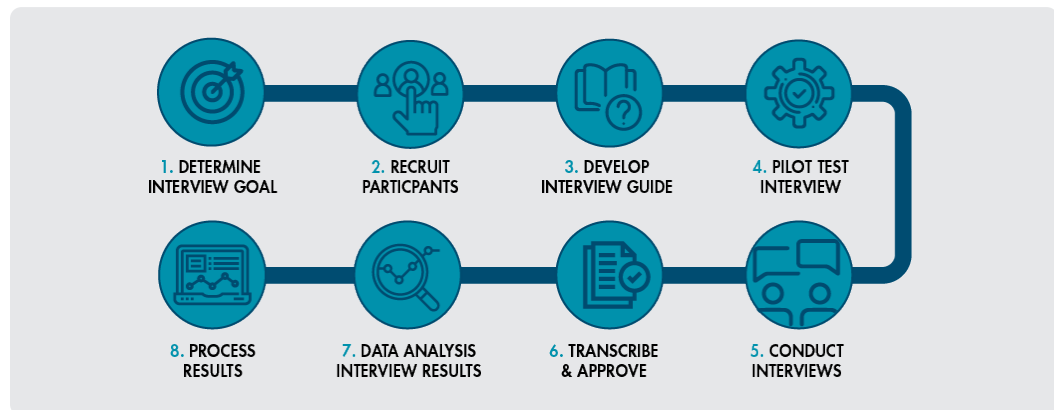


Figure 2.3: Interview protocol (own work, inspired by Spruijt (2016)).

1. Determination of interview goal

The goal of the interview is different for the two round of interviews. The first round of interviews namely aims to gather the different views of stakeholders on the 'ideal' development timeline and the decision making factors they use to determine this. Furthermore, the first round of interviews is also used to verify the conclusions drawn from the grey literature. The second round of interviews has the goal to determine if the responses of the interviewees are affected by the responses of the other candidates and to determine which points of debate remain.

2. Recruitment of participants

The second step of the protocol is the recruitment of participants. The participants for the interviews are stakeholders involved in the development process. To make sure that all the different interests and viewpoints in the development process are highlighted, the experts are selected from three different groups:

- Group 1: Municipality
- Group 2: Regional government/ regional transport body
- Group 3: Public transport provider

3. Interview guide

Step 3 of the interview protocol is the creation of an interview guide for each of the two rounds. These interview guides contain the topics and questions discussed during the interviews. An elaboration on the interview guides used per round can be found in chapter 6 and chapter 7. The interview guides themselves can be found in Appendix B.

4. Pilot test

The interview guides are tested to determine if the relevant information is obtained using the guides. When needed, changes are made to make the interview guide more suitable for the interview goal.

5. Interview

The next step in the interview protocol is the execution of the interviews. Due to COVID restrictions the interviews are held online (via Teams). With the consent of the participant, the interviews are recorded. This way, the interviewer can concentrate on the interview and does not have to rely on notes to draw conclusions from the interview.

6. : Transcript

The recordings of the interviews are transcribed and sent to the participants for the approval. The transcription method used for this is Edited Transcription, meaning that stammers, repetitions and grammatical errors are corrected in the transcription. This makes it

easy to read, while the essence and idea of the interview are maintained (Summa Lingua Technologies, 2021).

7/8. : Data analysis and processing

The next step is analysis of the approved transcripts. For the first round, the goal is to determine the different views on the development timeline and analyse the differences and similarities between them. To determine this, the data obtained from the interviews was categorised using qualitative coding.

Passages from the interview are coded according to themes and gathered in an encoding scheme, which gives an overview of the responses per theme (Saldaña, 2013). By applying this method the interviews are examined in a systematic way and the large amount of data retrieved in the interviews can be compared on themes relevant for the research.

The encoding scheme for the first round of interviews is created following the steps below. The steps are inspired by the encoding steps as used by Spruijt (2016); Saldaña (2013).

1. Assign structural codes to the interview

Each interviewee is assigned an interview code (A - G) and a group code (1-3). The groups correspond to the different types of organisation the participants work for: (1) municipality, (2) regional government/transport authority and (3) public transport provider.

2. Assign theme codes

To organise the information retrieved from the interviews, different theme codes were used. The themes are travel behaviour influences, decision making factors, stakeholders and development timelines. A description of each of those themes is given below.

- **Stakeholder interaction and involvement (ST)**

Passages about stakeholder interaction and involvement belong to this theme. Within the theme there is differentiated between the different stakeholders

- **Travel behaviour influence (TB)**

All factors identified as influences on travel behaviour are assigned to this category.

- **Decision making factor (DMF)**

All factors that play a role in the decision when to develop public transport in relation to the development of the residential area it serves, are assigned to this category.

- **Development timeline/strategy (DT/DS)**

Statements about the development timeline and strategy belong to this category.

3. Compose encoding scheme

When the content of an interview is organised in the different themes, the data can be added to the encoding scheme. In the end, this scheme will provide an overview of the information gathered in the different interviews organised per theme, which makes it easier to draw conclusions.

The second round of interviews discusses the results from the first round of interviews. As the interviewees respond directly to the answers of others, the data retrieved in this round of interviews is compared per interview subject.



PART I

THE INFLUENCE OF DEVELOPMENT
TIMING ON TRAVEL BEHAVIOUR

3

LITERATURE REVIEW

The influence of the development timeline on travel behaviour

The concept of transit-oriented development is a topic that has been the subject of considerable research attention over the past years (Ibraeva et al., 2020). The reason for this interest is the influence the built environment can have on travel behaviour. A built environment that is tailored to the use of sustainable modes of transportation can namely encourage the use of them, hereby serving as a replacement for the car (Faber et al., 2021). To determine if it matters at what moment people are subjected to such a built environment, it is important to understand the mechanisms that influence the relation between travel behaviour and the built environment, as well as the mechanisms that influence travel behaviour over time.

The review starts with a discussion on the relation between travel behaviour and the built environment, to create an in-depth understanding of the influence the built environment can have on travel behaviour. Then, this relation is linked to mechanisms known to influence peoples travel behaviour over time, to determine how timing can play a role in the extent of the influence. The article ends with a conclusion on the influence of development timing on travel behaviour and the formation of a hypothesis on the development strategy resulting in high ridership levels based on this.

3.1. Travel behaviour and the built environment

The built environment consists of buildings, open spaces and transport systems which together form the space we live, work and recreate in (Pacheco-Torgal et al., 2016). The design of this built environment is considered to be of influence on the travel behaviour. It is assumed that neighbourhoods with high densities in areas adjacent to high quality public transport and good walking and cycling infrastructure encourage people to use sustainable modes of transportation, where neighbourhood with large roads and lots of parking facilities encourage car use (Kamruzzaman et al., 2015; Ibraeva et al., 2020).

This relation between travel behaviour and the built environment has been recognised in research for several decades (van de Coevering et al., 2015; Wang and Lin, 2019), however the existence of a causal effect of this relation has long been contested. It is argued that there is no direct relation between travel behaviour and the built environment and the relation can be explained via other mechanisms (Faber et al., 2021; van de Coevering et al., 2016). As the goal of this section is to create an understanding of the relation between travel behaviour and the built environment, this section reviews literature on this causality discussion with the aim to create a conceptual model that captures relation between travel behaviour and the built environment including all the explaining mechanisms.

3.1.1. Causality discussion

The causal relation between travel behaviour and the built environment is often contested using mechanisms that explain the associating between travel behaviour and the built environment via other variables such as travel attitudes, socioeconomic-demographics and location preference (Faber et al., 2021; van de Coevering et al., 2016).

One of those mechanisms, **residential self-selection**, is described as the notion that people choose the place they live based on their travel preferences (Wang and Lin, 2019), which are the result of travel attitude, lifestyle and/or socio-demographics (van Wee and Handy, 2016; van de Coevering et al., 2016). It is suggested that this notion weakens the idea that the built environment influences travel behaviour (Faber et al., 2021), as people choose an environment due to its favourable characteristics in regard of their preferred way of travel, instead of the other way around.

Another theory, **the reversed causality theory**, is that the built environment can influence people's travel attitudes over time, which makes them more appreciative for a certain mode of transportation, which in its turn influences their travel behaviour (van de Coevering et al., 2016; Ramezani et al., 2021). This theory also weakens the notion of a causal relation the built environment and travel behaviour.

Table 3.1.1 gives an overview of some papers and their observed outcome on the subject.

Table 3.1: Articles on the influence of self-selection and travel attitudes in relation to travel behaviour and the built environment.

Reference	Conclusion
Adhikari et al. (2020)	An increase in area walkability leads to an increase in walk trips independent of preferences or life events.
Bruns and Matthes (2019)	Travel related aspects influence residential relocation decisions.
Clark et al. (2016)	Good PT and mixed land-use encourage a shift away from car commuting.
De Vos et al. (2018)	Travel attitude influences residential location, but people's mode choice and attitude might also change after relocation.
Ettema and Nieuwenhuis (2017)	Residential location choice and travel attitudes are associated to a limited extent.
Faber et al. (2021)	The built environment has effect on travel behaviour after attitudes and transport-related location choices are accounted for.
Guan et al. (2020)	The built environment still has an effect on travel behaviour after residential self-selection is accounted for.
Kamruzzaman et al. (2015)	Travel attitudes and residential location choice have a significant influence on travel behaviour.
Kroesen (2019)	Travel related reason for residential location choice originate from earlier travel behaviour and the previous residential locations.
Mokhtarian and van Herick (2016)	The influence of the built environment on travel behaviour lies between the 34 and 98 percent.
Ramezani et al. (2021)	Built environment influences travel attitudes, which in its turn effects travel behaviour.
van Herick and Mokhtarian (2020)	Around 38 percent of the influence of the built environment on travel behaviour can be attributed to self-selection.
van Wee et al. (2019)	Travel behaviour and the built environment influence travel attitudes.
van de Coevering et al. (2016)	There is a causal influence from the built environment on travel behaviour and travel.
van de Coevering et al. (2016)	Travel attitudes are influence by the built environment
Wang and Lin (2019)	People's attitudes might change after relocation. No evidence of residential-self selection.
Wolday et al. (2018)	Evidence of residential self-selection in central urban districts, but not in suburbs.

From Table 3.1.1 the following conclusions on the role of residential-self selection and reversed causality in the relation between the built environment and travel behaviour are drawn.

⇒ **Residential self-selection**

Bruns and Matthes (2019); De Vos et al. (2018); van Herick and Mokhtarian (2020); Wolday et al. (2018) all state that residential self-selection does partially account for the influence the built environment has on travel behaviour. They state that travel attitude influences residential location choice which is, at least partially, the reason for the choice of travel behaviour. According to Ettema and Nieuwenhuis (2017), the residential location choice and travel attitude are only associated to a limited extent. De Vos et al. (2021); Faber et al. (2021); Guan et al. (2020); Wang and Lin (2019) state that the built environment can also influence travel behaviour after residential self-selection is accounted for.

⇒ **Reversed causality**

According to Ramezani et al. (2021) a change in travel behaviour after relocation can be explained by the influence the built environment has on travel attitudes. They state that the built environment has an influence on travel attitudes which in its turn influence travel behaviour. This theory is supported by van de Coevering et al. (2016); Wang and Lin (2019); van Wee et al. (2019), who state that travel attitudes are influenced by the built environment.

⇒ **Causal relation**

However, van de Coevering et al. (2016) also conclude that even after attitudes and transport related location choices are taken into account, there still is an effect of the built environment on travel behaviour. This conclusion is underlined by Faber et al. (2021). According to (Adhikari et al., 2020), the built environment can influence travel behaviour independent of a preference for walking trips, which also is a causal finding of the relation between the built environment and travel behaviour.

All in all, it can be concluded that both the reversed causality hypotheses and residential self-selection play a role in the relation between the built environment and travel behaviour. However, there are also studies that recognise the causal relation between travel behaviour and the built environment.

3.1.2. Conceptual framework of the relation

The conclusions on the mechanisms playing a role in the relation between travel behaviour and the built environment are captured in the conceptual model given in Figure 3.1.

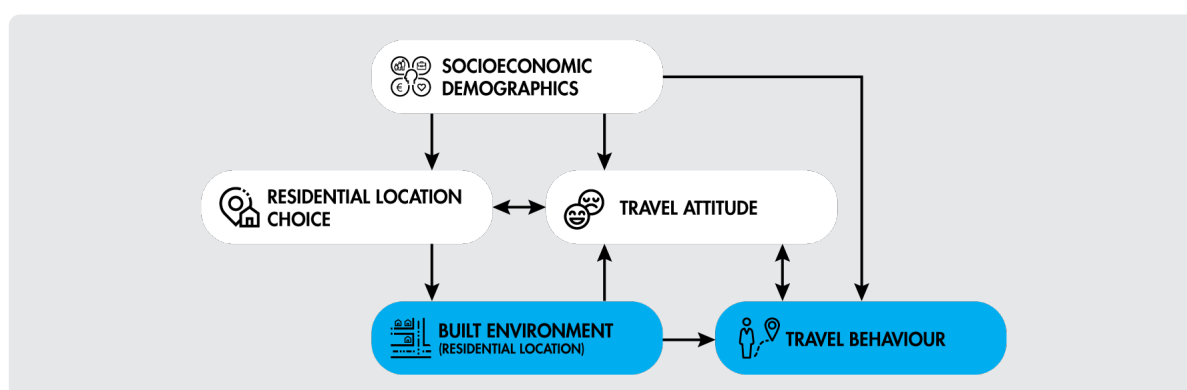


Figure 3.1: Overview of the mechanisms influencing travel behaviour in respect to the built environment (adjusted from Faber et al. (2021); van de Coevering et al. (2016)).

Considering this conceptual model, it can be concluded that the built environment can influence travel behaviour, either direct or indirect (via residential location and travel attitude). This means that the built environment can thus contribute to the use of sustainable modes of transportation.

3.2. When do people change their travel behaviour?

The phrase *Old habits die hard* aptly describes people's travel behaviour, as people do not change their travel habits easily (Hagggar et al., 2019), especially when it involves the car (Daramy-Williams et al., 2019). Friedrichsmeier et al. (2013) state that even when other influencing factors change, behaviour does not necessarily change accordingly due to habits. According to Havlíčková and Zámečník (2020) habit is the most important variable that hinders attempts to change travel behaviour. Thus, unveiling what makes people change their habits over time is quite important in the shift towards the use of more sustainable modes of transportation. This section discusses the events that make people change their travel behaviour and extends the conceptual model with the influences of both these events and habitual behaviour.

3.2.1. Life events as an opportunity to change travel behaviour

Life events have been generally acknowledged as a trigger for people to change their travel behaviour. These life events are the moments in someone's life when there is a major change in their situation, such as the birth of a child, moving home, entering the labour market or changing jobs (Olde Kalter et al., 2021). According to Zarabi et al. (2019) these life events can be a disruptive factor for habitual behaviour. Janke et al. (2020) state these moments can break people's travel habit and make them reconsider their travel behaviour (Janke et al., 2020). Table 3.2.1 gives an overview of articles related to the subject and gives an overview of the conclusions they have drawn.

Table 3.2: Articles on factors that make people change their habitual behaviour.

Reference	Conclusion
Beige and Axhausen (2017)	Relocation is an opportunity for policies aiming at travel behaviour change.
Busch-Geertsema and Lanzendorf (2017)	There is a decreased probability people change travel modes due to habits.
Clark et al. (2016)	The likelihood of a change in travel behaviour increases when people change employment or move to another place.
Hagggar et al. (2019)	Travel habits weaken after moving and are susceptible for change.
Janke et al. (2020)	Life events can change people's social and physical environment, hereby exposing them to new norms prompting them to change their travel attitudes and travel behaviour.
Janke et al. (2020)	Life events are windows of opportunity to make people change their travel behaviour.
Müggenburg et al. (2015)	Life events influence the adaption of long-term mobility decisions and everyday mobility decisions.
Oakil et al. (2014)	Residential relocation and childbirth cause car ownership changes.
Olde Kalter et al. (2021)	Life events (such as a new job, moving, or child birth) can result in a change in travel behaviour.
Thomas et al. (2016)	Relocation weakens travel habits and encourages reconsideration of one's views. However, only for a short period.
Walker et al. (2014)	Relocation can result in a change in travel habits.
Zarabi et al. (2019)	Residential relocation can be a disruptive factor for travel habits, how much depends on the habit strength.

From Table 3.2.1 it can be concluded that both habitual behaviour and life events influence travel behaviour. According to Busch-Geertsema and Lanzendorf (2017) there is a decreased probability that people change their travel behaviour due to habit. However, (Hagggar et al., 2019; Zarabi et al., 2019; Walker et al., 2014; Thomas et al., 2016) state that habit is weakened after relocation, which means that the probability of people changing their travel behaviour after relocation increases. This is underlined by Clark et al. (2016); Janke et al. (2020); Olde Kalter et al. (2021), who state that there is an increased chance that people change their travel behaviour following life events.

According to Janke et al. (2020); Beige and Axhausen (2017) life events can be seen as windows of opportunity for policies aiming to change travel behaviour. To take full advantage of these windows of opportunity, it is useful to know the period of time these windows are open. Although there are more and more studies that consider the relation between travel behaviour and life events over time (Adhikari et al., 2020; De Vos et al., 2018; Olde Kalter et al., 2021; Wang and Lin, 2019; Thomas et al., 2016), a comprehensive understanding of the time window within which these changes take place has yet to be achieved.

3.2.2. Extension of the conceptual model

From the previous section it can be concluded that life events can disrupt habitual behaviour and influence travel behaviour. This influence on travel behaviour is either caused by a change in the socioeconomic demographics such as household composition or employment or a change in built environment. The influence of life events and the relation between habitual behaviour and travel behaviour are added to Figure 3.1 to create the overview of influencing factors as given in Figure 3.2.

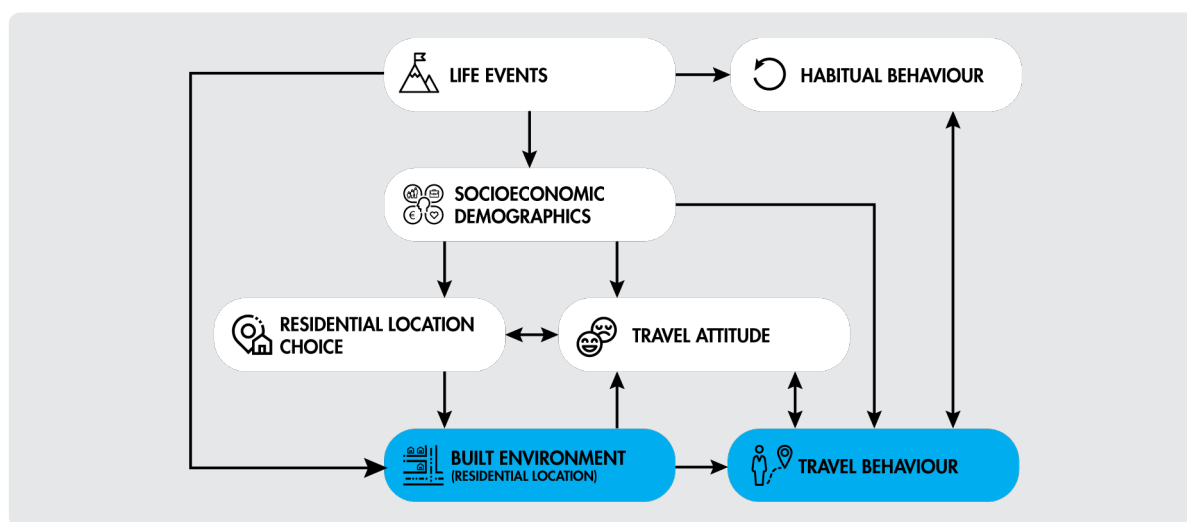


Figure 3.2: Overview of mechanisms influencing travel behaviour in respect to the development timeline.

3.3. Conclusion

This literature review discussed the mechanisms driving people's travel behaviour with regards to the relation between built environment and travel behaviour, and the influence of the moment in time. First of all, the literature review revealed that the built environment can influence travel behaviour, but that there are two mechanisms influencing this relation: residential-self selection and reversed causality via travel attitudes. Residential self-selection does partially account for the relation between travel behaviour and the built environment, as people choose an environment due to its favourable characteristics in regard of their preferred way of travel, instead of the other way around. Travel attitude can also be influenced by the built environment and can in its turn influence travel behaviour and residential location choice.

Second, the review revealed that there are two mechanisms that show the significance of the moment in time: habitual behaviour and life events. Habitual behaviour keeps people from reconsidering travel behaviour, while life events can be seen as windows of opportunity to make people change their travel behaviour. They do not only weaken habitual behaviour, but can also influence peoples travel attitude. Although several studies have investigated the time frame in which life events can influence travel behaviour, a comprehensive understanding of the period of time these windows are open has not yet been achieved.

The literature review also gives **answer to sub-research question 1**: What is the theoretical influence of development timing on travel behaviour?

1. What is the theoretical influence of development timing on travel behaviour?

The studied literature revealed that people who live in an area with a built environment tailored to sustainable modes of transportation, are more likely to use these sustainable modes than people who live in car-oriented neighbourhoods. Considering that habitual behaviour and life events both influence travel behaviour, there is a certain window of opportunity that people are more susceptible for a change in travel behaviour.

When the built environment is optimised for the use of public transport and people are subjected to this environment during this window of opportunity, theoretically, the chance is greater that they will use it. On the contrary, when people are subjected to good public transport after they have lived at a location for a while, habitual behaviour can reduce the change of people using it. All in all, it can be concluded that the development timing of public transport in a residential area can influence people's travel behaviour.

3.4. Hypothesis on the development strategy

The literature review shows that development timing can influence people's travel behaviour. This suggests that public transport should be provided from the moment the first people start to live in the area. If the public transport is provided some time later, the risk is that people will have developed other travel habits and the chance that they use the provided public transport is diminished.

Thus, the hypothesis is:



"If the public transport connection is developed late, people will have developed other travel habits and the chance that they use public transport when it is provided, will diminish."

This hypothesis is tested using case studies of past developments in the next chapter.

4

CASE STUDIES

Lessons from past developments

To test the hypothesis, the effects of three different development timelines are evaluated in this chapter. The goal of this chapter is to get an impression of the effect that different development timelines had on the public transport usage and of the modal split of the neighbourhood. The cases scrutinised are the Vinex neighbourhoods IJburg, Leidsche Rijn and Ypenburg, which are all greenfield locations located near existing city centres.

4.1. IJburg

IJburg is a Vinex neighbourhood in the east of Amsterdam, specifically designed to encourage the use of public transportation and discourage the use of cars. The area has a linear structure and has a direct connection with the city centre via a high frequency tram line (tram 26 or 'IJtram') (CROW, 2008). An overview of the area is given in Figure 4.1. This section describes the development timeline of this urban environment and evaluates the public transport connection and the car ownership levels in the neighbourhood.

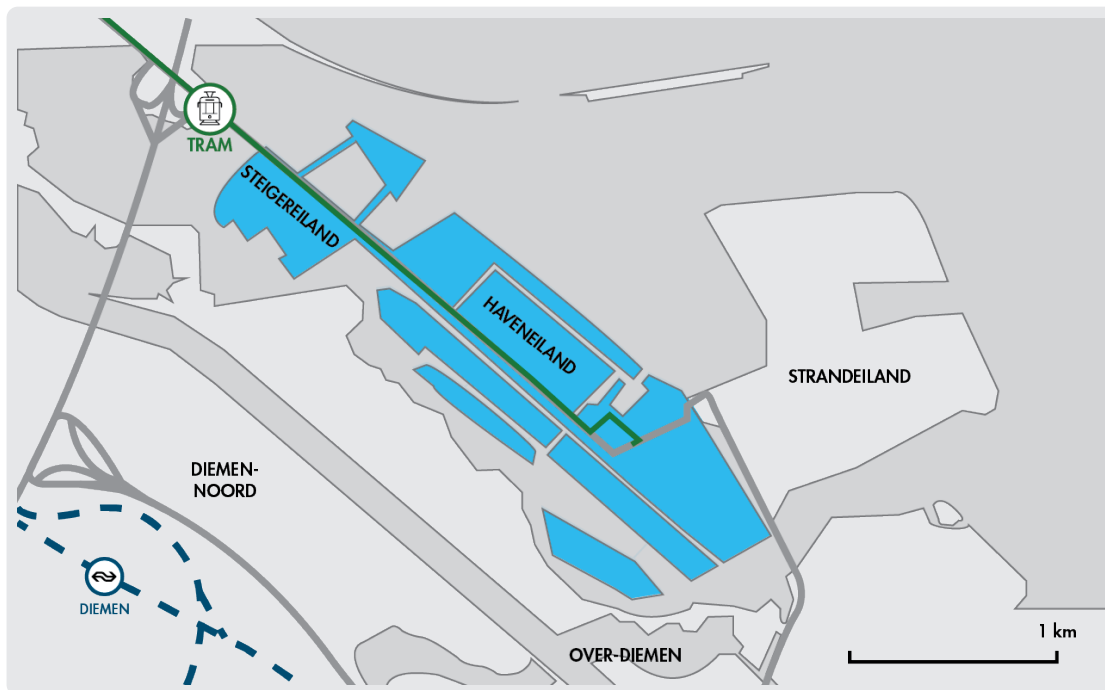


Figure 4.1: Overview of IJburg (own work).

4.1.1. Development timeline

The development of IJburg started in 1999 (Gemeente Amsterdam, 2018). One of the requirements for the development was the availability of the public transport connection from the moment the first resident would inhabit the area. When the first people started to live in IJburg in 2002, the tram connection was far from ready, and it was decided to use buses as a replacement for the tram. In 2005 the tram was put into operation (CROW, 2008). Over the years the frequency of the tram line was increased several times and in 2020 longer vehicles were deployed to accommodate the growing number of passengers (AT5, 2020). An overview of this timeline is given in Figure 4.2.

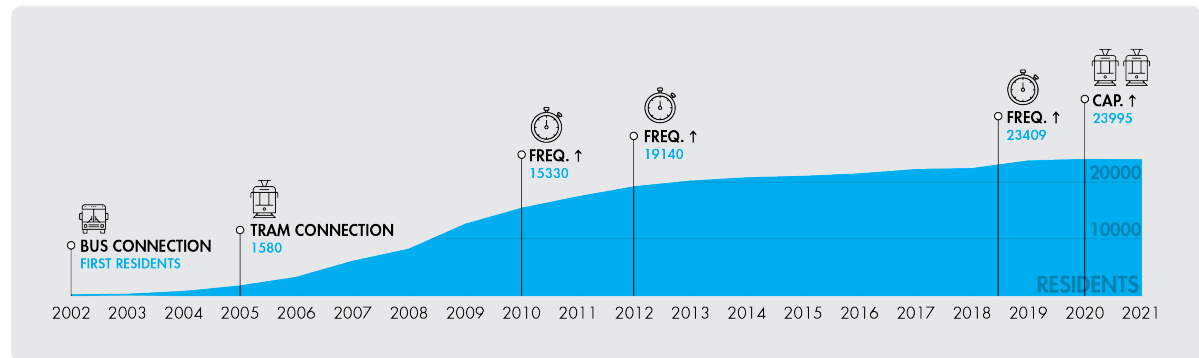


Figure 4.2: Public transport developments in relation to the number of residents (data on the number of resident per year received from CBS (2013, 2014, 2018, 2019a, 2020a, 2021a,b,c,d)).

4.1.2. Evaluation

The public transport connection and car-ownership levels are evaluated in this sub-section. First the provided public transport will be evaluated using newspaper articles and statistics on ridership levels, after which the car-ownership levels in the neighbourhood are evaluated using statistics on households and car-ownership.

Public transport connection

In the early days of the development, the tram line was not yet available and a bus service was provided instead. Therefore, both the bus and tram connection will be evaluated below.



Bus connection

The bus connection was not to the satisfaction of the residents. In 2004 they wrote a letter in which they stated that a neighbourhood designed for the use of public transport should actually provide a good public transport connection. The main complaints about the bus were the low frequency and the lack of space for strollers and bikes (Bewonersvereniging De IJbrug, 2004).



Tram connection

In 2005 the tram line was taken into operation. Initially around 5000 people used the tram connection, but after four years this amount was doubled as more houses were developed (Het Parool, 2009). According to Munneke (2011), in 2011 40-50% of the movements to and from IJburg took place via this tram line, which is considerably higher than that of other Vinex-neighbourhoods with a tram connection.

Figure 4.3 gives an overview of the relation between the amount of houses built and the amount of travellers using the tram line. As can be seen, the two grow simultaneously, meaning that the moment more people start to live in IJburg the amount of people using the tram line grows with an equal amount.

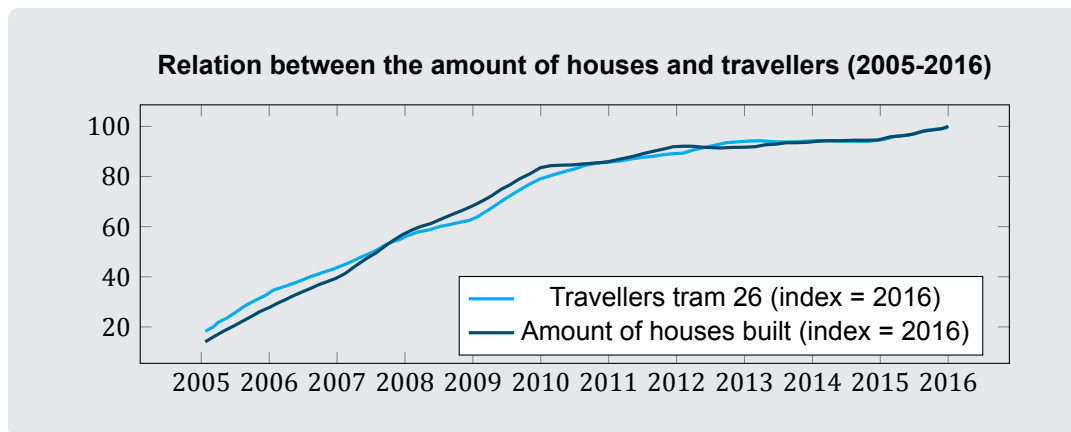


Figure 4.3: Relation between amount of houses built and travellers (Gemeente Amsterdam, 2018).

Regarding the feasibility of the project, the early development of the public transport connection meant that both the bus and tram connection were operated with losses in the first years. However, this decision was consciously made to make sure people used the public transport (CROW, 2008; Munneke, 2011).

Car ownership

Figure 4.4 gives an overview of the car ownership in IJburg over time. As can be seen the car ownership levels have been considerably constant over years. In the early days of the development the ownership levels were a little higher, but after that they have been constant at around 0.7 cars per household. In relation to the nationwide car-ownership levels this is relatively low, as the mean car ownership levels in the Netherlands lie at around 1 to 1.1 cars per household.

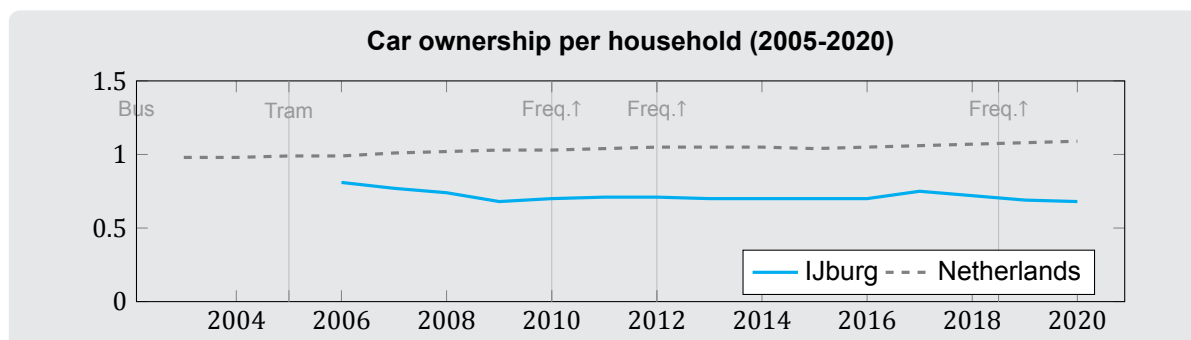


Figure 4.4: Car-ownership over the years (data retrieved from CBS (2013, 2014, 2018, 2019a, 2020a, 2021a,b,c,d)).

4.1.3. Conclusion

All in all, it can be concluded that the development timing of the public transport relative to the housing development in IJburg worked out well. Even though the tram was delayed, it still was provided relatively early in the development. This meant that it was operated with losses in the first years, but later in the development the ridership levels kept growing and growing. So much so that the frequency of the tramline was increased twice and longer vehicles needed to be deployed to accommodate this growth. The popularity of the tramline is also reflected in the car ownership levels. These lie around 0.7 cars per household, which is significantly lower than the nationwide car ownership levels. Thus, the early development of public transport resulted in high ridership levels and low car ownership levels.

4.2. Leidsche Rijn

Leidsche Rijn is the largest Vinex district ever developed in the Netherlands. The Vinex area consists of several sub-neighbourhoods which together are good for around 42 000 residents. As of today around 90% of the area is completed (Schonenberg, 2020). The area is connected with the city centre via train and so called HOV-buses, which are buses that operate on secluded bus lanes with only few stops (Gemeente Utrecht, 2022). An overview of the area is given in Figure 4.5. Originally, the space allocated for parking and roads for cars was deliberately kept small to promote public transport usage (Verhage, 2003), however this was changed due to a delay in the development of the secluded bus lanes and an increase in mobility of the residents (Boer, 2013). This section describes the development timeline and evaluates it in terms of public transport usage and car ownership.

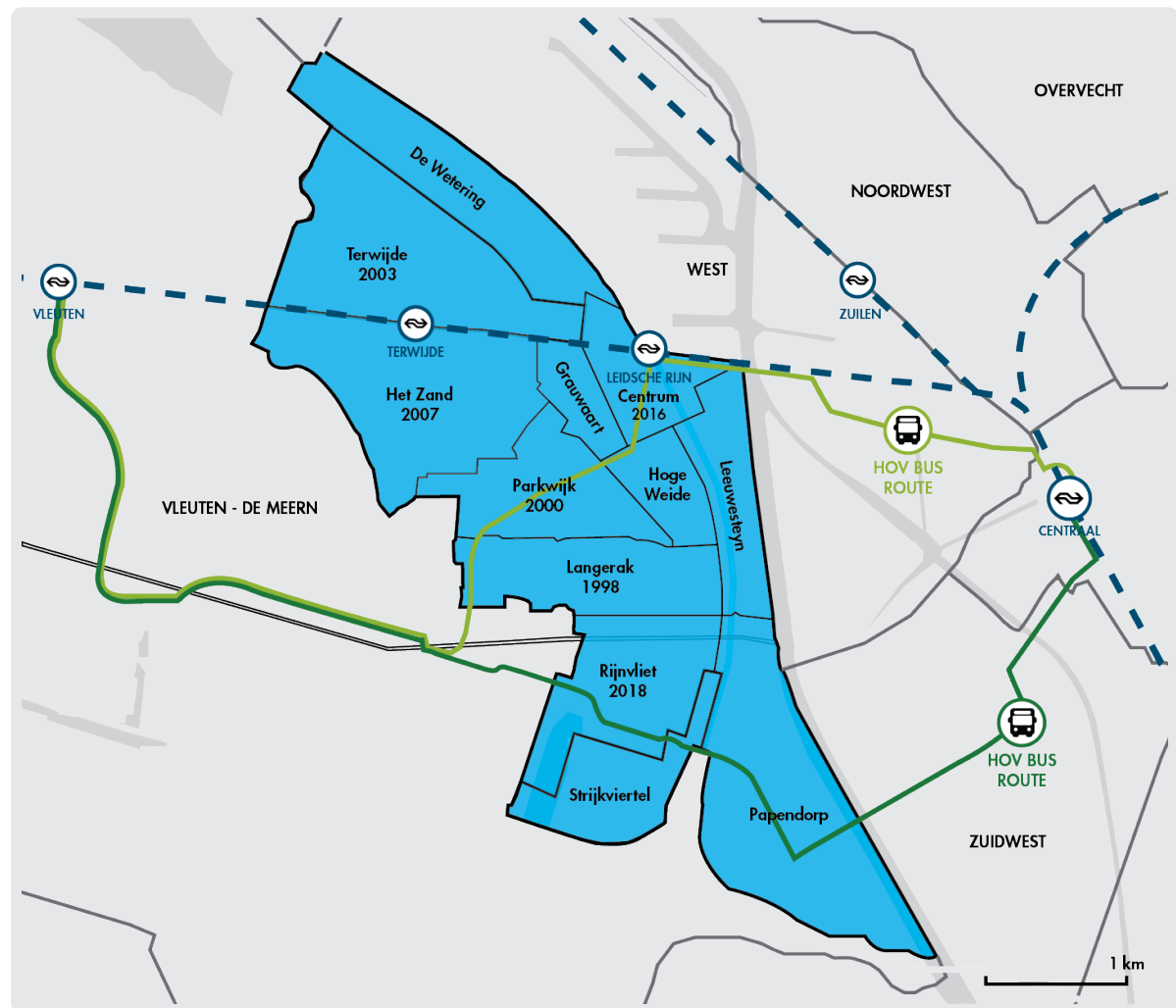


Figure 4.5: Overview of Leidsche Rijn (own work).

4.2.1. Development timeline

The development of Leidsche Rijn started in 1997 and in 1998 the first residents started to inhabit the area (Schonenberg, 2020). The development of high quality public transport access was developed months or even years after these residents occupied the area (ten Haaf, 1999). The first residents had to make do with the regular buses between Vleuten-De Meern and Utrecht (Janssen and van der Veen, 2011), which had low frequencies and stopped far away from the newly developed houses (Trouw, 1999). These buses were supplemented with a shuttle bus in 2002, which connected the neighbourhoods Langerak and Parkwijk to the regular bus between Vleuten-De Meern and Utrecht at Strijkviertel (RTV Utrecht, 2002). Later, this bus line became a standalone bus line from the city centre, via Leidsche Rijn, to the Meern. In addition to line 128, line 28 between Leidsche Rijn and Vleuten was taken

in operation in 2003. In 2005, the first secluded bus lanes were completed in Parkwijk. This meant that line 28 could follow the light green route as given in Figure 4.5. The largest part of the route was already completed in 2009, from that moment only the secluded bus lanes in Leidsche Rijn Centrum had to be completed (Infrastruct, 2010). The last part of the dark green route was taken into operation in 2021 (Meijenboom, 2021).

Next to bus connections, trains stations were developed as well. The train station Terwijde was taken in operation in 2003 and station Leidsche Rijn was completed in 2013 (Treinstationinfo.nl, 2021). An overview of the development timeline is given in Figure 4.6.

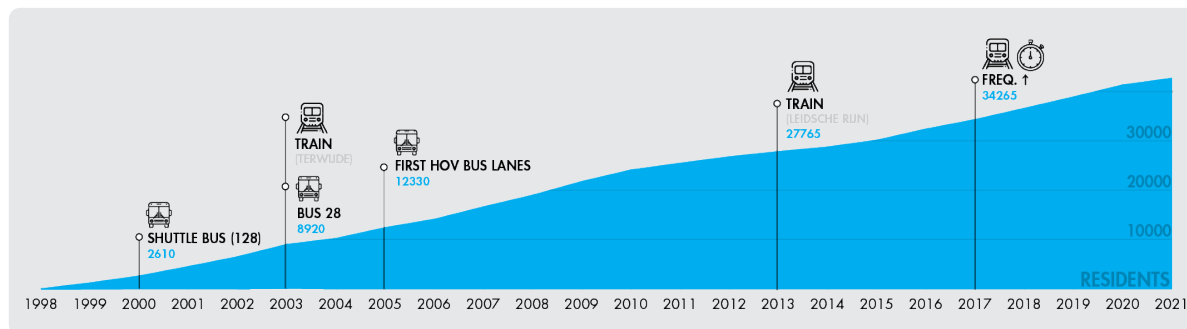


Figure 4.6: Public transport developments in relation to the number of residents (data on the number of resident per year received from CBS (2013, 2014, 2018, 2019a, 2020a, 2021a,b,c,d)).

4.2.2. Evaluation

This sub-section evaluates the public transport in Leidsche Rijn and the effect the development timeline had on the car ownership in the neighbourhood. First the provided public transport will be evaluated, after which the car-ownership levels in the neighbourhood are discussed.

Public transport

As there is no information on ridership levels of the bus connections, the success of the bus connections in Leidsche Rijn is evaluated by means of newspaper articles and evaluations of the neighbourhood. The success of the train connections is evaluated using ridership levels as well.



Bus connections

Generally, the public transport in Leidsche Rijn was considered to be inadequate during the first years of the development. Newspaper articles with titles like: "Leidsche Rijn is waiting for the bus" and "No bus in new district" make clear how dire the public transportation is considered to be in the early years (ten Haaf, 1999; Trouw, 1999). According to the Minister of Transport and Water Management, Mrs. Netelenbos, the regular buses between Vleuten-De Meern and Utrecht were not sufficient to be considered as proper public transport connection (Trouw, 1999). As a compensation for this, inhabitants were offered a public transport card which offered the card holder discounts on local transport services as a taxi, bike, bus or shared car, the so called "Pioneer card". The goal of this card was to offer residents a good alternative until the public transport was completed (de Kort, 2004). However, according to traffic and urban planners such a card is as much use as a plaster on a wooden leg (Trouw, 1999), which is underlined by the residents who found it a meagre alternative for the promised public transport (de Kort, 2004).

According to Janssen and van der Veen (2011) residents that chose the area specifically because of the promised high quality public transport system, found themselves obliged to buy a car because a lack of it (van de Poel, 1999). This is underlined by Dijst et al. (2000), who concluded that a shift from other modalities to car occurred more often after moving to Leidsche Rijn than the other way around. As a result, the intended parking standard of 1 car per household was exceeded in practice, resulting in bumper-to-bumper parking on the public road (van de Poel, 1999). In 2001 the Nature and Environmental federation of Utrecht even investigated if it was possible to freeze construction in order to achieve a breakthrough in the development of public transport. Eventually they decided not to go through with it, because

the development process continued (Janssen and van der Veen, 2011). All in all, it can be concluded that residents were not content with the provided transport in the early years of the development. According to the municipality, the public transport was indeed provided too late, but they argued this was unavoidable as public transport providers do not want to operate when there are too little travellers. In the end the HOV was realised, supported by an extra regular bus to compensate for the large distances between the stops (Janssen and van der Veen, 2011).



Train

The construction of the station Leidsche Rijn was planned to be finished in 2002. However, the construction was postponed, because of concerns about the robustness of the network between Utrecht and Woerden. The NS (Dutch railway company) didn't think it was justifiable to stop at the station, as there would be too few passengers that would use it in the first years. According to the municipality of Utrecht, this went against the arrangements that were made and could lead to an increase of the already growing troubles caused by cars in the neighbourhood (Trouw, 2002). Eventually, the station was not built until 2013. However, the station Terwijde was opened earlier than planned. A temporary stop was provided in December 2003 and the actual station opened in 2010 (Treinstationinfo.nl, 2021).

The number of passengers per day for each of those stations is given in Figure 4.7. As can be seen, the ridership levels of both stations keep growing over the years, meaning that the more people start to live in Leidsche Rijn, the more passengers start using the train.

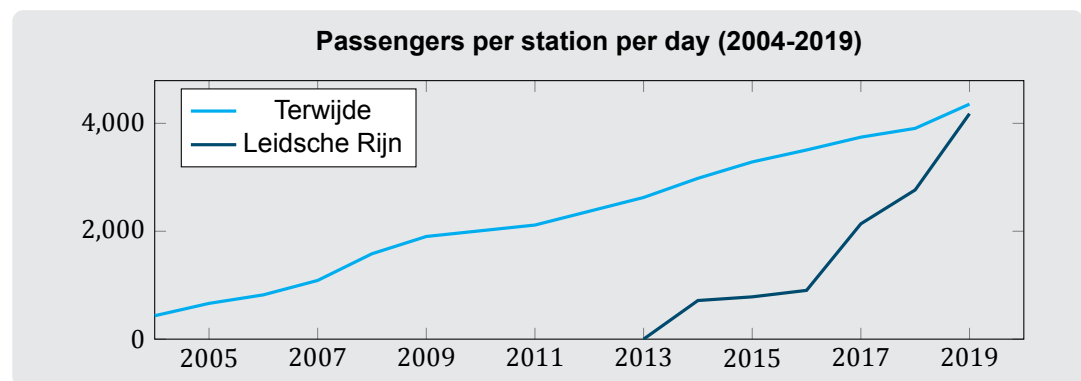


Figure 4.7: Passengers per station per day (2004-2019)
(data retrieved from Treinreiziger.nl (2009, 2019); NS (2020)).

Car ownership

Figure 4.8 gives an overview of the car-ownership per household over the years. As can be seen the car ownership is relatively high, especially from 2004-2015. After that the car ownership started to decrease. As of today it is comparable to the mean car ownership levels in the Netherlands.

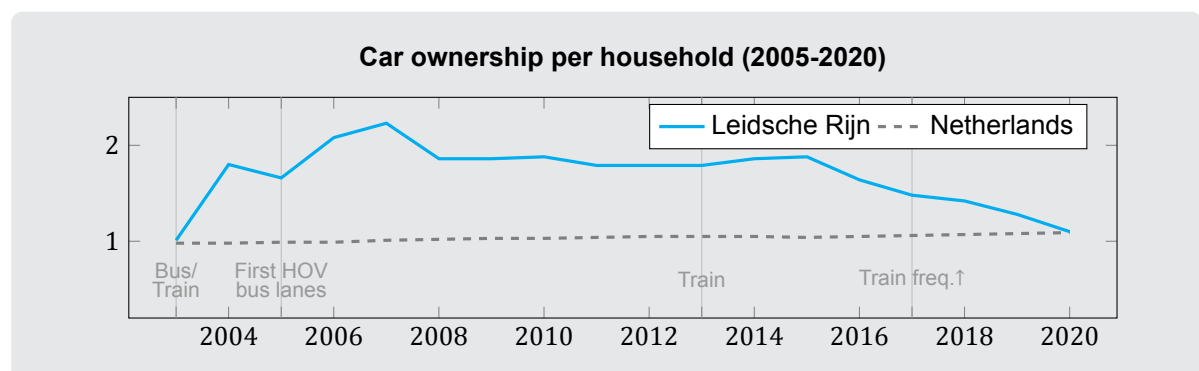


Figure 4.8: Car-ownership over the years (data retrieved from CBS (2013, 2014, 2018, 2019a, 2020a, 2021a,b,c,d)).

4.2.3. Conclusion

All in all, it can be concluded that the public transport connection in Leidsche Rijn was provided too late. The HOV bus network wasn't completed till 2009 and it took till 2013 for the first train to stop at the station Leidsche Rijn. Even though the municipality tried to compensate for the lack of public transport with pioneers card, the inhabitants of the area more often than not chose the car as their main mode of transportation. This led to parking problems, as the amount of cars per household exceeded the allocated space. The car ownership levels have consistently surpassed the nation-wide average, in the worst year being even twice as high.

However, it should be noted that the car ownership levels have started to drop from 2015, now lying around the the nation-wide average of about one car per household. From this moment the train ridership levels started to increase, which suggests there is a relation between the two. This decrease in car ownership levels and increase in train ridership levels could be of the improved public transport network with more frequent trams and buses. Thus, even though the public transport ridership levels have been low for years, not all is lost for the future when the public transport is provided after all.

4.3. Ypenburg

Ypenburg is a Vinex neighbourhood located between The Hague, Delft and Nootdorp of around 10 000 households. The area is surrounded by the motorways A13, A4 and A12, and is connected with the surrounding region via tram, bus and train. An overview of the area is given in Figure 4.9. This section describes the development timeline of this neighbourhood and evaluates the public transport connections and the car ownership levels of the neighbourhood.

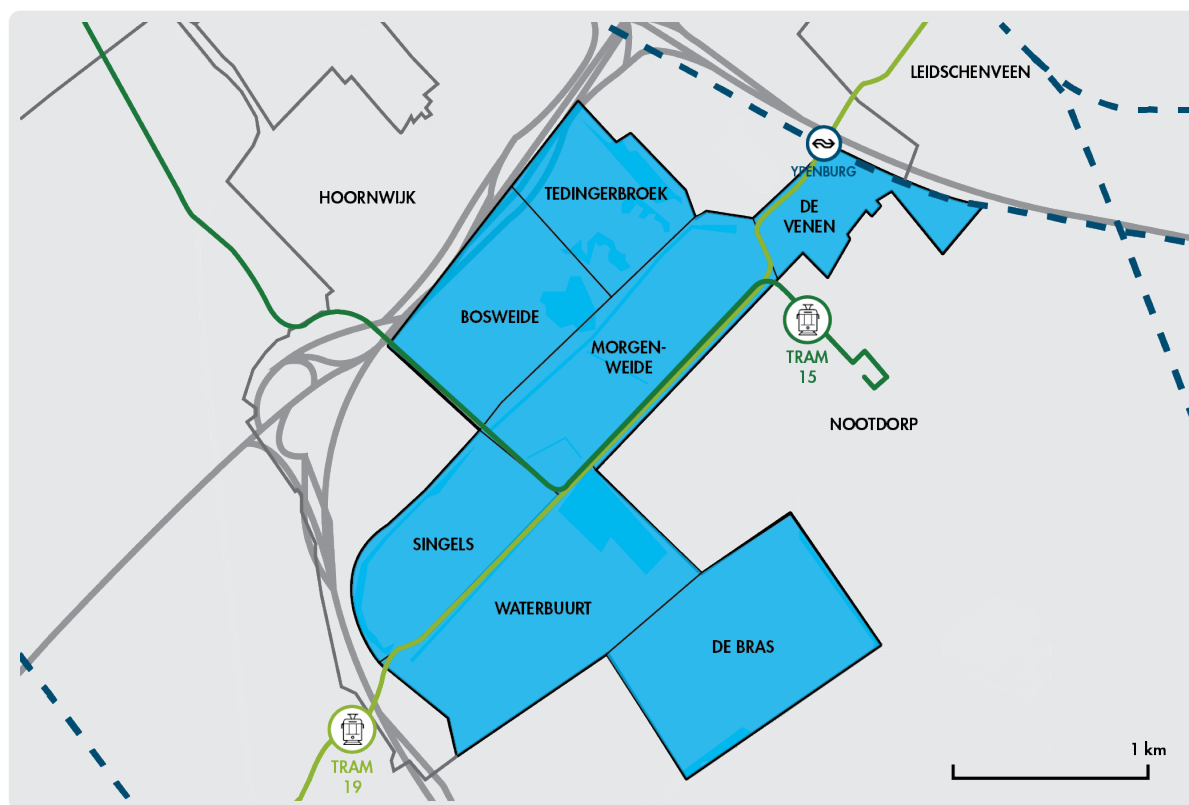


Figure 4.9: Overview of Ypenburg (own work).

4.3.1. Development timeline

The housing development of the Vinex neighbourhood Ypenburg started in 1997 (Haags Gemeentearchief, 2021) and in 1998 the houses of the sub-area Singels were ready (van Wandelen, 2018). The first public transport was provided in 1999, when several bus connections started to operate to the newly developed locations in Ypenburg (HTM, 1999). From 2001, tram 15 connecting Ypenburg

with the city centre of the Hague and Nootdorp started to operate (Lebouille and Molemaker, 2006). Furthermore, a bus connection between Leidschenveen and Rijswijk was taken in operation that year as well (Haags Openbaar Vervoer Museum, 2022). In the end of 2005, the train station was opened (Treinstationinfo.nl, 2021) and in 2010 tram tram 19 between Leidschedam and Delft was taken into operation. Originally it was planned that the tram would drive all the way to the university, however, as of today this is still not the case (Rosenberg, 2016).

Figure 4.10 gives an overview of the development timeline of Ypenburg. The statistics on inhabitants before 2002 are based on an assumption, as there is no systematic data available on the number of inhabitant before the annexation by the municipality of the Hague. The only mention about the population before 2002 comes from a newspaper article by NRC, in which it is stated that the first inhabitants received their key in 1998 and the neighbourhood counted 2800 residents in the year 2000 (Oostveen, 2000).

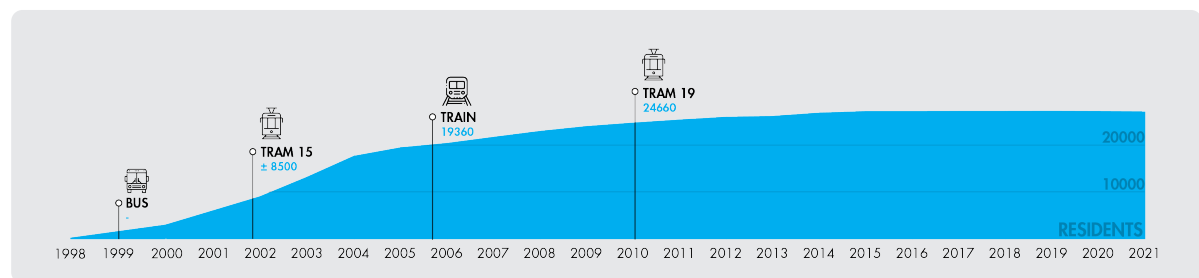


Figure 4.10: Public transport developments in relation to the number of residents (data on the number of resident per year received from CBS (2013, 2014, 2018, 2019a, 2020a, 2021a,b,c,d)).

4.3.2. Evaluation

This sub-section evaluates the public transport in Ypenburg. First the provided public transport connections will be evaluated, after which the car-ownership levels in the neighbourhood are discussed.

Public transport connections

The bus connections changed a lot over the years and data on the ridership levels could not be found. Therefore, only the tram and train connection will be evaluated. The tram connections will be evaluated using newspaper articles and data on the ridership levels in relation to other trams operating in the region. The train connection also is evaluated on the basis of ridership levels and newspaper articles.

Figure 4.11 gives an overview of the amount of passengers per tramline per day for tram operating in the region. The tramlines operating in Ypenburg are marked with a yellow border. The public transport connections will now be discussed one by one.

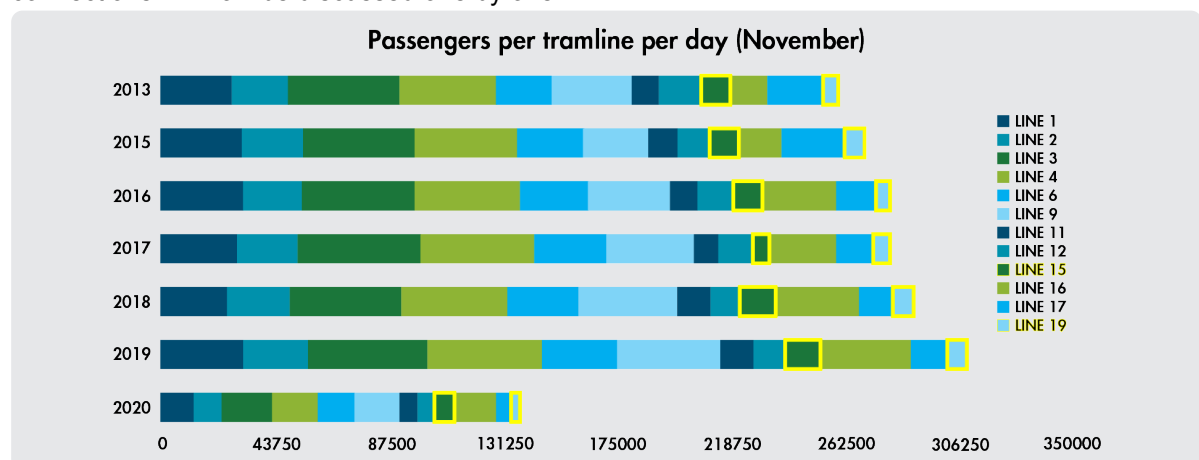


Figure 4.11: Amount of passengers per tramline per day in the Municipality of the Hague (2013-2020) (Source: Gemeente Den Haag (2021)).



Tram 15

Tram 15 started to operate in the early days of the development. The occupation rate of the tram in those early years was relatively low. At the time, the normal occupation rate for urban public transport varied between the 20 and 40%. The occupation rate of tram 15 in the early days of the development was much lower than that, as can be seen in Figure 4.12 (Lebouille and Molemaker, 2006).

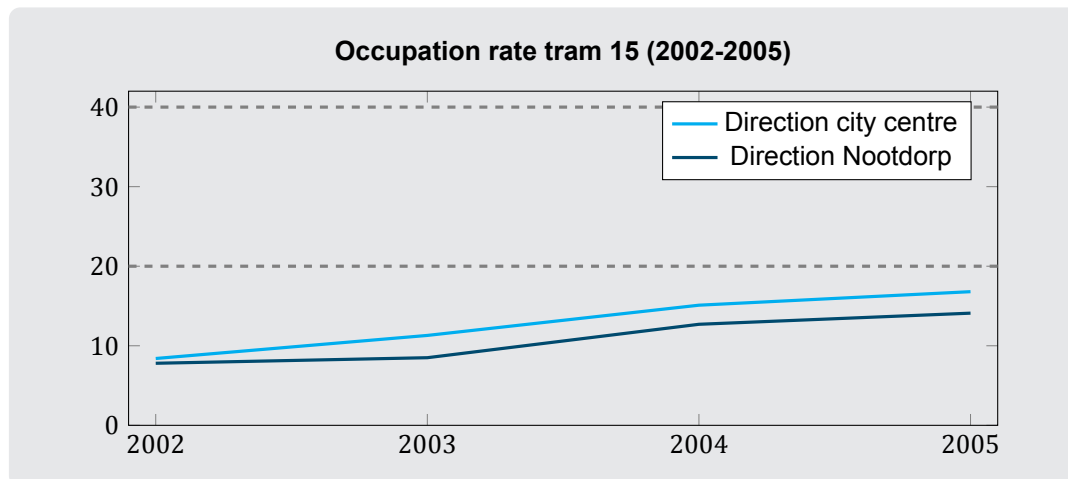


Figure 4.12: Occupation rate tram 15 (2002-2005) (data retrieved from (Lebouille and Molemaker, 2006)).

The ridership levels in these early days grew from around 1000 passengers per day in 2002 to around 2200 passengers per day in 2005 (Lebouille and Molemaker, 2006). From 2013-2016, the tram transported around 11 000 passengers per day and between 2018 and 2019 around 13 000 passengers. The ridership levels in 2020 dropped drastically due to Covid (Gemeente Den Haag, 2021). In relation to other trams in the region the tram transports a relatively low amount of passengers. However, in relation to the other tram operating in Ypenburg, line 19, the ridership levels are twice as high (Gemeente Den Haag, 2021).



Tram 19

Tram 19 started to operate in 2010. The first years it operated between Leidschendam Leidschenhage and Delft Tanthof, but later this route was shortened to terminate at Delft Station. According to Rosenberg (2016) the tram line is the least profitable line of the HTM. Before the route was shortened the tram transported around 7000 passengers per day and after only 5000 (Rosenberg, 2016; Gemeente Den Haag, 2021).



Train

The station in Ypenburg was opened in December 2005. Situated on the railway between Gouda and The Hague, it provided the residents with a fast connection with the Hague and the middle of the country (Gemeente Den Haag, 2017). In September 2006, almost a year after the opening, only 300 people per day used the station. This was far below the 800 passengers a day predicted by the NS and even further from the 1000 passengers set as a condition by the Ministry of Transport and Water Management for their contribution of five million euros for the construction of the station (Omroep West, 2006). As can be seen in Figure 4.13, this number wasn't reached until 2007. From 2007 onward, the number of passengers using the station started to increase drastically till the growth stagnated at around 2500 passengers a day in 2017.

This growth could partially have been caused by the housing development in Leidschenveen, which is located right next to Ypenburg. In 2002, around 7000 new residents moved here as new the first part of the housing development was completed. The number of residents increased to around 12 500 in 2005, 17 750 in 2010 and 21 000 in 2019 (CBS, 2013, 2014, 2021b).

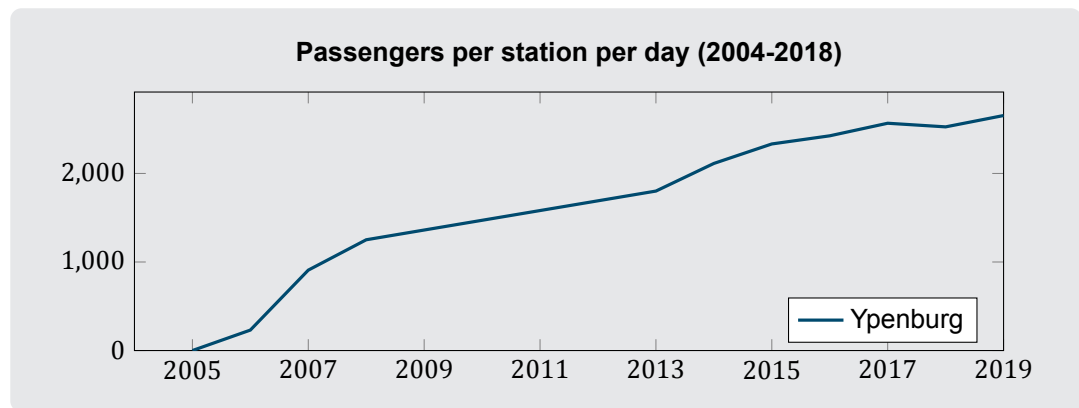


Figure 4.13: Passengers per day at Ypenburg station (2004-2018)
(data retrieved from Treinreiziger.nl (2009, 2019)).

Car ownership

The car ownership levels over the years are given in Figure 4.14. As can be seen they have been relatively constant over the years, a bit higher in the early years of the development and gradually decreasing after that. The car ownership levels in Ypenburg are only slightly higher than the nationwide average of around one car per household over the years. As of today, the car ownership levels are equal to the nationwide average.

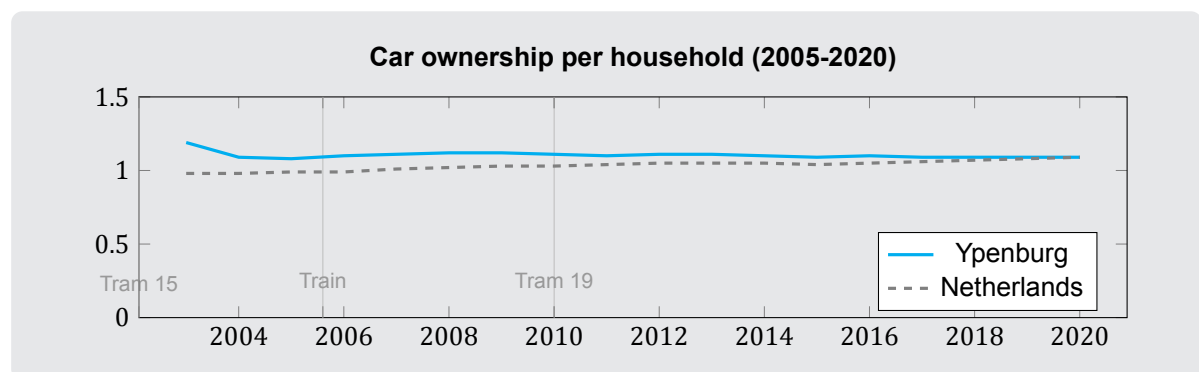


Figure 4.14: Car-ownership over the years
(data retrieved from CBS (2013, 2014, 2018, 2019a, 2020a, 2021a,b,c,d)).

4.3.3. Conclusion

The first public transport connection was provided relatively early in the development of the neighbourhood. This resulted in low ridership levels in the early days of the development, as not all houses were built. These ridership levels steadily increased when the neighbourhood was expanded. However, the ridership levels of the trams have never reached those of other trams operating in the neighbourhood. The ridership levels of the train were also low in the beginning, increasing significantly in the years to follow. The car-ownership levels have been at around one car per household over the years. People did not feel obliged to buy a car because there was a lack of public transport, but on average every household still felt the need for owning a car. Overall, it can be concluded that the early provision of public transport did have a positive effect on the mode choice of the residents.

4.4. Comparison

This section compares the outcomes of the different development timelines, an overview of which is given Figure 4.15. First the public transport connections of the three neighbourhoods will be compared, after which the car ownership levels are set side by side.

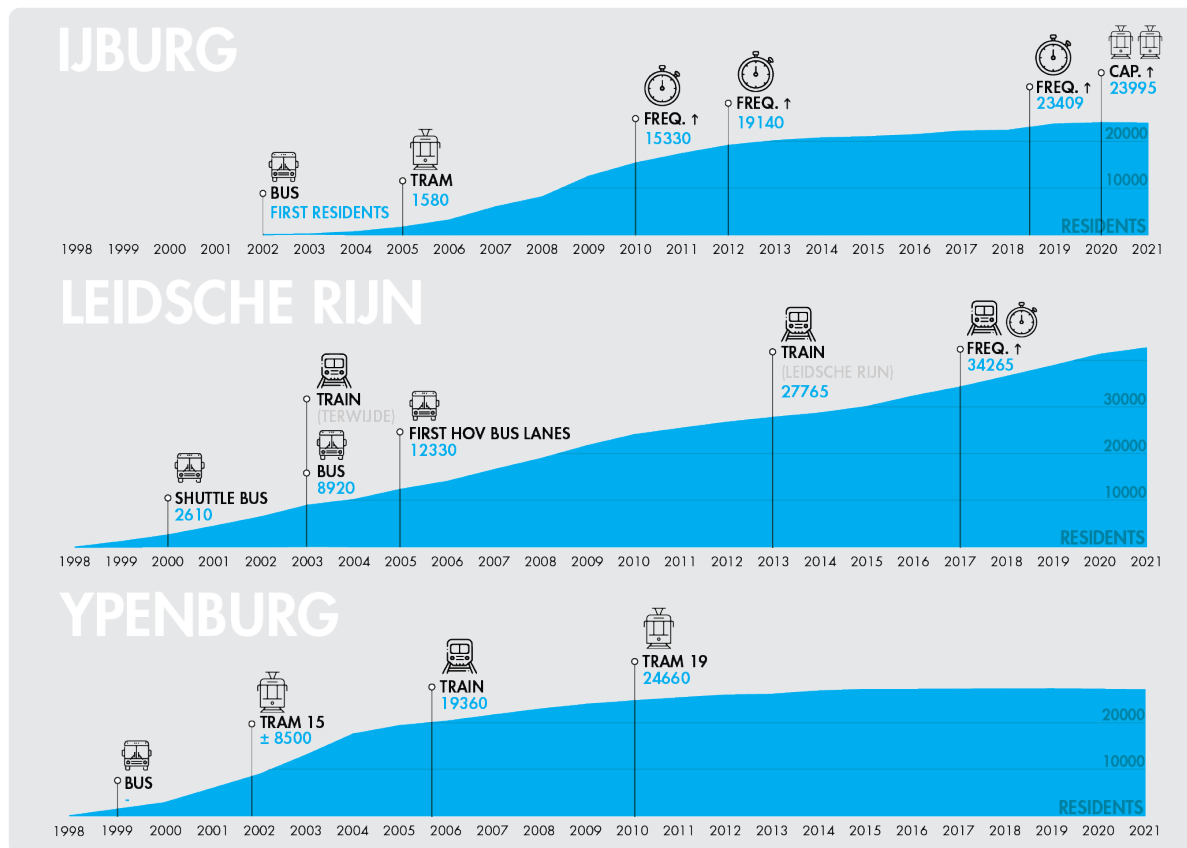


Figure 4.15: Public transport developments in relation to the number of residents (data on the number of resident per year received from CBS (2013, 2014, 2018, 2019a, 2020a, 2021a,b,c,d)).

4.4.1. Public transport

All three locations provided some kind of public transport in the early days of development. The difference lies in the quality of the provided public transport. In IJburg a bus connection was operated for the first residents and the tram connection started to operate when around 1580 people lived in the neighbourhood. In Leidsche Rijn, the first bus and trains started to operate when around 9000 people lived in the area. Before that, the only option to use public transport was the regular bus between Utrecht and De Meern which had a low frequency and a bus stop far away. The high-quality bus network was provided from the moment the area had around 12 500 residents and when 27 750 people lived in the area, the station Leidsche Rijn was completed. In Ypenburg, several buses operated in the early days of the development and the first tram connection started to operate when the area had around 8500 residents. The train station was taken into operation when 20 000 people lived in the area and a second tram connection at 25 000 people. It should be noted that the train and second tram also serve Leidschenveen, which means that the catchment area of these connections is actually larger.

The difference in quality translates to the satisfaction and usage. In general, there were a lot of complaints about the lower quality public transport (bus) in both IJburg and Leidsche Rijn. But, as the higher quality public transport was realised much earlier in IJburg (tram) than in Leidsche Rijn (HOV-bus), the residents of IJburg used the tram while the residents of Leidsche Rijn often felt obliged to buy a car as the higher quality was not available yet.

4.4.2. Car ownership

The car ownership levels of each of the neighbourhoods over the years are given in Figure 4.16. As can be seen, the ownership levels in Leidsche Rijn and Ypenburg are significantly higher than those of IJburg. Leidsche Rijn takes the cake when it comes to the highest ridership levels from 2004-2019, however both before and after that time period the ridership levels are similar to or lower than those of Ypenburg, which lie around the nationwide average of about one car per household.

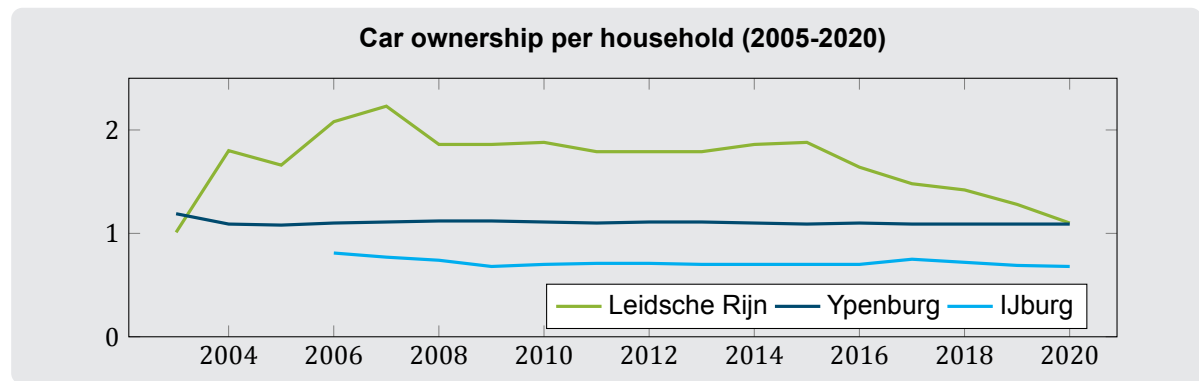


Figure 4.16: Car-ownership over time (data retrieved from CBS (2013, 2014, 2018, 2019a, 2020a, 2021a,b,c,d)).

4.5. Discussion & Conclusion

The case studies used to test the hypothesis, suggest that the early development of public transport results in less car usage in a newly developed residential area, however the results should be considered with a critical eye for several reasons.

First of all, the lower car ownership levels do not necessarily mean that more people use public transport and the evaluation of the connection only gives an indication of the usage over the years. This means that the exact effect of early implementation on the ridership levels remains unclear, as the percentage of public transport users is not known. Second, the differences between the case studies can also be caused by other factors that discourage or encourage car usage, such as the spatial layout of the built environment, the parking standards and the proximity to a highway. Third, the types of houses and thus types of people that live in a neighbourhood can also have an influence on car use, as families living in a family home are more likely to have and use a car than young starters living in an apartment. Even though the cases selected for the comparison are comparable in terms of location and development vision, there are still differences in those factors which could also (partially) explain the differences in car ownership levels and public transport usage.

Furthermore, the case studies also show that the provision of high-quality public transport in a later stage does not necessarily mean that it is doomed to fail, as average car-ownership levels can slowly decrease in the years after public transport is provided.

Nevertheless, the case studies revealed that people who start to live in a neighbourhood without (high-quality) public transport often feel obliged to own a car to get around and that people who have access to high-quality public transport own a car less often. Thus, the hypothesis:



"If the public transport connection is developed late, people will have developed other travel habits and the chance that they use public transport when it is provided, will diminish."

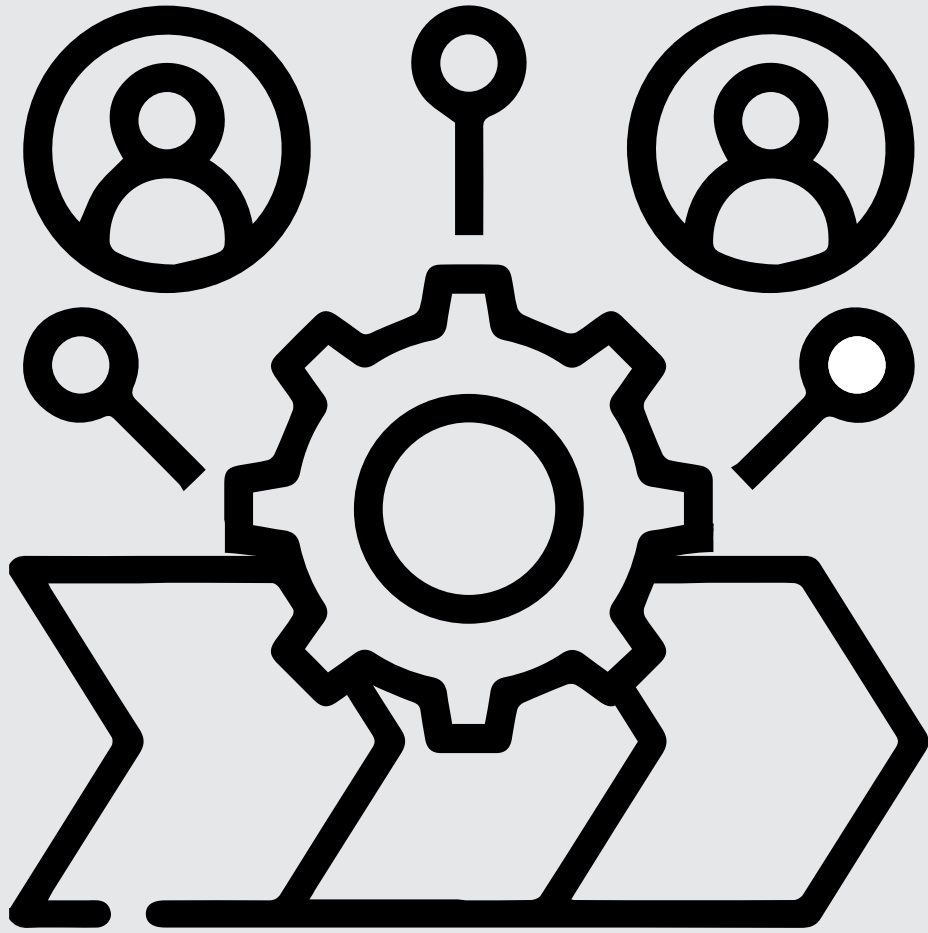
is confirmed, at least for the first decade or so after the development of the neighbourhood. Long-term, the ridership levels might rise, but the question remains if the same levels will be reached as when the public transport would have been provided from the start.

The case studies also give answer to sub-research question 2:

2. What lessons can be learned from past development timelines?

The lessons that can be learned from the case studies are:

- Early development of public transport results in lower car ownership levels.
- Late provision of public transport does not necessarily mean that people will not eventually use it, but it can take a while before the effects are noticeable.
- The quality of the public transport connections is important for the ridership levels.



PART II

DEVELOPMENT STRATEGIES IN PRACTICE

5

INTRODUCTION TO THE PROCESS Steps & stakeholder involvement

This chapter gives an introduction in the development process of transit-oriented neighbourhoods. The goal of this chapter is to get an impression of the playing field in which decisions on development timing are made. First, the development process itself is described, after which the stakeholders involved in the process are identified. Then, the interaction between the stakeholders is elaborated on and their involvement in the various stages of the process is determined. The chapter ends with an overview of the power and interest of the stakeholders and a conclusion on their role in the process. Hereby, it gives answer to sub-research question 3: **What stakeholders are involved in the development process and what is their role?**

5.1. The development of residential areas

Space in the Netherlands is scarce and homes, infrastructure, airports, industrial estates and nature all have to be fitted within it. To make sure that all these aspects are balanced, the Dutch government develops land-use plans in which they allocate space and designate areas for specific destinations (Rijksoverheid, 2021a). The development process of residential areas often starts on regional/municipal level, when an area is identified as a potential location for neighbourhood development (de Vries and den Otter, 2021). Usually the initiative for a development comes from governmental institutions, but market parties and citizens' initiatives do also exist (de Zeeuw, 2018). The vision and policy developed by the regional government and municipalities form the basis or starting points for the area development (de Vries and den Otter, 2021).

With these starting points in mind a development vision is created. In this vision the task at hand is specified and the ambitions and goals for the development are determined. The development vision forms the basis for the requirements and boundary conditions that the development should meet. These include the amount of houses that need to be built, the required amenities, the amount of work places, parking standards and the desired infrastructure and transport systems. With this in mind an urban plan can be drawn up, in which the spatial design of the area is captured. This plan indicates the location of different functions such as living and retail, green spaces and infrastructure.

This urban plan is ratified and developed further in the zoning plan. In this stage the different boxes in the area are filled in and building designs for those boxes are created. When the zoning plan is approved the construction can begin (de Vries and den Otter, 2021; de Zeeuw, 2018). Figure 5.1 gives an overview of the process as described above.

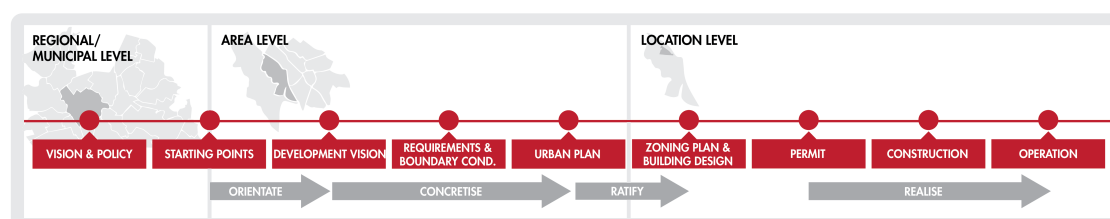


Figure 5.1: Steps in the area development process (own work).

Critical comment: It should be noted that the process has no orderly or sequential character as Figure 5.1 might suggest. It is a process with a lot of feedback loops and unexpected turns.

5.2. Stakeholders

A large number of stakeholders are involved in the various steps and scale levels of the development process. Both at governmental institutions - often spread over several departments - and market parties such as developing parties and public transport providers. Below a description of each of those stakeholders is given.

5.2.1. Governmental institutions

There are several layers of governmental institutions that all have a different role and interest in the development process.

National government

Area development is primarily a task of the regional governments and municipalities. The national government only focuses on national interests such as the main road, rail and waterway network and heritage preservation (Rijksoverheid, 2021a). Their land-use vision is enclosed in a national land-use plan, which provides information for regional governments and municipalities how land can and may be used and developed (Kenniscentrum InfoMil, 2021). Even though they are not directly involved in the planning, they still have a great influence as they are the main source of funding for the development of housing and sustainable modes of transportation (Poiani and Stead, 2014; Rijksoverheid, 2021a).

Regional government

The regional government is responsible for the land-use vision on a regional level and the accessibility of their region (Rijksoverheid, 2021b). They make sure there is enough green space in and around cities (Rijksoverheid, 2021a) and determine the maximum amount of houses that municipalities are allowed to build. Furthermore, they commission the regional and urban public transport and make decisions on the function areas should serve (Interprovinciaal overleg, 2021; Kenniscentrum InfoMil, 2021).

Transport authority

Some regions have a transport authority that commissions the regional and urban public transport in their region. They provide concessions for public transport providers and distribute subsidies for the operation of public transport in their region. Their work area includes the metro, tram and bus (Vereniging Openbaar vervoer Centrumgemeenten, 2014). They take over the task of the regional government when it comes to mobility.

Municipality

Municipalities are responsible for the spatial design within urban regions. They determine where houses are allowed to be built and what conditions apply. With regards to public transport, municipalities are responsible for preconditions for public transport such as local roads, bus lanes and bus stops (Vereniging Openbaar vervoer Centrumgemeenten, 2014). Their role during the development process varies depending on the partnerships they have with market parties (de Zeeuw, 2018). They have an interest in the coordinated development of public transport and housing development, because it is their task to provide a liveable environment for their residents. Today this often means looking for ways to limit car-use and offer more sustainable alternatives (Kersten et al., 2019). The development timing plays a major role in the success of these sustainable alternatives, as people will be less inclined to use it when it takes too long before it becomes available (see chapter 3).

5.2.2. Market parties

The government works together with several market parties to realise a development. A description of these parties and their interest in the development process is described below.

Public transport providers

Public transport providers operate and implement public transport with the goal to make a profit from the service they offer. To obtain the right to operate the public transport in a certain region, they participate in tenders to obtain the concession for that region (Rijksdienst voor Ondernemend Nederland, 2021). An exception to this process are the four large cities Amsterdam, The Hague, Rotterdam and Utrecht, whom may also grant this concession to their own public transport provider without having to organise

a tender (MuConsult, 2020). The development timeline is of interest, because it influences their expenses. If they have to operate the public transport connection from the moment the first houses are inhabited, the ridership levels will be low in the early days of development, which means the operation will not be profitable. However, this early availability could also result in higher ridership levels in the final stage of development, as people's travel habits were formed with the availability of the connection taken into consideration.

Developers

Developers design, build and sell houses on a development site with the goal to make a profit. They either buy the land they want to develop on or participate in tenders written out by the municipality (Michielsen et al., 2019). The development timeline is important for developers, as this timeline can influence the funding of the project. Projects with a long duration and uncertain outcome are difficult to finance and the interests are high. Therefore, developers often aim to build as fast as possible. However, the houses are often finished in stages to prevent market saturation (Michielsen et al., 2019).

Consultants

Consultants advise governmental institutions and private parties in the different stages of the development process. They draw up plans according to the requirements specified by their client.

5.3. Stakeholder interaction

This section elaborates on the interaction between the actors in the decision making process. The interaction between the stakeholders is determined with the help of both desk research and interviews with different stakeholders involved in the process. Figure 5.2 gives an overview of the interaction between the stakeholders, an elaboration on each of those connections is given below.

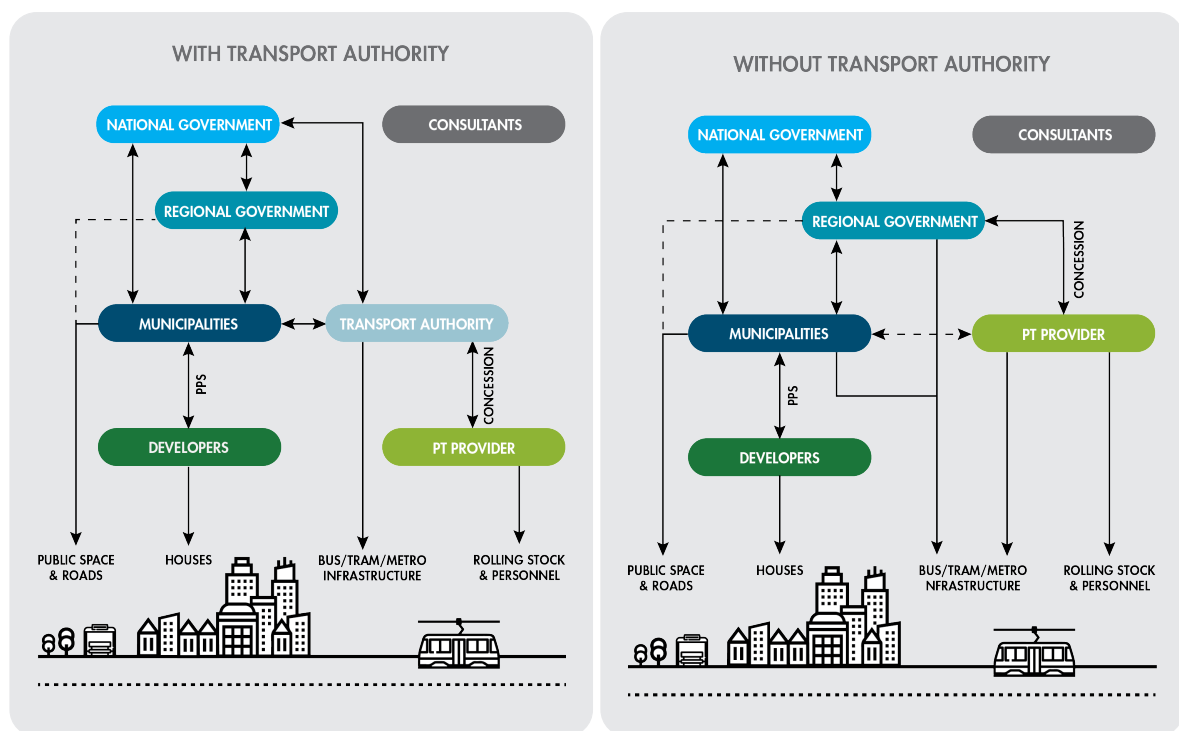


Figure 5.2: Stakeholder interaction (own work).

5.3.1. Governmental institutions

Governmental institutions work together to make land-use and transportation plans and to determine the distribution of the budget available for these plans. These partnerships take place on different governmental levels. Figure 5.3 gives an impression of the interaction between them.

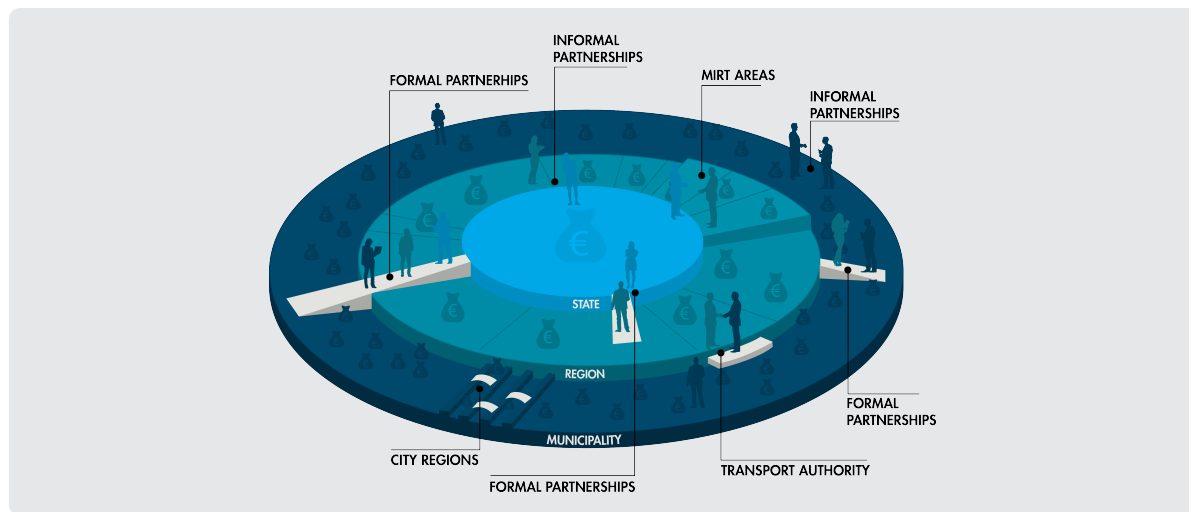


Figure 5.3: Interaction between government parties (image adapted from: Raad voor leefomgeving en infrastructuur (2018)).

Partnerships and interaction in policy making

When it comes to policy making, the different governmental institutions work together on several levels to determine the vision and policy for an area or region. This leads to land-use plans that form the legal boundary conditions for the development of urban areas. This collaboration takes place via several programmes, the most important will be elaborated on below.

- **Multi-Year Programme for Infrastructure, Spatial Planning and Transport (MIRT)**

👤 National government 👤 Regional government 👤 Transport Authority

The MIRT is a programme in which the national government works together with regional governments to determine the collective perspective and ambitions for the development of areas in that region. Via this programme, prospective mobility and infrastructure projects are ranked by priority and grants are assigned accordingly (Ministry of Infrastructure and Water Management, 2018). Projects are included in this programme when the national government is either directly involved in the funding or when regional governmental institutions need grants higher than the budget they receive on a yearly basis (MKBA-informatie, 2021).

- **Regional mobility programmes**

👤 Regional government 👤 Transport Authority 👤 Municipality

Regional mobility programs describe the collective perspective and ambitions of a region to make it more sustainable in terms of mobility. The programs are drawn up by the regional government, municipalities and other regional partners. Alignment of these programmes with the national programme takes place in the MIRT meeting between the national and regional government (Vereniging van Nederlandse Gemeenten and Interprovinciaal Overleg, 2019).

Interaction in development process

In general, the municipalities take the initiative for the development of large urban locations within their legislative bounds. For these large projects they need the (financial) support of the regional government, the transport authority (if there is one) and the national government. Usually the municipality works together with the regional parties and together they present their plans to the national government (Expert A, personal communication, November 16, 2021).

The difference between the two situations as presented in Figure 5.2 is the existence of a independent Transport Authority. For most regions the province acts as the Transport Authority, however for the regions Rotterdam/The Hague and Amsterdam this is different. They have a Transport Authority that is responsible for mobility in the region (MuConsult, 2020).

- **With Transport Authority**

When there is a Transport Authority, they have the responsibility for the public transport concessions (both infrastructure and transport related). They act on behalf of the municipalities, which are their formal bosses (Expert A, personal communication, November 16, 2021).

- **Without Transport Authority**

In most parts of the Netherlands, there is no independent transport authority. Then the regional government acts as the transport authority. This means that the concession for public transport is the responsibility of the regional government.

5.3.2. Public transport provider and governmental institutions

Public transport providers work together with governmental institutions via a concession. In this concession agreements are made about the obligations and regulations the public transport provider has to follow. This includes the provision of public transport access for to be developed areas when a certain percentage of the development is completed (Expert F, personal communication, November 23, 2021). Next to that, public transport providers also are in contact about small changes with either the Transport Authority (in case there is one) or the municipality (Expert D, personal communication, November 19, 2021).

5.3.3. Municipalities and developers

The development of a residential area almost always requires a private-public partnership, namely that between the municipality and one or more developers. This partnerships can occur in several forms. Figure 5.4 gives an overview of these different partnerships and distribution of the responsibilities within these different types of partnerships.

	CLASSIC	BOUWCLAIM	JOINT VENTURE LIGHT	JOINT VENTURE	PRIVATE EXPLOITATION	CONCESSION
Initiative	municipality	municipality or market	municipality or market	municipality or market	municipality or market	municipality
Land acquisition	municipality	market sells to mun.	free-for-all	free-for-all	market	municipality sells to market.
Land exploitation	municipality	municipality (with market input)	free-for-all	together	market (with exploitation agreement)	market
Planning	municipality	municipality (with market input)	together	together	municipality and market	market (within boundaries municipality)
Execution	municipality or market	market	free-for-all	together	market	market

Figure 5.4: Partnerships between municipality and market (de Zeeuw, 2018).

As can be seen from Figure 5.4, the role municipalities and developers play in public-private partnership can vary a lot depending on the type of partnership. This does not only affect their responsibilities in the development process, but also impacts their power with regards to the decision making process.

5.4. Stakeholder involvement

The involvement of the different stakeholders in the decision making process is determined with the help of interviews with different stakeholders involved in the process. The interviewees are referred to with an interviewees ID consisting of a letter and a number. The letters represent the interviewees and the numbers 1-3 indicate the group they belong to: (1) Municipality, (2) Regional government/Transport authority and (3) Public transport providers. The interviewees are only briefly discussed in this section, as their specific role is less relevant for this section. Their background and specific roles within the decision making process will be discussed in chapter 6 in more detail. The transcripts of the interviews

can be requested from the author.

The interviewees were asked to state the involvement of the actors in the different stages of the development process (see Figure 5.1). The information received from the interviews was compared by listing the responses on the involvement of each of the stakeholders per development phase. An overview of which is given in Table 5.4.3. This section describes the influence of the different stakeholders as identified by the interviewees. First the influence of governmental institutions is discussed, after which the market parties are elaborated on. The section ends with an overview of the different stakeholders in the various stages of the decision making process.

5.4.1. Governmental institutions

Below, the involvement of the governmental institutions in the different steps of the development process is discussed.

National government

According to interviewees A1, D1 and E2 the national government is only financially involved in area development. Interviewee E2 also states that their land-use vision does mention area development on a very high level, but with regards to the planning and design of the area they are not involved. Interviewee B2 underlines this by stating that they do not have a vision on the development of an area. According to interviewee A1, the only reason they might get involved in the development of an area is if they own the land, but this is rarely the case.

Regional government

The involvement of the regional government depends on the existence of an independent transport authority. According to interviewee G1 the involvement of the regional government in general is usually limited to checking their preconditions with regard to spatial policy, public transport flow or subsidies. Whether or not there is a transport authority, their involvement is more extensive.

- **With transport authority**

For the situation where there is an independent transport authority, the interviewees agree that the regional government is involved from 'Vision & Policy' until the 'Zoning plan'. In the 'Vision and Policy' they have a major role, but from the 'Starting points' until the 'Zoning plan' their influence is less. According to interviewee B1 they are partially responsible for the vision & policy for the area, but after that they are only involved when it concerns matters that cross municipal borders (B1) and to check preconditions with regard to spatial policy, public transport flow or subsidies (G1). According to interviewee A1, their involvement is larger if they own the land the area is developed on.

- **Without transport authority**

When there is no independent transport authority, the involvement of the regional government is different as they also fulfill the role of the transport authority. This means that their involvement is greater than for the regions where there is no transport authority (C1). Interviewee D1 states that, in this case, they are involved until the 'Urban plan', not with regards to urban planning, but to help think about how public transport should be implemented. According to interviewee G1 the involvement with regards to public transport starts earlier or later in the process depending on the size of the development. When it comes to large construction sites where new infrastructure is necessary, they are involved fairly quickly, because they are partially responsible for the infrastructure. However, when it comes to smaller locations, the involvement usually starts later on in the process. According to interviewee C1, they are off the radar on the location level until the construction starts. From that moment they start to get involved again, as they are the concessionaire of the public transport.

Transport authority

According to interviewee E2, the transport authority is involved right from the beginning of the process all the way until the operation. In the beginning the transport authority thinks along to determine where developments have to take place and what the plans are for the region. Then, on area level they are involved in the development of new public transport and new access roads. From the moment the different property lots are started to be filled in they are not really involved anymore. They are involved

again from the moment construction starts and they also play a role in the operation, as they are the concessionaire of the public transport. The latter is also mentioned by interviewee B2. Interviewee F3 adds to this that their involvement is very intensive in the beginning and they are less involved from the location level onward.

Municipalities

All stakeholders state that municipalities are involved throughout the complete development process. According to interviewees A1, E2 and G1 they are usually the ones that take the initiative for area development. According to interviewee D1 they feed and influence the regional government on their vision, as they are the ones that determine the policy in the end. From the area level onwards, municipalities are in the lead. According to interviewee A1 they arrange the preconditions necessary to realise the development, such as accessibility and energy supply (interviewee A1) and are responsible for the design of the area (C1). They involve the other parties in the process when they are needed. Amongst others the regional government and/or the transport authority and public transport providers for public transportation (E2, G1), consultants to advise on plans (B2, C1) and the national government, regional government and transport authority for funding (A1, E2). From the location level they get less and less involved. They issue building envelopes and lots and then it is up to project developers or self-build initiatives to fill in those lots (E2).

5.4.2. Market parties

Below, the involvement of the market parties in the different steps of the development process is discussed.

Developers

According to interviewee C1, D1 and E2 developers are usually involved from the 'Urban plan' to the 'Construction'. Sometimes they are involved earlier in the process, but this is only the case when it is their initiative (G1). Their true involvement often starts from the 'Zoning plan & Building design', as they start to design and fill in the building envelopes provided by the municipality (E2).

Public transport providers

According to the interviewees the involvement of the public transport provider is advisory in the earlier stages of the development and implementing in the later stages of the development. According to interviewee B1 their involvement in the decision making process depends on the type of public transport provider. Some public transport providers operate on a certain line when you tell them this is needed, but there are also public transport providers that advise on whether it is wise to develop a certain connection and what it should look like. The first role is also mentioned by interviewee G1, who states that the involvement of these types of public transport providers is not really present in the earlier development stages, as they do not have the manpower and funds to get involved in extensive planning processes and lobbies. The latter role is underlined by interviewee E2 and F3, who state that some public transport providers are consulted whether an idea is workable in practice. Furthermore, interviewee G1 also states that their involvement in the earlier development stages is dependent on their concession period, as they will not get involved in planning a connection of line that they might not operate in the future.

Consultants








According to interviewee B2, C1, D1, G1 consultants advise on the different plans that are developed in the process: the 'Development' vision, 'Urban plan' and 'Zoning plan'.

5.4.3. Overview

The involvement of the different stakeholders during the various stages of development are summarised in Figure 5.5 and Figure 5.6. The dotted lines represent a reduced involvement.

Critical comment: When comparing the two figures (Figure 5.5 and Figure 5.6), what is striking is that the involvement of the regional government for the situation without transport authority is less than that of the transport authority. This could be, because the interviewees had projects of different scale in mind, or because they had another interpretation of the development steps.

Table 5.1: Responses of interviewees on stakeholder involvement.

	National gov.	Regional gov.	Transport Authority	Municipalities	Developers	PT providers	Consultants
 A1	Financially involved.			'Initiative', 'Development vision', 'Boundary conditions', 'Zoning plan', 'Permits'		From/to: ➡ Advisory: 'Development vision' ➡ 'Construction' ➡ 'Operation'	
 B2	Not involved in development vision.	From/to: ➡ 'Vision & Policy' ➡ 'Zoning plan' Less from 'Development vision'.	From/to: ➡ 'Development vision' ➡ 'Operation'	Complete process.	Cannot start until the 'Zoning plan' is ready.	From/to: ➡ Advisory: 'Development vision' or 'Urban plan' ➡ 'Construction' ➡ 'Operation'	Advise governmental institutions when hired.
 C1		From/to: ➡ 'Vision & Policy' ➡ 'Operation' Off the radar from the start of 'Location level' till construction.		Complete process.	From/to: ➡ 'Urban plan' ➡ 'Construction' Less before 'Zoning plan'	From/to: ➡ Advisory: 'Urban plan' ➡ 'Construction' ➡ 'Operation' From 'Development vision' would be better.	'Development vision', 'Urban plan', 'Zoning plan'
 D1	Financially involved	From/to: ➡ 'Vision & Policy' ➡ 'Urban plan' Less from development vision to urban plan		From/to: ➡ 'Vision & Policy' ➡ 'Operation' Feed regional government on policy ideas.	From/to: ➡ 'Urban plan' ➡ 'Construction' Less before 'Zoning plan'	From/to: ➡ Advisory: 'Urban plan' ➡ 'Construction' ➡ 'Operation'	'Development vision', 'Urban plan', 'Zoning plan'
 E2	Only financially involved, not involved in the planning/design of the area.	From/to: ➡ 'Vision & Policy' ➡ 'Location level' Less from 'Development vision'.	From/to: ➡ 'Vision & Policy' ➡ 'Operation' Limited to none involvement on location level.	From/to: ➡ End 'Vision & Policy' ➡ 'Location level' Less and less from 'Location level'.	From/to: ➡ 'Urban plan' ➡ 'Construction' Less before 'Zoning plan'.	From/to: ➡ 'Development vision' ➡ 'Operation' Advisory role in planning.	'Development vision', 'Urban plan', 'Zoning plan'
 F3		From/to: ➡ 'Vision & Policy' ➡ 'Location level' Less from 'Area level'.	Very intensive in the beginning, less from the location level onward.	From/to: ➡ End 'Vision & Policy' ➡ 'Operation'		From/to: ➡ 'Development vision' ➡ 'Operation' More towards operation.	
 G1	From the start.	From/to: ➡ 'Vision & Policy' ➡ 'Operation'		From/to: ➡ 'Vision & Policy' ➡ 'Operation'	From the start if it is their initiative.	From/to: ➡ Advisory: 'Development vision' or 'Urban plan' ➡ 'Construction' ➡ 'Operation'	'Development vision', 'Urban plan', 'Zoning plan'

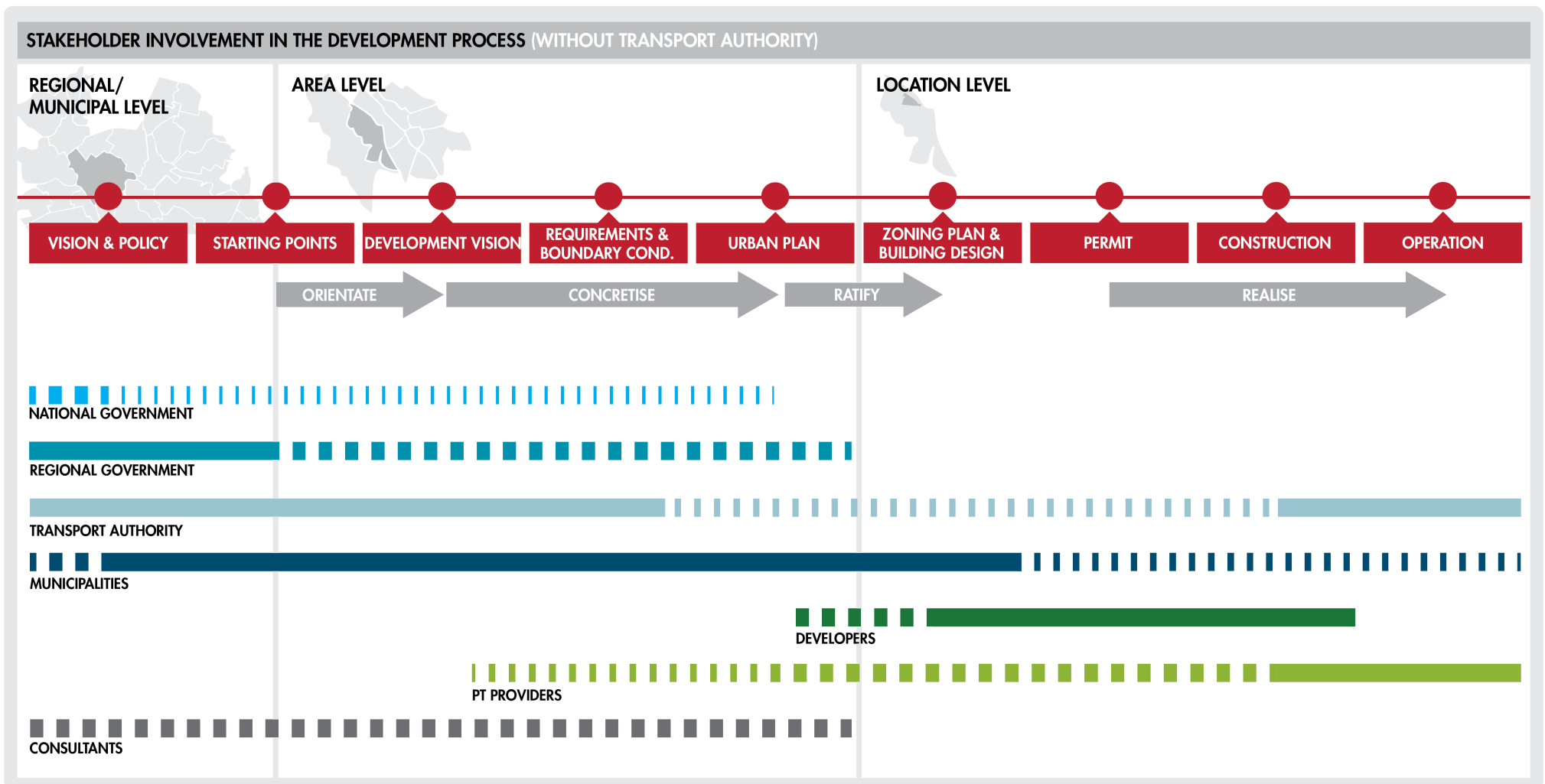


Figure 5.5: Stakeholder involvement in the development process with independent transport authority (own work).

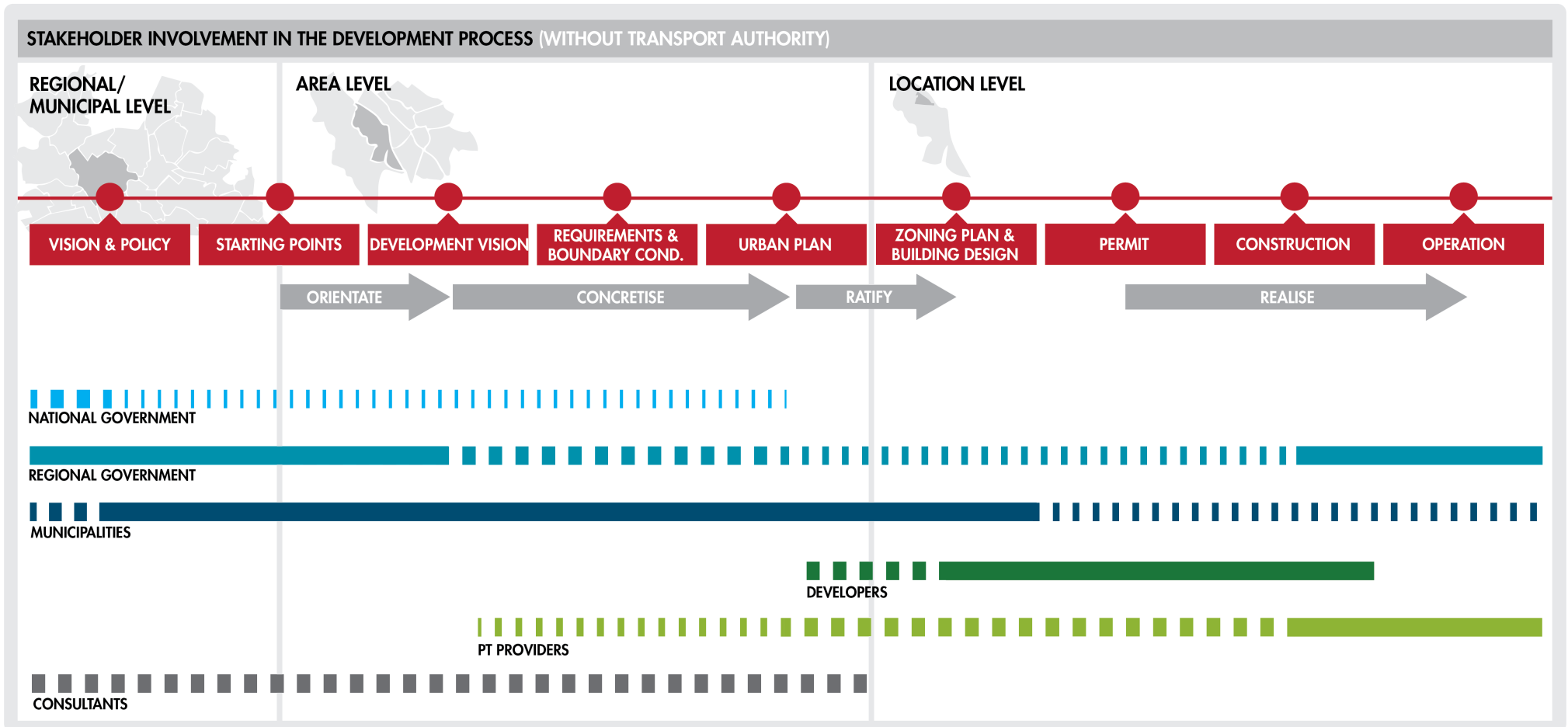


Figure 5.6: Stakeholder involvement in the development process without independent transport authority (own work).

5.5. Power and interest

The previous sections explained the role and involvement of the different stakeholders involved in the development process. In this section this information is used to map the stakeholders in a power interest grid, which shows the power and interest of the different stakeholders with regards to the development timeline. The x-axis shows the power of the different stakeholders to influence the development timeline and the y-axis the interest they have in this development timeline. The grid divides the stakeholders in 4 categories: crowd, context, subjects and players.

The power-interest grid is given in Figure 5.7. An explanation on the positioning of the different stakeholders in the grid is given below.

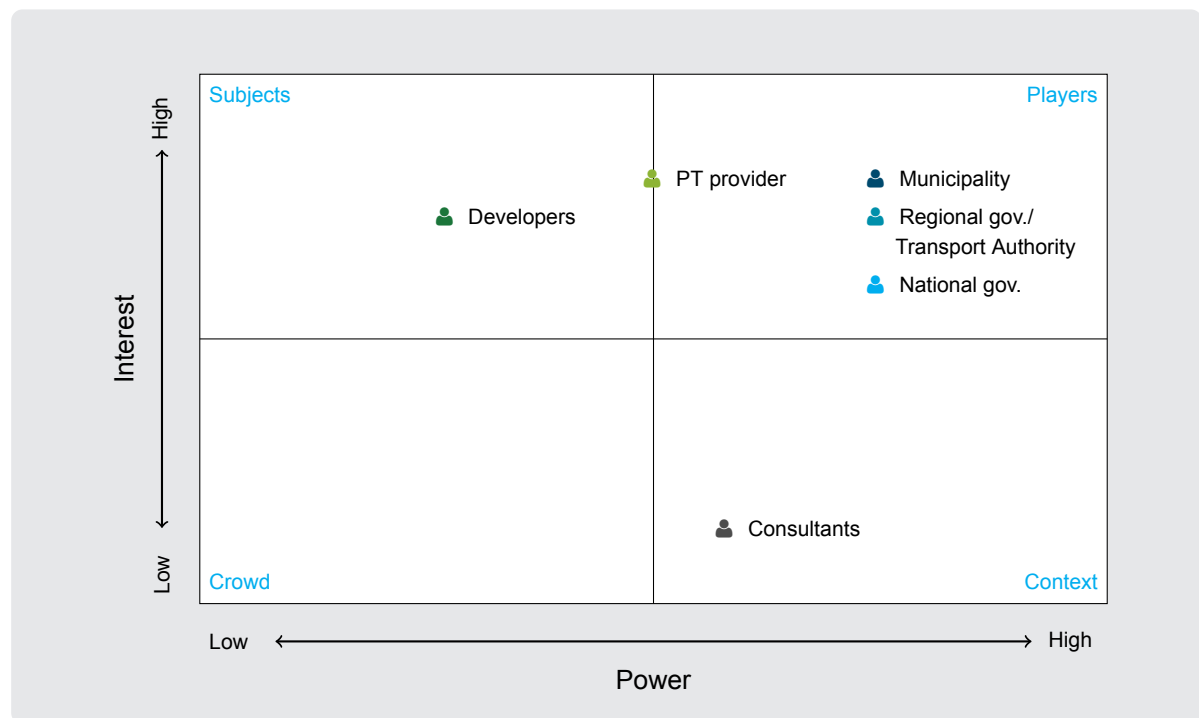


Figure 5.7: Power-interest grid.

The main players in the planning process are the municipalities and regional government/transport authority. Together they make decisions on the development vision for the area. The national government is involved when funding is needed for large projects. They have a lot of power, but little interest in the development process itself. The public transport providers are sometimes asked to give advice on the feasibility of public transport options in an area, but have no real vote in the decision. In the end, they have to provide public transport according to the conditions prescribed by the concession.

The developers have a high interest in the development of the area, but are not involved in the decision making process until the urban plan is drawn up and even in that stage they have a limited role. Their main involvement starts from the moment the building envelopes are issued by the municipality. However, when the initiative for area development comes from the developers, they have more power.

The consultants have no real interest in the development and only give advice on the different plans that need to be drawn up for the development. This way they do have quite some influence on the decisions made in the process.

5.6. Conclusion

This chapter discussed the different steps in development process and the stakeholders involved in it, an overview of which is given in Figure 5.5 and Figure 5.6. The conclusions on their role in the development process give answer to sub-research question 3:

3. What stakeholders are involved in the development process and what is their role?

The different stakeholders involved in the development process are:

Governmental institutions

- **National government**

The national government is involved in policy making on a high level, but not with regards to the planning and design of an area. Even though they are not directly involved in the planning, they still have a great influence as they are the main source of funding for the development.

- **Regional government**

The involvement of the regional government differs for the situation with transport authority and without transport authority. When there is a transport authority, their role is limited to checking preconditions with regard to spatial policy and the provision of subsidies. When there is no transport authority, the regional government is also responsible for the provision of public transport. Their involvement with regard to this area starts earlier or later in the project depending on the scale of the development.

- **Transport authority**

The transport authority is involved from the beginning all the way to the operation. They are involved in the development of regional strategies and the development of new public transport connections and infrastructure. On the location level they are more or less out of the picture, except for their role in the operation, for which they have contracts with public transport providers.

- **Municipalities**

Municipalities are involved throughout the entire development process. They are less involved in the vision & policy development on regional level, but feed the regional government with their ideas. They are usually the ones taking the initiative in area development and are in the lead from the area level onward. From the moment the location level is reached they get less and less involved, as from that moment the building envelopes are issued.

Market parties

- **Developers**

Developers fill in the building envelopes issued by the municipalities. Occasionally they are also involved in the development of the urban plan.

- **Public transport providers**

The main involvement of the public transport providers starts from the moment the construction starts. They operate the public transport connection and are often (partially) responsible for the construction of the infrastructure needed for it. They also have an advisory role in the creation of the development vision (less often) and the urban plan (more often).

- **Consultants**

Consultants are involved in the creation of the different plans that are used in the development process.

6

DELPHI ROUND 1

The decision making process according to stakeholders.

To obtain insights in the development process in practice, two rounds of interviews are conducted with different stakeholders involved in the process. The goal of these interviews is to determine how and why stakeholders make certain decisions and if there are points of debate amongst them. This chapter describes the first round, in which different stakeholders are asked to give their view on the decision making process. **The goal of this round of interviews is to determine the decision making factors used to make decisions on development timing and the perception of the stakeholders on the development strategy.** The chapter starts with an elaboration on the preparation and analysis of the interviews, after which the interview results are discussed. First the decision making factors identified will be elaborated on, after which the perception of the stakeholders on the right development strategy is discussed. The chapter ends with a conclusion on the decision making factors and the development strategy, and a discussion on the first round of interviews.

6.1. Preparation & analysis

The interviews are prepared and analysed following the interview protocol as described in subsection 2.2.3. This section elaborates further on the participants selected for the interviews, the interview guide used to conduct the interviews and the processing of the interviews.

6.1.1. Participant selection

The participants selected for the interviews are land-use and transportation planners from governmental institutions and transport providers that are involved in the decision making process around the development timeline. The interviewees are subdivided in three groups:

1. Group 1: Municipality
2. Group 2: Regional government/transport authority
3. Group 3: Public transport provider

These three groups were chosen, because they have the most power/interest in the development of public transport in a residential area. Area development is primarily a task of municipalities and the governing transport authority and the public transport provider has a major interest, as it is their goal to make a profit from the service they offer. Even though the national government has a lot of power, as they are the main source of funding, it was decided to exclude them from the research, because they are not involved in the planning process on a local level (see chapter 5). Table 6.1.1 gives an overview of the interview participants, their organisation, function and expertise. For privacy reasons each of the participants has received a code (A-G). Together with the group code this forms the interviewees ID.

Table 6.1: Interview participants.

	Organisation	Function	Expertise
 A1	City of The Hague	Strategist regional cooperation	Organises and oversees intra organisational collaborations. Expert in the field of the built environment (mobility, land-use, sustainability, housing, economics).
 B2	Transport Authority Rotterdam / The Hague	Transport planning expert	Involved in the transportation planning for Vinex-locations around The Hague. Expert in the field of transport planning in relation to the built environment.
 C1	City of Almere	Public transport coordinator	Responsible for local bus transit in Almere and regional bus transit between Almere and 't Gooi and Amsterdam.
 D1	City of Nijmegen	Strategic advisor mobility	Advises the mayor and alderman on mobility related projects. Expert in the field of transport planning in relation to the built environment.
 E2	Transport Authority Amsterdam	Senior project mentor	Expert in the field of traffic, transportation and infrastructure. Focuses on medium to long-term developments that impact the regional and national transport system.
 F3	GVB (Public transport company of Amsterdam)	Senior Transport developer	Works on short and long-term network development for the municipality of Amsterdam and its surrounding municipalities.
 G1	City of Utrecht	Senior policy coordinator mobility	Expert in the field of land-use and transport planning. Currently works on long-range public transport connections from and to the city of Utrecht.

6.1.2. Interview guide

To reach the goals set for this round of interviews an interview guide was created. This guide contains the questions and topics that were covered in the interview. As the interviews were conducted in a semi-structured form, these questions only form the basis of the interview. More questions were asked based on the response of the interviewees. The topics that were discussed in the interview are listed in Table 6.1.2. The complete interview guide can be found in Appendix B.

Table 6.2: Interview subjects Delphi round 1.

	Topic	Objective
1	Research introduction	Brief the interviewee on the goal of the research and interview.
2	Participant introduction	Determine the interest and expertise of the participant on the subject of land-use and transportation planning.
3	Decision making	Determine the decision making factors used to make a decision about the development timeline.
4	Stakeholder interaction and involvement	Validate and extend the knowledge on the involvement of stakeholders in the development process.
5	Travel behaviour	Determine the factors that the participant think influence travel behaviour.
6	Development timing	Determine the 'ideal' development strategy according to the participants.

6.1.3. Transcription & analysis

Using the encoding scheme as described in subsection 2.2.3, passages of the interview transcripts are coded according to four themes: (1) stakeholder involvement, (2) decision making, (3) travel behaviour influence and (4) development timing/strategy. The coding of these interviews helps to compare the interviews on the different subjects. The coded transcripts can be requested from the author.

6.2. Decision making factors

To gain insights in the decision making process around the development timeline, questions were asked on the decision making factors the interviewees use to make a decision on the development timing. Table 6.2 gives an overview of the decision making factors mentioned by the interviewees.


Table 6.3: Decision making factors as mentioned by the interviewees.


	Decision making factors		
 A1	Preconditions of the location	Business case	Mutual assurance
 B2	Costs	Benefits	Mutual assurance
 C1	Costs	Benefits	
 D1	Preconditions of the location	Costs	Benefits
 E2	Preconditions of the location	Costs	Benefits
 F3	Costs	Benefits	
 G1	Availability of money		


This section discusses the factors as mentioned by the interviewees one by one and elaborates on the similarities and differences between the answers. First the costs and benefits will be discussed, after which the money availability is elaborated on. Then, the location dependency is discussed and lastly the influence of mutual assurance on the decision is elaborated on.

6.2.1. Costs and benefits

The factors that are mentioned most frequently are the costs and benefits that are associated with a decision. According to interviewees B2, D1 and E2 the decisions on the development timing are based on the trade-off between these two. Interviewee C1 and F3 state this trade-off is used by public transport providers to determine if a public transport connection is profitable for them.

 B2: "You try to manage it in such a way that there is a reasonable amount of revenue for the public transport operator, but not everyone has already bought a car or two before the tram starts to operate"


 D1: "It is purely related to money. If you develop the bus connection first, the buses are empty in the beginning and you need to determine if that is worth it."

 E2: "It is a trade-off between the costs and benefits, your business case."

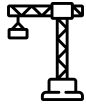
An explanation of the costs and benefits that are taken into account by the interviewees will be given below. First, the costs as mentioned by the interviewees will be discussed, after which the different views on the benefits of early implementation will be considered. Lastly, the use of traffic models to substantiate the cost-benefit analysis will be discussed.

Costs

Costs are the inhibiting factor for the early development of public transport. According to interviewees A1, B2, C1, E2 and F3 aligning the responsibilities with regards to costs is one of the most difficult parts in the decision making process. Interviewee F3 argues that this is partially the case because the costs and benefits do not always lie within the same organisation.

 F3: "The costs and benefits of a certain decision do not always lie with the same party. For instance, the party that develops the area always asks if public transport can operate from the moment the first houses are ready. They are often the party that receives the revenue from the land sale, but that money is not used for the operation costs of public transport."

To understand the complexity of the role costs play in the decision making process, a differentiation needs to be made between the two types of costs involved: the investment costs and the operation costs. The investment costs involve the infrastructure, land and building costs that are made before money can be made from the sale of houses and the operation of the public transport. The operation costs involve the operation and maintenance of a public transport connection (C1,E2).



Investment costs

The investment costs are funded by different parties involved in the development process, in which there is an distinction between investment costs for housing and public transport. According to expert A, a challenge related to the investment costs is that the preparation period for public transport transport is much longer than the investment period of housing, which means that the investments for public transport infrastructure have to made way before the other investments.

👤 A1: "The preparation process of public transport investments takes much longer than that of residential construction. It is a major investment that requires a lot of planning. In practice, housing development is slow in the Netherlands, but rail investments are even slower. So the main challenge is to keep the two together timing wise and make sure there is enough assurance on both sides."

The following complicates the decision making process even more:

👤 C1: "Due to financial consideration investments are postponed as long as possible. In the past the interest was significant and postponing investments saved you a lot of money. The interest is lower today, but you notice that, due to the economic crisis, people are much more critical towards costs and revenues and the practice of postponing investments as long as possible has remained."

Thus, the main challenges related to investment costs are related to timing. To make sure the public transport and housing development stay together timing wise, investments for public transport have to be made before housing investments. However, these investments are not made without assurance of the other parties on the development of housing. This is complicated even more, as investments are usually kept being pushed in the future as long as possible.



Operation costs

According to expert E2, the biggest constraint in the early development is not to finance the investment cost, but to finance the operation costs. Public transport heavily relies on subsidies to cover the public transport costs and with low ridership levels in the early years of the development these subsidies might not be enough.

According to interviewee A1 on average only 60% of the operating costs are covered by ticket sales, while the rest of the operational costs must be covered by subsidies provided by governmental institutions. This is only on average, the further towards the end of a line, the lower this cost coverage rate is. As public transport providers try to maximise their revenue, they are cautious to start operation to a newly developed area (Expert C1). Even more, because the ridership levels will be even lower in the early days of operation (Expert G1).

👤 C1: "Public transport providers try to maximise their revenue and even though there are some settlements between the public transport provider and the granter of the concession, they will still be cautious to start operation to a newly developed area."

Thus, even though the investment costs are taken care of, this does not mean that early provision of public transport is possible. The operation costs for early provision are substantial, which often makes it unfeasible to operate.

To summarise, the costs play an important role in the decision making process around development timing. Several interviewees revealed that aligning responsibilities with regards to costs is one of the most difficult parts in the decision making process, partially because the costs and benefits do not always lie within one organisation. In this process, a differentiation is made between the investment costs and the operation cost. Investment costs involve the infrastructure, land and building costs which are made before money can be made from the sale of houses and the operation of public transport. The main challenges related to investment costs concern the timing of the investments. The operation costs involve the operation and maintenance of a public transport connection, which often hold back the early development of public transport as they are considerable when the ridership levels are low. Thus, even when the investments are made on time this does not mean the public transport can start to operate from day one.

Benefits

The costs are balanced against the benefits of the early availability of public transport, which come down to decreased car usage and an increase in public transport ridership levels. This effect is mentioned by interviewees A1,B2,C1,D1,F3 and G1, who all state that the early availability of public transport has an influence on the amount of travellers. Two reasons are presented as the cause of this effect.



Habitual behaviour

A first reason for this is presented by interviewee F3, who states that you get the most public transport users if you provide public transport from the start due to habitual behaviour.

👤 F3: "You should not force people to initially use a different modality, because then people will already have developed a habit and it will be very difficult to pull them out of it. So our belief is that you get the highest ridership levels, also at a later stage, if you provide public transport from the start. In which there is room for discussion if that has to be in its final form from the start."



Life events

Interviewee A1 and C1 argue that it is important to provide public transport early, because people reconsider their travel behaviour when there are major changes in their lives.

👤 A1: "Something has to change for people to reconsider their travel behaviour, that is the moment you should catch them."

👤 C1: "You want to provide public transport from the moment the first 'zoning plans/building plans' are realised. This is relatively expensive, but theory and practice show that people reconsider their travel behaviour when there are major changes in their life such as a new job, kids, a break up or moving."

Even though most interviewees state that the early provision of public transport is a must, interviewee E2 states that it is not sacrosanct, as people will eventually move to another place and the new inhabitants then face the choice between different modes of transportation.

👤 E2: "A statement we hear a lot is: 'Make sure that there is public transport from the moment the first homes are ready, because once people choose the car, you can't get them out.' Well, that is partly true, but not completely. On average, people live in a house for 10 years and then move on. So the moment you are 10 years further, on average that entire residential area is renewed in terms of inhabitants. Not quite, some people leave sooner and some stay longer, but it's not like the area will never be a success if you do not provide public transport from day one. That is absolutely not true. You get a longer transition model [dutch: ingroeimodel], but that is a trade-off you have to make as well."

Interviewee A1 and B2 both mention that the extent to which there is a difference due to development timing is dependent on the knowledge people have on when the connection will be provided.

👤 A1: "If the timing is wrong, it will make a difference. How big of a difference is dependent on how sure people are the connection will actually be realised and how long it takes. If it is half a year, than cycling to a station located further away is fine, but when it is unsure if the connection will be realised you will probably think twice about living there or you will buy a car after all."

To summarise, most interviewees state early provision is important, as more people will use the public transport connection when it is provided early. The reasons provided for this are the formation of habitual behaviour and the influence of moving on the susceptibility of changing travel behaviour. However, it is also argued that this is only partially true, as people will eventually move to another place and the new inhabitants will have public transport available from the first day they live in the area. There are also interviewees that state that the extent to which the timing matters partially depends on the information there is on when the connection will be provided in the end.

The role of traffic models in the cost benefit analysis

Several interviewees mentioned that traffic models are used to substantiate the cost benefit analysis. According to interviewee E2 these models are used whenever you make a business case, as you need numbers and the traffic model is a tool that provides you those numbers. This is underlined by interviewee F3, who states that traffic models are used to determine the amount of travellers that can be expected in the final stage of a development. Interviewee A1 also mentions that all decisions made related to costs and benefits are substantiated with traffic models, but the problem is that public transport in these models is not modelled very well.

👤 A1: "First of all urban mobility behaviour is not correctly modelled and secondly the public transport has an infinite input capacity in the traffic model. So even when the capacity is reached, people will still travel by public transport according to the traffic model. Because of this, you have to do all kinds of post-processing in which you need to determine if the amount of travellers estimated fits the available capacity and if not you have to add capacity. But the fact that people start to change their behaviour if the capacity is reached, is not represented in the model. That's quite difficult if you want to substantiate public transport investments."

To put it briefly, traffic models are widely used as a way to generate the numbers required to substantiate the business case, but the suitability of these models to do this is questioned by one of the interviewees. According to that interviewee, public transport is not correctly modelled, which makes it hard to substantiate public transport investments

6.2.2. Money availability

Where other interviewees mentioned several decision making factors, interviewee G1 stated that the timing of the development of both houses and public transport is mainly determined by the availability of money at a certain moment in time.

👤 G1: "The choice when to develop what is mainly determined by the moment money is available for it. That means that in some cases housing construction is faster than infrastructure construction and in some cases the infrastructure is already there and you can build around it."

Thus, according to interviewee G1 the development timing of both public transport and houses depends on the availability of money during the development process.

6.2.3. Location dependency

Next to costs and benefits, another often called influence on the decision is the location the housing is developed. According to interviewee A1 the development location partially determines the need for early provision of public transportation, as the need for early provision of public transport is less when there already is some form of public transportation nearby.

👤 A1: "The choice for a certain development timeline is different from location to location. For locations with little to no public transport, it is sometimes decided to provide public transport on the promise of area development, but this is only possible with funding and/or if there is an assurance that the area development will take place. When there already is some public transport available, you can start with the area development, so you get certainty about the support for better transit and you can arrange public transport based on that."

Interviewee E2 states that, because of this, you always look for locations that already have public transportation, because then you don't have to build anything new. Furthermore, interviewee E2 also states that the feasibility of early provision is also dependent on the location, due to a difference in building densities.

👤 E2: "It is different per area. You look at what makes sense with regard to the construction densities. The moment you have a very large residential area with only a few houses here and there, you can't do anything with it in terms of public transport."

Interviewee D1 states that it is sometimes possible to alter the route of the existing public transport depending on the geographical preconditions.

👤 D1: "It depends on the geographical preconditions. If a detour is not large compared to the original route, that choice will be made sooner than if there is a whole a different route has to be taken that takes extra time."

Thus, it is stated that the preconditions of the location influence how early a public transport connection must be provided and also how early it can be provided.

6.2.4. Mutual assurance

Another reason to choose for a certain development timing mentioned by the interviewees is risk, or the mitigation of risk, as a result of mutual assurance. According to interviewee A1, mutual assurance is an important factor to decide whether or not to develop something at a certain moment in time.

👤 A1: "Deciding on houses first or public transport first, without any arrangements, is not going to work. On the development side there is too much uncertainty if the public transport will be developed and without that you get a development that is not tailored to public transportation. If the latter is the case, arranging public transport connection is not going to work, because of high parking standards etc. Starting with public transport is also not going to work, because of an uncertain business case and as too much risk the connection will operate with losses a consequence of that. You have to organise it with agreements, so you have enough certainty on both sides."

This phenomenon is also mentioned by interviewee B2, who states that certain developments only took place because of mutual assurance.








6.3. Development process

This section elaborates on the answers the interviewees have given in relation to their view on the development strategy. First, the perception of the different interviewees on the development timing are discussed, after which some comments on the decision making process are elaborated on.

6.3.1. Development timing

During the interviews, the interviewees were asked to state the development timing that, according to them, would be best. An overview of the answers as given by the interviewees is given in Table 6.3.1.

Table 6.4: Answers on the development strategy as given by the interviewees.

	Answer
 A1	The development strategy depends on the location. At some places the area development comes to a standstill if public transport is not provided. This is the case for the Binckhorst in the Hague. For that location an Environmental Impact Assessment was made and the message is crystal clear: more housing than currently planned is not possible without large problems related to emissions, available space, traffic jams, etc. This shows that area development depends one-on-one on decisions about public transport.
 B2	Inhabitants have to know that a high quality public transport connection will be provided in the near future. The question is if that has to be provided from the beginning or at the moment 10-15% of the houses is built. At least there has to be some form of public transportation that operates on the most important connection. From the moment that around 30% of the houses are built, it is useful for the tram to start operating.
 C1	You want to provide public transport from the moment the first 'zoning plans/building plans' are realised. This is relatively expensive, but theory and practice show that if you want people to use public transport you have to provide it from the start. In Almere we made public transport available from the moment around 60-100 houses were build.
	It is very much about the transition from nothing to the final form, certainly for bus.
 D1	Preferably as soon as possible of course, but you have to realise that is not possible nowadays. You have to find a balance together with the responsible party, which in our case is the regional government.
 E2	The development strategy is different per location. You ask the question: "What is logical?" also in relation to the densities. The moment you have a large residential area with only a few houses here and there, there isn't much that can be done with regards to the provision of public transport.
	We have some guidelines in the concession: from x number of homes in a certain district the public transport should be of a certain quality. Usually that starts with a bus, because we do not specify which type of public transport it should be.
 F3	From the moment around 250 to 300 homes are built, you should provide some form of public transportation. Then you start with a public transport connection in the main direction of travel and after a couple of years you add a second or third connection in different travel directions. There is often some sort of step-by-step plan incorporated into this.
 G1	You don't have to provide the final quality right from the start. When you are dealing with major developments it concerns substantial transport numbers. Those transport numbers are not reached in the temporary situation and you cannot provide rail transport until those numbers are reached. Thus, you need another (temporary) solution and the question is what that temporary solution should be. It should be of sufficient quality or should at least have significant speed towards the most important destinations and should be available from the start.
	In this transition period, it is important that residents know what the final form will be. You can imagine that when 1/3 of an area is developed, you actually have a lot of space left. Then you can temporarily offer extra parking spaces there, but you will have to communicate that those will not be available forever. If you don't, people will get used to have their car nearby and they will revolt the moment they will no longer be able to obtain a permit for their first or second car.

Interviewee B2, C1, E1, F3 and G1 all state that the provision of public transport in area should take place in stages. Starting with lower quality or lower frequency public transport and transitioning to higher frequencies and higher public transport when more people start to inhabit the area. Interviewees F3 and G1 both state that this temporary solutions should provide public transport in the main direction of travel. According to interviewee F3, this should be provided from the moment 250-300 houses are built. Interviewee B2 states that the lower quality public transport should be provided from the moment 10-15% of the houses are built and the final quality (not frequency) from the moment 30% of the houses are built. According to interviewee C1, public transport should be provided from the moment the first city blocks are realised. In the example of Almere, this were around 60-100 houses.

Interviewee A1 and E2 argue that the development strategy that should be followed depends on the location. According to interviewee A1 the need for early provision differs from location to location and the choice for the development timeline depends on how important public transport is for that location. Interviewee E2 states that the provision of public transport for locations where the houses are built spread over the area, thus a few houses here and there, is not possible.

A side note that is made by interviewee B2 and G1 is that people have to know when the public transport will be provided. If that is the case, people keep this in mind when making a decision whether or not to buy a car.

6.3.2. Comments on the decision making process

During the interviews, several comments were made with regard to the moment public transport needs to be considered in the decision making process and the involvement of stakeholders in this decision.

First of all, several interviewees mentioned that public transport has to be considered early in the development process. According to interviewee C1 this makes it easier to embed public transport in an area on a larger scale.

👤 C1: "It is easier to think carefully about public transport if you consider it on a larger scale level, because public transport systems have certain dimensions that can more easily be embedded in the design on that level. Hereby it is important to hold on to this in the years to follow."

Interviewee E2 and B2 underline this, by stating that thinking about the implementation late in the development process leads to less successful public transport. Whereas thinking about it in an early development stage leads to better results.

👤 E2: "In the past, areas were developed with room for a stop on the edge of the area. That doesn't work. You want a central stop with high densities around it. Luckily, that is getting better."

👤 B2: "In Leidsche Rijn, the public transport has worked out less well, simply because they did not involve public transport planners from the start. They started to design a neighbourhood that looks nice, started building it and then realised they had to provide public transport."

Furthermore, comments were made on the involvement of public transport providers earlier in the decision making process. According to interviewee E2, you have to involve public transport providers in the decision making process around the design of an area, because they know best when a public transport connection is feasible or not.

👤 E2: "We involve the public transport provider as early as possible and try to make arrangements on the moment they have to provide public transport in a newly developed area. The public transport provider sometimes offers to operate earlier depending on whether a municipality, developer or companies are willing to invest extra money during the start-up period. This is possible, but in practice it is not happening yet, but it is talked about."

Interviewee B2 states this depend on the type of public transport provider.

👤 B2: "Some public transport providers operate on a certain line when you tell them this is needed, but there are also public transport providers that advise on whether it is wise to develop a certain connection and what it should look like."

Interviewee G1 adds to this that it also depends on the concession period.

👤 G1: "You involve public transport providers in the process depending on the moment in the concession period. If it is the beginning of the concession period it is more logical to involve them than when this period is coming to an end."

Overall, there is a consensus that the public transport should be considered early in the development process, as the later it is planned the harder it is to develop an effective public transport connection. Some also state that the public transport providers should be involved earlier, as they know best which connections are profitable and which are not. However, other argue that this depends on the type of public transport provider and the horizon of the concession period.

6.4. Conclusion

Based on the interviews with the stakeholders involved in the decision making process around the development timeline, the following conclusions can be drawn on the decision making factors used to determine the development timeline and the development strategies as followed in practice.

6.4.1. Decision making factors

During the interview, the interviewees mentioned the different factors involved in the decision making process. The decision making factors used by the different stakeholders involved in the decision making process are the costs, benefits, money availability, mutual assurance or risk and the preconditions of the location. A short description of each of those decision making factors is given below.

1. Costs

The cost of early provision is the main factor working against the early development of public transportation. Several interviewees state that aligning responsibilities with regards to costs is the most difficult part in the decision making process. The costs can be split in two categories, investment costs and operating costs. The investment costs involve the infrastructure, land and building costs that have to be made before the operation of the public transportation can start. The main challenges related to investment costs concern the timing of the investments. The operation costs involve the operation and maintenance of the public transport connection, which often hold back the early development of public transport as they are considerable when the ridership levels are low. Thus, even when the investments are made on time this does not mean the public transport can start to operate from day one.

2. Benefits

From the answers given by the interviewees it can be concluded that early availability is seen as beneficial for the ridership levels of the public transport connection. This is due to the formation of habitual behaviour and the influence of moving on the susceptibility of changing travel behaviour. However, there is some discussion on the importance of early provision. Some state that early provision of public transport is a must if the goal is to get as many people as possible to use the provided public transportation, while others state that the timing does not matter as much as long as the final product is good. Most people state that early provision is important, but that it does not need to be at the final level of quality from the beginning.

3. Money availability

Next to the costs and benefits, money availability was also mentioned as a factor influencing the development timeline. According to the interviewee that mentioned this factor, a delay in the

availability of funding can result in a delay in development. Sometimes this means that housing construction is faster than infrastructure and sometimes it is the other way around.

4. Mutual assurance

Another reason the choose for a certain development timing is the risk. If there is no mutual assurance between parties on a development timeline, developers will be reluctant to develop houses with low parking standards, but public transport will only be developed when there is certainty about the area development.

5. Preconditions of the location

The preconditions of the location are often mentioned as an influence on the development timing, as the location determines the need for early provision of public transport. Some locations will have major accessibility problems when the public transport is not provided in an early stage. For other locations, where there already is some form of public transportation nearby, this is not needed and the public transport can be developed when it becomes clear what links are missing.

The decision making factors as mentioned by the different interviewees will be presented to the interviewees in the next round of interviews to determine if they agree on the decision making factors used and the value that is or should be assigned to them.

6.4.2. Development process

During the interview, the interviewees were asked questions on the decision making process and the development strategies resulting from it. The conclusions drawn with regards to this are discussed below.

Decision making process

With regards to the decision making process, the interviewees mention that it is important to plan the public transport early in the process, as the later it is planned the harder it is to develop an effective public transport connection. Furthermore, the interviewees stated that it might help to involve public transport providers earlier in the process, as they know best which connections are profitable and which are not.

Development strategy

The interviewees were also asked to state what would be the 'ideal' development strategy. Overall, most stakeholders state that the development of public transport in an area should take place in stages, as provision from day one is not feasible. Starting with a lower quality mode or lower frequency in the beginning and transitioning to higher frequencies and higher quality when more people start to live in the area. Some interviewees have quantified this by expressing the moment public transportation should be provided in a number of houses or percentage of houses built. For the lowest quality this varies between 100-250 houses or 10-15% of the houses and one interviewee stated that the higher quality public transport mode should be provided from the moment 30% of the houses in area is inhabited.

There are also stakeholders that state that the development strategy completely depends on the location. Not only at what moment public transport should be provided, but also how early it can be provided. The "should" refers to a different need for public transport per location. Some locations will suffer problems with congestion in the surrounding area if no public transport is provided, while others already have some sort of public transport nearby that people can use until the need for extension becomes clear. The "can" refers to the possibility to operate a somewhat profitable public transport connection, which is just not possible for some areas.

The statements on the development strategy as mentioned by the different interviewees will also be presented to the interviewees in the next round of interviews to determine if they agree on the strategy that should be followed in practice.

6.5. Discussion

This section reflects on the first round of interviews with the stakeholders in terms of information saturation and the representativeness of the stakeholders. First the saturation of information after the different interviews is discussed, after which the choice of interviewees is reflected on.

6.5.1. Information saturation

The first round of interviews consisted of seven interviews with stakeholders involved in the decision making process around development timing. The interviews were used to obtain information on stakeholder involvement, decision making factors and development timing. Figure 6.1 gives an overview of the amount of the new insights in the first round of interviews related to the stakeholder interaction, stakeholder involvement and decision making factors. With new insights related to the stakeholder interaction, collaborations or interaction between the different stakeholders are meant. The new insight related to stakeholder involvement refer to a different designation of the involvement of the stakeholders during the process and with decision making factors the amount of new decision making factors is meant.

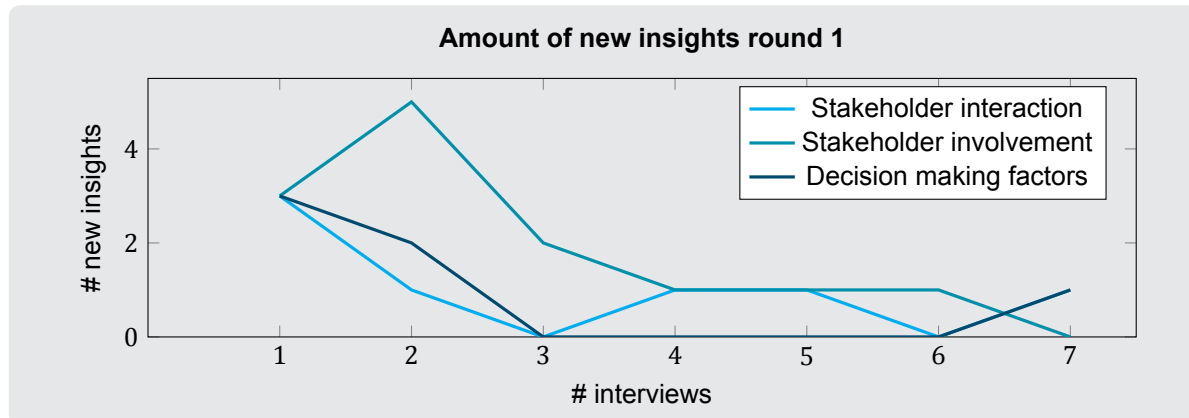


Figure 6.1: Interview saturation round 1.

From Figure 6.1 it can be observed that, overall, the amount of new insights on the different subjects decreases over time, which means the information received is becoming saturated. The fluctuations in the amount of new insight in stakeholder interaction and involvement might be the result of the different backgrounds of the interviewees, as each interviewee knows best when their party is involved in the development process and who they interact with. With regards to the decision making factors, it can be observed that the decision making factors used by the different stakeholders mostly come down to the same, as few new insights are gained after the first few interviews.

Regarding the opinions on the development strategy, it can be observed that, even though the opinions on the right development timing vary, no radically different opinions could be observed after several interviews. As the interviewees already represent the different parties involved in the development of public transport connections, it is assumed that they form a good representation of the differences in ideals in the field.

Because of this and the limited time available to execute the interviews, the choice is made to keep the amount of interviews at seven.

6.5.2. Interviewees

The interviewees selected for the interviews are all involved in the development of public transport in residential areas. Even though they all represent different parties, they still might be biased as they are involved in the mobility related planning of the development process. Other people might have different opinions on what development strategy should be followed, because they do not specialise in the mobility field.

7

DELPHI ROUND 2

Reflection on the answers of round 1

This chapter describes the second round of interviews, in which the interviewees were asked to react to the answers of the other interviewees in the previous round. **The goal of this round was to determine if the stakeholders agree on the decision making factors and the development strategy or if there are point of debate amongst them.** The chapter starts with an elaboration on the preparation of the interviews, after which the results of the interviews are discussed per interview topic. The chapter ends with a conclusion on the decision making factors and the development strategy and a discussion on the second round of interviews.

7.1. Interview preparation

In the second round of interviews, statements made by the interviewees in the first round are presented to the same seven interviewees in the second round. This is slightly atypical for a Delphi study, as normally the same questions with the answers given by the other interviewees are presented to determine if people change their mind by seeing the answers of others. However, as the first round of interviews was conducted in a semi-structured form, the decision was made not to follow this approach because of the lengthiness answers. Instead, statements made by the interviewees were presented according to two subjects: decision making factors and development strategy.

Table 7.1 gives an overview of the subjects covered in the second round of interviews, the full interview guide can be found in Appendix B.

Table 7.1: Interview subjects Delphi round 2.

	Topic	Objective
1	Introduction	During this part, a recap of the goal of the research is given and the interviewee is briefed on the content of the interview.
2	Decision making	In this part of the interview the decision making factors as mentioned by the interviewees in the previous round are discussed. The goal is to determine if the interviewees agree on the different decision making factors used and the credence that should be given to them.
3	Development strategy	This part of the interview discusses statements made on the development strategy. The goal of this part is to determine if the interviewees agree on the development strategy or if there are points of debate on it.

For this round, the interview transcripts were not coded, as the interviewees respond directly to the answers of others and the data retrieved in this round of interviews is compared per interview subject. The interview transcripts of this round can be requested from the author.

7.2. Results

The results will be discussed according to the slides with statements as presented to the interviewees, which are subdivided in two categories: (1) decision making factors and (2) statements on the development strategy.

7.2.1. Decision making factors

The reactions to the statements on decision making factors will be discussed below. First, the trade-off between the costs and benefits as main decision making factor for area development is discussed. Then, the importance of early provision of public transport is discussed, after which the reactions to role of money availability on development timing are elaborated on. Lastly, the location dependency of the decision is discussed.

Trade-off costs & benefits

The first statements relate to the trade-off between costs and benefits as main decision making factor for the decisions on the development timing. With regards to these statements, all stakeholders agree that the trade-off between the costs and benefits is an important consideration in the decision making process, but there a more nuanced definition is required.

The main point made by the interviewees is that a differentiation should be made between the financial costs and benefits and social costs and benefits. According to interviewee A1 and E2 decisions on the development timing are made based on a social cost-benefit analysis, in which a trade-off is made between the costs and the benefits it can provide for society. Interviewee B2, C1 and D1 underline this, stating that the social benefits are policy incentives to provide public transport early and it needs to be determined how much money it is worth to do so.

Decisions made by the public transport provider on the other hand are purely related to the financial costs and benefits or the business case (interviewee A1), as they are a market party whose goal it is to generate profit (interviewee D1). According to interviewee F3, this business case and the requirements set by the concession are the boundaries for the decisions made by public transport providers. Policy makers can influence this by providing larger subsidies for the operation of public transport (interviewee B2, C1).

According to interviewee A1, the story changes when the business case of the whole area is considered instead of the business case of the public transport only. In this case, factors such as real estate values are also considered in the trade-off. In this situation, the statement: "the costs and benefits of a certain decision do not always lie with the same party", becomes apparent. This distinction between the consideration of the whole area development or the public transport only is also mentioned by interviewee C1, who states that public transport is only a part of the area development. The statement that the costs and benefits do not always lie within the same organisation is underlined by interviewee D1 and E2 as well. According to interviewee E2, the government and public transport users generate the money and the public transport provider profits from that. According to interviewee D1, society benefits from the decrease in car usage as a result from good public transport, which can be considered as a benefit for the governmental institution from a policy point of view. However, from a financial point of view, there are no financial benefits for governmental institutions.

Critical comment on the use of social cost-benefits analyses.

According to interviewee A1, there are flaws in the decision making process with the help of a social cost benefit analysis, as these are based on traffic models that do not provide the complete picture of the alternatives. According to the model, measures that do not provide a decrease in travel time are useless measures. However, an attractive stop or good walking accessibility can influence someones decision as well. Furthermore, the capacity of public transport is infinite, which is not a correct representation either. This means that a lot of extra calculations are needed to gain insight in the benefits of stations, as the model does not provide that. Interviewee A1 also mentions that this is not clear to a lot of people using the model.

Importance of early provision

Another subject discussed during the second round of interviews, is the importance or benefits of early provision. Overall, all interviewees agree that early provision will result in high public transport usage. Interviewee A1 states that, if you give public transport a place in the behavioural pattern early on, the chance people will use it on a more structural basis is greater. This is underlined by interviewee C1, D1 and F3, who agree that it is important that public transport is provided in an early stage, as people will not easily change their behaviour once they have established a routine. Interviewee E2 states that if you really want to make public transport a success, it helps if public transport is available from the moment the first inhabitants live in the area. However, interviewee E2 also argues that there are all kinds of alternatives to make the existing public transport accessible when the public transport nearby is not ready. Interviewee A1, B2 and D1 also mentioned that the perspective on good public transport is important as well, as people might show different behaviour when they have a perspective on the time frame in which the public transport will be provided than when there is no perspective at all.

Even though the interviewees agree that early provision will result in high public transport usage, there are also some interviewees that, at least partially, agree with the statement that it is not true that an area will never be a success in terms of public transport usage when the public transport is not provided from day one. Interviewee F3 states that it will make very little difference in the long term, but argues that it may take up to 20-25 years, as it differs per area type how fast people move. This is underlined by interviewee G1, who states that people live longer in some types of areas than in others. Interviewee A1 also agrees with that, stating that in practice no one is average, which makes it a nice maxim, but it might not be applicable in practice. According to interviewee D1 the statement is true when you only consider people, but is not true when you consider spatial planning as well. If a neighbourhood has a parking standard of 2 cars per household, you will never get rid of them again.

Money availability

The next statement presented to the interviewees relates to the influence of money availability on the development timing, namely that the moment money is made available, influences the development timing (interviewee G1). Interviewee F3 states that this can indeed be of influence and argues it can be frustrating as you want to provide good service for the future inhabitants, but the money is not there to do so.

This statement is refuted by interviewee A1, C1, D1 and E2, who argue that money availability is not something that you cannot influence. Interviewee D1 argues that it is a matter of long-term planning in which you create momentum to receive money on the right moment. This is underlined by interviewee A1 and C1, who state you can influence the moment money becomes available, as this depends on a game played between the different governmental institutions. According to interviewee E2 you do not start with a public transport development until the moment money is available. Interviewee G1 argues that even though you cannot develop the public transport until the money becomes available, the area development still needs to continue because of the housing shortage. Interviewee B2 adds to this that, even though you make arrangements, it is often different in practice.

Location dependency

The fourth subject discussed relates to the location dependency of the decision, namely that the pre-conditions of the location influence how early a public transport connection can and must be provided.

Interviewee A1, B2, C1 and E2 all agree that it depends per location how important it is to provide public transport early in the development. According to interviewee A1 there are locations that will experience problems with congestion and emission when no public transport is provided, which means that the need for early provision in those areas is high. This is underlined by interviewee B1, who argues that an area that already has traffic problems is more in need of early provision than an area that does not have those problems. Furthermore, interviewee B2 also argues that if there is a public transport connection nearby, the provision of a new connection is less urgent. This is also mentioned by interviewee C1 and A1. Another argument is provided by interviewee E2, namely that the urgency is greater when it concerns areas with high housing densities. The reason provided for this is that high housing densities mean that there are a lot of people living in a relatively small area and there is simply no room for all of those people to own a car.

Interviewee F3 on the other hand states that it is only dependent on the location when public transport can be provided and not when it must be provided, as you always want to provide it early. According to interviewee F3, this possibility to provide public transport depends on the housing density, as there are better chances for public transport when the housing density is higher. This is also mentioned by interviewee E2, who states that the reason not to provide public transport to areas with low housing densities, is that you cannot get it profitable.

Another argument on location dependency is provided by interviewee A1, who states that different types of area attract different types of people and you should take that into account when considering the mobility options to provide. Areas with low density housing attract more people who use a car as their main mode of transportation, which is less for areas with high housing densities. According to interviewee A1 and D1, a problem that can arise when you do not provide public transport for low density locations, the inhabitants of those locations will drive to work in a high density location which means there will still be congestion around those work hubs.

Lastly, the statement that it is location dependent if a detour can be made with the public transport connection in the area was often contradicted. According to interviewee C1, D1 and E2, detours are often not possible, as the timetables are very tight. Furthermore, a detour makes the line less attractive for the other passengers using the line, thus detours are a dirty word in the public transport world (interviewee C1 and E2). Interviewee B2, however, does think that a small detour might sometimes be an option.

7.2.2. Development strategy

The reactions to the statements on the development strategy will be discussed now. First, the use of a transition period from low quality to the intended final quality as the way to develop public transport will be discussed, after which the quantification of the moment public transport needs to be provided is elaborated on.

Transition

All interviewees agree that the final quality does not have to be provided from day one. Interviewee D1 states that there needs to be some form of public transport from the start and the possibility should be there to increase the frequency as more people start to inhabit the area. According to interviewee D1 this early form of public transport could also be a community bus service or taxi-bus. Interviewee C1 argues that there are three levels of public transport service levels: the lowest level with options like a bus service on demand or a bus that only operates during peak-hours, the middle level with regular buses and the highest level with high frequency buses. Interviewee F3 argues that the lowest quality should be a service with a frequency of at least 4 times per hour, otherwise you just as well should not provide it. However, interviewee F3 also argues that it depends on the location how the public transport service you provide should look like. This location dependency is also mentioned by interviewee A1 and E2, who argue if there is a public transport connection nearby, people can cycle to that location during the transition period, meaning that the definitive public transport connection can be built later on in the development. Interviewee F3 states that, if chosen for this option, good amenities such as bicycle parking racks, should be provided at those locations.

With regards to the transition model, interviewee A1 argues that there are things at play that can only be done right once. For example, when the opted final quality is light rail, infrastructure should be suitable for the final quality, because otherwise it will not be possible anymore in a later stage and you might regret the decision you made earlier on. Thus, waiting and see what is required is not always possible.

Quantification

Overall, the interviewees agree that a generic quantification of the moment public transport needs to be provided is not possible, as it depends on the preconditions of the locations and the type of area. Interviewee E2 and F3 argue that expressing it in percentages of houses built is not suitable, as the size of the area can differ quite a lot from area to area. However, interviewee G1 states that because of these differences in size, percentages are better than numbers. According to interviewee G1, it is mainly about the maximum amount of time you can make people wait, which is one or two years, thus you should provide public transport when around 10% of the houses are built. Interviewee F3 argues it is also dependent on how long it takes before the rest of the area is developed. If that increases very

slowly, it is a completely different situation than when it goes up at fast pace. When that is the case, you only take the loss in a limited number of years, while at a slow pace it would concern a much larger time. This story is underlined by interviewee C1, who states that at around 500 people some form of public transport should be provided, but that this number is not an absolute truth, as it depends on the growth rate and the eventual size of the area.

7.3. Conclusion

Based on the second round of interviews the following conclusions can be drawn on the agreements and points of debate related to the decision making factors and the development strategy.

7.3.1. Decision making factors

During the interview, several decision making factors were discussed, namely the trade-off between costs and benefits, the influence of money availability and the preconditions of the location. The conclusions on the agreements and points of debate over the decision making factors are described per decision making factor.

1. Trade-off costs & benefits

All stakeholders agree that the trade-off between costs and benefits is an important consideration in the decision making process, however some stakeholders argue that it is not only about the financial costs and benefits, but also about the social costs and benefits. According to them, governmental institutions make decisions on development timing using a social cost benefit analysis, in which a trade-off is made between the costs and benefits for society. Decisions made by the public transport provider on the other hand are purely related to the financial costs and benefits or the business case. Thus, all stakeholders agree that the trade-off between costs and benefits is an important decision making factor, but the costs and benefits considered depend on the party that is considered.

2. Importance of benefits

There is a consensus that early provision of public transport results in higher public transport ridership levels, but the importance of this early provision is debated, especially in the long term. The fact is that people move from time to time, which means that after a certain period of time, the whole area is renewed in terms of residents. This means that those residents will have public transport available from the moment they start to live in the area. It is argued that this means that, in the long term, people will use the public transport connection regardless of the development timing. However, it is also argued that people will not move all at once, which means that there will be a transition period with people who do not have developed a travel habit and people who have, thus the usability of the maxim in practice is debatable. Furthermore, it is also argued that this might be true when people are considered, but it is not true in terms of spatial planning as it is very hard to get rid of a high parking standard. Thus, the importance of early provision remains a point of debate, especially considering the long-term effects. For short-term effects that can be observed with the first residents, early provision is considered to be important.

3. Money availability

The timely availability of money as a factor that can hinder development timing also is a subject of debate. There are some stakeholders that experience money availability as a limiting factor for the development. However, it is also argued that the moment money becomes available can be influenced and it is a matter of long-term planning to arrange that it is available at the right moment. On the other hand, it is also argued that things do not always go according to plan, which means there is a dependency on the moment money becomes available. Thus, the question whether or not money availability can be seen as a decision making factor, remains a point of debate.

4. Preconditions of the location

All stakeholders agree that the preconditions of the location influence the development timeline. Several stakeholders argue that it is location dependent how important it is to provide public transport, as areas which have no existing public transport connection nearby and are prone to traffic problems have a higher urgency for early provision, than areas where there already is a high quality connection nearby. This is contradicted by one interviewee, who argues that you always

want to provide public transport as early as possible. There are also interviewees that state that the location influences the possibility to provide public transport in an early stage. One of the reasons stated to be a limiting factor is the housing density, as low housing densities scattered across a large area are not feasible for the operation of public transport. This is not contradicted by any interviewee, however the statement that the geographical location sometimes makes it possible to make a detour with an existing line is heavily debated as this causes problems with turnaround times and makes the line less attractive for the other users. Overall it can be concluded that the preconditions of the location are seen as a determining factor in the decision making process, but the interpretation of how the location can influence decisions, differs.

7.3.2. Development strategy

Regarding the development strategy, all interviewees agree that the final quality cannot be provided from day one, as this is not financially feasible. It is argued that it is best to start with a lower quality and/or frequency option and upgrade the connection as the number of inhabitants grows. Some argue that this could for example consist of on-demand buses or buses that only operate at peak moments, however it is also argued that the provided public transport should have a frequency of at least 4 times per hour. Several interviewees also mention that shared mobility and good accessibility to the existing public transport network are also good options when the provision of public transport is not feasible yet. Thus, there is not one clear vision of what should be provided in the early days of development, the only thing that is agreed upon is that something should be provided.

When implementing this transition strategy, it is argued that the final quality should always be kept in mind, as the infrastructure should be suitable for it when there are enough people inhabiting the new neighbourhood. If this is not considered from day one, it might not be possible to fit the public transport connection in the newly-built area. Furthermore, it is also argued that the lowest quality of public transport should be attractive enough for the residents, otherwise it might as well not be provided.

Thus, the interviewees agree that the best way to tackle the provision of public transport in a growing residential area is to follow a transition strategy, starting with a basic quality and/or frequency public transport connection and gradually upgrading it to the final quality. Hereby, this final quality should be kept in mind and the public transport must be attractive enough for people to want to use it.

7.4. Discussion

The second round of interviews consisted of interviews with the same seven stakeholders interviewed in the first round. The interviews were used to determine if the interviewees agree with each other on the decision making factors that are used to make decisions and on the development strategy.

Regarding the decision making factors, the interviewees agreed on all the decision making factors mentioned by the other interviewees except the money availability. This means that some of the interviewees were influenced by the answers of others, as not all interviewees mentioned all the decision making factors in the first round. The statement that money availability also is an influencing factor was not agreed upon. The main argument against it being that is something you can influence rather than something you have to base your decision on. An extra Delphi round would have offered the possibility to presents this argument, to determine if this would change the mind of the interviewee that considers money availability as a decision making factor or not.

Another point of debate that remains after the second round is the importance of early implementation. Most interviewees mention that early provision is important for the ridership levels, however one interviewee argued that on the long term it is not that important. Several arguments were made to undermine the provided argument which might have changed the mind of the interviewee if a third round would take place.

As for the development strategy, almost all interviewees already mentioned the transition strategy from a basic quality to the final quality in the first round of interviews. However, the location dependency was not mentioned by all interviewees in the first round, but underlined by all interviewees in the second round. Again, this means that answers of the interviewees in the first round influenced the answers given in the second round.

Next to underling or debating each others statements, the interviewees introduced nuances to the statements, hereby providing a more in-depth view of the process. Furthermore, interviewees sometimes mentioned aspects that were not included in the statements but that were mentioned in the first round. This provided information on factors that were considered to be important, but were underexposed in the second round. These aspects were not presented to all the interviewees, which means that it is not clear if these aspects are a subject of debate or if the interviewees agree upon them.

Overall, it can be concluded that the second Delphi round did change or add to the answers given in the first round. Furthermore, it highlighted which aspects were overlooked while interpreting the answers and provided extra insights in the aspects that were considered. An extra Delphi round would have offered the possibility to resolve some of points of debate, however due to time constraints the decision was made to leave it at two rounds.

8

INTERPRETATION OF THE RESULTS

The development process in practice

The research on the development process and the two rounds of interviews provide insights in the considerations in the decision making process around development timing. **The goal of this chapter is to translate the knowledge obtained during the interviews to conclusions on the development process as followed in practice.** First, the decision making factors used to make decisions on development timing are discussed after which the development strategy as followed in practice is elaborated on.

8.1. Decision making factors

The decision making factors mentioned in the interviews are the cost, benefits, the preconditions of the location, mutual assurance and money availability. Where all the other decision making factors were mentioned multiple times and underlined by all the other interviewees, money availability was only mentioned once and not agreed upon. Because of this, and the fact that it is more of a variable that can influence the development than a decision making factor, the decision is made to exclude it from the list of decision making factors. Thus, the decision making factors identified are the costs, benefits, preconditions of the location and mutual assurance. Figure 8.1 gives an overview of those factors and the tools used to determine them.

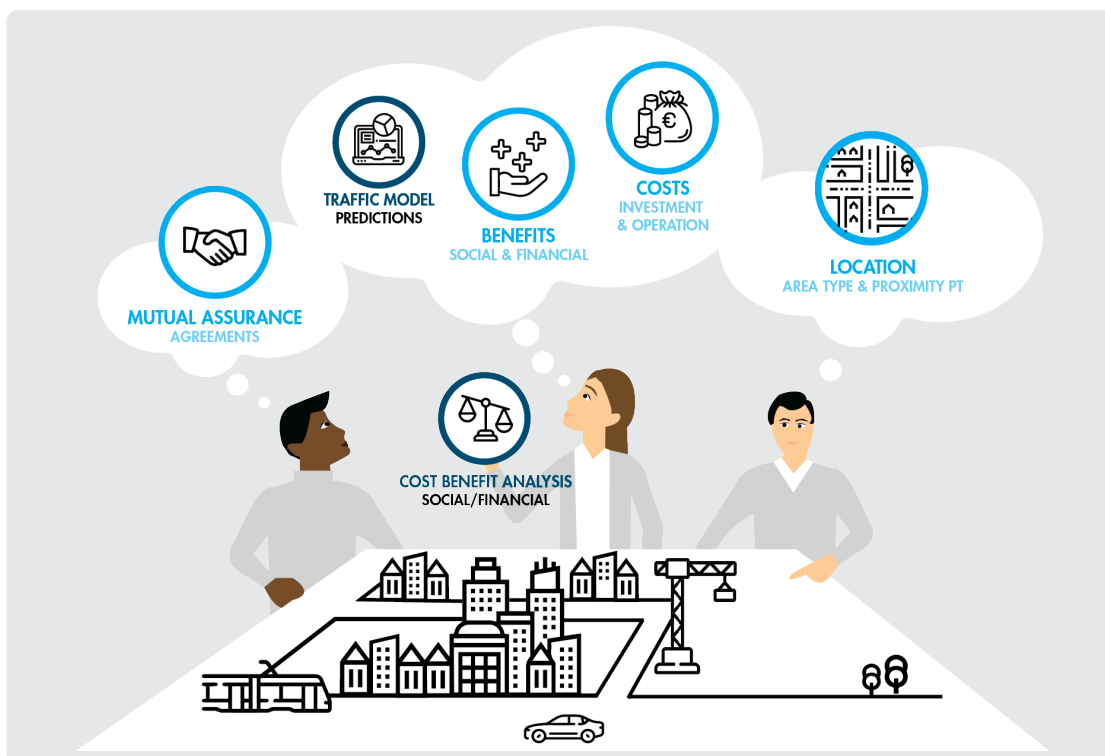


Figure 8.1: Decision making factors (own work).

Cost benefit trade-off

From the interviews it can be concluded that the trade-off between the costs and benefits is an important consideration in the decision making process. Depending on the stakeholder this trade-off is made with the help of either a social or a (financial) cost benefit analyses. Governmental institutions use social cost benefit analyses, in which a trade-off is made between the costs (both financial and social) and benefits for society, e.g. less congestion and emission due to a reduction in car usage. Decisions made by the public transport provider are made based on the financial costs and benefits or the business case, as they operate and implement public transport with the goal to make a profit from the service they offer. The cost benefit analyses are substantiated with the help of traffic models that provide predictions on the costs and benefits of different alternatives.

Location dependency

The interviews also made clear that the location can be a determinant for the decision making process. The interviews suggested that the influence could work in two ways, namely as an influence on how early the public transport connection **can** be provided and how early it **must** be provided.

The 'can' relates to the possibility to feasibly operate public transport at a certain location. An example of this is that provision of public transport for areas with only a few houses here and there is not feasible, because many stops would be needed and only few people would use them. This means that when the area is developed in such a way that the finished houses are scattered across the area, nothing much can be done in terms of public transportation. For developments where the houses are grouped in higher densities on the other hand, the prospects are better, as one stop would provide access for many people.

The location dependency is also related to how early public transport 'must' be provided, or in other words the urgency there is for public transport in an area. If the development concerns an area which has no existing public transport connection nearby or an area that is prone to traffic problems, the early provision of public transport is more urgent than when there already is a high quality connection nearby. It can be argued that the early provision of public transport is always important, but as there only is a limited budget to develop several areas, prioritising certain areas is necessary. When this is the case, the type of location is an important determinant in the decision on the development strategy.

Mutual assurance

The last factor identified is the need for mutual assurance between the different parties involved in the development. If there is no mutual assurance between parties on a development timeline, there will be a reluctance to start with the development, as there is a risk that this will have financial consequences. Developers of the public transport connection do not want to be finished way before the houses are finished, as this means that there will be no people to use it. Housing developers on the other hand will be reluctant to develop houses with low parking standards if no public transport is provided, as they are afraid that those houses will not be sold. With the current housing market this will probably be less likely, but to prevent ongoing back-and-forth arguments between the different stakeholders that can only cause delays, mutual assurance and agreements are still important to make the early provision possible.

With the identification of the decision making factors used by the stakeholders involved in the decision making process, an answer is provided to sub-research question 4:

4. What are the decision making factors used by the different stakeholders?

The decision making factors used by the different stakeholders are:



COSTS



BENEFITS



LOCATION



ASSURANCE

8.2. Development strategy

Considering the decision making factors and arguments of the stakeholders, it can be concluded that it is not possible to develop a timeline that works for all situations. Provision from day one is way too expensive and factors as the proximity to existing public transport, the spatial layout of the area and the development order and speed all influence the need and feasibility to provide public transport transport at a certain moment in time. Thus, a tailor-made solution is required for each development.

This tailor-made solution can, however, be created using a similar approach. Namely a transition from a basic quality or frequency public transport connection to the final quality. This way, the first inhabitants do have access to public transportation, but the expenses do not skyrocket. This transition strategy is considered to be the best solution possible within the boundaries of the available budget.

Depending on the location, the public transport for the first inhabitants could for example consist of on-demand buses or regular buses that operate at a minimum frequency. If there already is a public transport connection nearby, the decision could also be made to make that connection attractive to use, for example by making it accessible by bicycle and provide good bicycle parking. Another option is to provide shared mobility for the first inhabitants. When the number of inhabitants grows, the public transport connection should evolve with them, meaning that regular public transport should start to operate. This is an intermediate level, where regular buses or a tram line are provided, but not immediately with high frequencies. The public transport connection can then be upgraded again by operating in higher frequencies, in more directions or adding another transport mode.

A visualisation of this transition strategy is given in Figure 8.2.

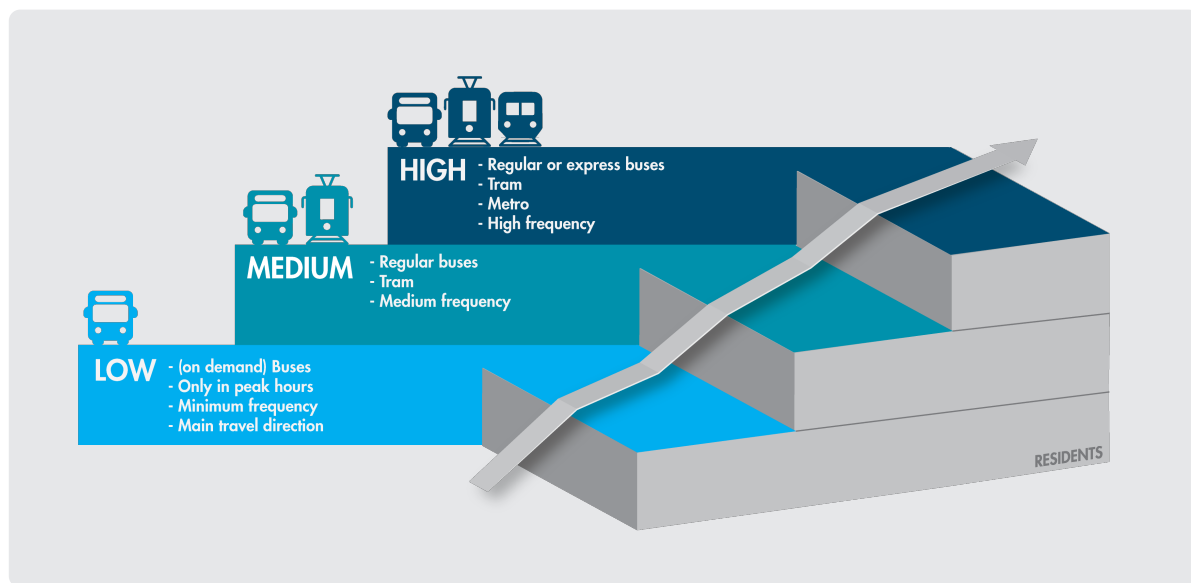


Figure 8.2: Development strategy as followed in practice (own work).

It should be noted that the levels in Figure 8.2 are only an indication of the options considered for stages and are not necessarily followed in practice. They are based on the statements of different interviewees on which types of public transport are usually considered at what moment in time.

Another aspect that was often mentioned by the interviewees, is that people have to know when the public transport will be provided, as people might show different behaviour when they have a perspective on the time frame in which the public transport will be provided than when there is no perspective at all. People keep this in mind when making decisions, for example in the decision whether or not to buy a car.

The 'ideal' development strategy as identified by the interviewees provides the answer for sub-research question 5.

5. What is the 'ideal' development strategy according to the stakeholders?

All stakeholders agreed that the 'ideal' development strategy is different per situation, which means that a tailor-made solution is required for each development. To provide the public transport as early as possible, a transition strategy is used. This transition strategy starts with the provision of a basic quality and/or frequency public transport connection for the first inhabitants, which is upgraded as more and more inhabitants start to live in the area. In this strategy the type and frequency of public transport can be tuned to the specific situation. The interviewees also argued that it is important that people know when the public transport will be provided, as this might influence their decision to look for alternative transport options such as the car.

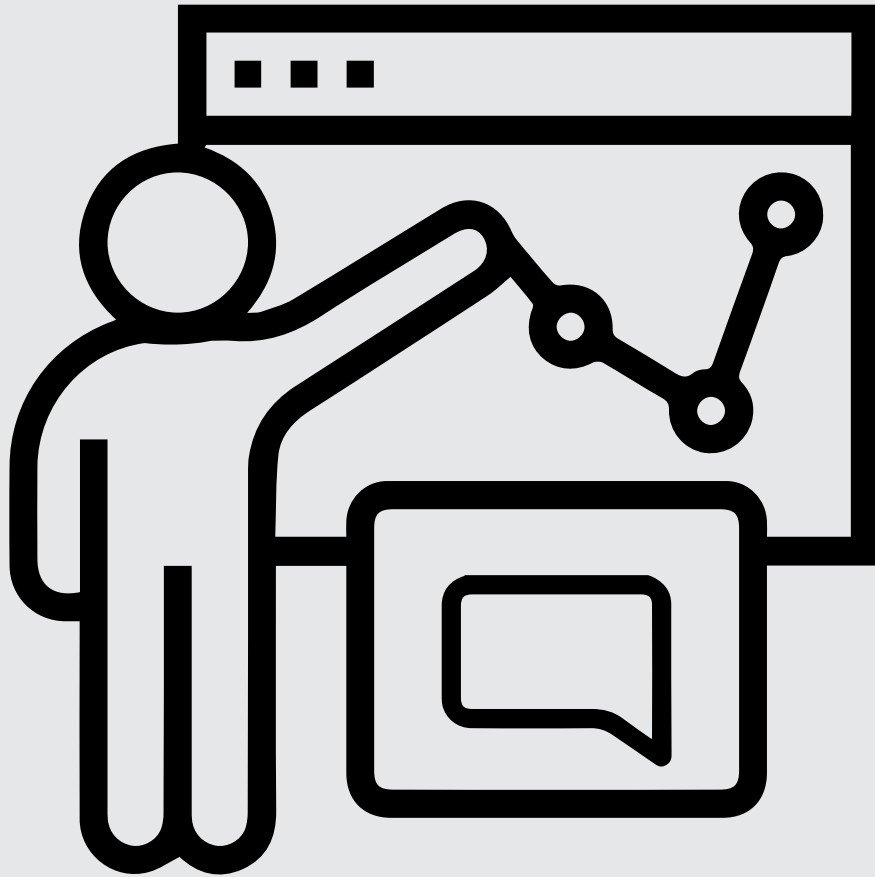
Even though all interviewees agree that the transition strategy is the best way to provide public transport as early as possible, the importance of this early development is questioned.

One of the interviewees stated that, on average, people move every ten years, which means that after ten years the whole area is renewed in terms of inhabitants. It is argued that, because of this, it does not matter as much if public transport is not provided early in the development, as the new inhabitants will have provision from day one. On the long term, this might be true, but there are two main arguments why this is debatable.

First, no one is average and not all inhabitants would move to another place at once. This means that there is a gradient in people moving away. As a result, there would be some new people, who will form a travel routine based on the options available, but there are also people that already have developed travel habits. This means that, just as when public transport is provided early in the development, there will only be few public transport users in the early days and an increase will follow as more new people will move to the area.

Second, providing public transport after several years would mean that there should be alternatives in the mean time. These alternatives could be provided in the form of shared mobility or good cycling and walking infrastructure, but such an area without high-quality public transport would miss options in terms of accessibility. As a result, there is a large chance that people are in need of a car, which could result in higher car ownership levels in the area. The spatial layout should be suitable for those cars, otherwise there will be parking problems and congestion. The problem is, if the spatial layout is tailored to car use to prevent or solve these problems, car use will also become more attractive. As a result, people moving to the area might choose the area because it is attractive for car use. This residential self-selection will sustain the car-oriented character and the public transport connection might not be a success. On the other hand, if the public transport provided is of a high quality, people might also self-select the area because of that.

Overall, the fact that not all is lost when public transport is not provided from day one, as the area renews in terms of inhabitants after several years, should be considered as nice back-up rather than a reason to provide public transport in a later stage.



CONCLUSION, DISCUSSION & RECOMMENDATIONS

9

CONCLUSION, DISCUSSION & RECOMMENDATIONS

What first? Public transport or houses? That is the question. Even though it is generally assumed that early provision of public transport is favourable, the significance of this notion had not yet been studied, and the considerations of the different parties involved in the decision making process in practice are unclear. Therefore, the aim of this research was to explore what development strategy of public transport in a residential area results in high ridership levels while still being feasible for the different parties involved. This final chapter gives a conclusion on this and discusses the research results and the implications and limitations of the research. The chapter ends with recommendations for further research and future development processes.

9.1. Conclusion

This research aimed to explore what development strategy of public transport in a residential area results in high ridership levels while still being feasible for the different parties involved. To determine this, five sub-research questions were stated, that together synergise to answer the main research question.

Sub-research question 1: What is the theoretical influence of development timing on travel behaviour?

The studied literature revealed that people who live in an area with a built environment tailored to sustainable modes of transportation, are more likely to use these sustainable modes than people who live in car-oriented neighbourhoods. Considering that habitual behaviour and life events both influence travel behaviour, there is a certain window of opportunity that people are more susceptible to a change in travel behaviour. Thus, when the built environment is optimised for the use of public transport and when people are subjected to this environment during the window of opportunity, theoretically, the chance is greater that they will use the provided services. On the contrary, when people are subjected to good public transport after they have lived at a location for a while, habitual behaviour can reduce the chance of them using public transport. All in all, it can be concluded that the development timing of public transport in a residential area can, at least theoretically, influence people's travel behaviour. This suggests that public transport should be provided as early as possible.

Based on this literature review the following hypothesis was formulated:



"If the public transport connection is developed late, people will have developed other travel habits and the chance that they use public transport when it is provided, will diminish."

This hypothesis was tested with the aid of case studies, in which the effects of three different development timelines on travel behaviour were studied.

Sub-research question 2: What lessons can be learned from past development timelines?

These case studies suggest that the early development of public transport results in less car usage in a newly developed residential area. However, they also show that the quality of public transport and the built environment play a role in this as well. The case studies namely revealed that people who move to a neighbourhood without (high-quality) public transport, often feel obliged to own a car to get around and that people who do have access to high-quality public transport own a car less often. Furthermore, the case studies also show that the provision of high-quality public transport in a later stage does not necessarily mean that it is doomed to fail, as average car-ownership levels can slowly decrease in the years after public transport is provided. Nevertheless, the hypothesis that late provision leads to a decreased chance in people using public transport, can be accepted. At least for the first decade or so after the development of the neighbourhood.

The answers to the first two sub-research questions suggest that high ridership levels can be achieved by providing public transport early in the development. To determine to what extent this is feasible for the different parties involved in the development process, insights are needed in these stakeholders, their role in the process and their perspective on the development strategy. To determine this, the different stakeholders and their roles were identified first.

Sub-research question 3: What stakeholders are involved in the development process and what is their role?

The desk research and interviews reveal that the stakeholders involved in the development process belong to two categories: governmental institutions and market parties. The governmental institutions involved are the national and regional governments, transport authorities and municipalities. The market parties involved are public transport providers, developers and consultants.

The national government is involved in policy making on a high level, but not with regards to the planning and design of an area. Next to that, they are financially involved in the process, as they provide grants for the development and subsidise public transport. The involvement of the regional government differs for the situation with and without separate transport authority. If there is a transport authority, the role of the regional government is limited to checking the preconditions regarding spatial policy and the provision of subsidies. When there is no transport authority, however, the regional government is responsible for the provision of public transport as well. Municipalities are involved throughout the entire development process. They are usually the ones taking the initiative in area development and are in the lead during the development process.

The main involvement of the public transport providers starts from the moment the construction of the public transport infrastructure commences. They operate the public transport connection and are often (partially) responsible for the construction of the infrastructure needed for it. They can also have an advisory role in the creation of the development vision and urban plan. Developers fill in the building envelopes issued by the municipalities. Occasionally they are also involved in the development of the urban plan. Consultants are involved in the creation of the different plans that are used in the development process.

To determine the development strategies these stakeholders follow, and the reasoning behind them, the following two research questions were answered.

Sub-research question 4: What are the decision making factors used by the different stakeholders?

Based on the interviews with stakeholders, the following decision making factors could be identified:



COSTS



BENEFITS



LOCATION



ASSURANCE

The costs and benefits are weighed in a costs and benefits analysis. Depending on the stakeholder the weighed costs and benefits are different. Governmental institutions use social cost-benefit analyses, while public transport providers base their decisions on the financial costs and benefits, as their

goal is to make a profit from the service they offer. The preconditions of the location influence how early the public transport connection can and must be provided. The 'can' relates to the possibility to feasibly operate public transport at a certain location and the 'must' to the need for early provision. The last decision making factor, assurance, relates to the need of mutual assurance between the different parties involved, to start with the development in the first place. This shows that the stakeholders themselves can be of influence as well.

All these decision making factors are weighed in the decision about the development timing of an area. The development strategy proposed by the stakeholders was identified as follows:

Sub-research question 5: What is the 'ideal' development strategy according to the stakeholders?

All stakeholders agreed that development strategies differ per situation, and a tailor-made solution is required for each development. The interviewees revealed that the approach to provide public transport as early as possible, is a transition from basic to higher quality public transport as more and more inhabitants start to live in the area. With this approach, the type and frequency of public transport can be tuned to the specific situation. Furthermore, the interviewees also argued that, whatever strategy is used, it is important that people know when the public transport connection will be provided, as this might influence their decision to seek alternative transport options.

The answers to these sub-research question lead to the answer on the main research question:

Main research question:

"What development strategy of public transport in a residential area results in high ridership levels while still being feasible for the different parties involved?"

The literature, case studies and interviews reveal that there is no unequivocal answer to the question: "What development strategy should be followed to achieve high ridership levels while still being feasible for the different parties involved?"

The literature suggests that public transport should be provided as early as possible, as there is a certain window of opportunity in which people are more susceptible to a change in travel behaviour. This window of opportunity is the result of the interplay between life events and habitual behaviour. Where habitual behaviour keeps people from changing their travel habits, life events, such as moving, are a trigger to change them. This, together with the effect of the built environment on travel behaviour, suggests that the chance that people will use public transport, is greater when they are subjected to it during this window of opportunity, than when they are subjected to it later. The case studies provide a more nuanced view. They do suggest that the early development of public transport results in less car usage in a newly developed residential area, but they also show that the public transport quality and the built environment play a role in this as well. Furthermore, the case studies show that the provision of high-quality public transport in a later stage does not necessarily mean that it is doomed to fail, as car-ownership levels can slowly decrease in the years after public transport is provided.

The interviewed stakeholders argue that provision from day one is not feasible, as the revenues during early implementation are low and the budget available to subsidise public transportation is limited. They stated that a tailor-made solution is required for each location, as the feasibility of the development strategy and the need for early provision highly depend on the location. These tailor-made solutions are often devised using the same approach, being a transition from a basic to the final quality public transport connection as the development of the area progresses. This way, the first inhabitants do have access to public transportation, but the expenses do not skyrocket.

In short, the development strategy needs to be tailored to the specific development, as the feasibility of a development strategy and the need for early provision are highly dependent on the location.

9.2. Discussion

This section reflects on the relevance and significance of the research. First, the implications of the research are discussed, after which the research methods and results are reflected on. Lastly, the limitations of the research scope are discussed.

9.2.1. Implications

This study has contributed to a better understanding of the influence of development timing on travel behaviour, and to the clarification of the challenges of providing public transport in an early stage. Where previous research focused on either the influence of the built environment on travel behaviour, or the moments in time that people are most susceptible for a change in travel behaviour, this research combined the two topics to explore if development timing can influence travel behaviour as well. The research shows promising results of early implementation for a reduction in car ownership levels and increase in public transport usage. This implies that policy measures aimed at the early provision of public transport can increase the use of public transport.

The research also provided insights in the development process as followed in practice, identifying the different points of view of the stakeholders and unveiling factors that hinder the early provision of public transport. As a result, the study contributed to the clarification of the challenges of providing public transport in an early stage. Identification of those challenges is a first step towards resolving them.

9.2.2. Reflection on the research methods and results

This research used a multitude of research methods to determine what development strategy results in high ridership levels while still being feasible for the different parties involved. This section reflects on the results obtained using these research methods and indicates strengths and limitations of the followed method.

Literature review

Academic literature was used to create a theoretical framework describing the mechanisms that influence travel behaviour related to the development timing of public transport in a residential area. The framework suggested that, when the built environment is optimised for the use of public transport and people are subjected to this environment during a window of opportunity, the chance is greater that they will use it. As only few studies have considered the relation between travel behaviour and life events over time (Adhikari et al., 2020; De Vos et al., 2018; Olde Kalter et al., 2021; Wang and Lin, 2019; Thomas et al., 2016) a comprehensive understanding of the time window within which these changes take place remained unclear. Nevertheless, the literature strongly suggests that the early development of public transport results in higher ridership levels than late development.

Case studies

The case studies suggested that people who move to a neighbourhood without (high-quality) public transport often feel obliged to own a car to get around, and that people who have access to high-quality public transport own a car less often. However, the case studies might not portray the causal effect of development timing on travel behaviour, as the differences between the case studies can also be caused by other factors than a varying development timeline. Differences in the built environment or the quality of public transport provided are examples of these factors. This is hard to avoid, as there will always be differences in variables between the selected cases. However, future research could zoom in on the influence of those other variables to get a better understanding of how they might influence the result. Furthermore, a limited sample size and missing data mean that the exact effect of early implementation on the ridership levels remains unclear.

Interviews

Insights in the development process as followed in practice were obtained with the help of two rounds of interviews following the Delphi method. The method used was slightly atypical for a Delphi study, as the interviews took place in a semi-structured form and the material presented to the interviewees in the second round were statements from the interviews rather than the same questions with the answers as is usual for a Delphi study. This approach was chosen, because of the long and sometimes off-topic answers given in the first round.

This method offered an advantage over just one round of interviews, as the answers of the interviewees in the first round did make them reconsider their answer in the second round. Generally, the answers of the other interviewees were underlined, resulting in interviewees considering certain aspects only after they were presented to them. However, some statements remained a point of debate after the second round. An extra Delphi round would have offered the possibility to resolve some of the points of debate, however, due to time constraints the decision was made to leave it at two rounds.

A limitation of this method is that the interpretation of the answers given by the interviewees after the first round might have steered the answers given in the second round. That is to say, decision making factors and development strategies were identified based on the answers given in the first round and those were presented to the interviewees in the second round. By following this technique, a narrow vision might have been presented. Aspects that were also considered to be important could hereby have remained underexposed, as the researcher did not identify them. However, interviewees sometimes mentioned those aspects again in the second round, which means that this problem partially resolved itself. Still, these aspects were not presented to all the interviewees, which means that it is not clear if these aspects are a subject of debate or if the interviewees agree upon them. This, again, might be resolved by organising another round of interviews or by letting the interviews be interpreted by several people.

Another limitation is that, due to the semi-structured interview method, not every subject was discussed to the same extent with every interviewee, as the conversation veered from the initially set topic multiple times. Even though this is not necessarily wrong, as new insights were obtained by diverting from the set topics, it might have had an influence on the results. This can be prevented by following the interview guide more strictly and not adjusting the questioning to the strayed topic. On the other hand, such an approach would have the risk that important topics are missed, as the only subjects discussed are those chosen by the interviewer.

Lastly, the results obtained during this interviews might be biased, as all of the interviewees are involved in the mobility-related planning of area development. Housing developers, for example, might have had a different view on the importance and need for public transport than people involved in mobility planning. Furthermore, the representation of governmental institutions among the interviewees was higher than the representation of market parties, which might also have influenced the results. However, due to time constraints, it was decided to exclude people not involved in the planning of public transport connections and not find additional interviewees to balance the amount of interviewees from each group. This bias could be avoided by selecting participants from a more diverse group in future research.

9.2.3. Limitations of the scope

The scope also limited the research and there are several extensions or differences of focus of the scope that could have led to different or additional findings. First of all, the stakeholders considered in this research did not include the national government or parties related to heavy-rail transport, but only stakeholders involved in the development and operation of urban public transport such as bus, tram and metro. A lot of urban public transportation, however, is linked to or relies on transport by train and, even though the national government is not directly involved in the planning of urban transport, they still have a great influence as they are the main source of funding for the development. The inclusion of these parties will result in another set of stakeholders with their own influence on and interest in the development timing, which might result in different or additional opportunities and obstacles for early implementation of public transport.

Second, the research focused on residential areas located in and around urban areas in the Netherlands. The extension of the scope to other areas could give different results, as the the decision making process, preconditions of the locations and travel habits in other countries differs from those in the Netherlands. To determine if the findings of this research also apply to other areas, case studies and decision making processes in other areas should be studied as well.

9.3. Recommendations

This thesis explored the influence of development timing on travel behaviour and determined the different factors and strategies used to make decisions on development timing in practice. Following this

research, several scientific studies can be executed to gain a better understanding of this influence and several recommendations can be made to improve the development process as followed in practice.

9.3.1. Recommendations for further research

The explorative study as presented in this thesis uncovered many possibilities for further research. The recommendations for further research on this topic are split up into two sections: recommendations on research on the influence of development timing on travel behaviour and recommendations on research related to the development process in practice.

Recommendations related to the influence of development timing

As stated before, this research explored the influence of development timing on travel behaviour. The research suggests that there is an effect of development timing on travel behaviour, but the exact effect of development timing on the travel behaviour remains unclear. Future research could address this by applying a longitudinal research design to evaluate the influence of the availability of public transport on travel behaviour over time. Hereby, changes in travel preferences and travel behaviour as a result of public transport availability can be observed and conclusions can be drawn on the effect of early availability in comparison to late availability. Furthermore, expanding the research to other areas of the world could provide a more complete picture of the influence of development timing on travel behaviour as well.

Analysis of the influence of public transport quality might be useful to determine if the early provision of any type of public transport is beneficial, or if the quality of public transport plays a major role in this as well. This could be useful information for stakeholders involved in the decision making process, as they would know what type of public transport would be beneficial and which they better not invest their money in as the effect would be minimal or non existing. Additionally, analysis of other influencing factors such as the proximity to the public transport connection or the ease of car use in the area could also improve the understanding of the boundary conditions needed to make early provision of public transport beneficial.

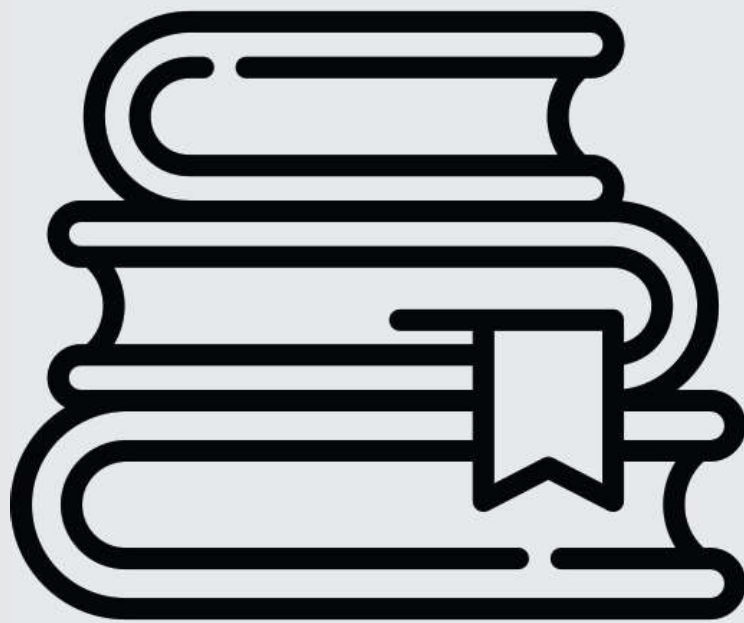
Recommendations related to research on the development process in practice

This research focused on urban public transportation in the Netherlands and therefore only gave a narrow view of the considerations regarding the development timeline in practice. Future research could address this in several ways. First of all, in the Dutch situation, the interest and influence of the national government and parties related to heavy-rail transport could be taken into account, which could give a more complete picture of the different interests and interactions that need to be considered in the decision making process. Inclusion of those parties might also reveal different or additional opportunities and obstacles for early implementation of public transport. Second, the scope could be extended to non-urban areas. This way, the barriers of early provision in areas with lower densities and a different proximity to the existing public transport network can be studied. Furthermore, the scope could also be extended to other areas of the world, to determine if the decision making process in other countries results in different barriers for early implementation or not.

9.3.2. Recommendations for practice

Planning of the public transport connection should take place in an early stage. This has two major advantages. First of all, it is possible to arrange the necessary funding on time, and second, the planning of public transport in an early stage can help to make the area more suitable for early provision. When public transport is considered early in the planning process, the growth pattern of houses alongside the public transport connection can be carefully planned, ensuring that the large housing densities around the public transport connection are developed first.

The interviews uncovered furthermore that the development strategy often followed in practice is a transition from basic public transport to high quality public transport. When applying this strategy, careful attention should be paid to the quality of public transport provided from the start, to ensure that people are persuaded to leave their car at home, or better still, at their dealership.



BIBLIOGRAPHY

Bibliography

- Adhikari, B., Hong, A., & Frank, L. D. (2020). Residential relocation, preferences, life events, and travel behavior: A pre-post study. *Research in Transportation Business & Management*, 36, 100483, <https://doi.org/10.1016/J.RTBM.2020.100483>.
- AT5 (2020). De tram van IJburg naar Centraal is ineens twee keer zo lang. <https://www.at5.nl/artikelen/203299/de-tram-van-ijburg-naar-centraal-is-ineens-twee-keer-zo-lang>.
- Beige, S. & Axhausen, K. W. (2017). The dynamics of commuting over the life course: Swiss experiences. *Transportation Research Part A: Policy and Practice*, 104, 179–194, <https://doi.org/10.1016/J.TRA.2017.01.015>.
- Bewonersvereniging De IJbrug (2004). IJburg - De IJbrug voor en door bewoners : Vertraging IJtram. <http://www.ijbrug.nl/ijburg/tiki-print.php?page=Vertraging+IJtram>.
- Boer, J. (2013). Leidsche Rijn. <https://www.nul20.nl/dossiers/leidsche-rijn>.
- Bruns, A. & Matthes, G. (2019). Moving into and within cities – Interactions of residential change and the travel behavior and implications for integrated land use and transport planning strategies. *Travel Behaviour and Society*, 17, 46–61, <https://doi.org/10.1016/j.tbs.2019.06.002>.
- Busch-Geertsema, A. & Lanzendorf, M. (2017). From university to work life – Jumping behind the wheel? Explaining mode change of students making the transition to professional life. *Transportation Research Part A: Policy and Practice*, 106, 181–196, <https://doi.org/10.1016/J.TRA.2017.09.016>.
- CBS (2013). Kerncijfers wijken en buurten 1999-2009. <https://opendata.cbs.nl/#/CBS/nl/dataset/80859ned/table?ts=1634652880387>.
- CBS (2014). Kerncijfers wijken en buurten 2009-2012. <https://opendata.cbs.nl/#/CBS/nl/dataset/70904ned/table?ts=1634651459065>.
- CBS (2018). Kerncijfers wijken en buurten 2013-2015. <https://opendata.cbs.nl/#/CBS/nl/dataset/82931NED/table?ts=1634653709367>.
- CBS (2019a). Kerncijfers wijken en buurten 2016. <https://opendata.cbs.nl/#/CBS/nl/dataset/83487NED/table?ts=1634724128240>.
- CBS (2019b). Sterke groei in steden en randgemeenten verwacht. <https://www.cbs.nl/nl-nl/nieuws/2019/37/sterke-groei-in-steden-en-randgemeenten-verwacht>.
- CBS (2020a). Kerncijfers wijken en buurten 2017. <https://opendata.cbs.nl/#/CBS/nl/dataset/83765NED/table?ts=1634653483956>.
- CBS (2020b). Prognose: Bevolking blijft komende 50 jaar groeien. <https://www.cbs.nl/nl-nl/nieuws/2020/51/prognose-bevolking-blijft-komende-50-jaar-groeien>.
- CBS (2021a). Kerncijfers wijken en buurten 2018. <https://opendata.cbs.nl/#/CBS/nl/dataset/84286NED/table?ts=1642758160279>.

- CBS (2021b). Kerncijfers wijken en buurten 2019. <https://opendata.cbs.nl/#/CBS/nl/dataset/84583NED/table?ts=1642758310769>.
- CBS (2021c). Kerncijfers wijken en buurten 2020. <https://opendata.cbs.nl/#/CBS/nl/dataset/84799NED/table?ts=1642758324608>.
- CBS (2021d). Kerncijfers wijken en buurten 2021. <https://opendata.cbs.nl/#/CBS/nl/dataset/85039NED/table?ts=1642758337883>.
- Clark, B., Chatterjee, K., & Melia, S. (2016). Changes to commute mode: The role of life events, spatial context and environmental attitude. *Transportation Research Part A: Policy and Practice*, 89, 89–105, <https://doi.org/10.1016/j.tra.2016.05.005>.
- CROW (2008). Amsterdam IJburg: vanaf de eerste paal met het OV. <https://www.crow.nl/kennis/bibliotheek-verkeer-en-vervoer/kennisdocumenten/amsterdam-ijburg-vanaf-de-eerste-paal-met-het-ov>.
- Daramy-Williams, E., Anable, J., & Grant-Muller, S. (2019). Car use: Intentional, habitual, or both? Insights from anscombe and the mobility biography literature. *Sustainability (Switzerland)*, 11(24), <https://doi.org/10.3390/su11247122>.
- de Kort, A. F. (2004). Eindevaluatie Pionierskaart: puntje voor puntje. Technical report, Ministerie van Verkeer en Waterstaat, Rotterdam, 2004.
- De Vos, J., Ettema, D., & Witlox, F. (2018). Changing travel behaviour and attitudes following a residential relocation. *Journal of Transport Geography*, 73, 131–147, <https://doi.org/10.1016/j.jtrangeo.2018.10.013>.
- De Vos, J., Waygood, E. O. D., Letarte, L., & Cao, M. (2021). Do frequent satisfying trips by public transport impact its intended use in later life? *Transportation 2021*, pages 1–19, <https://doi.org/10.1007/S11116-021-10209-0>. <https://link.springer.com/article/10.1007/s11116-021-10209-0>.
- de Vries, M. & den Otter, P. (2021). Leidraad Gebiedsontwikkeling & Smart Mobility. Technical report, Metropoolregio Amsterdam, Amsterdam, 2021. <https://smartmobilitymra.nl/wp-content/uploads/2021/07/MRA-smart-mobility-leidraad-V9.pdf>.
- de Zeeuw, F. (2018). Zo werkt gebiedsontwikkeling. *Praktijkstoel Gebiedsontwikkeling*.
- Deboosere, R., El-Geneidy, A. M., & Levinson, D. (2018). Accessibility-oriented development. *Journal of Transport Geography*, 70, 11–20, <https://doi.org/10.1016/J.JTRANGEO.2018.05.015>.
- Dijst, M., Timmermans, P., & Steenbrink, P. A. (2000). Parkeren voor de deur? Mobiliteit in Leidsche Rijn. *Leidsche Rijn Monitor*, pages 31–44.
- Ettema, D. & Nieuwenhuis, R. (2017). Residential self-selection and travel behaviour: What are the effects of attitudes, reasons for location choice and the built environment? *Journal of Transport Geography*, 59, 146–155, <https://doi.org/10.1016/J.JTRANGEO.2017.01.009>.
- Faber, R., Merkies, R., Damen, W., Oirbans, L., Massa, D., Kroesen, M., & Molin, E. (2021). The role of travel-related reasons for location choice in residential self-selection. *Travel Behaviour and Society*, 25, 120–132, <https://doi.org/10.1016/j.tbs.2021.07.003>.
- Friedrichsmeier, T., Matthies, E., & Klöckner, C. A. (2013). Explaining stability in travel mode choice: An empirical comparison of two concepts of habit. *Transportation Research Part F: Traffic Psychology and Behaviour*, 16, 1–13, <https://doi.org/10.1016/J.TRF.2012.08.008>.
- Gemeente Amsterdam (2018). Startnotitie HOV Oostflank. Technical report, Gemeente Amsterdam, 2018.
- Gemeente Den Haag (2017). Bestemmingsplan Ypenburg. https://www.planviewer.nl/imro/files/NL.IMRO.0518.BP0183HYpenburg-50VA/t_NL.IMRO.0518.BP0183HYpenburg-50VA_2.4.html.

- Gemeente Den Haag (2021). Kerncijfers editie 2021 Selectie van statistische informatie over de gemeente. Technical report, Gemeente Den Haag, 2021.
- Gemeente Utrecht (2022). Openbaar vervoer. <https://www.utrecht.nl/wonen-en-leven/verkeer/openbaar-vervoer/>.
- Guan, X., Wang, D., & Jason Cao, X. (2020). The role of residential self-selection in land use-travel research: a review of recent findings. *Transport Reviews*, 40(3), 267–287, <https://doi.org/10.1080/01441647.2019.1692965>.
- Haags Gemeentearchief (2021). Leidschenveen-Ypenburg, jongste stadsdeel van Den Haag. <https://haagsgemeentearchief.nl/ontdek-de-stad/verhalen-van-de-stad/leidschenveen-ypenburg-jongste-stadsdeel-van-den-haag>.
- Haags Openbaar Vervoer Museum (2022). Terug in de tijd, 09 januari 2002. <https://hovm.nl/%f0%9f%93%b7-terug-in-de-tijd-09-januari-2002/>.
- Haggan, P., Whitmarsh, L., & Skippon, S. M. (2019). Habit discontinuity and student travel mode choice. *Transportation Research Part F: Traffic Psychology and Behaviour*, 64, 1–13, <https://doi.org/10.1016/J.TRF.2019.04.022>.
- Havlícková, D. & Zámecník, P. (2020). Considering habit in research on travel mode choice: A literature review with a two-level methodology. *Transactions on Transport Sciences*, 11(1), 18–32, <https://doi.org/10.5507/TOTS.2020.004>.
- Het Parool (2009). IJburg-tram 26 overvol. <https://www.parool.nl/nieuws/ijburg-tram-26-overvol~ba69e995/>.
- HTM (1999). Vervoerplan 1999-2004. Technical report, HTM, 1999. <https://denhaag.notubiz.nl/document/9799308/1/219857%20HTM%20VERVOERPLAN%201999-2004%20VOOR%20HET%20STADSGEWEST%20HAAGLANDEN%20MEERJARENVISIE>.
- Ibraeva, A., Correia, G. H. A., Silva, C., & Pais Antunes, A. (2020). Transit-oriented development: A review of research achievements and challenges. *Transportation Research Part A: Policy and Practice*, 132(2020), 110–130, <https://doi.org/10.1016/j.tra.2019.10.018>.
- Infrastruct (2010). Tram naar De Meern en Vleuten. <https://infrastruct.wordpress.com/2010/01/07/tram-naar-de-meern-en-vleuten/>.
- Interprovinciaal overleg (2021). Mobiliteit. <https://www.ipo.nl/thema-s/mobiliteit/>.
- ITDP (2018). Principles for transport in urban life: better together. https://itdpdotorg.wpengine.com/wp-content/uploads/2014/07/ITDP-OCO-Building-Blocks_FINAL_large.jpg.
- Janke, J., Thigpen, C. G., & Handy, S. (2020). Examining the effect of life course events on modality type and the moderating influence of life stage. *Transportation* 2020 48:2, 48(2), 1089–1124, <https://doi.org/10.1007/s11116-019-10077-9>. <https://link.springer.com/article/10.1007/s11116-019-10077-9>.
- Janssen, I. & van der Veen, M. (2011). De Leidsche Rijn: duurzame idealen in uitvoering. <https://adoc.pub/de-leidsche-rijn-duurzame-ideal-en-in-uitvoering.html>.
- Kallio, H., Pietilä, A.-M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. *Journal of Advanced Nursing*, 72(12), 2954–2965, <https://doi.org/10.1111/JAN.13031>.
- Kamruzzaman, M., Mostafiz Shatu, F., Hine, J., & Turrell, G. (2015). Commuting mode choice in transit oriented development: Disen-tangling the effects of competitive neighbourhoods, travel attitudes, and self-selection. *Transport Policy*, 42, 187–196, <https://doi.org/10.1016/j.tranpol.2015.06.003>. <http://dx.doi.org/10.1016/j.tranpol.2015.06.003>.

- Kenniscentrum InfoMil (2021). Wet ruimtelijke ordening . <https://www.infomil.nl/onderwerpen/ruimte/ruimtelijke/wet-ruimtelijke/>.
- Kersten, R. A. E. M., Schroots, S. M. F., Amerika, H., & Bregman, A. G. (2019). Reiswijzer gebiedsontwikkeling 2019: Een praktische routebeschrijving voor marktpartijen en overheden. Technical report, Bouwend Nederland, Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, NEPROM and VNG, Den Haag, 2019.
- Kroesen, M. (2019). Residential self-selection and the reverse causation hypothesis: Assessing the endogeneity of stated reasons for residential choice. *Travel Behaviour and Society*, 16, 108–117, <https://doi.org/10.1016/j.tbs.2019.05.002>.
- Kuiken, A. (2016). Verkeer in steden dreigt vast te lopen. <https://www.trouw.nl/nieuws/verkeer-in-steden-dreigt-vast-te-lopen~bec66e87/>.
- Lebouille, R. & Molemaker, R.-J. (2006). Onrendabel openbaar vervoer in nieuwbouwwijken vraagt om heldere keuzes. Technical report, Ecorys, 2006.
- Meijenboom, F. (2021). Met nieuwe busbaan en bredere brug in de Dichterswijk vlot van centrum naar Leidsche Rijn. <https://www.ad.nl/utrecht/met-nieuwe-busbaan-en-bredere-brug-in-de-dichterswijk-vlot-van-centrum-naar-leidsche-rijn~ab677cf8/>.
- Michielsen, T., Groot, S., & Veenstra, J. (2019). Het bouwproces van nieuwe woningen. *CPB boek*. <https://www.cpb.nl/sites/default/files/omnidownload/cpb%20boek%20woningmarkt%20-%20boek%2033.pdf>.
- Ministry of Infrastructure and Water Management (2018). Summary: The Dutch Multi-Year Programme for Infrastructure, Spatial Planning, and Transport (MIRT). Technical Report 107287en, Ministry of Infrastructure and Water Management, Den Haag, 2018. <https://www.government.nl/documents/leaflets/2018/02/07/the-dutch-multi-year-programme-for-infrastructure-spatial-planning-and-transport-mirt---summary>.
- MKBA-informatie (2021). Meerjarenprogramma Infrastructuur, Ruimte en Transport (MIRT). <https://www.mkba-informatie.nl/mkba-basics/abc-van-de-mkba/meerjarenprogramma-infrastructuur-ruimte-en-transport-mirt/>.
- Mokhtarian, P. L. & van Herick, D. (2016). Quantifying residential self-selection effects: A review of methods and findings from applications of propensity score and sample selection approaches. *Journal of Transport and Land Use*, 9(1), 7–26, <https://doi.org/10.5198/jtlu.2016.788>.
- MuConsult (2020). Inbesteding Stadsvervoer. <https://muconsult.nl/cases/inbesteding-stadsvervoer/>.
- Müggenburg, H., Busch-Geertsema, A., & Lanzendorf, M. (2015). Mobility biographies: A review of achievements and challenges of the mobility biographies approach and a framework for further research. *Journal of Transport Geography*, 46, 151–163, <https://doi.org/10.1016/J.JTRANGE.2015.06.004>.
- Munneke, C. (2011). *Woningbouwontwikkeling langs binnenstedelijke light rail trajecten* [Master thesis, Rijksuniversiteit Groningen], Repository Rijksuniversiteit Groningen. https://frw.studenttheses.ub.rug.nl/814/1/Scriptie_Woningbouwontwikkeling.pdf.
- NS (2020). Reizigersgedrag 2019. <https://dashboards.nsjaarverslag.nl/reizigersgedrag>.
- Oakil, A. T. M., Ettema, D., Arentze, T., & Timmermans, H. (2014). Changing household car ownership level and life cycle events: An action in anticipation or an action on occurrence. *Transportation*, 41(4), 889–904, <https://doi.org/10.1007/S11116-013-9507-0>.
- Okoli, C. & Pawlowski, S. D. (2004). The Delphi method as a research tool: an example, design considerations and applications. *Information & Management*, 42(1), 15–29, <https://doi.org/10.1016/J.IM.2003.11.002>. <https://www.sciencedirect.com/science/article/pii/S0378720603001794>.

- Olde Kalter, M. J., La Paix Puello, L., & Geurs, K. T. (2021). Exploring the relationship between life events, mode preferences and mode use of young adults: A 3-year cross-lagged panel analysis in the Netherlands. *Travel Behaviour and Society*, 24, 195–204, <https://doi.org/10.1016/J.TBS.2021.04.004>.
- Omroep West (2006). Aantal reizigers NS-station Ypenburg teleurstellend. <https://www.omroepwest.nl/nieuws/999830/aantal-reizigers-ns-station-ypenburg-teleurstellend>.
- Oostveen, M. (2000). Suburbia voor beginners. <https://www.nrc.nl/nieuws/2000/04/01/suburbia-voor-beginners-7488898-a1230054>.
- Pacheco-Torgal, F., Rasmussen, E., Granqvist, C.-G., Ivanov, V., Kaklauskas, A., & Makonin, S. (2016). *Start-Up Creation*. Elsevier, 2016, <https://doi.org/10.1016/C2014-0-04828-9>.
- Pan, H., Li, J., Shen, Q., & Shi, C. (2017). What determines rail transit passenger volume? Implications for transit oriented development planning. *Transportation Research Part D: Transport and Environment*, 57, 52–63, <https://doi.org/10.1016/J.TRD.2017.09.016>.
- Pojani, D. & Stead, D. (2014). Dutch planning policy: The resurgence of TOD. *Land Use Policy*, 41, 357–367, <https://doi.org/10.1016/j.landusepol.2014.06.011>. <http://dx.doi.org/10.1016/j.landusepol.2014.06.011>.
- Puylaert, G. (2021). HTM wil gebiedsontwikkeling aanjagen. *OV-magazine*, pages 6–9. <https://www.ovmagazine.nl/nieuws/htm-wil-gebiedsontwikkeling-aanjagen>.
- Raad voor leefomgeving en infrastructuur (2018). Van B naar anders: investeren in mobiliteit voor de toekomst. Technical report, Raad voor leefomgeving en infrastructuur, Den Haag, 2018. www.rli.nl.
- Ramezani, S., Hasanzadeh, K., Rinne, T., Kajosaari, A., & Kyttä, M. (2021). Residential relocation and travel behavior change: Investigating the effects of changes in the built environment, activity space dispersion, car and bike ownership, and travel attitudes. *Transportation Research Part A: Policy and Practice*, 147, 28–48, <https://doi.org/10.1016/J.TRA.2021.02.016>.
- Rijksdienst voor Ondernemend Nederland (2021). Dutch public transport concessions. <https://business.gov.nl/regulation/public-transport-concession/>.
- Rijksoverheid (2021a). Beleid ruimtelijke ordening. <https://www.rijksoverheid.nl/onderwerpen/ruimtelijke-ordening-en-gebiedsontwikkeling/beleid-ruimtelijke-ordening>.
- Rijksoverheid (2021b). Wat is de Rijksoverheid . <https://www.werkenvoornederland.nl/over-de-rijksoverheid/wat-is-de-rijksoverheid>.
- Rosenberg, H. (2016). Tram 19, een tram naar nergens. https://www.ad.nl/delft/tram-19-een-tram-naar-nergens~a193e479/?cb=9935b1d4a6aaa305a3a6e7af9046bc92&auth_rd=1.
- RTV Utrecht (2002). Beter openbaar vervoer Leidsche Rijn . <https://www.rtvutrecht.nl/nieuws/58949/beter-openbaar-vervoer-leidsche-rijn>.
- Saldaña, J. (2013). *The Coding Manual for Qualitative Researchers*. SAGE Publications, 2 edition, 2013.
- Schmalz, U., Spinler, S., & Ringbeck, J. (2021). Lessons Learned from a Two-Round Delphi-based Scenario Study. *MethodsX*, 8, 101179, <https://doi.org/10.1016/J.MEX.2020.101179>.
- Schonenberg, L. (2020). De geschiedenis van Leidsche Rijn.
- Snellen, D., Hilbers, H., & Hendriks, A. (2005). nieuwbouw in beweging. Technical report, Ruimtelijk Plabureau, Den Haag, 2005. https://www.pbl.nl/sites/default/files/downloads/Nieuwbouw_in_beweging.pdf.

- Spruijt, C. (2016). *Improving the use of traffic models in transport and infrastructure planning Identification of problem issues and explorative research on possible improvements* [Master thesis, Delft University of Technology], TU Delft repository. <https://repository.tudelft.nl/islandora/object/uuid%3A1fb5d1c8-9a9b-40ad-ad48-56e609c26165?collection=education>.
- Summa Lingua Technologies (2021). Verbatim vs. Intelligent vs. Edited Transcription Explained. <https://summalinguae.com/data/verbatim-vs-intelligent-vs-edited-transcription/>.
- ten Haaft, G. (1999). Leidsche Rijn wacht op de bus. <https://www.trouw.nl/nieuws/leidsche-rijn-wacht-op-de-bus~bd0b2884/?referrer=https%3A%2F%2Fwww.google.com%2F>.
- Thomas, G. O., Poortinga, W., & Sautkina, E. (2016). Habit Discontinuity, Self-Activation, and the Diminishing Influence of Context Change: Evidence from the UK Understanding Society Survey. *Plos ONE*, 11, <https://doi.org/10.1371/journal.pone.0153490>. <http://gtr.rcuk.ac>.
- Treinreiziger.nl (2009). Aantal in- en uitstappers (2006) - grootte. <https://www.treinreiziger.nl/aantal-in-en-uitstappers-2006-grootte/>.
- Treinreiziger.nl (2019). Aantal in- en uitstappers per station bij NS 2013-2018. <https://www.treinreiziger.nl/aantal-in-en-uitstappers-per-station-2013-2018/>.
- Treinstationinfo.nl (2021). Nederlandse treinstations. <https://www.treinstationinfo.nl/nederland/>.
- Trouw (1999). Geen bus in nieuwe wijk. <https://www.trouw.nl/nieuws/geen-bus-in-nieuwe-wijk~b68ccb53/>.
- Trouw (2002). Station Leidsche Rijn voorlopig van de baan. <https://www.trouw.nl/nieuws/station-leidsche-rijn-voorlopig-van-de-baan~b01e4a0f/>.
- Twin, A. (2021). Tools for fundamental analysis: Delphi method. <https://www.investopedia.com/terms/d/delphi-method.asp>.
- van de Coevering, P., Maat, K., & van Wee, B. (2015). Multi-period Research Designs for Identifying Causal Effects of Built Environment Characteristics on Travel Behaviour. *Transport Reviews*, 35(4), 512–532, <https://doi.org/10.1080/01441647.2015.1025455>.
- van de Coevering, P., Maat, K., Kroesen, M., & van Wee, B. (2016). Causal effects of built environment characteristics on travel behaviour: A longitudinal approach. *European Journal of Transport and Infrastructure Research*, 16(4), 674–697, <https://doi.org/10.18757/EJTIR.2016.16.4.3165>.
- van de Poel, P. (1999). Met pionierskaart toch de auto in. <https://www.volkskrant.nl/mensen/met-pionierskaart-toch-de-auto-in~bf072369/>.
- van Herick, D. & Mokhtarian, P. L. (2020). How much does the method matter? An empirical comparison of ways to quantify the influence of residential self-selection. *Travel Behaviour and Society*, 18, 68–82, <https://doi.org/10.1016/j.tbs.2019.09.002>.
- van Wandelen, J. (2018). Historische inleiding. https://www.haagseherinneringen.nl/pagina/331/historische_inleiding.
- van Wee, B. & Handy, S. (2016). Key research themes on urban space, scale, and sustainable urban mobility. *International Journal of Sustainable Transportation*, 10(1), 18–24, <https://doi.org/10.1080/15568318.2013.820998>.
- van Wee, B., De Vos, J., & Maat, K. (2019). Impacts of the built environment and travel behaviour on attitudes: Theories underpinning the reverse causality hypothesis. *Journal of Transport Geography*, 80, 102540, <https://doi.org/10.1016/J.JTRANGE.2019.102540>.

- Vereniging Openbaar vervoer Centrumgemeenten (2014). Rol van gemeenten in openbaar vervoer. https://vng.nl/files/vng/rol_van_gemeenten_in_openbaar_vervoer.pdf.
- Vereniging van Nederlandse Gemeenten & Interprovinciaal Overleg (2019). Regionale Mobiliteitsprogramma's Handreiking. <https://vng.nl/sites/default/files/2020-01/handreiking-1.0-regionale-mobiliteitsprogrammas.pdf>.
- Verhage, R. (2003). The Role of the Public Sector in Urban Development: Lessons from Leidsche Rijn Utrecht (The Netherlands). *Planning Theory & Practice*, 4(1), 29–44, <https://doi.org/10.1080/1464935032000057191>. <https://www.tandfonline.com/action/journalInformation?journalCode=rptp20>.
- Walker, I., Thomas, G. O., & Verplanken, B. (2014). Old Habits Die Hard: Travel Habit Formation and Decay During an Office Relocation. <http://dx.doi.org/10.1177/0013916514549619>, 47(10), 1089–1106, <https://doi.org/10.1177/0013916514549619>.
- Wang, D. & Lin, T. (2019). Built environment, travel behavior, and residential self-selection: a study based on panel data from Beijing, China. *Transportation*, 46(1), 51–74, <https://doi.org/10.1007/s11116-017-9783-1>.
- Wilson, C. (2014). Semi-Structured Interviews. *Interview Techniques for UX Practitioners*, pages 23–41, <https://doi.org/10.1016/B978-0-12-410393-1.00002-8>.
- Wolday, F., Cao, J., & Næss, P. (2018). Examining factors that keep residents with high transit preference away from transit-rich zones and associated behavior outcomes. *Journal of Transport Geography*, 66, 224–234, <https://doi.org/10.1016/J.JTRANGEO.2017.12.009>.
- Zarabi, Z., Manaugh, K., & Lord, S. (2019). The impacts of residential relocation on commute habits: A qualitative perspective on households' mobility behaviors and strategies. *Travel Behaviour and Society*, 16, 131–142, <https://doi.org/10.1016/J.TBS.2019.05.003>.



APPENDIX

A

Scientific paper

What first? Public transport or houses?

A study on the development timing of public transport in a residential area.

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Abstract

Modern cities are seeking possibilities to create healthy, sustainable and liveable urban environments. Yet these endeavours should not come at the expense of the accessibility of the city. Therefore, many cities try to promote the use of sustainable modes of transportation by developing transit-oriented neighbourhoods. An ongoing debate related to these developments is the development timing of the public transport connection. Even though it is generally assumed that early provision of public transport is favourable, the significance of this notion has not yet been studied, and the considerations of the different parties involved in the decision making process in practice are unclear. Therefore, the aim of this research is to explore what development strategy of public transport in a residential area results in high ridership levels while still being feasible for the different parties involved. This is done through an evaluation of both the influence of development timing on travel behaviour and an evaluation of the development process based on stakeholder interviews. The results suggest that it is indeed beneficial to provide public transport from the moment the first inhabitants start to live in the area. However, the study also revealed that provision in a later stage does not necessarily mean that it is doomed to fail, as the car-ownership levels can slowly decrease in the years after the public transport is provided. The stakeholder interviews show development strategy needs to be tailored to the specific development, as the feasibility of a development strategy and the need for early provision are highly dependent on the location and the budget available for the subsidisation of public transport is limited. Thus, a tailor made solution is required for each location.

Key words: Development timing; Public transport; Travel behaviour; Mode choice.

1 Introduction

The Netherlands is undergoing a population growth that is projected to continue for the coming 50 years (CBS, 2020b). This growth is expected to be the strongest in cities and their surrounding suburbs, which leads to emerging issues such as congestion and environmental pollution experienced by growing cities all around the world (Pan et al., 2017). Therefore, more and more cities are seeking possibilities to solve these issues and create healthy, sustainable and liveable urban environments for today and tomorrow (Ibraeva et al., 2020). Unregulated growth of urban areas will result in a growing number of cars in and around cities. Not only will this lead to more congestion, but it will also contribute to greenhouse emissions (Kuiken, 2016). Therefore, many cities try to promote the use of sustainable modes of transportation within their legislative bounds (Ibraeva et al., 2020). But how does one get people to use sustainable modes of transportation instead of their car?

A planning concept that has become increasingly popular in this endeavour is the integration of land-use and transportation planning. The reason for this interest is the influence both the public transport quality as well as the spatial layout of an area can have on travel behaviour. High quality public transport in a built environment with a spatial layout tailored to the use of sus-

tainable modes of transportation can namely encourage the use of them, hereby serving as a replacement for the car (Faber et al., 2021). In practice, this means a collaboration between different institutions, who all have their own interests and priorities.

One of the ongoing debates in the development of transit-oriented neighbourhoods, is the right development timing of a public transport connection relative to the development of the residential area it serves (Puylaert, 2021). If the public transport connection is provided early, this will result in low ridership levels in the first years of the development, as not all of the intended users live there yet. These low ridership levels are a significant expense for the public transport provider, considering that they need to pay the operating costs even though they ride empty. However, this early provision also has advantages, as residents are more likely to use the offered transit connection when it is provided from the moment they start to live there (Thomas et al., 2016). The reason for this is that people are more likely to change their habits after life events such as moving. Late development on the other hand, might result in the formation of other travel habits such as car travel. As those habits do not easily change (Haggard et al., 2019), the risk may exist that people will not start to use the connection when it is provided in a later stage.

Even though it is generally assumed that early provision of public transport is favourable, the significance of this notion has not yet been studied, and the considerations of the different parties involved in the decision making process in practice are unclear. Therefore, the aim of this research is to explore what development strategy of public transport in a residential area results in high ridership levels while still being feasible for the different parties involved. This is done through an evaluation of both the influence of development timing on travel behaviour and the decision making process around this development timing.

The paper begins with a review of the existing knowledge on the mechanisms influencing travel behaviour in relation to the development timeline, after which the methods and approach used to determine the development strategy are discussed. Then, the results on the influence of development timing and the considerations of the different parties involved in the decision making process in practice are summarised. The paper ends with a conclusion on the development strategy, a discussion on the implications and limitations of the research and recommendations for future research.

2 Literature review

The relation between the built environment and travel behaviour has been the subject of considerable research attention over the past years (Faber et al., 2021). To determine if it matters at what moment people are subjected to such a built environment, it is important to understand the mechanisms that influence the relation, as well as the mechanisms that influence travel behaviour over time. The section starts with a discussion on the relation between travel behaviour and the built environment, after which this relation is linked to mechanisms known to influence peoples travel behaviour over time. The resulting conceptual model is used to form a hypothesis on the influence of development timing on travel behaviour.

2.1 Travel behaviour and the built environment

The built environment consists of buildings, open spaces and transport systems which together form the space we live, work and recreate in (Pacheco-Torgal et al., 2016). The design and spatial-layout of this built environment can have an influence on the travel behaviour of its residents. Neighbourhoods with high densities in areas adjacent to high quality public transport and good walking and cycling infrastructure encourage people to use sustainable modes of transportation, where neighbourhood with large roads and lots of parking facilities encourage car use (Kamruzzaman et al., 2015; Ibraeva et al., 2020). This relation between travel behaviour and the built environment has been recognised in research for several decades (van de Coevering et al., 2015; Wang and Lin, 2019), however the existence of a causal effect of this relation has long been contested using mechanisms that

explain the associating via other variables (Faber et al., 2021; van de Coevering et al., 2016).

One of those mechanisms, residential self-selection, is described as the notion that people choose the place they live based on their travel preferences (Wang and Lin, 2019), which are the result of travel attitude, lifestyle and/or socio-demographics (van Wee and Handy, 2016; van de Coevering et al., 2016). Several studies show that notion weakens the idea that the built environment influences travel behaviour, as people choose an environment due to its favourable characteristics in regard of their preferred way of travel, instead of the other way around (Bruns and Matthes, 2019; De Vos et al., 2018; van Herick and Mokhtarian, 2020; Wolday et al., 2018). However there are also studies that show that residential location choice and travel attitude are only associated to a limited extent (Ettema and Nieuwenhuis, 2017) and that the built environment can also influence travel behaviour after residential self-selection is accounted for (De Vos et al., 2021; Faber et al., 2021; Guan et al., 2020).

Another theory, the reversed causality theory, is that the built environment can influence people's travel attitudes over time, hereby making them more appreciative for a certain mode of transportation, which in its turn influences their travel behaviour Ramezani et al. (2021). This theory is supported by van de Coevering et al. (2016); Wang and Lin (2019); van Wee et al. (2019), who state that travel attitudes are influenced by the built environment. However, there are also studies that conclude that even after attitudes and transport related location choices are taken into account, there still is an effect of the built environment on travel behaviour (van de Coevering et al., 2016; Faber et al., 2021).

All in all, it can be concluded that both the reversed causality hypotheses and residential self-selection play a role in the relation between the built environment and travel behaviour, but that there also is a causal relation between the two. The conclusions on the mechanisms playing a role in the relation between travel behaviour and the built environment are captured in the conceptual model given in Figure 1.

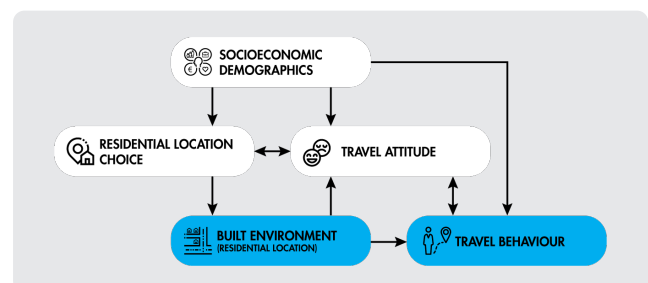


Figure 1. Conceptual model of the relation between travel behaviour and the built environment (adjusted from Faber et al. (2021); van de Coevering et al. (2016))

2.2 When do people change their travel behaviour?

The phrase *Old habits die hard* aptly describes people's travel behaviour, as people do not change their travel habits easily (Haggar et al., 2019; Busch-Geertsema and Lanzendorf, 2017), especially when it involves the car (Daramy-Williams et al., 2019). Even when other influencing factors change, behaviour does not necessarily change accordingly due to habits (Friedrichsmeier et al., 2013). According to Havlíčková and Zámecník (2020) habit is the most important variable that hinders attempts to change travel behaviour. Thus, unveiling what makes people change their habits over time is quite important in the shift towards the use of more sustainable modes of transportation.

Life events have been generally acknowledged as a trigger for people to change their travel behaviour (Janke et al., 2020; Olde Kalter et al., 2021; Clark et al., 2016). They are the moments in someone's life when there is a major change in their situation, such as the birth of a child, moving home, entering the labour market or changing jobs (Olde Kalter et al., 2021). These life events can be seen as windows of opportunity for policies aiming to change travel behaviour, as people are more susceptible for a change in travel behaviour after those events (Janke et al., 2020; Beige and Axhausen, 2017).

All in all, it can be concluded that life events can disrupt habitual behaviour and influence travel behaviour. This influence on travel behaviour is either caused by a change in the socioeconomic demographics such as household composition or employment or a change in built environment. Adding the influence of life events and the relation between habitual behaviour and travel behaviour to Figure 1 gives the conceptual framework as given in Figure 2.

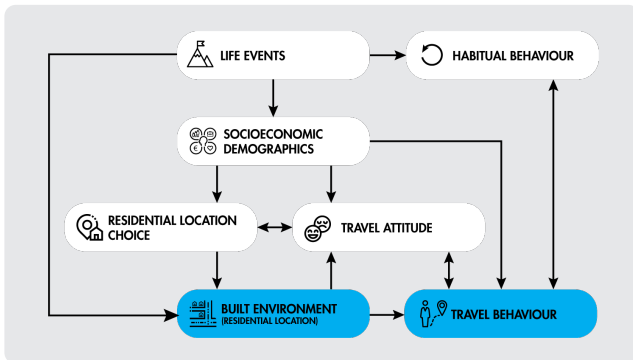


Figure 2. Conceptual model of the mechanisms influencing travel behaviour in respect to the development timeline.

2.3 Hypothesis

The studied literature revealed that people living in an area with a built environment tailored to sustainable modes of transportation, are more likely to use these sustainable modes than people who live in car-oriented

neighbourhoods. Considering that habitual behaviour and life events both influence travel behaviour, there is a certain window of opportunity that people are more susceptible for a change in travel behaviour. Thus, when the built environment is optimised for the use of public transport and people are subjected to this environment during this window of opportunity, theoretically, the chance is greater that they will use it. On the contrary, when people are subjected to good public transport after they have lived at a location for a while, habitual behaviour can reduce the change.

Based on this literature review the following hypothesis is formulated:

"If the public transport connection is developed late, people will have developed other travel habits and the chance they use the public transport when it is provided is diminished."

3 Methodology

This study on development timing of public transport in residential area is based on information obtained from literature, case studies and interviews using the Delphi method. The research is split into two main parts: a part on the influence of development timing on travel behaviour and a part on the development process in practice.

3.1 Influence of development timing

The hypothesis on the influence of development timing on travel behaviour was tested with the help of case studies, in which the effects of three different development timelines on travel behaviour were studied.

For the evaluation of past development strategies, three so called Vinex neighbourhoods were scrutinised. These neighbourhoods are the result of the eponymous policy briefing note originating from the 1990's, which allocated greenfield locations near existing city centres for new-town housing projects. The aim was to catch up on housing construction and reduce travel movements by car to relieve the environment. To accomplish this, the built environment was designed to ensure good accessibility by public transport, cycling and walking (Snellen et al., 2005). These neighbourhoods were chosen, because their aim was to promote public transport usage and they are built following the same vision, which makes them suitable to be compared.

The three cases vary from a place where the public transport connection was developed early in the development, to a developing neighbourhood that obtained access to public transport years after the first inhabitants. The cases are compared based on the success of their public transport connection as well as the car ownership levels. This data is gathered using government documents, ridership levels published by public transport providers, newspaper articles and evaluations of neighbourhoods.

3.2 Development process in practice

A large number of stakeholders are involved in the development process, both governmental institutions - often spread over several departments - and market parties such as developing parties and public transport providers (Rijksoverheid, 2021; Michielsen et al., 2019; Rijksdienst voor Ondernemend Nederland, 2021). To determine the feasibility of development strategies in practice, two rounds of semi-structured interviews are held with 7 of those stakeholders.

The participants selected for the interviews are land-use and transportation planners from governmental institutions and transport providers that are involved in the development of public transport in residential areas. The interviewees are from three groups: Municipal government (1), Transport authority (2) and Public transport provider (3). Table 1 gives an overview of the interview participants, their organisation, function and expertise.

These three groups were chosen, because the stakeholders in these three groups have the most power/interest in the development of public transport in a residential area. That is to say, area development is primarily a task of municipalities and the governing transport authority. Together they make decisions on the development vision for the area. From the market parties, the party with the largest interest are the public transport providers, as it is their goal to make a profit from the service they offer. The national government also has a lot of power, as they are the main source of funding (Pojani and Stead, 2014; Rijksoverheid, 2021), however it was decided to exclude them from the research, as they are not involved in the actual planning process.

As the views of those different stakeholders on the development strategy might not align, the Delphi method was applied. The Delphi method is an iterative feedback technique that has been specifically designed to achieve a

consensus from a group of experts (Okoli and Pawlowski, 2004). It uses several rounds of interviews, in which each of the participants is asked to respond to the (anonymous) statements of the other participants until a group consensus is reached (Schmalz et al., 2021). For this research, the technique is applied to explore if there is a consensus on the development strategy that has to be followed. This is done through two round of interviews.

In the first round, the interviewees were asked to give their view on the development strategy they think must be followed and the decision making factors they use to determine this. Furthermore, the participants were asked to validate the identified stakeholders and to state the influence of each of the stakeholders per development phase. The results from this round were analysed using qualitative coding. The encoding scheme for the first round of interviews was created following the steps below, which are inspired by the encoding steps as used by Spruijt (2016); Saldaña (2013).

- (1) Assign structural codes to the interview
Each interviewee was assigned an id code (A - G) and a group code (1-3). The groups correspond to the different types of organisation the participants work for: (1) Municipal government, (2) Transport authority and (3) Public transport provider.
- (2) Assign theme codes
To organise the information retrieved from the interviews, different theme codes were used: travel behaviour influences, decision making factors, stakeholders and development strategy.
- (3) Compose encoding scheme
The coded data was added to the encoding scheme, which gives an overview of the information from the interviews per theme. This way, similarities and differences in the answers could be identified.

From this scheme, statements on the decision making factors and development strategies were selected to

Table 1
Interview participants.

	Organisation	Function and expertise
A1	City of The Hague	Organises and oversees intra organisational collaborations. Expert in the field of the built environment (mobility, land-use, sustainability, housing, economics).
B2	Transport Authority Rotterdam The Hague	Involved in the transportation planning for Vinex-locations around The Hague. Expert in the field of transport planning in relation to the built environment.
C1	City of Almere	Responsible for local bus transit in Almere and regional bus transit between Almere and 't Gooi and Amsterdam.
D1	City of Nijmegen	Advises the mayor and alderman on mobility related projects. Expert in the field of transport planning in relation to the built environment.
E2	Transport Authority Amsterdam	Focuses on medium to long-term developments that impact the regional and national transport system.
F3	GVB (Public transport company of Amsterdam)	Works on short and long-term network development for the municipality of Amsterdam and its surrounding municipalities.
G1	City of Utrecht	Expert in the field of land-use and transport planning. Currently works on long-range public transport connections from and to the city of Utrecht.

present to the interviewees in the second round. This is slightly atypical for a Delphi study, as normally the same questions with the answers given by the other interviewees are presented to determine if people change their mind by seeing the answers of others. However, as the first round of interviews was conducted in a semi-structured form, as this round was also used to obtain information on the process itself, the decision was made not to follow this approach. Both because of the lengthiness answers and because not all topics were related to the goal of the Delphi study, which was to determine what development strategies are feasible in practice. The data retrieved in this round of interviews was compared per interview subject.

The Delphi method has the advantage that the views of a group of experts can be aggregated without the need of a group meeting (Twin, 2021). Furthermore, individuals can express their own opinions in stead of group thinking. However, this also has its disadvantages, as group thinking might help to resolve the points of debate during the discussion. Another disadvantage is that the method can be time consuming and the interviewees need to make a commitment.

Considering that the goal is to identify if there are differences in opinion on the development strategy, it is useful that the views of the different stakeholders are collected separately. By collecting the opinions separately, the opinions of all stakeholders are heard and there are no persons dominating the discussion.

Furthermore, a group discussion could also result in a focus on a specific topic, while other topics are neglected. The differences in opinion that are normally discussed in a group session were instead presented to the participants in the second round. This gave them the opportunity to reconsider their answer based on the opinions of others, while they are not under pressure in the heat of a discussion. As a result, all opinions are heard and the points of debate become clear.

4 Results

4.1 Influence of development timing on travel behaviour

The case studies scrutinised in this research are IJburg, Leidsche Rijn and Ypenburg. Figure 3 gives an overview of the offered level of service of public transport in relation to the number of residents per area. The evaluation of those timelines in terms of the public transport and car ownership levels is given below.

4.1.1 Public transport

All three locations provided some kind of public transport in the early days of development. The difference lies in the quality of the provided public transport. In IJburg, a bus connection was operated for the first residents, and the tram connection started to operate when

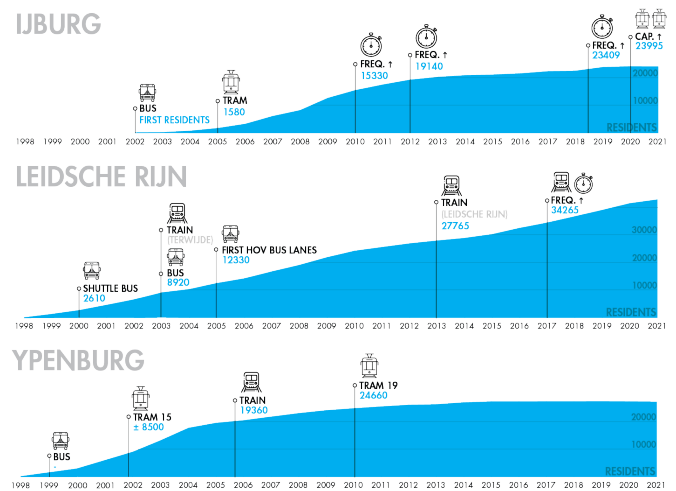


Figure 3. Public transport developments in relation to the number of residents (data on the number of resident per year received from CBS (2013, 2014, 2018, 2019, 2020a, 2021a,b,c,d)).

around 1580 people lived in the neighbourhood. In Leidsche Rijn, the first bus and trains started to operate when around 9000 people lived in the area. Before that, the only option to use public transport was the regular bus service between Utrecht and De Meern, which had a low frequency and a bus stop far away from the neighbourhood. The high-quality bus network was provided from the moment the area had around 12 500 residents and when 27 750 people lived in the area, the train station Utrecht Leidsche Rijn was completed. In Ypenburg, several buses operated in the early days of the development and the first tram connection started to to operate when the area had around 8500 residents. The train station was taken into operation when 20 000 people lived in the area and a second tram connection at 25 000 people.

The difference in quality translates to the satisfaction and usage of the passengers. In general, there were a lot of complaints about the lower quality public transport (bus) in both IJburg and Leidsche Rijn. But, as the higher quality public transport (tram) was realised much earlier in IJburg than in Leidsche Rijn (HOV-bus), the residents of IJburg used the tram while the residents of Leidsche Rijn often felt obliged to buy a car as the higher quality public transport was not available.

4.1.2 Car ownership levels

The car ownership levels of each of the neighbourhoods over the years are given in Figure 4. As can be seen, the ownership levels in Leidsche Rijn and Ypenburg are significantly higher than those of IJburg. Leidsche Rijn takes the cake when it comes to the highest ridership levels from 2004 to 2019, however both before and after that time period the ridership levels are similar to or lower than those of Ypenburg, which lie around the nationwide average of of about one car per household.

Car ownership per household (2005-2020)

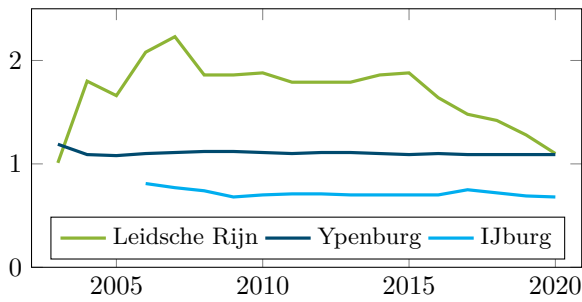


Figure 4. Car-ownership over the years (data retrieved from CBS (2013, 2014, 2018, 2019, 2020a, 2021a,b,c,d))

4.2 Development process in practice

4.2.1 Decision making factors

The decision making factors mentioned in the first round of interviews are the costs, benefits, preconditions of the location, mutual assurance and money availability.

The factors that were mentioned most frequently are the costs and benefits. According to most interviewees, the decisions on the development timing are based on the trade-off between these two. In this trade-off, the investment and operation costs of the provision of public transport are weighed against the benefits of early provision. In the second round of interviews, the interviewees added that governmental institutions use social cost-benefit analyses, while public transport providers base their decisions on the financial costs and benefits, as their goal is to make a profit from the service they offer. Regarding those benefits, most interviewees state that early provision is important, as more people will use the public transport connection when it is provided early. However, it was also argued that this is only partially true, as people will move to another place every ten years on average, and the area will thus be renewed in terms of inhabitants after those ten years. These inhabitants will have public transport available from the first day they live in the area, which means there will be little difference in ridership levels in the long term. In the second round, several arguments were made to undermine this, the main being that no one is average and this statement is only true when you only consider people, but is not true when you consider spatial planning as well.

Another factor that was mentioned frequently, was the location dependency. The interviewees suggested that the influence of this factor could work in two ways, namely as an influence on how early the public transport connection can and must be provided. The 'can' relates to the possibility to feasibly operate public transport at a certain location. An example of this is that provision of public transport in areas with only a few houses scattered across the neighbourhood is not feasible, because many stops would be needed and only few people would

use them. When an area is developed this way, nothing much can be done in terms of public transportation. For developments where the houses are grouped in higher densities on the other hand, the prospects are better, as one stop can provide access for many people. The location dependency is also related to how early public transport 'must' be provided, or in other words, the urgency there is for public transport in an area. If the development concerns an area which has no existing public transport connection nearby or an area that is prone to traffic problems, the early provision of public transport is more urgent than when there already is a high quality connection nearby. However, it is also argued that the early provision of public transport is always important. A counterargument provided against this is that there only is a limited budget to develop several areas, which means that prioritising certain areas is necessary.

The fourth factor that was mentioned multiple times, is the need for mutual assurance between the different parties involved in the development. The interviewees argue that if there is no mutual assurance between parties on a development timeline, there will be a reluctance to start with the development, as there is a risk that this will have financial consequences.

Where all the other decision making factors mentioned above were stated multiple times and were underlined by all the other interviewees, money availability was only mentioned once and not agreed upon. The main argument provided against it was, that it is something one can influence rather than something one has to base one's decision on.

4.2.2 Development strategy

Regarding the development strategy, all interviewees agree that the final quality cannot be provided from day one, as this is not financially feasible. It is argued that it is best to start with a lower quality and/or frequency option and upgrade the connection as the number of inhabitants grows. Some argue that this could, for example, consist of on-demand buses or buses that only operate at peak moments. However, it is also argued that the provided public transport should have a frequency of at least 4 times per hour. Several interviewees also mention that shared mobility and good accessibility to the existing public transport network are also good options when the provision of public transport is not feasible yet. Thus, there is not one clear vision of what should be provided in the early days of development. The only thing that is agreed upon is that something should be provided.

When implementing this transition strategy, it is argued that the final quality should always be kept in mind, as the infrastructure should be suitable for it when there are enough people inhabiting the new neighbourhood. If this is not considered from day one, it might not be possible to fit the desired public transport connection

in the newly-built area. Furthermore, it is also argued that people have to know when the public transport will be provided, as people might show different behaviour when they have a perspective on the time frame in which the public transport will be provided than when there is no perspective at all.

5 Conclusion

The literature, case studies and interviews reveal that there is no unequivocal answer to the question: "What development strategy should be followed to achieve high ridership levels while still being feasible for the different parties involved?"

The literature suggests that public transport should be provided as early as possible, as there is a certain window of opportunity in which people are more susceptible to a change in travel behaviour. This window of opportunity is the result of the interplay between life events and habitual behaviour. Where habitual behaviour keeps people from changing their travel habits, life events, such as moving, are a trigger to change them. This, together with the effect of the built environment on travel behaviour, suggests that the chance that people will use public transport, is greater when they are subjected to it during this window of opportunity, than when they are subjected to it later. The case studies provide a more nuanced view. They do suggest that the early development of public transport results in less car usage in a newly developed residential area, but they also show that the public transport quality and the built environment play a role in this as well. Furthermore, the case studies show that the provision of high-quality public transport in a later stage does not necessarily mean that it is doomed to fail, as car-ownership levels can slowly decrease in the years after public transport is provided.

The interviewed stakeholders argue that provision from day one is not feasible, as the revenues during early implementation are low and the budget available to subsidise public transportation is limited. They stated that a tailor-made solution is required for each location, as the feasibility of the development strategy and the need for early provision highly depend on the location. These tailor-made solutions are often devised using the same approach, being a transition from a basic to the final quality public transport connection as the development of the area progresses. This way, the first inhabitants do have access to public transportation, but the expenses do not skyrocket.

In short, the development strategy needs to be tailored to the specific development, as the feasibility of a development strategy and the need for early provision are highly dependent on the location.

6 Discussion and recommendations

This study has contributed to a better understanding of the influence of development timing on travel behaviour,

and clarification of the challenges of providing public transport in an early stage. Where previous research focused on either the influence of the built environment on travel behaviour, or the moments in time that people are most susceptible for a change in travel behaviour, this research combined the two topics to explore if development timing can influence travel behaviour as well. The research shows promising results of early implementation for a reduction in car ownership levels and increase in public transport usage. This implies that policy measures aimed at the early provision of public transport can increase the use of public transport. The research also identified the different points of view of the stakeholders and unveiled factors that hinder the early provision of public transport.

There are, however, two main limitations to this research. The first is that the case studies might not portray the causal effect of development timing, as the differences between the case studies can also be caused by other factors than a varying development timeline. This, a limited sample size and missing data all mean that the exact effect of early implementation on the ridership levels remains unclear. Future research could address this limitation by applying a longitudinal research design to evaluate the ridership levels over time. The second limitation concerns the areas and stakeholders studied in the research. The stakeholders considered in this research did not include the national government or parties related to heavy-rail transport, but only stakeholders involved in the development and operation of urban public transport such as bus, tram and metro. The inclusion of these parties will result in another set of stakeholders with their own influence on and interest in the development timing, which might result in different or additional opportunities and obstacles for early implementation of public transport.

Furthermore, future research is recommended to determine if the early provision of any type of public transport is beneficial, or if the quality of public transport plays a major role in this as well. Additionally, this topic also relates to a recommendation for practice: careful attention should be paid to the quality of public transport provided from the start, to ensure that people are persuaded to leave their car at home, or better still, at their dealership.

References

- Beige, S. & Axhausen, K. W. (2017). The dynamics of commuting over the life course: Swiss experiences. *Transportation Research Part A: Policy and Practice*, 104, 179–194, <https://doi.org/10.1016/J.TRA.2017.01.015>.
- Bruns, A. & Matthes, G. (2019). Moving into and within cities – Interactions of residential change and the travel behavior and implications for integrated land use and transport planning strategies. *Travel*

- Behaviour and Society*, 17, 46–61, <https://doi.org/10.1016/j.tbs.2019.06.002>.
- Busch-Geertsema, A. & Lanzendorf, M. (2017). From university to work life – Jumping behind the wheel? Explaining mode change of students making the transition to professional life. *Transportation Research Part A: Policy and Practice*, 106, 181–196, <https://doi.org/10.1016/J.TRA.2017.09.016>.
- CBS (2013). Kerncijfers wijken en buurten 1999-2009. <https://opendata.cbs.nl/#/CBS/nl/dataset/80859ned/table?ts=1634652880387>.
- CBS (2014). Kerncijfers wijken en buurten 2009-2012. <https://opendata.cbs.nl/#/CBS/nl/dataset/70904ned/table?ts=1634651459065>.
- CBS (2018). Kerncijfers wijken en buurten 2013-2015. <https://opendata.cbs.nl/#/CBS/nl/dataset/82931NED/table?ts=1634653709367>.
- CBS (2019). Kerncijfers wijken en buurten 2016. <https://opendata.cbs.nl/#/CBS/nl/dataset/83487NED/table?ts=1634724128240>.
- CBS (2020a). Kerncijfers wijken en buurten 2017. <https://opendata.cbs.nl/#/CBS/nl/dataset/83765NED/table?ts=1634653483956>.
- CBS (2020b). Prognose: Bevolking blijft komende 50 jaar groeien. <https://www.cbs.nl/nl-nl/nieuws/2020/51/prognose-bevolking-blijft-komende-50-jaar-groeien>.
- CBS (2021a). Kerncijfers wijken en buurten 2018. <https://opendata.cbs.nl/#/CBS/nl/dataset/84286NED/table?ts=1642758160279>.
- CBS (2021b). Kerncijfers wijken en buurten 2019. <https://opendata.cbs.nl/#/CBS/nl/dataset/84583NED/table?ts=1642758310769>.
- CBS (2021c). Kerncijfers wijken en buurten 2020. <https://opendata.cbs.nl/#/CBS/nl/dataset/84799NED/table?ts=1642758324608>.
- CBS (2021d). Kerncijfers wijken en buurten 2021. <https://opendata.cbs.nl/#/CBS/nl/dataset/85039NED/table?ts=1642758337883>.
- Clark, B., Chatterjee, K., & Melia, S. (2016). Changes to commute mode: The role of life events, spatial context and environmental attitude. *Transportation Research Part A: Policy and Practice*, 89, 89–105, <https://doi.org/10.1016/j.tra.2016.05.005>.
- Daramy-Williams, E., Anable, J., & Grant-Muller, S. (2019). Car use: Intentional, habitual, or both? Insights from anscombe and the mobility biography literature. *Sustainability (Switzerland)*, 11(24), <https://doi.org/10.3390/su11247122>.
- De Vos, J., Ettema, D., & Witlox, F. (2018). Changing travel behaviour and attitudes following a residential relocation. *Journal of Transport Geography*, 73, 131–147, <https://doi.org/10.1016/j.jtrangeo.2018.10.013>.
- De Vos, J., Waygood, E. O. D., Letarte, L., & Cao, M. (2021). Do frequent satisfying trips by public transport impact its intended use in later life? *Transportation 2021*, pages 1–19, <https://doi.org/10.1007/S11116-021-10209-0>.
- Ettema, D. & Nieuwenhuis, R. (2017). Residential self-selection and travel behaviour: What are the effects of attitudes, reasons for location choice and the built environment? *Journal of Transport Geography*, 59, 146–155, <https://doi.org/10.1016/J.JTRANGEO.2017.01.009>.
- Faber, R., Merckies, R., Damen, W., Oirbans, L., Massa, D., Kroesen, M., & Molin, E. (2021). The role of travel-related reasons for location choice in residential self-selection. *Travel Behaviour and Society*, 25, 120–132, <https://doi.org/10.1016/j.tbs.2021.07.003>.
- Friedrichsmeier, T., Matthies, E., & Klöckner, C. A. (2013). Explaining stability in travel mode choice: An empirical comparison of two concepts of habit. *Transportation Research Part F: Traffic Psychology and Behaviour*, 16, 1–13, <https://doi.org/10.1016/J.TRF.2012.08.008>.
- Guan, X., Wang, D., & Jason Cao, X. (2020). The role of residential self-selection in land use-travel research: a review of recent findings. *Transport Reviews*, 40(3), 267–287, <https://doi.org/10.1080/01441647.2019.1692965>.
- Haggag, P., Whitmarsh, L., & Skippon, S. M. (2019). Habit discontinuity and student travel mode choice. *Transportation Research Part F: Traffic Psychology and Behaviour*, 64, 1–13, <https://doi.org/10.1016/J.TRF.2019.04.022>.
- Havlíčková, D. & Zámečník, P. (2020). Considering habit in research on travel mode choice: A literature review with a two-level methodology. *Transactions on Transport Sciences*, 11(1), 18–32, <https://doi.org/10.5507/TOTS.2020.004>.
- Ibraeva, A., Correia, G. H. A., Silva, C., & Pais Antunes, A. (2020). Transit-oriented development: A review of research achievements and challenges. *Transportation Research Part A: Policy and Practice*, 132(2020), 110–130, <https://doi.org/10.1016/j.tra.2019.10.018>.
- Janke, J., Thigpen, C. G., & Handy, S. (2020). Examining the effect of life course events on modality type and the moderating influence of life stage. *Transportation* 2020 48:2, 48(2), 1089–1124, <https://doi.org/10.1007/S11116-019-10077-9>. <https://link.springer.com/article/10.1007/s11116-019-10077-9>.
- Kamruzzaman, M., Mostafiz Shatu, F., Hine, J., & Turrell, G. (2015). Commuting mode choice in transit oriented development: Disentangling the effects of competitive neighbourhoods, travel attitudes, and self-selection. *Transport Policy*, 42, 187–196, <https://doi.org/10.1016/j.tranpol.2015.06.003>. <http://dx.doi.org/10.1016/j.tranpol.2015.06.003>.
- Kuiken, A. (2016). Verkeer in steden dreigt vast te lopen. <https://www.trouw.nl/nieuws/verkeer-in-steden-dreigt-vast-te-lopen~bec66e87/>.
- Michielsen, T., Groot, S., & Veenstra, J. (2019). Het bouwproces van nieuwe woningen. *CPB boek*. <https://www.cpb.nl/sites/default/files/>

- omnidownload/cpb%20boek%20woningmarkt%20-%20boek%2033.pdf.
- Okoli, C. & Pawlowski, S. D. (2004). The Delphi method as a research tool: an example, design considerations and applications. *Information & Management*, 42(1), 15–29, <https://doi.org/10.1016/J.IM.2003.11.002>. <https://www.sciencedirect.com/science/article/pii/S0378720603001794>.
- Olde Kalter, M. J., La Paix Puello, L., & Geurs, K. T. (2021). Exploring the relationship between life events, mode preferences and mode use of young adults: A 3-year cross-lagged panel analysis in the Netherlands. *Travel Behaviour and Society*, 24, 195–204, <https://doi.org/10.1016/J.TBS.2021.04.004>.
- Pacheco-Torgal, F., Rasmussen, E., Granqvist, C.-G., Ivanov, V., Kaklauskas, A., & Makonin, S. (2016). *Start-Up Creation*. Elsevier, 2016, <https://doi.org/10.1016/C2014-0-04828-9>.
- Pan, H., Li, J., Shen, Q., & Shi, C. (2017). What determines rail transit passenger volume? Implications for transit oriented development planning. *Transportation Research Part D: Transport and Environment*, 57, 52–63, <https://doi.org/10.1016/J.TRD.2017.09.016>.
- Pojani, D. & Stead, D. (2014). Dutch planning policy: The resurgence of TOD. *Land Use Policy*, 41, 357–367, <https://doi.org/10.1016/j.landusepol.2014.06.011>. <http://dx.doi.org/10.1016/j.landusepol.2014.06.011>.
- Puylaert, G. (2021). HTM wil gebiedsontwikkeling aanjagen. *OV-magazine*, pages 6–9. <https://www.ovmagazine.nl/nieuws/htm-wil-gebiedsontwikkeling-aanjagen>.
- Ramezani, S., Hasanzadeh, K., Rinne, T., Kajosaari, A., & Kyttä, M. (2021). Residential relocation and travel behavior change: Investigating the effects of changes in the built environment, activity space dispersion, car and bike ownership, and travel attitudes. *Transportation Research Part A: Policy and Practice*, 147, 28–48, <https://doi.org/10.1016/J.TRA.2021.02.016>.
- Rijksdienst voor Ondernemend Nederland (2021). Dutch public transport concessions. <https://business.gov.nl/regulation/public-transport-concession/>.
- Rijksoverheid (2021). Beleid ruimtelijke ordening. <https://www.rijksoverheid.nl/onderwerpen/ruimtelijke-ordening-en-gebiedsontwikkeling/beleid-ruimtelijke-ordening>.
- Saldaña, J. (2013). *The Coding Manual for Qualitative Researchers*. SAGE Publications, 2 edition, 2013.
- Schmalz, U., Spinler, S., & Ringbeck, J. (2021). Lessons Learned from a Two-Round Delphi-based Scenario Study. *MethodsX*, 8, 101179, <https://doi.org/10.1016/J.MEX.2020.101179>.
- Snellen, D., Hilbers, H., & Hendriks, A. (2005). nieuwbouw in beweging. Technical report, Ruimtelijk Planbureau, Den Haag, 2005. https://www.pbl.nl/sites/default/files/downloads/Nieuwbouw_in_beweging.pdf.
- Spruijt, C. (2016). *Improving the use of traffic models in transport and infrastructure planning Identification of problem issues and explorative research on possible improvements* [Master thesis, Delft University of Technology], TU Delft repository. <https://repository.tudelft.nl/islandora/object/uuid%3A1fb5d1c8-9a9b-40ad-ad48-56e609c26165?collection=education>.
- Thomas, G. O., Poortinga, W., & Sautkina, E. (2016). Habit Discontinuity, Self-Activation, and the Diminishing Influence of Context Change: Evidence from the UK Understanding Society Survey. *Plos ONE*, 11, <https://doi.org/10.1371/journal.pone.0153490>. <http://gtr.rcuk.ac>.
- Twin, A. (2021). Tools for fundamental analysis: Delphi method. <https://www.investopedia.com/terms/d/delphi-method.asp>.
- van de Coevering, P., Maat, K., & van Wee, B. (2015). Multi-period Research Designs for Identifying Causal Effects of Built Environment Characteristics on Travel Behaviour. *Transport Reviews*, 35(4), 512–532, <https://doi.org/10.1080/01441647.2015.1025455>.
- van de Coevering, P., Maat, K., Kroesen, M., & van Wee, B. (2016). Causal effects of built environment characteristics on travel behaviour: A longitudinal approach. *European Journal of Transport and Infrastructure Research*, 16(4), 674–697, <https://doi.org/10.18757/EJTIR.2016.16.4.3165>.
- van Herick, D. & Mokhtarian, P. L. (2020). How much does the method matter? An empirical comparison of ways to quantify the influence of residential self-selection. *Travel Behaviour and Society*, 18, 68–82, <https://doi.org/10.1016/j.tbs.2019.09.002>.
- van Wee, B. & Handy, S. (2016). Key research themes on urban space, scale, and sustainable urban mobility. *International Journal of Sustainable Transportation*, 10(1), 18–24, <https://doi.org/10.1080/15568318.2013.820998>.
- van Wee, B., De Vos, J., & Maat, K. (2019). Impacts of the built environment and travel behaviour on attitudes: Theories underpinning the reverse causality hypothesis. *Journal of Transport Geography*, 80, 102540, <https://doi.org/10.1016/J.JTRANGE.2019.102540>.
- Wang, D. & Lin, T. (2019). Built environment, travel behavior, and residential self-selection: a study based on panel data from Beijing, China. *Transportation*, 46(1), 51–74, <https://doi.org/10.1007/s11116-017-9783-1>.
- Wolday, F., Cao, J., & Naess, P. (2018). Examining factors that keep residents with high transit preference away from transit-rich zones and associated behavior outcomes. *Journal of Transport Geography*, 66, 224–234, <https://doi.org/10.1016/J.JTRANGE.2017.12.009>.

B

Interview guides

B.1. Interview guide round 1

Below, the interview guide used during the first round of interviews is given.

Introduction _____ ±5 min

- Self-introduction
- Introduction research (+ scope)
- Goal of the interview
- Recording and data processing

Participant introduction _____ ±5 min

EN

- What is your background and role within your organisation?
- To what extent are you involved in the development process of public transport in new residential areas?

NL

- Wat is je achtergrond en de rol binnen de organisatie waar je werkt?
- In welke mate ben je betrokken bij het ontwikkelingsproces van openbaar vervoer in nieuwbouwwijken?

Questions on decision making _____ ±10 min

EN

- On what basis is decided when to develop the public transport connection (relative to the development timeline of the residential area)?
- Which interest does your organisation have in this decision?
- How can your organisation influence this decision?

NL

- Op basis waarvan wordt er gekozen wanneer de ov verbinding wordt ontwikkeld (t.o.v. de totale ontwikkelingstijdlijn van de woonwijk)?
- Welk belang heb je of heeft jouw organisatie bij deze keuze?
- Op welke manier kan jouw organisatie invloed uitoefenen op deze keuze?

Questions on stakeholder involvement and interaction _____ ±15 min

Show stakeholder interaction and development timeline with stakeholder involvement.

EN

- Considering the stakeholder interaction visualised in this figure, what do you think the arrows mean and are there any missing?
- What is missing or incorrect about the moment of involvement of the stakeholders?

NL

- Als je de stakeholder interaction in dit plaatje bekijkt, wat houden de pijlen volgens jou in en missen er nog interacties?
- Wat mist of klopt er niet aan de momenten dat mensen het proces beïnvloeden?

Questions on travel behaviour _____ ±10 min

EN

- At what moment do you think people reconsider their travel behaviour?
- Why do you think people reconsider their travel behaviour?

NL

- Wat zijn volgens jou de momenten dat mensen hun reisgedrag heroverwegen?
- Waarom heroverwegen mensen hun reisgedrag volgens jou?

Questions on the development timeline _____ ±20 min

EN

- Based on what indicators would you consider transit-oriented developments a success?
- Which transit-oriented developments do you consider to be successful and which not? Why?
- Considering past results with different development timelines, what would you consider to be the ideal development order?

NL

- Op basis waarvan zou je een ov georiënteerde woonwijk een succes noemen?
- Welke OV georiënteerde woonwijken vind je een succes en welke juist niet? En waarom?
- Als je kijkt naar in het verleden behaalde resultaten met bepaalde ontwikkelingsvolgordes, wat zou volgens jou dan de ideale ontwikkelingsvolgorde zijn?

B.2. Interview guide round 2

Below, the interview guide used during the second round of interviews is given.

Introduction _____ ±5 min

Recap previous round, goal of the interview, recording permission and data processing.

Decision making factors _____ ±15 min

Statements cost-benefit trade-off

EN

NL

- "It is purely related to money. If you develop the bus connection first, the busses are empty in the beginning, and you need to determine if that is worth it."
- "You try to manage it in such a way that there is a reasonable amount of revenue for the public transport operator, but not everyone has already bought a car or two before the tram starts to operate"
- "It is a trade-off between the costs and benefits, your business case."
- "The costs and benefits of a certain decision do not always lie with the same party."

"Het is puur een geldkwestie. Bied je eerst overaan, dan zijn de bussen in eerste instantie leeg en moet je het er met elkaar over gaan hebben of het de investering waard is."

"Je wil het zo op elkaar af proberen te stemmen dat er een redelijke hoeveelheid omzet te behalen valt voor het openbaar vervoer, maar niet iedereen al een auto of twee auto's gekocht heeft voordat de tram rijdt."

"Het is afweging tussen de kosten en baten, je business case"

"De kosten en baten van een project liggen niet altijd bij dezelfde partij."

Statement money availability

EN

NL

- "The choice when to develop what is mainly determined by the moment money is available for it. That means that in some cases housing construction is faster than infrastructure construction and in some cases the infrastructure is already there, and you can build around it."

"Die keuze die wordt vooral bepaald door het moment waarop er geld is. Zo pragmatisch is het eigenlijk wel. Dus dat betekent dat in sommige gevallen de bouw sneller gaat dan de aanleg van infrastructuur en in sommige gevallen ligt de infrastructuur er al en kan je er omheen bouwen."

Statements benefits/importance early development

EN

NL

- "If the timing is wrong, it will make a difference in ridership levels."
- "It is important to provide public transport in an early stage, as travel behaviour becomes a habit for people over time. The moment you move or find a new job, that is the moment people think about their mobility behaviour. You can still argue how extensive the public transport has to be, but you should not force people to initially use a different modality, because then people will already have developed a habit and it will be very difficult to pull them out of it."

"Er zal een verschil zijn in reizigersaantallen als de timing niet klopt."

"Het is van belang is om in een zo vroeg mogelijk stadium zo'n wijk van openbaar vervoer te voorzien. Met name ook omdat we zien dat mobiliteit voor mensen op een bepaald moment ook een gewoonte aan het worden is. Juist het moment dat je ergens nieuw gaat wonen of werken, is dat natuurlijk het moment om fundamenteel na te gaan denken, hoe ga ik nou verplaatsen? Je kunt nog discussiëren over hoe uitgebreid het moet zijn, maar in ieder geval moet je mensen niet gaan verplichten om in eerste instantie met een andere modaliteit te gaan, want dan zitten mensen op enig moment al in een gewoonte en dan wordt het wel heel moeilijk om ze daar weer uit te trekken"

EN

- "You want to provide public transport from the moment the first 'zoning plans/building plans' are realised. This is relatively expensive, but theory and practice show that if you want people to use public transport you have to provide it from the moment they start to live in the area."
- "On average, people live in a house for 10 years and then move on. So, the moment you are 10 years further, on average that entire residential area is renewed in terms of inhabitants. Not quite, some people leave sooner and some stay longer, but it's not like the area will never be a success if you do not provide public transport from day one. That is not true. You get a longer transition model, but that too is a trade-off of course."

NL

- "Je wil openbaar vervoer aanbieden vanaf het moment dat de eerste blokken huizen in de wijk gereed zijn. Dat is relatief duur, maar de theorie en praktijk laten zien dat als je wil dat mensen ov gaan gebruiken, je het aan moet bieden vanaf het moment dat ze er gaan wonen"
- "Mensen wonen gemiddeld genomen tien jaar in een huis, dus op het moment dat je 10 jaar verder bent is gemiddeld genomen de hele woonwijk vernieuwd qua inwoners. Het is dus niet zo dat het nooit meer iets wordt als je niet vanaf de eerste dag ov aanbiedt. Je krijgt alleen een langer ingroeimodel."

Statements on location dependency

EN

- "It is different per area. You look at what makes sense with regard to the construction densities. The moment you have a very large residential area with only a few houses here and there, you can't do anything with it in terms of public transport."
- "It depends on the geographical preconditions. If a detour is not large compared to the original route, that choice will be made sooner than if there is a whole a different route has to be taken that takes extra time."
- "The choice for a certain development timeline is different from location to location. For some locations the area development is not possible without public transport. At other locations, when there already is some public transport available, you can start with the area development, so you get certainty about the support for better transit and you can arrange public transport based on that."

NL

- "Het is maatwerk per gebied. Je kijkt wat logisch is ook ten aanzien van de dichtheden waarin wordt gebouwd. Op het moment dat je een hele grote woonwijk hebt met hier en daar een plukje huizen, dan kan je daar niks mee wat betreft openbaar vervoer."
- "Het hangt een beetje af van de geografische omstandigheden. Als de bus er niet al te ver voor hoeft om te rijden ten opzichte van de oorspronkelijke route dan zal die keuze eerder gemaakt worden dan als er een hele andere route gereden moet worden die extra tijd kost"
- "Het hangt heel erg af van de locatie. Op sommige plekken zie je dat de gebiedsontwikkeling vastloopt zonder ov. Op andere plekken, waar je kan doorbouwen op wat er is, kun je soms wel eerst de gebiedsontwikkeling doen, zodat je zekerheid krijgt over het draagvlak voor beter ov."

Development timing

±10 min

Statements on transition strategy

EN

- "When it concerns new residential areas, you should provide public transport from the moment the first 250 houses are ready. At that moment you start with public transport in the main direction of travel and a few years later it can be extended with a second or third connection. This involved a st"

NL

- "Als het gaat om nieuwe wijken, dan moet je al bij de eerste oplevering van 250 huizen openbaar vervoer hebben geregeld. Dan is het natuurlijk vaak wel zo dat je begint met openbaar vervoer in de belangrijkste reis richting en kan het zijn dat je pas een aantal jaren later met nog een en tweede of zelfs een derde verbinding komt. There often is a step-by-step plan involved."

EN

NL

- "You do not have to provide the final quality from the start. When it concerns large developments you talk about a substantial ridership levels that are not yet there during the transition period. You cannot operate a rail connection if no people use it, but the question is what that temporary situation should be. It should have enough quality, or at least speed, in the most important travel directions."
 - "It is about the transition model."
- "Je hoeft niet per se meteen de eindkwaliteit te hebben. Als het gaat om grote ontwikkelingen dan gaat het ook over substantiële vervoersaantallen en in die tijdelijke situatie zijn die er gewoon nog niet. Je kan niet dat railvervoer laten rijden als er nog geen mensen in zitten, maar het is wel heel erg de vraag wat dan die tijdelijke oplossing is. Dat moet wel voldoende kwaliteit hebben, in elk geval snelheid, richting de belangrijkste bestemmingen."
 - "Het gaat om het ingroeimodel"

Statements on quantification

EN

NL

- "Some type of public transport has to be provided, the question is if that should be from the moment the first houses are built or from the moment around 10-15% of the area is completed. From the moment around 30% of the houses are built the tram should start to operate."
 - "When there are 250-300 houses you should provide some form of public transport."
 - "From the moment the first groups of houses are ready (60-100 houses)."
- "Er moet een vorm van openbaar vervoer zijn en of dat vanaf het begin is of vanaf het moment dat 10-15% van de woningen er staat is de vraag. Vanaf 30% moet de tram wel gaan rijden."
 - "Bij 250-300 huizen moet je wel iets van openbaar vervoer bieden"
 - "Vanaf het moment dat de eerste blokken huizen opgeleverd worden (60-100 huizen)"