Rethinking the traditional commute

A thesis on Intermodal commuting via Multimodal Hubs

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Abstract

Today, traditional car-dependent commuting towards cities causes high CO_2 emissions, congestion and air pollution. Moreover, parked cars occupy vast amounts of scarce public space. These problems will be aggravated when our cities continue to attract more activity. It's time to rethink the traditional commute. Facilitating intermodal travel to combat these issues has become an important policy objective for cities around the world. Yet, there is still much to learn about intermodality. In this study, the aim is to gain more insight into the factors that drive intermodal commuting behavior. The following research question is asked: To what extent do the various determinants of travel mode choice play a role in stimulating intermodal commuting?

Answering this question has been achieved through quantitative inquiry of intermodal commuters in the city of Groningen; a moderately sized city in the Netherlands. The questionnaire has been designed on a theoretical basis that consists of the determinants of travel mode choice. These are: *instrumental-, affective*- and *symbolic* determinants, *socioeconomic characteristics, mobility related policy at the workplace* and *amenities at interchange locations.* Data of 86 respondents has been analyzed using ordinal logistic regression and descriptive statistical analysis. In the sample, around 80% of intermodal commuters had to pay for parking at the workplace and 80% indicated that their employer stimulates park and ride usage. These results underline the importance of progressive mobility policies of employers, as well as public transport systems and cycling infrastructure that connect multimodal hubs to workplaces, in stimulating intermodal commuting. This is true for Park & Bike and Park & Ride combinations specifically. Herein, it is important to ensure a public transport system that operates on a highly frequent basis. This can add to the levels of *autonomy* and *flexibility* that commuters experience while using intermodal travel options, as high frequency of departures gives people more freedom to choose when to travel to and from their workplace. Extra amenities such as kiosks, wireless internet and toilets at multimodal hubs do not seem to be effective in stimulating intermodal travel, as most respondents in the sample indicated that adding these amenities will not stimulate them to commute intermodally more often. Results indicate that investing in affordability and frequency of departures has better chances to further stimulate intermodal commuting. The presented results in the study are heavily influenced by the SARS-CoV-2 pandemic and therefore not representative of the population of intermodal commuters in Groningen. The collapse of travel demand and the social distancing measures are the main causes of this.

Chapter 1: Introduction

1.1 Background

Mobility and attitudes towards mobility are evolving as a result of ongoing societal change. Since the automobile became affordable to the general public by mass production of the Model T Ford in the U.S., it's popularity grew exponentially. Boosted by a fast realization of motorway networks all over the (western) world, the car became a symbol of status, progress and freedom and we became more and more dependent on its usage.

Nowadays the dominance of the private, fossil fuel-powered, automobile in combination with ongoing urbanization is causing environmental and spatial problems, which are becoming ever more apparent in daily life. Most so in our cities, where traffic congestion has increased throughout the years at the expense of accessibility (KIM, 2018). Where a large amount of scarce and valuable public space is occupied by cars that are not used most of the time (Van Liere et al., 2017). Furthermore, the role of private, fossil fuel-powered, automobility in the current climate crisis is undisputed. In the Netherlands around 20% of total CO_2 emissions is caused by transport (Hoen & Meerwaldt, 2017). It has become apparent that our current form of car usage is extremely inefficient in its usage of both energy and space.

Meanwhile, our cities, being the powerhouses of the contemporary economy, are attracting ever more economic activity and people, thereby generating more mobility towards the city, potentially exacerbating the aforementioned problems associated with car usage.

The city of Groningen, the biggest city in the Northern Netherlands, is expected to grow from around 202.000 inhabitants in 2018 (BAG, 2018) to 250.000 inhabitants in the coming 15 years (RTV Noord, 2017). The challenge for Groningen, and similar cities, is to accommodate for this growth in a sustainable fashion. In facing this challenge, decreasing private automobile usage in favor of 'green modes' such as public transport, cycling and walking is increasingly being viewed as an important policy objective (Buehler, 2011; Municipality of Groningen, 2018). Moreover, because of the aforementioned environmental and spatial problems associated with car usage, such as increasing congestion, the green modes are also becoming more attractive for the individual.

The 'green' transport modes are much more efficient in their use of energy and space than de car (Van Liere et al., 2017; Sims et al., 2014). CO_2 emissions per kilometer of a green mode user are significantly lower than those of car users (Milieucentraal.nl, 2019) Furthermore, the green modes do not have as high ownership costs as the car which makes the green modes socially more fair to invest in (Gebhardt et al., 2016). Yet, 'green modes' (walking, cycling and public transport) do have some disadvantages when compared to the private car. Although e-bikes and speed pedelecs provide increasingly tough competition, the car is still the transport mode with the highest flexibility; it takes people from door to door, where they want and whenever they want, with relatively short travel times. Cycling is even more flexible than the car, yet it's time efficiency decreases over larger distances. Traveling speed in public transport is comparable to the car, yet it cannot take a person from door to door and is limited in its flexibility.

As a consequence, in green mode usage, one often has to use multiple transport modes to get from A to B. This is known as 'intermodal travel' or 'intermodality' (Gebhardt et al., 2016). Indeed, Hamersma and de Haas (2020) report that in the Netherlands, in 88% of the intermodal trips, one of the ‘green’ modes (public transport, cycling and walking) is used as the primary travel mode. Intermodal travel is becoming increasingly attractive, as the negative externalities of private car use are ever more apparent. This is facilitated by advances in the integration of transport services in the form of ticketing, information and physical infrastructures such as interchanges and hubs (Ibid.). Moreover, the attitudes of people towards mobility seem to be changing as sharing mobility concepts are gaining popularity at the expense of the popularity of car-ownership (Ibid.). Well-functioning intermodal travel is assumed to be a key factor for a sustainable and scalable urban transportation system (Ibid.).

As such, it does not come at a surprise that multiple local, regional and national governments across the world are aiming to improve intermodal urban transport. In the city of Groningen, the municipal government is doing this by stimulating park and ride usage around the cities edges, accompanied by providing a high-quality bus rapid transit (BRT) service (Municipality of Groningen, 2018). The regional public transport agency is also stimulating multi- and intermodal travel with its ‘mobility hubs’ program. According to their definition hubs are nodes in the transportation network in which various transportation modes come together (Reisviahub.nl, 2019). Hubs function as interchange locations. Interchanges are integral to intermodal travel and can be regarded as a weak link in intermodal travel as waiting time is experienced negatively by travelers (KIM, 2019). With the hubs program, the regional public transport agency aims to make the waiting time pleasant and productive by adding all sorts of amenities such as wireless internet and water tap points. By gravitating amenities and activities towards the hub locations they are trying to make intermodal travel by using public transport more attractive. The Dutch national government also sees an important role for multimodal hubs in a robust, safe and sustainable future mobility system (Ministry of Infrastructure, 2019). In their report, a visionary outlook is presented on what a safe, robust and sustainable mobility system in 2040 is likely to look like following contemporary trends and ambitions. Specifically in mobility ‘between regions and cities’ the importance of intermodal travel via multimodal hubs is highlighted.

To date, the travel behavior of people who travel intermodally via mobility hubs and park and rides is not yet well studied (Gebhardt et al. 2016). According to Gebhardt et al. (2016, p. 1184) ‘’*…Neither the characteristics of the intermodal supply nor the availability of information, which shape daily decisions concerning transport mode and route choice among intermodal passengers, are yet completely understood. This is also true for the socio-demographic attributes that foster or hinder intermodal behavior.*’’

This study aims to contribute to closing this research gap by gaining insight in the factors that drive commuters to travel intermodally via mobility hubs and by investigating the role that these hubs play in stimulating intermodal travel. Here, the choice is made to focus the research specifically on commuters because in this, predominantly car-oriented group, huge strides are still to be made regarding the transition towards a more sustainable form of mobility.

1.2 Research questions & -design

In order to achieve these goals, primary- and secondary research questions are formulated. The main research question that guides this thesis is the following: To what extent do the various determinants of travel mode choice play a role in stimulating intermodal commuting?

The following secondary research questions are formulated as to contributing incrementally to answering the main research question: 1. What are the characteristics of the intermodal commuters, and the characteristics of their intermodal commuting behavior, in and around Groningen? 2. To what extent do personal socioeconomic characteristics affect intermodal commuting towards Groningen? 3. To what extent do the instrumental, affective and symbolic determinants of travel mode choice affect intermodal commuting towards Groningen? 4. To what extent can amenities at multimodal hubs stimulate intermodal commuting towards Groningen? 5. To what extent does the mobility policy at the workplace affect intermodal commuting towards Groningen?

The secondary research questions are answered through quantitative empirical research in and around the city of Groningen. Questionnaires are used for the inquiry of intermodal commuters. Data is collected by the promotion of an online questionnaire at various park and ride locations and on social media. Because of the SARS-CoV-2 pandemic, the choice was made to mostly collect data at park and ride locations and not at train stations. This will be further explained in chapter 3: methodology.

The collected data is processed and analyzed using IBM SPSS statistics. Descriptive analysis as well as ordinal regression analysis is then used to analyze the extent to which various factors play a role in stimulating commuters to travel intermodally via hubs (Leard Statistics, 2019)

1.3 Societal and academic relevance

As mentioned before, one of the goals of this research project is to gain insight into the factors that drive commuters to travel intermodally via mobility hubs. The results presented in this study can help planners and policymakers to design policy and infrastructure that aligns with the specific characteristics and preferences of intermodal commuters in order to further stimulate intermodal travel among this group. As argued in section 1.1, stimulating intermodal travel is associated with increased usage of 'green' transport modes such as public transport, cycling and walking. Stimulating intermodal commuting can thus make our transport systems more sustainable and efficient. As a secondary consequence, the business case of the Dutch public transport system could become more robust through a more diversified user base. Currently, public transport ridership in the Netherlands is dominated by students who can use it for free through subsidies (CBS, 2019).

This research, further, aims to contribute to the theoretical debate in the transport planning and travel behavior literature by focusing on the determinants of intermodal travel behavior of one specific group. More insight into the motivations and user characteristics of intermodal commuters contributes to understanding the complex relations between the built environment, life situations, lifestyles and intermodal travel behavior (Scheiner and Holz-Rau, 2010).

As elaborated upon in the last part of section 1.1 this research focuses on commuters. People who work from 12 to more than 30 hours per week use the car relatively a lot more compared to the Dutch average (CBS, 2019). This is true when measured in the number of trips, distance and travel time. Even when controlled for the total amount of trips made, distance traveled and travel time spend, the working people still travel much more than average by car. By far the most vehicle kilometers are made during rush hour when people commute to work, which causes traffic jams every day. Thus, stimulating this group to rethink their traditional commute from home to work can alleviate a large chunk of the spatial- and environmental problems sketched out in section 1.1.

1.4 Reading guide

In the second chapter, the theoretical framework that serves as the backbone of the presented study is laid out. It contains a review of the academic literature on the topic of intermodal travel behavior and its determinants. The third chapter presents and explains the chosen methods for data collection and -analysis. This chapter also accounts for where and when the data was collected and a reflection on the quality of the data is presented. In the fourth chapter, the findings of the study are presented. Subsequently, in chapter 5, the implications of the raw data are discussed and the formulated research questions are answered. The limitations of the study are also reflected upon in this chapter. The chapter, and thus the thesis, ends by formulating recommendations for further study on the topic of intermodal travel behavior via multimodal hubs.

Chapter 2: Theoretical Framework

In this chapter, international academic literature on the topic of intermodal travel is reviewed and useful concepts are extracted. A lot of research has been done on the factors that motivate people to choose for a certain mode of transport. The choice for a combination of modes in an intermodal commute is driven by similar mechanisms. The theories used in this thesis thus strongly resonate with the literature on the determinants of travel mode choice. Clauss and Döppe (2016) classify various determinants of travel mode choice as either *instrumental, affective* or *symbolic*. In this theoretical framework, the same categories are adhered to. These are supplemented by other categories of determinants of travel behavior such as factors related to socio-economic characteristics, the built environment and travel policies at the workplace.

This chapter starts with a dive into the concept of *intermodality* in section 2.1. In section 2.2 the *instrumental* determinants of travel mode choice are elaborated upon. Next, in section 2.3, earlier scholarly work on the *affective* determinants of travel mode choice is reviewed. Subsequently, in section 2.4 literature on the *symbolic* determinants of travel mode choice is discussed. Then, in section 2.5, the effect of socioeconomic characteristics on travel mode choice is elaborated upon. Section 2.6 shows a discussion of the effect of the built environment on travel mode choice. Thereafter, the effects of mobility related policies at the workplace on travel mode choice are debated in section 2.7. At the end of this chapter, in section 2.8, the discussed concepts and determinants of travel mode choice are summarized into a conceptual model that also visualizes the relations between them.

2.1 Intermodality and Multimodality

Since this is a study about intermodal travel or ‘intermodality’, it will be helpful to define this concept and outline the field of study in which it is nested. Intermodal travel can be defined as traveling from A to B in one seamless journey by using more than one transport mode (Buehler and Hamre, 2013; Gebhardt et al., 2016). For instance, whilst traveling from home to work, switching from a private car to the bus at a Park and Ride (P+R) and traveling the last 500 meters from the bus stop to the workplace on foot, is considered an intermodal trip. The same goes for a lot of trips in which public transport is the main mode of travel since access- and egress trips, by bike or on foot, are often needed to get from door to door (Ettema et al., 2018; KIM, 2019). In the mentioned examples it is pretty clear that such a trip can be characterized as ‘intermodal’. However, this is not always the case. Gebhardt et al. (2016), point out that in research the transport modes ‘walking’ and ‘public transport’ are sometimes interpreted differently by scholars. To illustrate this argument, one can think about the following example: imagine a man who lives in a busy street and sometimes has to park his car one block away from his front door. Then, in the morning, when starting his journey to the office, he first has to walk 100 meters before he reaches the car. He then travels to work and parks his car in the office parking lot. Can this then be considered an intermodal trip? The man indeed did use multiple modes of transport to travel from A to B; on foot and by car. Yet, most scholars will not consider this an intermodal trip since in this example walking is only used as a natural bridge to the first mode, between modes or from the last mode. To distinguish if walking is really used as a transport mode in a trip, thresholds can be used. Diaz Olvera et al. (2014), for example, state that the part of the journey that consists of walking has to take at least five minutes before being considered as an actual mode of transport in an intermodal trip. As for public transport, commuters could switch from a train to a bus whilst traveling from A to B. This would be considered an intermodal trip as the bus is a different mode of transport than the train. If a commuter would interchange from a bus onto another bus during one seamless journey, this will not be considered intermodal by most scholars as the traveler, although he interchanges, does not switch modes (Gebhardt et al., 2016).

To get a better grasp of the concept of 'intermodality' and to be able to see the place of this concept in the wider field of study, the concepts that are related to it are explained and discussed here. Intermodality is a fairly new field of study and part of a larger body of research on *intrapersonal variability of travel behavior* (Buehler and Hamre, 2013). Drawing on the work of Buehler and Hamre (2013), intrapersonal variability of travel behavior consists of four dimensions in which the work of scholars in this field can be placed: temporal, spatial, purpose and modal. The temporal dimension is related to variability in timing and frequency of travel. The spatial dimension connects to variability in geographic location and route choice. The purpose dimension consists of the variability in the activities facilitated by travel. Lastly, the modal dimension focuses on variability in the modes of transport that are being used over time. 'Intermodality' is similar to 'multimodality' and often used to describe the same or strongly related phenomena. The definitions of multimodality differ across studies but they generally boil down to the following: multimodality is the use of at least two modes of transport during a specified period of time. This time period can be anything such as a day or a week. However, when multiple modes of transport are used in one trip it is conceptualized as intermodal.

Monomodality, a concept also related to the modal dimension of interpersonal variability in travel behavior, is the opposite of multimodality and can be defined as using only one mode of transport during a certain period of time or journey. Figure 1 visualizes the position of the concept of intermodality within the greater body of research it is situated.

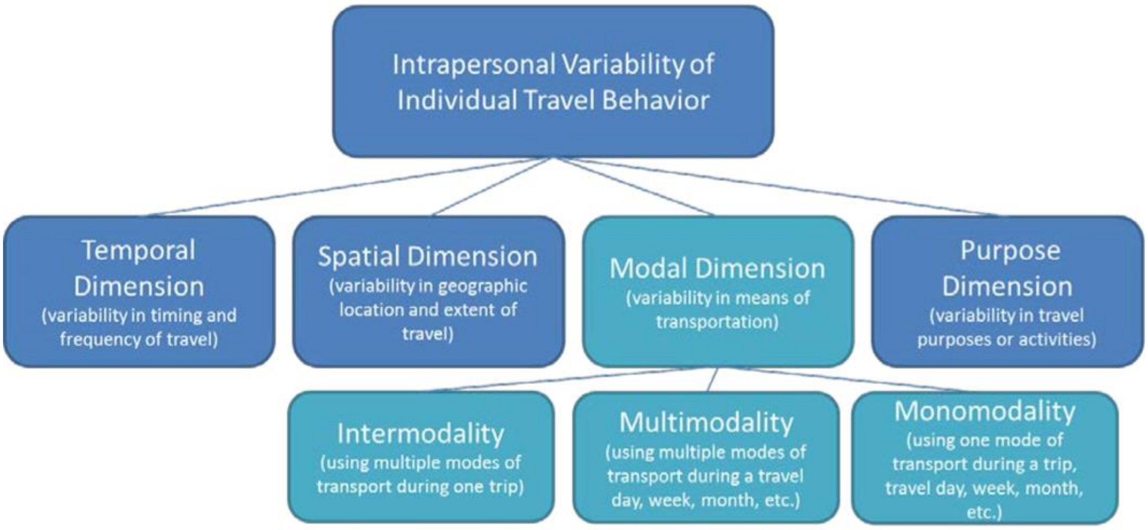

Figure 1: Positioning of intermodal travel within its greater body of research (Buehler and Hamre, 2013, P. 11)

In the introduction, the point has been made that intermodal travel behavior is associated with increased usage of 'green' and active transport modes such as public transport, cycling and walking. Stimulating intermodal travel towards cities can alleviate congestion, improve accessibility, decrease

CO_2 emissions and free up public space. It has to be noted, however, that some forms of intermodal travel are more promising in this respect than others. Hamersma and de Haas (2020) report that intermodal trips in which public transport is the primary mode of transportation are more promising in terms of sustainability and urban accessibility than intermodal trips in which the car is the primary mode of transportation. Hamersma and de Haas (2020) go on to argue that monomodal trips are sometimes more promising in terms of sustainability- and accessibility terms when for example solely an active mode or public transport is used to get from A to B. Thus, stimulating intermodal trips does not have to be an objective in itself. Yet, especially over longer distances, intermodal trips are often more sustainable, and better for urban accessibility, than their monomodal counterparts as public transport does not provide the same level of service everywhere and because active modes are not viable over longer travel distances. Thus, the efforts that are being made by regional governments and transit authorities to facilitate intermodal travel are not surprising.

Intermodal travel options vary significantly in possible combinations of modes and in terms of their potential for increased sustainability and urban accessibility. But what determines the attractiveness of intermodal travel options for commuters? And what are the drivers behind the choice for intermodal travel? In the following section, the existing literature will be further elaborated upon to provide possible answers to these questions.

2.2 Intermodality and instrumental determinants of travel mode choice

In this section the effect of instrumental determinants on travel mode choice is discussed. Using public transport as an example, the section starts off with elaborating on the classic instrumental determinant *time efficiency*. *Travel cost, sustainability* and *flexibility* are also discussed here.

As stated in section 2.1, intermodal trips often require the use of public transportation. In their qualitative study in which 60 inhabitants of Hamburg are interviewed, Clauss and Döppe (2016) find public transport is considered to be quite unreliable and to be providing a low sense of privacy and autonomy. Moreover, public transport offers a very restricted route choice. Although the sample size is small and limited to the context of Hamburg, it is not at all unimaginable that these perceptions are shared with other people in different European cities. Public Transport in contemporary cities can often be crowded and prone to delays. Many public transport agencies around the world report high on-time performance, often upward of 95% of arrivals and departures being on time (Rosenthal et al., 2017). However, these numbers can set a distorted image. Walker (2010) points out that on-time performance is calculated by the percentage of trains that are on time. During rush hour, when public transport runs at peak capacity, the trains/buses are the most likely to be late because they run when the system has the least margin for error (Walker, 2010). So, although public transport agencies are reporting high on-time performance, public transport can still be experienced as unreliable.

Interchanging can add to this unreliability; if the train is late, one might miss the bus and have to wait for the next one. Multiple studies have focused on the reliability of- and traveler satisfaction with intermodal trips in relation to the features of access travel modes (e.g. Rietveld et al., 2001). These studies highlight that intermodality often entails greater travel time, uncertainty related to potential delays and also reduced comfort. Brons and Rietveld (2010) report that this travel time unreliability in turn negatively impacts the use of intermodal options. According to the Dutch 'KIM' (2019) travelers have a great aversion for interchanging. A quite old, yet still quite relevant assessment of the importance of various quality aspects of public transport points out that for home-to-work commuting 'frequency' is the most important, followed by 'without interchange' and 'access- and egress transport' (Bakker, 1997). All of these factors are related to travel time and time efficiency. Time efficiency is considered important by all travelers on all distances (KIM, 2019). Most people will try to reduce their travel time as much as possible.

However, this cannot be seen as absolute truth. Redmond and Mokhtarian (2001) found in their study on ideal commuting time that commuters rather have 16 minutes of commuting time than having no commuting time at all. This suggests that travel in itself has value. This can be, for example, when travel time can be spent productively or if the journey has nice scenery (Ettema et al., 2016). The findings of Redmond and Mokhtarian (2001) might also suggest that people prefer to keep their private- and working life physically separated. According to a study by Susilo et al. (2012), a significant share of rail commuters evaluates their travel time as well spent as they can work or do other productive things on board of the train. In the Netherlands, this is facilitated in trains and busses by the integration of power outlets and wireless internet in the vehicles. The ability to do all sorts of things during traveling is a significant advantage when traveling by public transport compared to the private car. This will, however, change when autonomous driving becomes mainstream through advances in ICT and artificial intelligence.

Time efficiency is a classic *instrumental* determinant of travel mode choice according to Clauss and Döppe (2016). Instrumental determinants of travel mode choice refer to general practical aspects of mode choice and are nested in economic theory (Clauss and Döppe, 2016). These determinants are important trough the desire of maximizing ones expected utility of the transport mode in relation to individual preferences. As stated above, in travel mode choice or in determining satisfaction with intermodal travel options the importance of *time efficiency* is evident. But how traveling time is experienced differs from real traveling time. Van Nes et al. (2014) show in their study on intermodal trips that one minute in egress/access trips or one minute spent waiting on the train is experienced as longer than one minute while riding the train. Waiting time during interchanges and access and egress trips thus contribute strongly to the travelers' experienced traveling time.

Next to *time efficiency*, the *cost* of using a travel mode is regarded as a core *instrumental* determinant of travel mode choice (Gardner and Abraham, 2007). People tend to reduce their travel expenses no matter what their level of income is. However, Gardner and Abraham (2007) find also that car-owners often only count the running costs of the car when calculating their travel expenses. Taxes and vehicle depreciation are thus often not accounted for. Similar to the findings of Van Nes et al. (2014) on travel time, Arentze and Molin (2013) point out that sensitivity to various costs of travel is not uniform among people. Ticket costs for public transport or costs for park and ride are perceived more negatively than the costs for fuel. This might explain some of the change resistance car-users demonstrate when asked to switch to public transport. Next to *monetary cost*, Clauss and Döppe (2016) state that people also view the environmental impact of their travel behavior as costs. *Sustainability* can thus also be categorized as one of the *instrumental* determinants of travel mode choice.

Another important *instrumental* determinant of mode choice is *flexibility*. As stated in the introduction, in our infrastructural landscape the car is the most flexible of all travel modes. The private automobile can take people wherever they want, whenever they want, all the way from door to door, independent of weather conditions. Jensen (1999) points out the importance of flexibility of a transport mode for independence in terms of time and place of departure. According to Clauss and Döppe (2016), varying degrees of flexibility is the reason to choose the private car over public transport. Factors that attribute to flexibility include *availability* (e.g. Commins and Nolan, 2011; Ewing and Cervero, 2010), *freedom of route choice, independency from weather conditions* and e*ase to use* (Clauss and Döppe, 2016). All these factors can also co-determine the choice for various intermodal travel options.

2.3 Intermodality and affective determinants of travel mode choice

In this section the *affective* determinants of travel mode choice are discussed. These include *autonomy, fun to drive, stresslessness, privacy, relaxation* and *comfort*. Affective determinants of travel mode choice are those that are related to individual preferences (Clauss and Döppe, 2016) and enabled by freedom of action to choose on the basis of these preferences (Scheiner and Holz-Rau, 2010). Before the early 2000s, research on the mechanisms behind travel mode choice and travel behavior, in general, was mostly focused on objective variables such as factual socio-economic characteristics, demographics and spatial structure (Scheiner and Holz-Rau, 2010). The more precise the effects of the various objective determinants on travel behavior were calculated, the more it became clear that they only partly determine transport mode choice (Scheiner and Holz-Rau, 2010). Through interdisciplinary research on the topic more subjective determinants, related to individual preferences, were introduced (ibid). This was primarily done by integrating 'attitudes' or so-called 'mobility styles' into explanation models of travel behavior (e.g. Bagley and Mokhtarian, 2002; Golob, 2003). This approach argues that travel demand also needs to be explained through cultural terms, rather than terms of demography, spatial structure etcetera (Scheiner and Holz-Rau, 2010).

According to Clauss and Döppe (2016), *affective* determinants comprise of the following factors: *autonomy, fun to drive, stresslessness, privacy, relaxation* and *comfort*. In a way, these *affective* determinants can also be defined as feelings evoked by traveling with a certain mode (Anable and Gatersleben, 2005). Some of these factors speak for itself. Perceived *privacy* is an important factor in determining mode choice as an individual (Clauss and Döppe, 2016). The amount of perceived *privacy* is influenced by the available personal space of a particular mode, as well as the possibility of protecting oneself from contact with other people. Following this line of reasoning, *privacy* can also be associated with safety. In various studies, researchers have found that the inside of a private car is experienced as a safe and private space that provides control over the environment and prevents intrusion by others (e.g. Guiver, 2007). In the same study, Guiver (2007) found that buses can be seen as vulnerable spaces for users. Privacy can help to reduce stress and increase relaxation (Clauss and Döppe, 2016). This shows that the described affective determinants can be interrelated.

Clauss and Döppe (2016), interestingly, find that almost all positive affective determinants are associated with car use. This goes for example for freedom and *autonomy* which can respectively be defined as the possibility to *'live by one's own laws'* (Clauss and Döppe, 2016, P. 96) or the feeling of control*.* These feelings are logically less often attached to public transport, where the freedom to move around is constrained by fixed routes, stops and schedules. The way the car has been presented in media also reproduces and strengthens these perceptions; in Hollywood action movies the 'cool' and charismatic protagonist almost always drives a car. It is almost silly to imagine agent 007 as a fervent bus user. In marketing, car manufacturers sell the car as a representation of freedom, modernity, high social status, individuality or autonomy. The dominance of the car is moreover sustained by path-dependency and lock-in mechanisms such as past investments in car infrastructure, consumer lifestyles and resistance from vested interests (Geels, 2012).

Grotenhuis et al. (2006) indeed agree that the private car is tough competition for public transport and thus, for intermodal travel. Efforts of governments to stimulate public transport in favor of the car have rarely succeeded in achieving the desired modal shift. From the viewpoint of the customer, the inferior quality and level of service provided by public transport are keeping them from seeing public transport as an adequate alternative. Grotenhuis et al. (2006) argue that *information provision* plays an important role in overall satisfaction with public transport. The potential of *information provision* to stimulate intermodal trips remains contested in research. Yet scholars agree that *information provision* would have the most potential to affect travelers' behavior if multimodal data were integrated. *Information provision* in intermodal trips plays a role in various stages of the trip: During travel planning in the 'pre-trip' stage, on wayside locations such as bus stops, multimodal hubs and train stations, and information provided on the inside of the vehicle (Grotenhuis et al., 2006). Adequate and reliable multimodal *information provision* can facilitate intermodal trips by giving the traveler back their sense of control and autonomy. Information provision can also help people save travel time by providing them with the ability to consciously choose their multimodal options during interchanging on intermodal trips, or by facilitating a well-planned trip beforehand.

Anable and Gatersleben (2005) study the relative importance that people attach to *instrumental* and *affective* determinants of travel mode choice. They compare their results for travel motives; leisure and commuting. Interestingly they find that on commuting journeys, respondents attach more importance to instrumental aspects than to affective aspects. Whereas on leisure journeys, respondents perceive instrumental and affective factors as equally important.

The advantage of intermodal travel is that, through combining multiple travel modes, people can create *mobility styles* that possibly fit their personal preferences in a better way than any other single mode could in a monomodal trip. To illustrate this, imagine a person who really likes driving a car and sees car ownership as an important part of their identity. Driving a car gives this person the feeling of control, flexibility and freedom. This person could, at the same time, find traffic jams very stressful and unhealthy. To avoid the negative experience of the traffic jam while still being able to enjoy driving the car, this person could choose to park the car at a park and ride at the cities edge and continue his or her journey via a highly frequent bus service. In such a situation, one can create a more ideal commute for themselves while also contributing to the solution of societal problems such as air pollution, congestion and parking pressure in urban areas.

2.4 Intermodality and symbolic determinants of travel mode choice

In this section, the three symbolic determinants of travel mode choice are elaborated upon. While instrumental determinants of travel mode choice relate more to rationality and objectivity, affective and symbolic determinants are more related to the identity of the self, to social position and thus to subjectivity (Lanzini and Khan, 2017). Clauss and Döppe (2016) state that *status, prestige* and *personal identification* make up the symbolic determinants of travel mode choice. According to them, symbolic meaning can be distinguished into *social expression* and a *social identity process*. In other words, social expression describes a process that involves how individuals present themselves (Clauss and Döppe, 2016). For example, riding your bike to work every day can help portray and define yourself as a sporty individual. According to Clauss and Döppe (2016), the social identity process relates to the desire to express characteristics of the group one sympathizes with, as to underline one's own identity. For example, driving around in a luxurious car can act as a symbol of 'having achieved a lot in life'. Similarly, one could choose to ride a motorcycle to underline their identity of being a 'tough guy'. Immediately it becomes clear that this is all very subjective; it depends on what groups of people perceive as 'achievement' or 'being tough'.

Clauss and Döppe (2016) argue that symbolic determinants of travel mode choice are usually associated with ownership. They refer to the work of multiple scholars in describing the symbolic attributes that are related to car ownership. The usage of a privately owned car can be associated with the feeling of power (Steg, 2005). Steg (2003) finds that fervent car users perceive their cars as symbols of freedom, independence and social status. Moreover, Hiscock et al. (2002) find that cars can serve as symbols of high income and masculinity. Yet, symbolic determinants of travel mode choice can also be associated with non-ownership; the exact opposite. Car- and bicycle sharing is becoming increasingly popular (Gebhardt et al. (2016). Not owning a car has become a symbol of environmentalism. By not owning a car individuals in certain social groups can underline their identity as an environmentally conscious person. Social identification can thus also relate to doing something 'good', behaving responsibly or adapting innovations (Clauss and Döppe, 2016). Being a novelty among some groups, Intermodal commuting options, such as park and ride or park and bike, can provide people with new ways to express their identity through travel behavior.

2.5 Intermodality, the lifestyle & life situation dichotomy and its effect on travel mode choice

In section 2.5.1, the conceptual dichotomy of *lifestyles* and *life situations* and their relation to travel behavior is discussed. In the light of this discussion, the concept of residential self-selection and its effect on travel mode choice is then also explained. The *life situation* represents socioeconomic characteristics of individuals that affect travel behavior. The effect of each of these characteristics on the prevalence of inter- and multimodal travel patterns is elaborated upon in section 2.5.2.

2.5.1 Mobility styles and life situations

The instrumental, affective and symbolic determinants of travel mode choice and the importance assigned to those by the individual represent that what Scheiner and Holz-Rau (2010) refer to as *lifestyle* or *mobility style*, socio-economic characteristics represent to what these same authors refer to as *life situation*. The determinants related to *mobility style* are associated with the attitudes towards traveling and the activity of traveling itself, while the determinants related to *life situation* refer to external, objective, conditions not specifically related to travel such as income, education, the home address and gender. The factors are related to the *life situation* and act as enabling or constraining factors on an individual's preferred *lifestyle/mobility style* (Scheiner and Holz-Rau, 2010). The much-debated hypothesis of *residential self-selection* relates strongly to explanations of travel behavior.

Residential self-selection in relation to travel behavior is the process in which individuals choose their residential location to specifically fit their preferred mobility style. Location is, naturally, a very important determinant of travel behavior. For instance, residential location in relation to the location of bus stops, train stations, or multimodal hubs determines strongly the probability that an individual will use public transport. Residential location choice is largely determined by personal preferences and constrained by the 'life situation'. The degree to which residential self-selection affects travel behavior is in turn strongly affected by the local housing market (Scheiner and Holz-Rau, 2010).

When the housing market is controlled by the supply side, as is often the case in regions that experience population growth, individual preferences on the demand side are harder to realize (ibid). This happens when demand for houses is high but the supply is limited. Conversely, in areas with lower population growth rates, the effect of residential self-selection on mobility is probably higher as individuals are more likely to realize their personal preferences related to mobility and other things. This is because in areas with lower population growth rates the demand for houses does not tend to outweigh the supply of houses as much. In these regions people are more likely to find a house that matches their specific (transport related) preferences with a price that fits within their budgetary limitations. Figure 2 visualizes the relations between the concepts as described above.

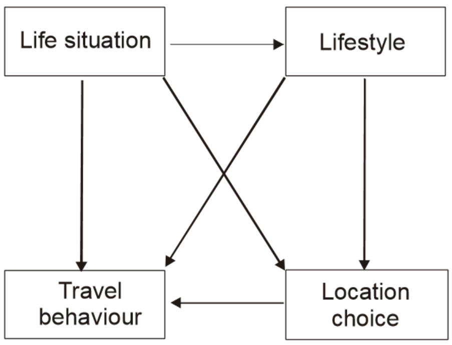

Figure 2: A conceptual model of terms used to categorize factors affecting travel behavior and mode choice (Scheiner and Holz-Rau, 2010, p. 6)

2.5.2 Socioeconomic characteristics and intermodality

That what Scheiner and Holz-Rau (2010) call the *life situation* is often referred to as socioeconomic characteristics of the individual by other authors. Buehler and Hamre (2011) aim to find out what the socioeconomic and demographic determinants of multimodal travel in the USA are. In doing so, they also provide a comprehensive review of earlier findings on this topic.

Kuhnimhof et al. (2006) study weekly travel data in Germany using the German Mobility Panel. They find that multimodal people are more likely to be young or old, live in urban areas, have a small household size and do not own a driver's license. This seems logical as people living in urban areas have better access to public transport. Kuhnimhof et al. (2006) also find that people with higher educational attainment are more likely to be multimodal. Diana & Mokhtarian (2009) and Kuhnimhof et al. (2012) also report these findings.

Block-Schachter (2009) studies the travel behavior of MIT students in Cambridge, Massachusetts. Interestingly, the author finds that the likelihood of an individual being multimodal increases when their neighbors also exhibit multimodal travel patterns. This is most likely caused by social learning processes.

Vij et al. (2011) evaluate multimodality by studying the six-week 'MobiDrive' dataset. Through multivariate estimation, they find that women and single people are more likely to be multimodal. Their results further suggest that having children increases the likelihood that people use the car for a higher percentage of their trips. People who do not have children are more likely to use green modes in their multimodal tours.

Lastly, multiple authors report that awareness of environmental impacts of different modalities increases the likelihood that someone exhibits multimodal travel patterns (Chlond, 2012; Kuhnimhof et al. (2012). This makes sense as this awareness helps people to choose for the 'green modes' such as cycling, walking and public transport. As established earlier, the use of 'green modes' goes hand in hand with intermodal travel.

In their own research, Buehler and Hamre (2013) find that in the United States people with higher income are more likely to be multimodal car users and multimodal 'greens' than people with middle income. 'Multimodal greens' in this context refers to people that rely mostly on combinations of public transport, cycling and walking for their travel needs. Buehler and Hamre (2013) explain that this pattern may be related to the enlarged travel options in more expensive urban neighborhoods that offer shorter trip distances, more frequent public transport services and infrastructure that is better suited for walking and cycling purposes. Following this line of reasoning, in the Netherlands, the difference between middle and higher incomes is expected to have less of an effect on multimodality as there is generally less spatial inequality in the Netherlands as compared to the United States. The findings of Buehler and Hamre (2013) further mostly support the earlier findings of the authors discussed above.

2.6 Intermodality and the built environment

In this section, the effect of the built environment on intermodal travel behavior is discussed. As interchanging is integral to intermodal travel, the effect of the location of- and the amenities at interchange locations are elaborated upon specifically

2.6.1 The built environment and travel behavior

The interdependencies between population structure, the built environment and travel developed since the 1970s as a field of study in de spatial- and transport sciences (Scheiner and Holz-Rau, 2010). For example, Fried et al. (1977) already developed a theory to explain travel behavior in which they synthesized personal- and spatial determinants. This insight, that urban form might significantly influence travel behavior, found its way into the traditionally ''spaceless'' science of transport planning (Scheiner and Holz-Rau, 2010). After the second world war, in the 1950s and 1960s, spatial- and transport planning was a science and a practice in a paradigm of technical rationality, using 'predict and provide' methods which were typical at the time (Allmendinger, 2017). In the 1970s spatial- and transport planning were integrated with one of the aims being to create a more sustainable transport demand by implementing land-use and urban form concepts into transport planning (Scheiner and Holz-Rau, 2010).

The merge of urban form concepts with transport planning led to new insights on the relationship between the built environment and travel behavior. For example, Ewing and Cervero (2001;2010) distilled in their two famous literature reviews the ''7 D's'' as measures of the built environment that influence travel: density, diversity, design, destination accessibility, distance to transit, demand management and demographics. In their meta-analyses in which the findings of 62 relevant studies were incorporated, Ewing and Cervero (2010) accurately calculated the elasticities of travel variables with respect to changes in these measures of the built environment. However, for all the variable pairs discussed by Ewing and Cervero (2010) the relationships between travel variables and measures of the built environment are inelastic and thus, only partly influence travel behavior. Nevertheless, the effect of a combination of changes in these measures of the built environment could influence travel behavior significantly. In this thesis about intermodal travel behavior, the use of this study remains limited. Ewing and Cervero (2010) calculated the effect of each 'D' variable on the use of each mode separately. The effect of each variable on the use of intermodal travel options was not taken into account. However, the weighted average elasticities of transit use with respect to the built environment variables are relevant within the scope of this thesis, as trips from A to B by public transport are often intermodal trips. This is because of the needed 'access' and 'egress' trips (e.g. Ettema et al., 2018; KIM, 2019). According to Ewing and Cervero (2010), diversity of land use, number of intersections/street density and distance to nearest transit stop are all positively associated with public transport use and thus with intermodal travel. Yet, it has to be noted again that intermodal trips can vary greatly in terms of the combination of modes, routing and purpose (e.g. Gebhardt et al., 2016). This means that built environment variables that are stimulating bicycle usage could also be positive for intermodal traveling. Even 'D' variables supportive of using the private car could stimulate intermodal travel when used in combination with Park and Ride or Park and Bike facilities. When this line of argumentation is followed it becomes difficult to associate individual built environment variables with the use of intermodal options as a whole.

Intermodal commuting options can be diverse in the combinations of vehicles that are being used. What all intermodal trips have in common, though, is that they always require interchanging. The location, facilities and the level of service at interchange locations thus become a crucial part of the intermodal commute.

2.6.2 Multimodal 'mobility hubs'

Because interchanging is an integral part of intermodal travel, interchange locations become a crucial area's in the effort to stimulate intermodal travel. Interchange locations include train stations, bus stops, park and ride's, airports, and multimodal hubs with more alternative modes.

A lot of larger (>200.000 inhabitants) European cities now have Park and Ride (P&R) facilities. Mingardo (2013) writes about P&R's and analyses their effect on transport and the environment. In the Netherlands, the first P&R was introduced in the town of Schagen in 1979. In 2003 there were 386 P&R locations registered and operational. Despite their undeniable popularity, their supposed traffic- and congestion reducing effects remain debated in the literature. Today, there is considerable proof that P&R's bring about so-called 'unintended effects' which include increased car traffic through induced demand, abstraction form public transport, abstraction from the bike, 'park & walk', and trip generation (Mingardo, 2013).

P&R's are often mainly based on one form of public transport, being either train or bus. Their location differs and can accordingly be categorized into three different kinds of P&R that all serve a certain purpose (Mingardo, 2013):

1) Remote P&R. This type of P&R is located at the origin of the daily commute, relatively far from the central city. Its function is to collect drivers at the beginning of their commute and is thus often located in residential areas.
2) Peripheral P&R. This type of P&R has a destination function that is aimed at intercepting drivers just before their final destination at the edge of the central city.
3) Local P&R. This type has a field function that aims to intercept drivers somewhere along their way from the place of origin towards the destination.

In his analyses of rail-based P&R's in Rotterdam and The Hague, Mingardo (2003) finds that for peripheral P&R's unintended, traffic increasing, effects slightly outweigh the positive, traffic reducing, effects of the P&R. For remote P&R's, however, this is the other way around.

Despite critical views, P&R locations have been essential in enabling intermodal travel options. They might indeed not always instigate a reduction of car traffic but they can spatially redistribute traffic more efficiently by keeping cars away from inner cities and away from bottlenecks in the transportation network. In doing so P&R's can indeed reduce congestion.

In more recent years, other travel modes have been added to existing interchange locations such as P&R's and train stations. In the Netherlands, the national railway operator has installed bike-sharing systems on stations of larger towns and cities. Here, people can interchange from rail to bike easily with the same transit card. On P&R's more bike parking places and even bike faults have been installed. In the northern Netherlands, interchange locations are now served by 'hub-taxi's' that get people from their homes towards the transportation node. In other words, interchange locations have become more multimodal, increasing the opportunities for intermodal travel. In doing so, these interchange locations have become multimodal hubs within the transportation network.

Because interchanging is crucial in intermodal travel, adding various amenities and functions to multimodal hubs might hypothetically stimulate intermodal travel as these can make an interchange more smooth, productive or pleasant. For example, these amenities could include wireless internet, comfortable waiting areas, toilets, information provision, kiosks or artworks. The importance of information provision in public transport journeys has already been discussed in chapter 2.3. The effects of these kinds of 'hub-facilities', such as information provision, wireless internet and comfortable waiting areas, on the stimulation of intermodal travel have not yet been studied in earlier academic publications

2.7 Intermodality and mobility policies at the workplace

As this is a study on intermodal commuting, transport policies at the workplace cannot be left undiscussed. These policies can have a considerable effect on the mode choice for the everyday commute. Mobility related policies at employers vary on two levels: (parking) facilities at the workplace and mobility-related benefits for employees.

Hamre and Buehler (2014) study the effect of these policies on the travel behavior of employees in the Washington D.C. region. They find that free car parking at the workplace is related to more car-dependent commuting. Further, they find that commuters that are offered either public transport benefits, shower/locker facilities or bike parking facilities are more likely to either ride public transportation, walk or cycle to work. Thus, stimulating intermodal commuting. Lastly, the research by Hamre and Buehler (2014) shows that the inclusion of free parking in benefit packages offsets the effects of pro-public transport, -walking and-cycling provisions.

Recognizing the importance of mobility-related policies at the employer in determining commuting behavior, the Dutch national government provides funding for local governments that aim to stimulate sustainable mobility at the employer level. This is called the 'Werkgeversaanpak' (employers approach) which is part of the program called 'Beter Benutten' (better utilization of existing infrastructure) (Beter Benutten, 2020).

2.8 Conceptual model

This section can be seen as a summary of the theoretical framework outlined above. This chapter started with an explanation of the concept of intermodality; traveling from A to B using more than one vehicle (Buehler and Hamre, 2013). Subsequently, through reviewing existing literature, the concepts and theories that might be of influence on intermodal travel were explored and discussed. All the concepts that are of influence on intermodal commuting are here summarized into a conceptual model that also describes their interrelations (figure 3 on the next page). This model is being applied as a tool to do research throughout this thesis.

The conceptual model starts with the *instrumental-, affective* and *symbolic* determinants of travel mode choice that are comprehensively discussed in the past chapter. Clauss and Döppe (2016) provide a solid basis for this. The instrumental determinants include *time efficiency, sustainability, monetary cost and flexibility*. Factors that make up *flexibility* include *availability, freedom of route choice, independency from weather conditions* and *ease to use*. The affective determinants of travel mode choice consist of *autonomy, fun to drive, stresslessness, privacy, relaxation and comfort*. Lastly, the symbolic determinants are comprised of *status, prestige* and *personal identification* and include processes of social expression and social identification. The assigned importance to instrumental-, affective and symbolic determinants of travel mode choice make up the *mobility style* of an individual.

Then, on the left side of the model, the concept of *life situation* is situated. The *life situation* is represented by the *socioeconomic characteristics* of the individual that influence mode choice and thus intermodal commuting. Buehler and Hamre (2013) provide solid research on the influence of these characteristics on multimodal travel behavior. The relevant socio-economic characteristics consist of *age, household composition, level of educational attainment, place of residence, gender, income* and *awareness of environmental impacts*.

Scheiner and Holz-Rau (2010) provide a good explanation of how the *life situation* of an individual and their preferred *mobility style* interrelate. The socio-economic characteristics that represent the *life situation* act as constraining and enabling factors on the preferred *mobility style,* thereby influencing commuting mode choice. Simultaneously, the *life situation* also determines the preferred mobility style through factors such as *income* and *place of residence.*

Next, for measuring the effect of the built environment on travel mode choice, Ewing and Cervero (2010) accurately calculated elasticities of various built environment variables for various usage of various single modes. Since in intermodal travel multiple modes are used in the same trip, it becomes impossible to operationalize these variables. But since interchanging is integral to intermodal travel, the places where people interchange or *multimodal hubs* become crucial. The *location* (Mingardo, 2013) of these hubs as well as the *amenities* at these hubs might be of influence to intermodal commuting. These factors are taken into account in the conceptual model.

Lastly, the conceptual model includes factors related to travel policy at the workplace. These are *(parking) facilities at the workplace* and *mobility-related benefits*. Research from Buehler and Hamre (2013) proves that these factors can have a considerable effect on commuting mode choice.

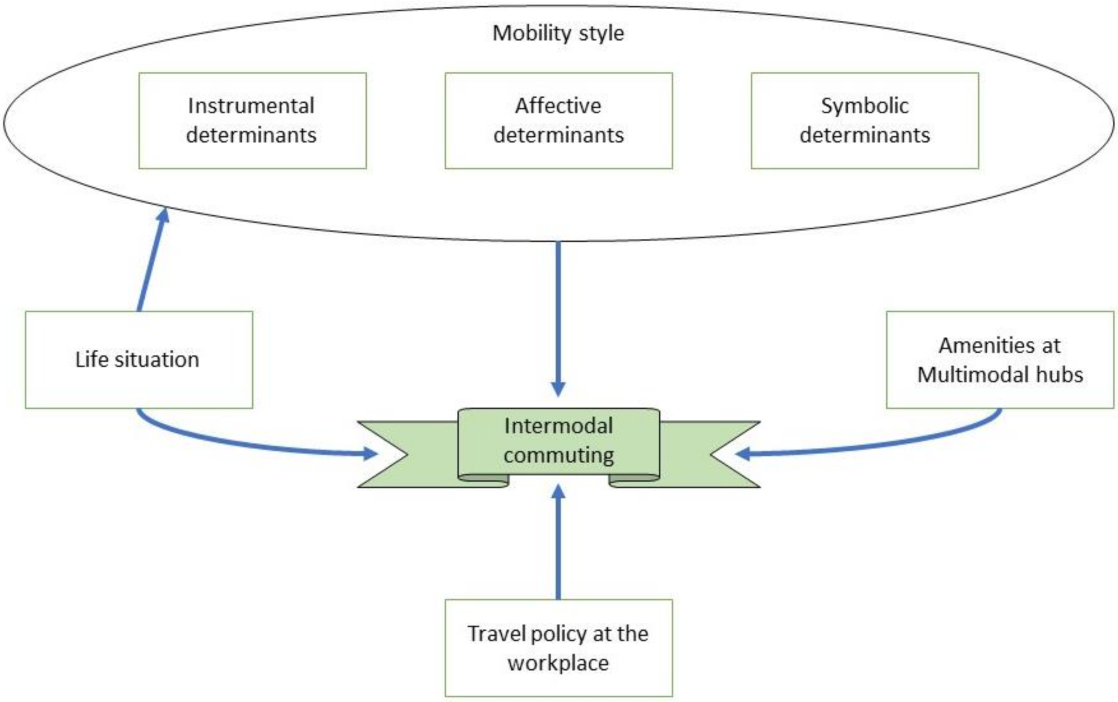

Figure 3: Conceptual model of the factors that influence the choice for commuting intermodally.

Compared to earlier work on the topic of determinants of mode choice and intermodal options, the theoretical approach in this thesis has a more broad scope. Most authors cited in this study only study the determinants of travel mode choice from one perspective. Ewing and Cervero (2010), for example, only look at the built environment, Clauss and Döppe (2016) on the other hand take a broad perspective on individual preferences but not include any built environment variables. This study focuses specifically on intermodal commuting, but the theoretical approach is comprehensive, incorporating more kinds of variables that might influence the choice for commuting intermodally. This is where the added value of this study lies in contributing to the existing scientific debate about multimodal travel behavior.

Chapter 3: Methodology

In this chapter, the methodology used to approach the stated research questions is elaborated upon. The chapter starts with a description of the area in which the study is situated. Then the methods used for data collection will be discussed, followed by a discussion of the methods for data analysis. Then, some ethical considerations are discussed. In the final part of this chapter, the quality of the data and the process of data collection are reflected upon.

3.1 Study area

The area in which this study is situated in the city of Groningen and its surrounding peri-urban and rural places. The infrastructure, transport policies, spatial structure, organizations and people make up the context in this study of the drivers of intermodal commuting. In this section, the context in which the study is situated is elaborated upon.

The city of Groningen is the biggest in the Northern Netherlands with around 202.000 inhabitants (BAG, 2019). Groningen is also the economical, educational, scientific and cultural center of the northern Netherlands, providing a large share of the jobs and innovation in the region. Because of this, Groningen attracts a lot of people from the surrounding rural areas which sometimes experience population decline. A study from OIS Groningen (2013) pointed out that the city provides 131.700 jobs, half of which are filled by people from outside the city. Considering the current economic climate, on average around 70.000 people are coming into the city on a daily basis as part of their work-related commute. This number is expected to rise as Groningen is expected to grow to 250.000 inhabitants in the coming 15 years (RTV Noord, 2017). One of the biggest challenges for Groningen is to accommodate growth in a sustainable fashion. Next to working people, Groningen also houses lots of students as it is home to multiple big educational institutions such as the University of Groningen and the Hanze university of applied sciences. Because of this, a lot of students commute to Groningen daily as well. As this study focuses on work-related commuting, students are left out of the picture. This choice is made because working people are predominantly the cause of problems related to car usage such as congestion, parking pressure and air pollution (CBS, 2019) (see also chapter 1.3). As students most often make use of public transportation, they already engage with intermodal travel, making their commuting behavior more sustainable than most.

To accommodate the mobility the city generates, the city provides a high-quality Bus Rapid Transit system, called ‘Q-Link’. that connects some larger rural villages and suburban neighborhoods to the Park and Ride locations and all the main activity locations, such as the central station, the inner city, the academic hospital, the campus and business parks. Since 2019, a large part of the busses in Groningen are ‘zero-emission’ as 164 electric buses are now operated in the region, exemplifying the ambitions of the region towards sustainable mobility.

Because the public transport system is very well-connected to the numerous P&R locations, the options for intermodal commuting are quite well-developed and attractive. From P&R locations buses towards the city center depart every 5 to 10 minutes. The P&R locations also accommodate bicycle storage and special bicycle lockers. Usage of P&R and other forms of sustainable mobility is also successfully promoted by ‘Groningen Bereikbaar’ (Groningen Accessible), a public-private partnership between regional governments and large employers focused primarily on keeping the city accessible during large infrastructural projects that are going on.

These factors combined make for P&R infrastructure that is quite well used with an occupancy rate averaging at around 70% during the busiest hours (Groningen Bereikbaar, 2020). Figure 4 shows the locations of P&R locations in and around the city of Groningen.

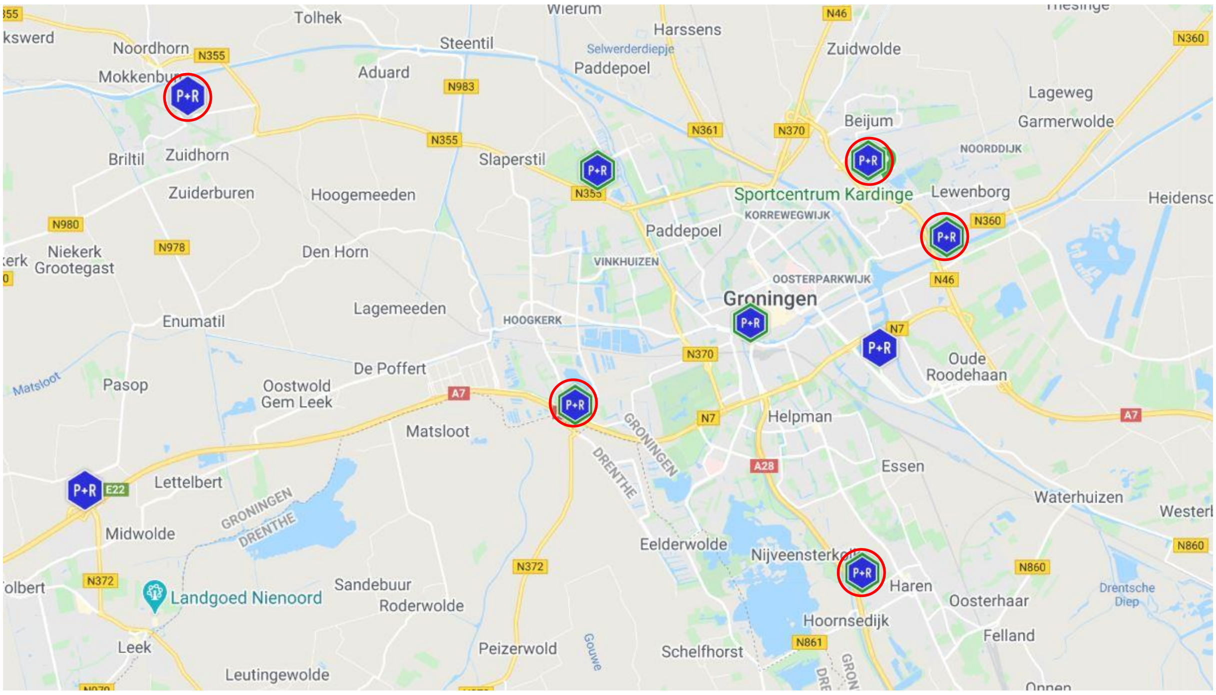

Figure 4: Park and Ride locations in and around the city of Groningen (Groningen Bereikbaar, 2019). Locations where data is collected are circled red

Groningen is quite compact as a city, comprising a surface of almost 84 square kilometers which houses around 202.000 inhabitants (BAG, 2019). Spatial development policy is focused on keeping the city compact by mostly focusing on redeveloping old industrial zones within city limits (Municipality of Groningen, 2018). Furthermore, the city offers high-quality cycling infrastructure. The combination of short distances, good cycling infrastructure and the high student population result in a modal split that is dominated by the bicycle. More than 60% of the trips being made in the city are by bicycle (Municipality of Groningen, 2018).

To further improve intermodal travel options and to instigate transit-oriented-development-type spatial development, the regional public transport agency (OV-bureau Groningen Drenthe) has launched the 'hub' program. This program is mostly focused on improving interchange location such as some of the P&R locations in figure 4. By adding amenities such as wireless internet, kiosks and water taps, they aim to make intermodal journeys more easy, pleasant and productive (Reisviahub.nl, 2019). The program is also actively improving the connectivity of the 'hubs' by adding bicycle racks, charging stations for e-bikes and the 'hub taxi'; a taxi that drives between people's homes and the nearest 'hub' at reduced fares. The 'hubs' are thus multimodal nodes in the transport network where people can interchange onto a variety of travel modes. Figure 5 shows the geographical location of these 'hubs' in and around the city of Groningen.

Figure 5: Location of multimodal 'hubs' in and around Groningen (Reisviahub.nl, 2019)

The contextual background, that is the city of Groningen and its surroundings, suits this research well. As congestion on road infrastructure and air pollution are seen as problematic in Groningen (e.g. RTV Noord, 2014), the societal relevance of studying intermodal commuting here is evident. Even more so as Groningen keeps on growing and keeps on generating mobility. Further, Groningen attracts a lot of daily commuters and has relatively well-developed options for intermodal travel. Yet, the largest share of the work-related commuting with a distance of more than 15 kilometers is still undertaken solely by car (MuConsult, 2019). In this study, the aim is to gain insight into intermodal travel behavior and its drivers. When this commuting behavior is better understood, policymakers and urban planners might be better equipped to further stimulate intermodal travel in Groningen and other cities.

3.2 Data collection

To answer the research questions posed in this study, a questionnaire survey is conducted. According to Clifford et al. (2010), there are three overarching steps in conducting any questionnaire survey that need to be considered. These are: *defining a strategy for conducting surveys*, *sampling* and *survey design*. As part of the strategy for data collection, the characteristics of the locations where data is collected are also elaborated upon in this subchapter. Furthermore, in this section, the connection between the research questions, the conceptual model and the questionnaire is explained.

3.2.1 Survey strategy

In this study, primary data is collected by inquiry of intermodal commuters through an online survey that is promoted via social media and by spreading flyers with QR codes on different multimodal interchange locations around Groningen. The used flyer can be found in appendix B. By scanning the QR code with a smartphone or by typing the link, participants are redirected to the online questionnaire designed with a program called 'Typeform'. This way, a lot of potential respondents can be reached in a relatively short amount of time while the ability to approach the target group is retained. Control questions are added to the questionnaire as an extra measure to reassure that the participants are indeed intermodal commuters that work in Groningen. These control questions are the following two: 'Do you work in the city of Groningen?' and 'Do you use intermodal commuting options to travel to work on multiple days per month?'. If either of these is answered with 'No', then the respondent will be redirected to a screen that states that they are not part of the target group for the study.

A quantitative study design is a logical choice for a study like this as the main research question is specifically aimed to *test* the effect that the various determinants of travel mode choice have on stimulating intermodal travel: *To what extent do the various determinants of travel mode choice play a role in stimulating intermodal commuting?* As the aim is to *test* and not as much to *explore* an unexplored topic, the choice for a quantitative study design is suitable. A qualitative study design, on the other hand, would fit a more explorative research question better. To answer the formulated research questions without risking biased conclusions, a representative sample of the population of work-related intermodal commuters towards Groningen is needed. By conducting an online questionnaire survey, the relatively high number of respondents needed for a representative sample is feasible within the limited amounts of time and other resources that this research project is subject to (Clifford et al., 2010). Questionnaire surveys furthermore produce results that are easily quantifiable, comparable and generalizable (Clifford et al., 2010).

Other strategies for conducting questionnaire surveys such as face-to-face interviews, telephone interviews, postal surveys and drop and pick-up questionnaires have been considered but were deemed inferior for the scope of this study (Clifford et al., 2010). Face-to-face interviews, for example, require immediate participation and time investment from the participant as they are approached. As this study requires approaching people who are in the middle of their home-work commute, a time consuming face-to-face interview becomes impossible. Aside from this, face-to-face interviews have the potential for interviewer-induced bias (Clifford et al., 2010). Furthermore, the unequal relationship between interviewer and respondent based on issues of gender, ethnicity and power, can influence responses (Kobayashi, 1994). Postal surveys and telephone interviews are also out of the question as enormous amounts of time and money are needed to phone or post all the people needed to find enough respondents that are intermodal commuters.

According to Clifford et al. (2010), using the strategy of administering online questionnaires has its own distinct disadvantages like not knowing who is responding and where they are. These drawbacks are largely nullified by actively promoting the questionnaire to intermodal commuters on various multimodal hubs and by adding control questions. One drawback that cannot be countered is that people without internet access are excluded from the study (Clifford et al., 2010). However, this is considered only a minor issue since almost everyone in the Netherlands in this day and age has a smartphone or at least access to the internet.

3.2.2 Sampling

At least 66.000 working people commute to Groningen from outside the city (OIS Groningen, 2013). The precise amount intermodal commuters towards Groningen is unknown. Yet, based on a large survey aimed at employees of large companies in the city of Groningen, a rough estimation of this number can be made. This survey was conducted by a research bureau called MuConsult in 2019 commissioned by Groningen Bereikbaar. 8419 people responded to the questionnaire. The results are representative of the 55.884 employees who are working at the partner companies of Groningen

Bereikbaar, but not necessarily for the entire population of people working in Groningen. However, it is the biggest and most recent survey targeted at this group in the region. Therefore the numbers presented in the Muconsult report offer the best representation of the travel behavior of people working in Groningen. The Muconsult report is further not used as a source of data in this study because it is focused on documenting the travel behavior of the respondents and the changes herein over time. This does not match with the aims of study presented here as it is focused on what motivates the choice for traveling in a certain way.

Muconsult (2019) found that in total, 32% of the people commute by car to their workplace. These also include P&R users; 16% of the car users travel via a Park & Ride. This is 5,1% of the total population. This number, however, seems to be offset by one employer that stimulated P&R use a lot. At this specific company 39% use park and rides versus 3 % at other companies. Still for determining the number of intermodal commuters the 5,1% is used. Further, 10% of the population travels to work using public transport. If we assume that all these home-work journeys are also intermodal we arrive at 15,1% of the working population. Then the total population of intermodal commuters would be around 22.000

Taking this number into account a sample size of at least 378 respondents is needed for generalizing the findings to the total population of intermodal commuters in the Groningen region. This is calculated using a sample size calculation with a confidence interval of 95% and a margin of error of 5% (surveysystem.com, 2019). The following formula is used in the calculation:

$$\text{Sample size} = \frac{Z^2 * (p) * (1-p)}{c^2}$$

Where: Z = Z value , p = percentage picking a choice, expressed as decimal and
c = confidence interval, expressed as decimal.

However, the needed number of 378 respondents is only true when various identifiable groups in the population are also represented significantly in the sample. Due to the SARS-CoV-2 pandemic, the set goal of 378 respondents could not be met. The influence of the SARS-CoV-2 pandemic on this study will be further discussed in sections 3.5.1 and 3.6.2.

3.2.3 Locations

Next to data collection via Facebook and LinkedIn, data is collected by spreading flyers with QR codes on multiple multimodal interchange locations. Because of the SARS-CoV-2 virus, flyers were only spread on park and ride locations. Here it was possible to spread the flyers while adhering to social distancing measures, by putting the flyers behind the windshield wipers. Spreading of the flyers was done on the following locations in Groningen: P&R Zuidhorn, P&R Hoogkerk, P&R Kardinge, P&R Meerstad and P&R Haren. Figure 4 shows these locations on a map. These locations were chosen as the occupancy rates here were relatively high as compared to a location such as P&R Reitdiep or P&R Leek.

3.2.4 Questionnaire design

Clifford et al. (2010) prescribe some basic design guidelines that any questionnaire should adhere to. These include three basic principles: *keep it simple, define terms clearly* and *use the simplest wording possible*. Next to these principles, Clifford et al. (2010) list five 'things to avoid' in designing survey questions: *Long complex questions, two or more questions in one, jargon, biased or emotionally charged terms* and *negative words like 'not' or 'none'*. The questionnaire used in this study was designed with these guidelines in mind. The full questionnaire can be found in appendix A.

The concept of 'intermodal travel' is used regularly throughout the questionnaire. As to *define terms clearly* (Clifford et al., 2010), every time a respondent is asked about their intermodal travel behavior, a clear definition is provided of what intermodal travel entails. Respondents can then read that 'Intermodal travel means traveling from A to B by using multiple transport modes. In this study, walking is only considered as a transport mode when the walking part of the intermodal commute takes longer than 5 consecutive minutes of walking.' The threshold for walking to be considered a transport mode, as suggested by Diaz Olvera et al. (2014), is with this explanation also operationalized in the questionnaire.

In evaluating the importance individuals attach to various determinants when choosing for intermodal commuting options, a five-point Likert scale has been used. Clifford et al. (2010) note that Likert scales are suitable for researching attitudes and opinions. A five-point scale offers a balance between the quality of information it provides and the easiness of answering the questions for the respondent.

3.2.5 Operationalization of the conceptual model

The questionnaire is aimed at retrieving all the information needed to answer the research questions. To remind the reader, the secondary research questions are repeated here: 1. What are the characteristics of the intermodal commuters, and the characteristics of their intermodal commuting behavior, in and around Groningen? 2. To what extent do personal socioeconomic characteristics affect intermodal commuting towards Groningen? 3. To what extent do the instrumental, affective and symbolic determinants of travel mode choice affect intermodal commuting towards Groningen? 4. To what extent can amenities at multimodal hubs stimulate intermodal commuting towards Groningen? 5. To what extent does the mobility policy at the workplace affect intermodal commuting towards Groningen?

The determinants about which the respondents are asked, originate from the theoretical framework and the conceptual model. The *instrumental, affective* and *symbolic* determinants of travel mode choice are operationalized in Likert type questions with a five-point scale. Other determinants, such as *socioeconomic characteristics* and *travel policy at the workplace,* are operationalized using simple 'yes/no' or multiple choice questions. To answer the fourth research question, the *amenities on interchange locations* from the conceptual model are operationalized in the survey. Respondents are asked if the addition of certain amenities on interchange locations will make intermodal travel more attractive for them. These answers are then categorized on a three-point ordinal scale.

3.3 Data analysis

Ordinal regression analysis is performed to analyze the effect of independent variables related to *socioeconomic characteristics,* and *mobility policy at the employer* on the dependent variable of the *degree of intermodal travel*, measured in how much times per week respondents commute intermodally to their work.

''Ordinal logistic regression (often just called 'ordinal regression') is used to predict an ordinal dependent variable given one or more independent variables. It can be considered as either a generalization of multiple linear regression or as a generalization of binomial logistic regression. As with other types of regression, ordinal regression can also use interactions between independent variables to predict the dependent variable.'' (Leard Statistics, 2019, accessed on 20-2-2020 via https://statistics.laerd.com/spss-tutorials/ordinal-regression-using-spss-statistics.php)

According to Leard statistics, the used data has to adhere to four assumptions to perform ordinal regression. The first two can be checked in advance of retrieving the data: The dependent variable should be measured at the ordinal level and one or more independent variables have to be included that are either rational, ordinal or nominal. The last two assumptions are checked through testing the data in spss: 'there is no multicollinearity' and 'the odds are proportional'.

Ordinal regression offers a part of the answer to the main research question: *To what extent do the various determinants of travel mode choice play a role in stimulating intermodal commuting?* Ordinal regression analysis is chosen as it is a good method to test how well multiple different independent variables predict one dependent ordinal variable. Through regression analysis the effect of multiple determinants of travel mode choice on the degree of intermodal travel can be calculated all at once. Factors relating to *socioeconomic characteristics* and *mobility policy at the workplace* are incorporated in the ordinal regression model. Another part of the answer comes from descriptive analysis of the results of Likert-type questions about the determinants of travel mode choice that they feel are important for their choice to commute intermodally. By calculating the mean importance people attach to each variable, the relative importance of the *instrumental, affective* and *symbolic* determinants for choosing intermodal commuting options is found.

To analyze how multimodal hubs can facilitate intermodal travel, descriptive analysis of ordinal variables is performed. Respondents are asked if certain *amenities* will make intermodal travel more attractive for them. By calculating the average assigned score it becomes apparent how much potential the suggested amenities have on stimulating intermodal travel.

3.4 Ethical considerations

3.4.1 Doing research during a pandemic

Because this research is conducted during the SARS-CoV-2 pandemic, measures are taken to not contribute to the further spreading of the virus. The researcher adheres to the social distancing measures by keeping at least the advised 1,5-meter distance from respondents. This is safeguarded by only spreading the flyers on P&R locations by putting them behind the windshield wipers. The envisioned data collection strategy of also administering the flyers directly to people in station areas has to be let go as a result. Instead, as to diversify the data collection techniques, Facebook and LinkedIn are used to promote the online questionnaire to the research population.

3.4.2 Privacy

In the survey, people are asked about their private lives. It includes questions about their income and family situation. Therefore, privacy is an important issue to consider in this research. In the dataset, the personal identity of the respondents cannot be traced. Respondents are further not asked any personal details that could lead to tracing their identity. The respondents are thus guaranteed anonymity.

3.5 Reflection on the quality of the collected data and the process of data collection

3.5.1 the data collection process

Data was collected from the 19th of May 2020 through the 7th of July 2020. Initially, the online questionnaire was only promoted by spreading flyers on the P&R locations. Table 1 &-2 show the number of flyers spread on the various locations. To diversify data collection methods, on the 4th of June the questionnaire was shared on LinkedIn and on the 2nd of July on the Facebook page of Groningen Bereikbaar, which has 10.000 followers. These efforts eventually led to 128 responses of which 86 were valid in the sense that these respondents were part of the population of intermodal commuters who work in Groningen. The other respondents either did not work in Groningen, did not commute intermodally regularly or were suspected of being insincere in answering the questions. The number of respondents that each method of promotion generated is presented in figure 6. The response rate was around 8%. This is calculated by the number of responses divided by the amount of flyers spread times one hundred.

P&R Location	**Amount of flyers**	**Date**
Meerstad	39	19-5-2020
Kardinge	101	19-5-2020
Hoogkerk	181	25-5-2020
Kardinge	104	27-5-2020
Meerstad	34	27-5-2020
Haren	107	28-5-2020
Hoogkerk	246	9-6-2020
Meerstad	103	9-6-2020
Kardinge	122	11-6-2020
Zuidhorn	31	16-6-2020
Hoogkerk	183	17-6-2020
Meerstad	121	22-6-2020
Haren	165	25-6-2020
Total	**1537**	

Total amount of flyers spread per location
Zuidhorn 31
Haren 272
Meerstad 297
Kardinge 327
Hoogkerk 610
1537

Table 1 & -2: The amount of flyers spread each day per location & the total amount of flyers spread per location

Figure 6: The 'locations' where the respondents were recruited

3.5.2 Influence of the SARS-CoV-2 pandemic

On the 23rd of March, the Netherlands went in a so-called 'intelligent lockdown' to slow down the rapidly spreading SARS-CoV-2 virus. The following measures were taken:

- People were advised to stay at home as much as possible
- People were advised to work from home as much as possible
- People were advised not to use public transport with an exception for those with 'vital' jobs such as in healthcare
- 'Social distancing' of at least 1,5 meters is advised and mandatory in public space
- All events were canceled
- Schools and universities closed their doors. Education was resumed online.
- Museums, cinema's, theatres, bars, restaurants and nightclubs also closed down
- Businesses that rely on physical contact, such as barbers and masseurs, had to close down.

As a result travel demand collapsed. Especially in public transport but to a lesser degree also car traffic. As the 'intelligent lockdown' continued, the spreading of the virus slowed down. This eventually lifted some of the pressure on the healthcare system. Slowly some of the imposed measures were lifted. First, the barbers opened shop again, then the primary schools, etcetera. As the Netherlands comes out of the lockdown, travel demand is again on the rise. Figure 7, on the next page, visualizes the number of trips for each modality per day. Here the developments described above are visible.

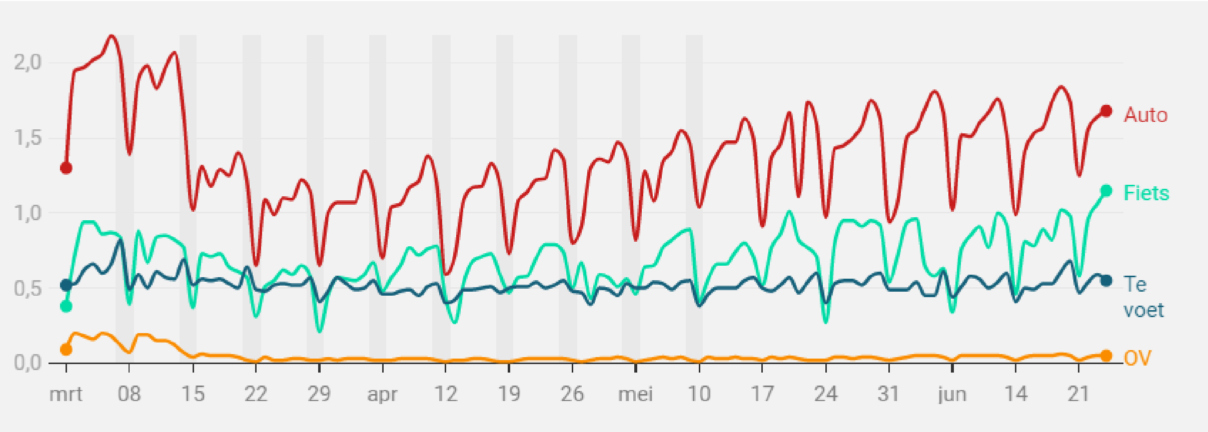

Figure 7: trend of travel demand in the Netherlands during the SARS-CoV-2 pandemic in the number of trips per person per day (X-axis) for each modality. The Y-axis shows the date, starting at the 1st of march. The red line represents the car, turquoise the bike, blue walking and orange represents public transport. (NVP, 2020)

As described in section 3.5.1, because of social distancing measures, data was mainly collected on park and ride locations. With the drop in demand for public transport, the occupancy rate of the park and rides also plummeted. Figure 8 visualizes this in a graph. In accordance with the other locations, the occupancy rate of P&R Meerstad dropped from around 60% to 10% in two weeks.

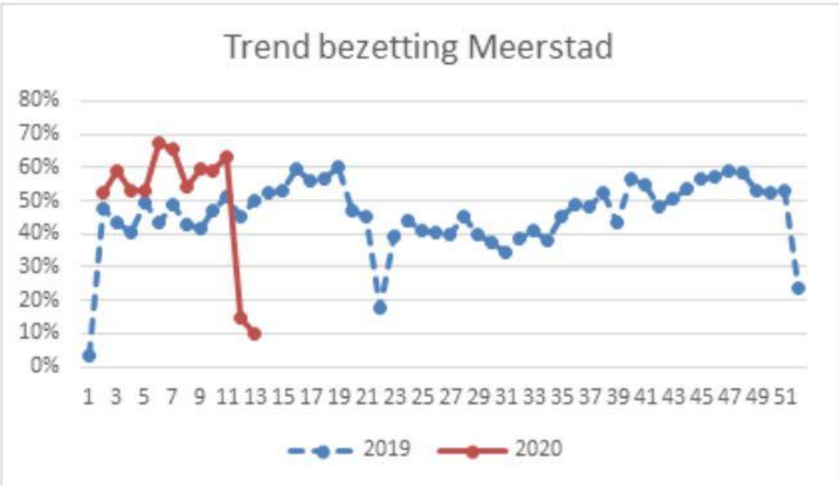

Figure 8: Biweekly occupancy rate (X-axis) of the car park at Park and Ride Meerstad in 2019 and 2020. The Y-axis shows the week numbers. *(Groningen Bereikbaar, 2020)*

During the 'intelligent lockdown' public transport was mostly used by people with vital professions, such as functions in healthcare and the food supply chain. Everyone was further advised to work from home as much as possible. Till the 1st of June, transit companies operated on reduced capacity through using the holiday schedule. Because the 1,5-meter distance also had to be maintained in transit, busses and trains could only utilize 40% of their carrying capacity. After the 1st of June, the 1,5 meter rule was let go in transit but transit users were required to wear a face mask instead. This meant that after the 1st of June the carrying capacity in public transport went up again.

Because of the measures to reduce the spreading of the SARS-CoV-2 virus, the most people who still used public transport and Park and Rides to commute to Groningen were healthcare professionals. Specifically, healthcare professionals who work at the academic hospital UMCG. Therefore, people working at the UMCG are overrepresented in the sample. This is also due to the mobility policy of the UMCG; workers cannot park their car for free at the hospital and are, therefore 'forced' to use the Park and Ride locations.

Because the sample is not representative of the population of intermodal commuters who work in Groningen, findings cannot be generalized. However, the sample is representative of commuters who use P&R/P&B to travel to their workplace in Groningen during a pandemic. Answering the research questions is still possible although the use of this study in informing mobility-related urban policy is limited.

Chapter 4: Results

In this chapter, an analysis of the collected data is presented. The various subsections relate to the research questions. First, the characteristics of the intermodal commuters and their travel behavior are elaborated upon in sections 4.1 and 4.2. This relates to the first research question: 'What are the characteristics of the intermodal commuters, and the characteristics of their intermodal commuting behavior, in and around Groningen?'. Then, the findings on the mobility policy at the workplace of the intermodal commuters are presented in section 4.3.

The first three sections of chapter 4 culminate in section 4.4, where an analysis is presented of the extent to which the *socioeconomic characteristics* and the *travel policy at the workplace* affect the choice for intermodal commuting options. Ordinal regression analysis is performed in this section. Here, the results are presented to answer the second and fifth research questions: 'To what extent do personal socioeconomic characteristics affect intermodal commuting towards Groningen?' and 'To what extent does the mobility policy at the workplace affect intermodal commuting towards Groningen?'.

Then, in section 4.5, an analysis of the Likert type questions is presented. This analysis covers the *mobility style* part of the conceptual model. The analysis presented here is aimed at answering the third research question: 'To what extent do the *instrumental, affective* and *symbolic* determinants of travel mode choice affect intermodal commuting towards Groningen?'.

lastly, in section 4.6, an analysis is presented on the influence of *amenities at multimodal hubs* to stimulate intermodal commuting. These findings relate to the fourth research question: 'How can multimodal hubs facilitate intermodal commuting?'. After all the findings are presented, the answer to the main research question is formulated in chapter 5: 'To what extent do the various determinants of travel mode choice play a role in stimulating intermodal commuting?'

4.1 Intermodal travel behavior

First, the characteristics of the travel behavior of the respondents in the sample are presented. This relates to the first research question. The findings presented include the division of interchange locations that are the most frequently used by the respondents, the degree of usage of intermodal commuting options per week, the combinations of transport modes which are most frequently used and the preferred transport modes when not choosing for an intermodal option.

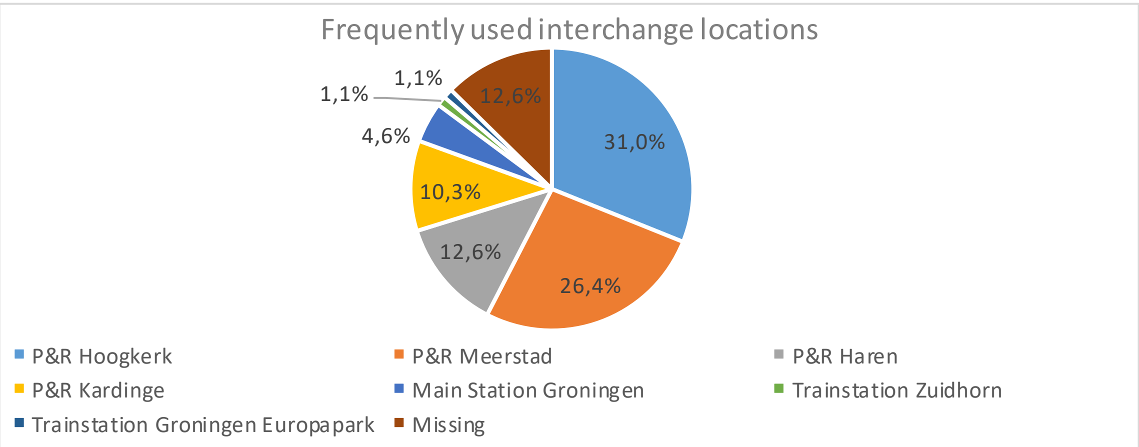

Figure 9: The frequently used interchange locations in the sample by percentage

Figure 9 shows the interchange location that the respondents frequently use in their intermodal commuting trips. P&R Hoogkerk is the interchange location that is frequently used by the most respondents. This is mostly due to its size; 990 cars can be parked there, which is also the reason that the most flyers were spread there. As can be seen in table 2 on page 28, more flyers were administered at P&R Kardinge than at P&R Meerstad. Yet, in the sample, more users of P&R Meerstad are represented. This is likely caused by a higher percentage of P&R Meerstad users that belong to the researched population of intermodal commuters who work in Groningen. At P&R Kardinge more people were probably filtered out because they answered with 'no' to at least one of the two control questions. In this case, it would seem that P&R Kardinge is used differently as compared to Meerstad.

Figure 10 shows the average amount of days per week people in the sample use an intermodal option to commute towards Groningen. The average amount of days for the whole sample lies between 3 and 4 days. This number corresponds quite well with the average amount of days people commute to Groningen in total, both intermodal and otherwise. This points out that in the sample the respondents are already quite heavy intermodal users in the sense that a large share of their total amount of commuting trips is already intermodal.

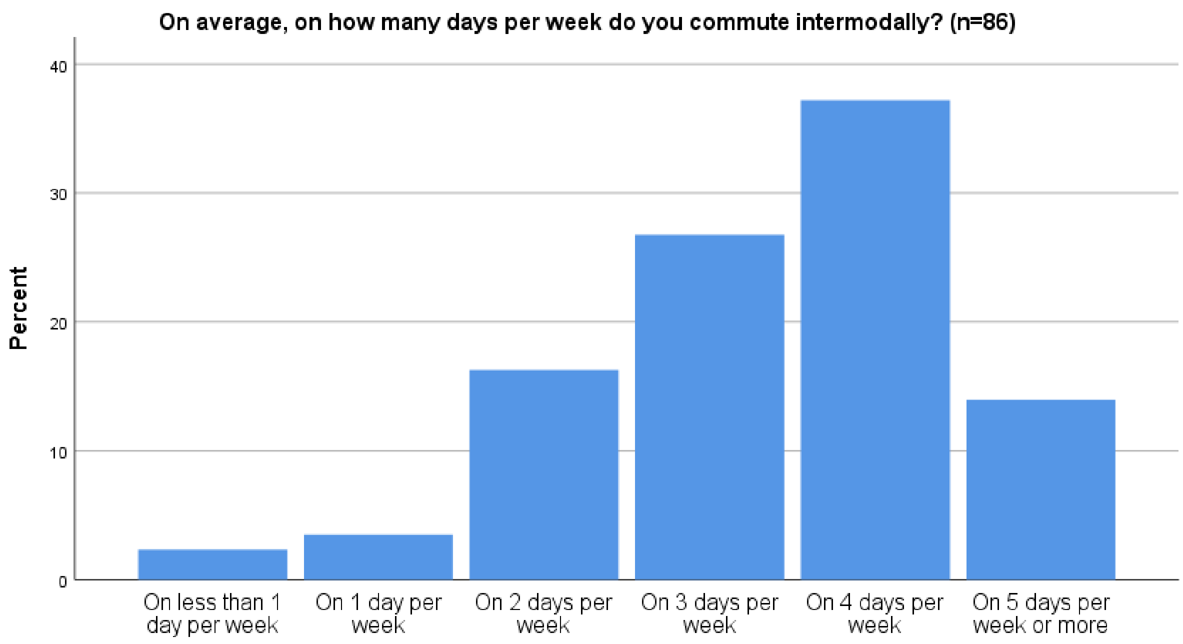

Figure 10: Average amount of days per week the respondents commute to Groningen intermodally

Figure 11, on the next page, shows the various combinations of transportation modes that the respondents use in their 'standard' one-way intermodal commute. Park & Ride and Park & Bike are the most frequently used combinations at respectively 41% and 27%. People who do not have a train station or bus stop close to their working place are more likely to use the Park & Ride & Walk options. Over 10% use intermodal combinations other than the ones described, including Park & E-bike, bike-train-bike and bike-train-walk. As touched upon in section 3.2.4, respondents could only consider 'walking' as a transport mode when a consecutive walk as part of the intermodal commute takes more than 5 minutes of time.

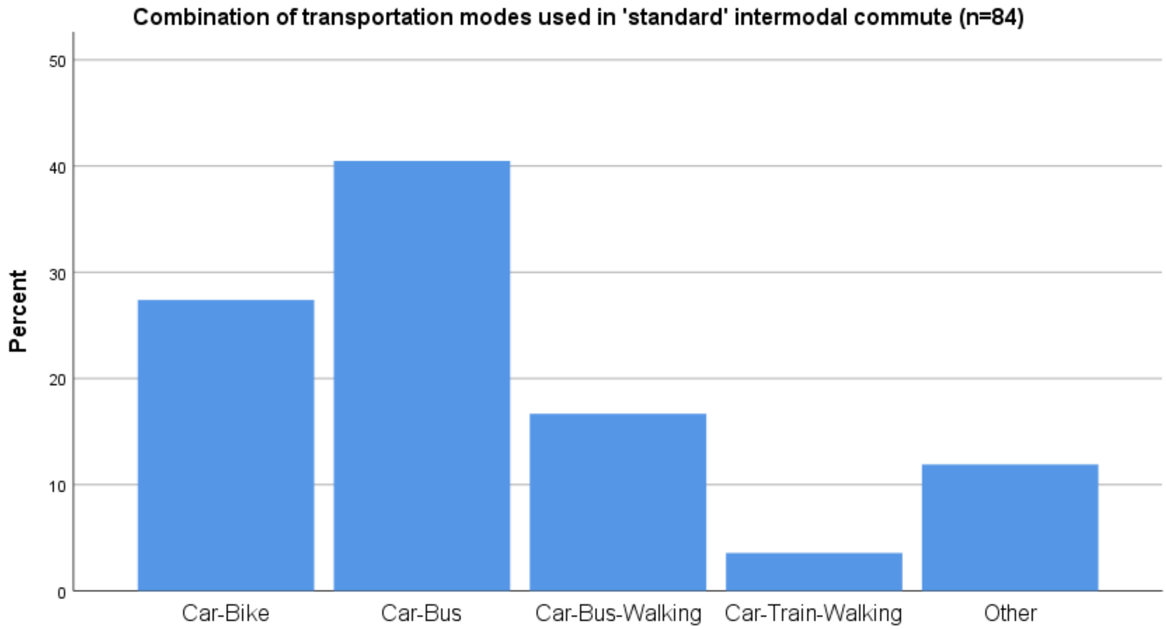

Figure 11: Combinations of transport modes used during the respondents' 'standard' intermodal commute

Respondents were further asked what transport mode they use in the instances that they do not use an intermodal option for the home-to-work commute. Figure 12 shows the responses. This variable indicates how the availability of intermodal options alters the modal split.

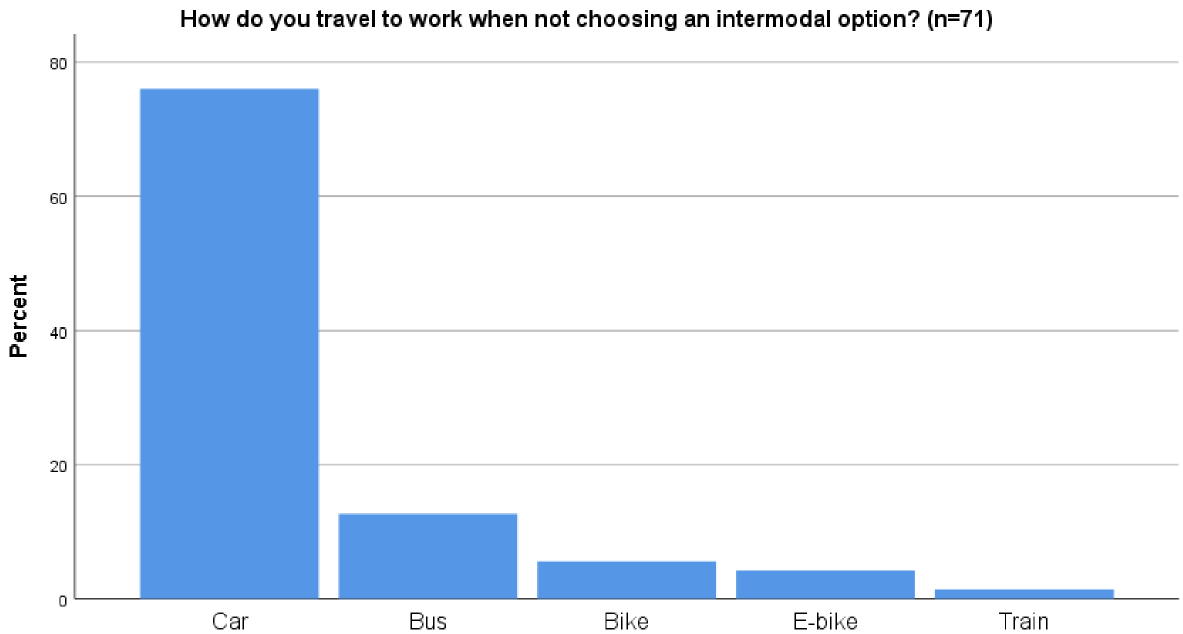

Figure 12: Transport mode that people would choose when not using an intermodal commuting option

At 76%, by far the most people would use the car to travel to work when not using an intermodal option. This indicates that in these cases, the availability of Park and Ride facilities prevents trips solely made by car. However, it can be observed that the availability of Park and Ride can also reduce public transport ridership and bike usage, as some of the respondents would have used the train, bus or bike in a monomodal trip if the intermodal option was not available as a choice.

4.2 'Life situation' of the intermodal commuter

In this section the findings on the 'life situation', or the *socioeconomic characteristics*, of the intermodal commuters in Groningen are presented. Findings on the following factors are presented respectively: *gender division, age division, educational attainment, income* and *household composition.* These factors relate to answering the first research question: 'What are the characteristics of the intermodal commuters, and the characteristics of their intermodal commuting behavior, in and around Groningen?'. However, these factors are also used in the ordinal regression analysis presented in section 4.4 to answer the second research question: 'To what extent do personal socioeconomic characteristics affect intermodal commuting towards Groningen?'

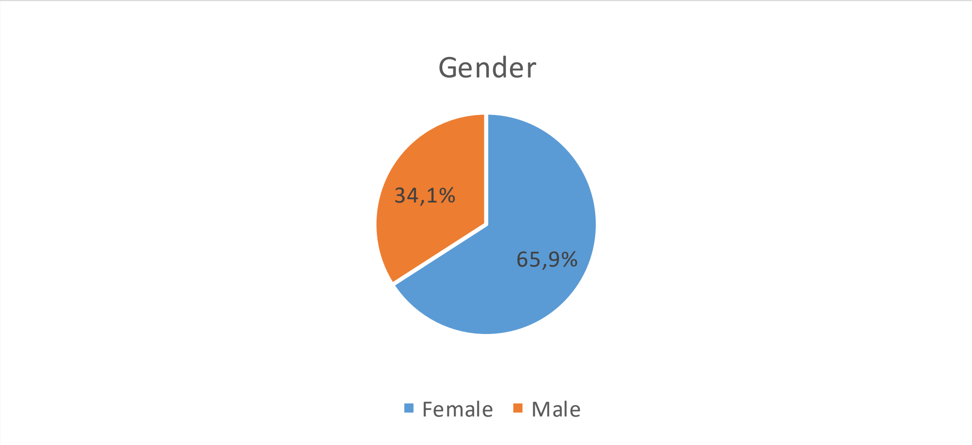

Figure 13: Gender division in the sample

As can be seen in figure 13, females are overrepresented in the sample. There is a probable explanation for this. As elaborated upon in section 3.6.2, because of the 'intelligent lockdown' during the SARS-CoV-2 pandemic, mostly people with 'vital' professions used public transport. Because of this and because of the mobility policy of the region's largest hospital: UMCG, healthcare workers were overrepresented in the sample. And because women are still overrepresented in the healthcare sector (Wielenga-van der Pijl et al., 2018), there were probably significantly more women than men at the Park & Ride locations during data collection.

Figure 14, on the next page, visualizes the age distribution in the sample. The mean age in the sample is 45 years. This is older than the mean age of the working population in the Netherlands, which was 41 in 2018 (CBS, 2019). The histogram shows a more or less normally distributed age curve. The group 25-30 is, however, an outlier in this. This might be due to the relatively small sample size in the study.

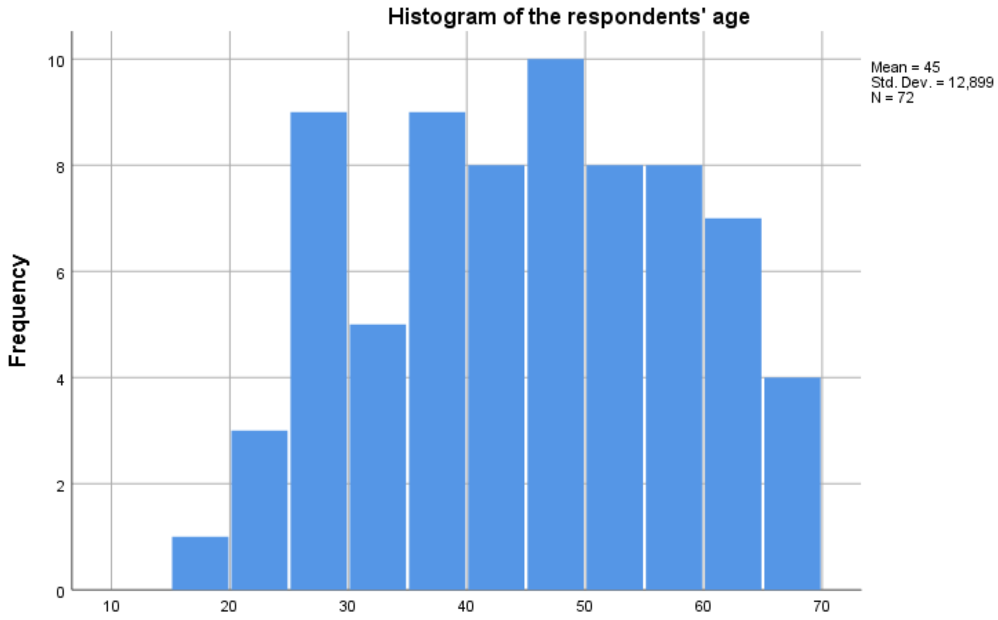

Figure 14: Histogram of the respondents' age in years

Next, 'educational attainment' of the respondents is visualized. Figure 15 shows the highest completed educational grade of the intermodal commuters in the sample. The categories used in the questionnaire correspond to the ones used by Statistics Netherlands. The figure shows that the intermodal commuters in the sample are highly educated. 75% of the respondents has either a college- or university level degree. This number is significantly higher than the Dutch national average. According to onderwijsincijfers.nl (2020), in 2019 33% of the people between the ages of 15 and 75 had a degree in higher education.

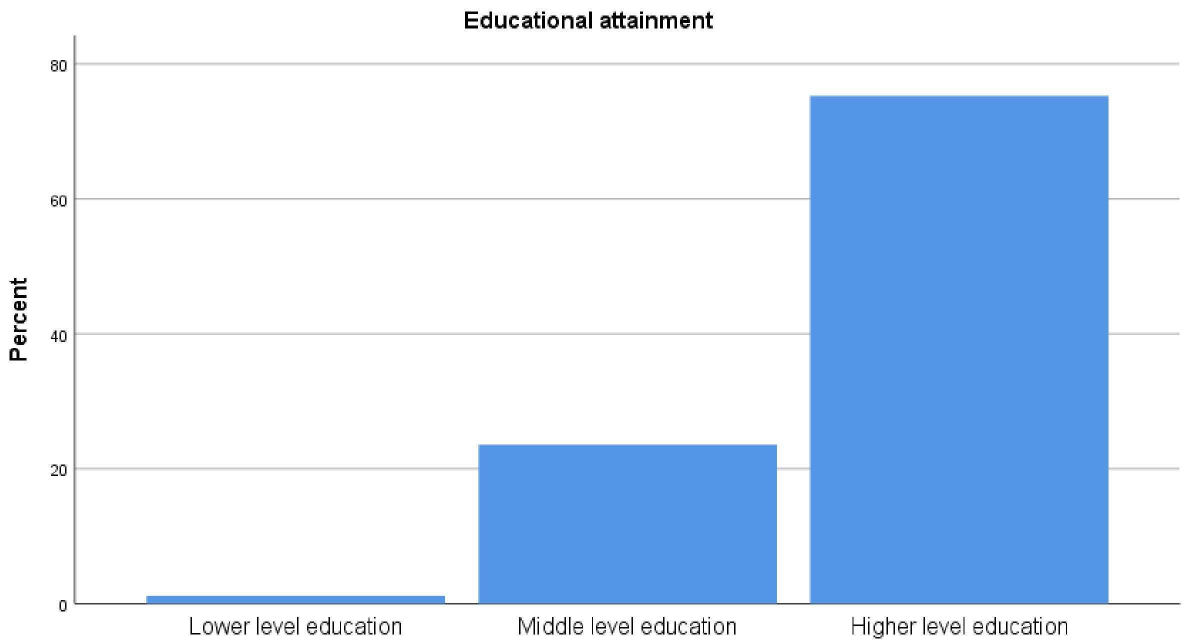

Figure 15: Intermodal commuters' highest attained grade in education

Net disposable annual income is also higher in the sample of intermodal commuters than the national average. Figure 16 shows this, as the net disposable annual income of 48% of the intermodal commuters is higher than 34.000 euro. On average only 34% of Dutch households has a higher income than this (CBS, 2018). The relatively high income of the respondents is related to their level of educational attainment which is also high as compared to national averages.

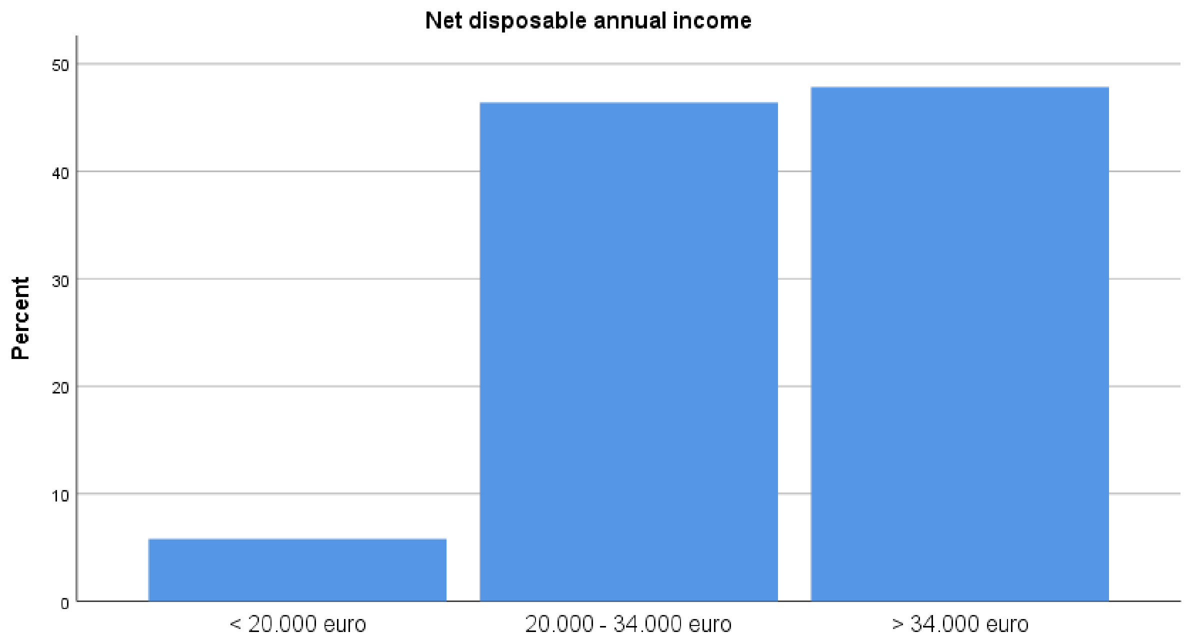

Figure 16: Net disposable income of the intermodal commuters

Next, 'household composition of the intermodal' commuters is described. Figure 17 visualizes the number of people making up the respondents' households.

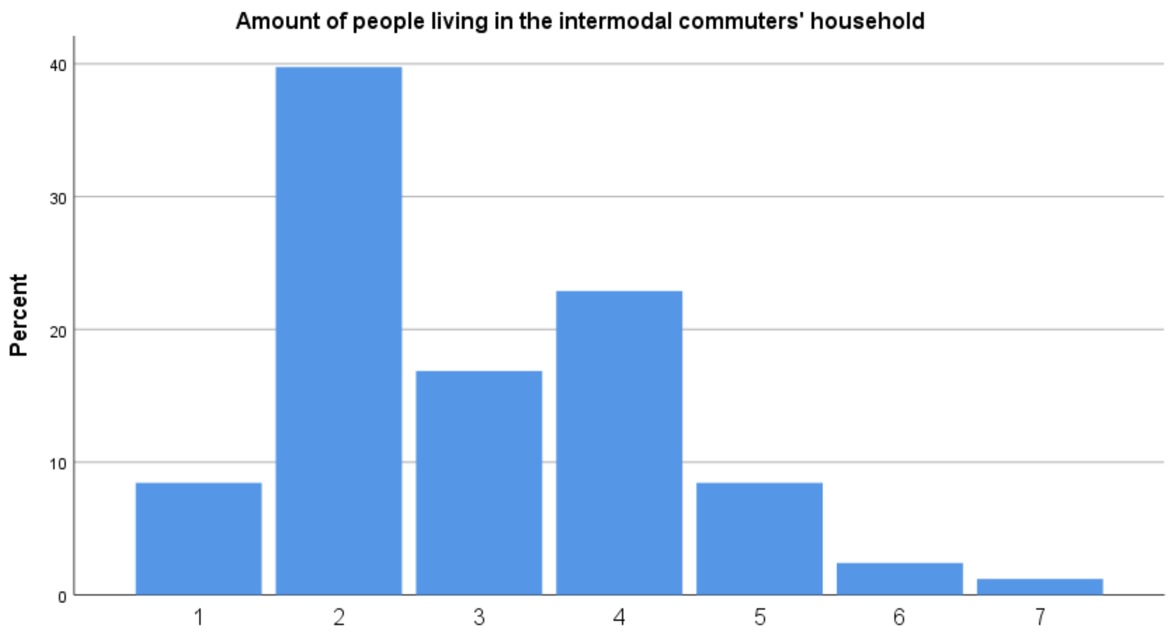

Figure 17: Household size of the intermodal commuters in the sample

The average household size intermodal commuters in the sample is 3,0 people. 37% of the respondents are living together with a partner or spouse in a 2-person household. The largest share of the intermodal commuters in the sample lives in a household together with a partner or spouse and one or more kids. This share makes up 42% of the sample. Further, all intermodal commuters in the sample have a driver's license and own at least one car in their household.

4.3 Mobility policy at the workplace

In this section, the findings on the mobility policy at the respondents' workplace are presented. In section 4.4, the effect of the mobility related policies at the workplace on the degree of intermodal is tested to answer the fifth research question: 'To what extent does the mobility policy at the workplace affect intermodal commuting towards Groningen?'. In this section findings on the following factors are presented: *Parking policy at the workplace, mobility related benefits, stimulation of park and ride usage* and *showering facilities*.

First, the parking policy at the workplace of the intermodal commuters is looked at. Figure 18 shows in what way parking at the employer is facilitated. The figure shows that by far the most intermodal commuters in the sample would have to pay to park their car at the workplace or do not even have car parking space available to begin with. This might be a high-impact variable in affecting the choice between monomodal and intermodal commuting options, as it directly influences the cost of travel.

Figure 18: parking policy at the workplace

Subsequently, the data on the mobility-related benefits from the employer is presented. Figure 19, on the next page, visualizes the difference in mobility-related benefits received from the employers of the intermodal commuters in the sample. In 58% of the cases, the received mobility-related benefit is independent of which transport mode is chosen. This is positive for stimulating intermodal travel as it gives the employee maximum flexibility and liberty in choosing a transport mode or a combination of modes in an intermodal trip.

Respondents were further asked if Park and Ride usage is in any way stimulated by their employer. 79% answered this question with 'yes', indicating that indeed a very large share of the intermodal commuters is stimulated by their employer to travel in such a way as to reduce CO_2 emissions and mitigate congestion in Groningen. Moreover, 69% of the intermodal commuters stated that their employer had facilities to take a shower and change clothes. This number goes to show that employers of intermodal commuters create an environment in which the use of active modes to travel to work is promoted.

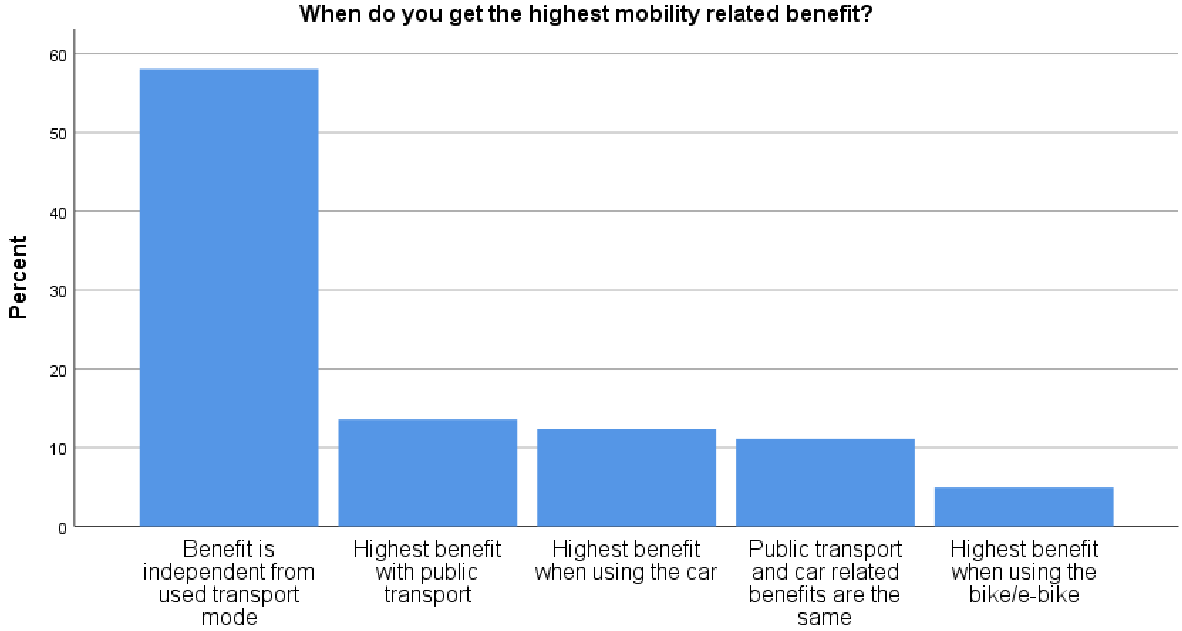

Figure 19: Mobility related benefits at the employers of intermodal commuters

4.4 Ordinal regression analysis

In this section, findings are presented to answer the second and fifth research questions: 'To what extent do personal socioeconomic characteristics affect intermodal commuting towards Groningen?' and 'To what extent does the mobility policy at the workplace affect intermodal commuting towards Groningen?'. This is done by ordinal regression analysis. The effect of factors relating to the 'Life situation' or *socioeconomic characteristics* and *mobility related policy at the workplace* are tested. The ordinal regression analysis points out to what extent the tested variables affect the ordinally measured variable 'average number of days per week commuting intermodally'.

In this analysis, the dependent variable is the *'average number of days per week commuting intermodally'*. The independent variables are *'parking policy at the workplace', 'mobility benefits for employees', 'stimulation of P+R usage', 'Availability of showers and dressing rooms at the employer', 'gender', 'income', 'educational attainment', 'household size', 'number of cars in the household'* and *'age'*. These variables were chosen because they represent the *socioeconomic characteristics* and the *mobility policy at the workplace* parts of the conceptual model. The effect of these factors on stimulating intermodal travel was not tested using descriptive analysis of Likert type questions. That is why they are tested here. Vice versa, because the variables related to the effect of amenities at hub locations on intermodal travel are operationalized as based on the respondents' opinion, these factors cannot be used as independent variables in the ordinal logistics model.

Using ordinal logistic regression, it can be tested if the independent variables significantly affect the dependent variable. The null hypothesis is that the independent variable does not affect the dependent variable. In this analysis cumulative odds ordinal logistic regression with proportional odds if performed.

To perform this analysis, four assumptions have to be met. The first two were already discussed in section 3.5. The third assumption is that there can be no multicollinearity. This was tested in SPSS using 'collinearity diagnostics'. For all independent variables, the 'Tolerance' and 'VIF' results were higher than 0.1 and lower than 10 respectively. It can thus be assumed that there is no multicollinearity. The fourth assumption is there should be proportional odds. The assumption of proportional odds was also met, as assessed by a full likelihood ratio test comparing the fit of the proportional odds location model to a model with varying location parameters, $\chi^2(60) = 52{,}141$, $p = .755$.

None of the tested independent variables had a statistically significant effect on the number of intermodal commuting trips per week. To be clear, this does not mean that any of the tested variables do not stimulate intermodal commuting. It indicates that for people who are already commuting intermodally regularly, the tested independent variables do not cause them to take any more or any less intermodal commuting trips. The relative small size of the sample is also likely to affect these results. Figure 22 shows the results of the ordinal logistic regression model.

Tests of Model Effects

Source	Type III Wald Chi-Square	df	Sig.
Kunt u gratis uw auto parkeren bij uw werkgever?	1,083	2	,582
Wanneer krijgt u de hoogste reiskostenvergoeding voor uw woon-werk reis?	,298	4	,990
Zijn er bij uw werkgever faciliteiten om te douchen en om te kleden?	,539	1	,463
Wordt P+R gebruik gestimuleerd door uw werkgever?	1,259	1	,262
Wat is uw geslacht?	1,589	1	,207
Wat is uw hoogst voltooide opleiding?	,520	1	,471
Hoe hoog is uw netto besteedbaar jaarinkomen?	4,907	2	,086
Uit hoeveel personen bestaat uw huishouden?	2,158	1	,142
Hoeveel auto's zijn er in uw huishouden aanwezig?	,000	1	,999
lftd_jr	1,494	1	,222

Dependent Variable: Op hoeveel dagen per week is uw woon-werk reis gemiddeld gezien intermodaal*?

Figure 22: Results of the ordinal regression model

4.5 Instrumental, affective and symbolic determinants

In this section, the importance of *instrumental, affective* and *symbolic* determinants in choosing for intermodal commuting options is tested. This is done to answer the third research question: 'To what extent do the *instrumental, affective* and *symbolic* determinants of travel mode choice affect intermodal commuting towards Groningen?'. Respondents were asked to assign importance to the various determinants in their choice for their most-used intermodal commuting option. Most notably, these intermodal options constitute of Park & Ride and Park & Bike combinations. Figure 20 visualizes the assigned importance on an ordinal scale with 1 meaning very unimportant and 5 meaning very important.

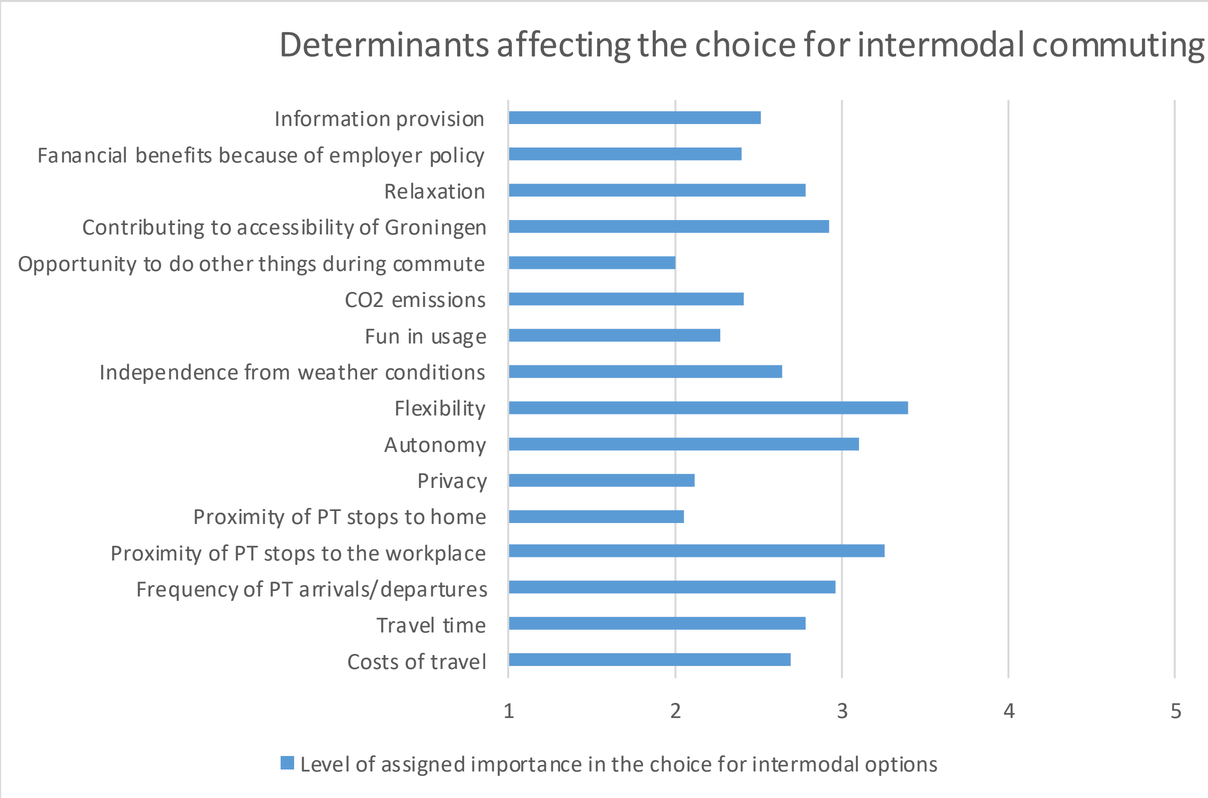

Figure 20: Average assigned importance to 16 determinants in the choice for intermodal commuting; mostly Park & Ride and Park & Bike. 1= very unimportant, 2= unimportant, 3=neutral, 4= Important, 5= very important

The intermodal commuters in the sample regard most determinants as relatively unimportant in their choice for intermodal options. Only 'experienced high *flexibility*' when using an intermodal commuting option, 'experienced high *autonomy'* when using an intermodal commuting option and 'proximity of public transport stations to the workplace' are seen as relatively important when choosing for an intermodal commuting option. It has to be noted, however, that the differences in the importance assigned to the various factors are generally small. Respondents were also given the option of typing in something else that they find important in their choice for their most-used intermodal option. Most of the entries in this option point to the notion that parking the car at the workplace is too expensive or even 'impossible'. Some respondents feel that they do not really have a choice at all as a result of the parking policy at the workplace.

The second least important determinant according to the respondents is 'proximity of a public transport stop to the home'. This is very logical as by far the largest share of the respondents use Park & Ride and Park & Bike commuting options, in which the first part of the trip is always travelled by car. Naturally, the proximity of a public transport stop to the workplace becomes more important during a park and ride trip.

When the various determinants of travel mode choice are grouped in the categories of instrumental-, affective-, and symbolic determinants Clauss and Döppe (2016) laid out. The average assigned importance for determining the choice for intermodal commuting options are quite similar to each other with no significant outlier of one category being more or less important in determining the choice for intermodal options. This is visualized in figure 21.

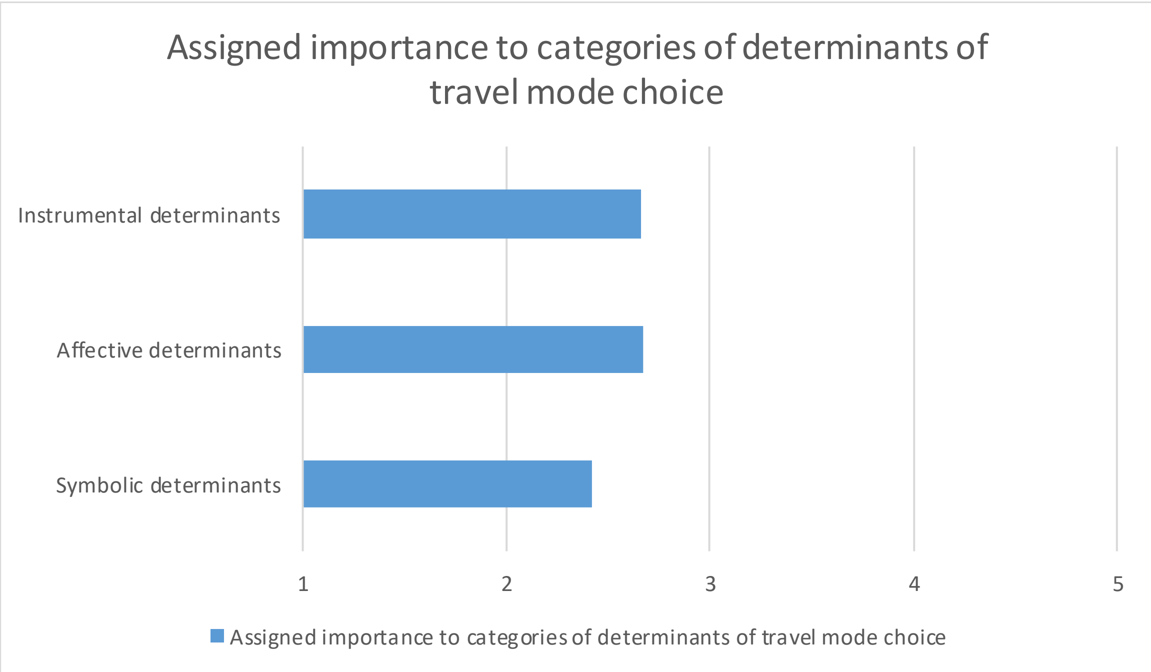

Figure 21: Average assigned importance to the three categories of determinants of travel mode choice in choosing for intermodal commuting options. 1= very unimportant, 2= unimportant, 3=neutral, 4= Important, 5= very important

4.6 Amenities at multimodal hubs

As interchanging is integral to intermodal travel as well as a 'weak link' in intermodal commuting trips, *amenities* at these interchange location or multimodal hubs might play an important role in facilitating intermodal travel. In this section, the results from the questionnaire on this topic are discussed. This relates to the fourth research question: 'To what extent can amenities at multimodal hubs stimulate intermodal commuting towards Groningen?'.

As part of the 'hub' program, some interchange locations in Groningen have extra amenities such as wifi, dynamic departure information panels and water tap points. Respondents were asked if these kinds of amenities make intermodal commuting more attractive. The result is visualized in figure 23. Aside from the ones that could not answer the question because 'their' interchange location does not have these amenities, 42% of the respondents answered that intermodal travel does not become more attractive for them because of these 'extra' amenities. However, a sizeable 14% of the respondents say that these amenities do make intermodal travel more attractive.

The respondents were also asked if they made more intermodal commuting trips since amenities like the ones mentioned were added on 'their' interchange location. On this, the respondents answered overwhelmingly with 'No'. This result is in line with the results of the ordinal logistic analysis in the sense that, once already commuting intermodally regularly, changes in other variables do not cause the respondent to make more intermodal commuting trips. An explanation for these results is that a large share of the respondents in the sample are more or less 'forced' by their employer to travel intermodally via Park and Ride locations due to discouraging parking at the workplace location. This leads to intermodal commuting not really being a choice which results in almost all commuting trips already being of an intermodal character. This argument is strengthened by the questionnaire results presented in section 4.1: indeed, a large share of the respondents' total amount of commuting trips is already intermodal. Both the total commuting trips made per week and the total intermodal commuting trips made per week lie on average between 3 and 4 days per week.

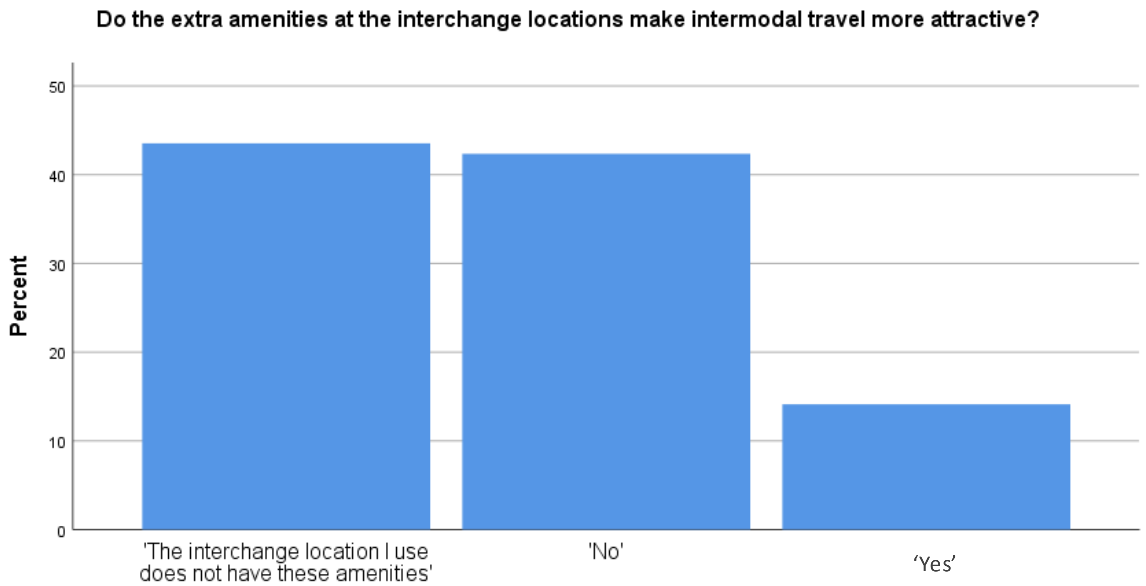

Figure 23: Effect of the extra amenities at interchange locations, such as dynamic departure information panels, free wifi and water tap points, on the attractiveness of intermodal travel

This study further investigated what amenities might stimulate travelers to choose even more often for intermodal commuting options, when added on their frequently used interchange location. Respondents were asked: 'Would you use intermodal commuting options more often if x amenity was added to 'your' interchange location?'. Changes in the level of service of public transport itself were also added. Figure 24 shows the result of this series of questions. Answers were measured on an ordinal scale ranging from 1: 'adding this amenity would have no such effect' to 3: 'adding this amenity could attribute to me commuting intermodally more often'. A neutral option was also added. People who already had said amenity on 'their' interchange location are excluded from this analysis.

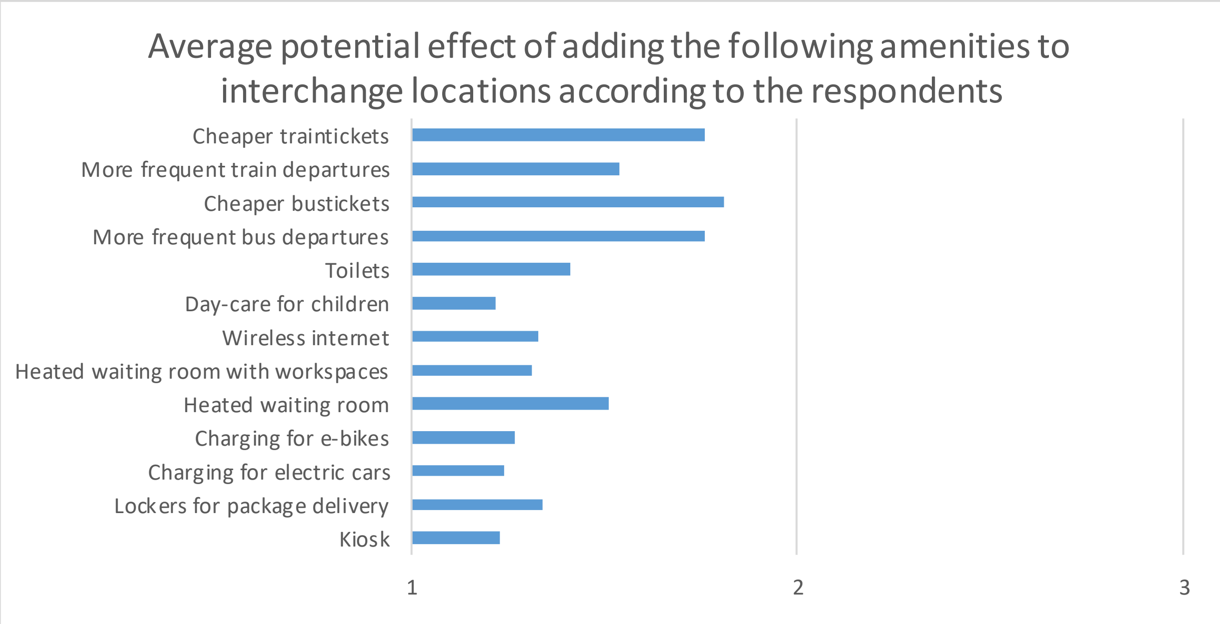

Figure 24: Average potential effect of adding the following amenities to interchange locations on the number of intermodal commuting trips made. 1= 'no effect', 2= 'neutral' and 3= 'This could stimulate me to make more intermodal trips

In general, it can be observed that, for all suggested amenities to be added, respondents find that they will have no real effect on the number of intermodal commuting trips they will make. The earlier discussed argument of a large share of the respondents' total amount of commuting trips already being intermodal might also have its effect in this question. It is an explanation of why these numbers are overall quite low.

Comparing the various 'amenities' still yields interesting results. The suggestions of adding amenities all scored relatively low as compared to suggested improved level of service of public transport itself. The same goes for lowering the cost of public transport. These results are not surprising as the basic level of service and the cost of public transport are things that are important for every public transport user. Even stronger, the literature provides evidence that public transport users find short travel time the most important (KIM, 2019). The suggested amenities to be added are often much more 'niche' than this, and thus interesting for a smaller share of users. This corresponds with findings presented in the KIM report titled 'The choice of the passenger' (2019). Time efficiency is situated at the bottom of the pyramid of customer wishes, which is inspired by the Maslow pyramid of human needs.

Chapter 5: Discussion and conclusion

In this chapter, the produced results will be thoroughly discussed in relation to earlier academic writing elaborated upon in the theoretical framework. The limitations of this study will also be discussed. Based on the presented findings, the research questions will be answered.

In section 5.1, the first research question will be answered: 'What are the characteristics of the intermodal commuters, and the characteristics of their intermodal commuting behavior, in and around Groningen?'. Section 5.2 relates to the second and fifth research questions: 'To what extent do personal socioeconomic characteristics affect intermodal commuting towards Groningen?' and 'To what extent does the mobility policy at the workplace affect intermodal commuting towards Groningen?'. The third research question will be answered in section 5.3: 'To what extent do the instrumental, affective and symbolic determinants of travel mode choice affect intermodal commuting towards Groningen?'. In section 5.4 the fourth research question will be answered: 'To what extent can amenities at multimodal hubs stimulate intermodal commuting towards Groningen?'. Subsequently, in section 5.5 the main research question will be answered and the implications for policymakers and transport planners are discussed. Thereafter, in section 5.6, the study is reflected upon. In the final section of this thesis, recommendations will be made to other scholars engaging in the topic of intermodal travel and multimodal hubs.

5.1 Travel behavior and characteristics of intermodal commuters the Groningen area

This study set out to find out what the characteristics of the intermodal commuters were, as well as the characteristics of their intermodal travel behavior. First, the findings on intermodal travel behavior are elaborated upon.

The results point out that the intermodal commuters in the sample mostly used Park & Ride and Park & Bike options. This is not very surprising as respondents were mostly recruited on the Park and Ride locations. However, the relative abundance of Park & Bike users as compared to Park & Ride users stands out. As many aspects of this study are influenced by it, this is also a result of the SARS-CoV-2 pandemic. Another important finding on intermodal travel behavior is that in the sample the respondents are already quite heavy intermodal users in the sense that a large share of their total amount of commuting trips is already intermodal. This affects the results of the ordinal regression analysis because the respondents had limited options to make more intermodal commutes in their workweek than they already do.

The results of this study further show that intermodal commuters in the sample live in relatively large households, are female, are highly educated and have a relatively high income as compared to the general Dutch population. Their average age corresponds quite well with the mean age of the working Dutch population, resulting in the intermodal commuter from the sample not being especially old nor young. The small sample size, however, makes it hard to generalize the findings in this study over the whole population of intermodal commuters.

These findings correspond partly with findings presented in existing academic literature already covered in the theoretical framework. Buehler and Hamre (2013) also found that in the United States people with higher incomes are more likely to be multimodal car users and multimodal 'greens' than people with middle income. The intermodal commuters in the sample have more in common with Buehler and Hamre's (2013) 'multimodal car users' since they were using mostly Park & Bike and

Park & Ride combinations. Kuhnimhof et al. (2006), found that multimodal people are more likely to be young or old, live in urban areas, are highly educated, have a small household size and do not own a driver's license. For intermodal commuters in the Groningen region, this is clearly different, except for the 'educational attainment' variable. The varying results of the studies are largely due to the targeted population, as Kuhnimhof et al. (2006) study Germany as a whole.

5.2 The effect of personal socioeconomic characteristics and mobility related policies at the workplace on intermodal commuting

The main aim of this study is to find out to what extent the determinants of travel mode choice play a role in stimulating intermodal travel. The conceptual model at the end of chapter 2 consists of all the variables that could be of influence in the choice for intermodal commuting options, according to existing academic literature. Ordinal logistic regression analysis was performed to assess which personal *socioeconomic characteristics* and what *mobility related policies at the workplace* were related to heavier intermodal use. No correlations were found here. This has likely to do with the fact that a large share of the respondents' total amount of commuting trips is already intermodal. The amount of intermodal commuting trips taken per week thus seems to be most affected by the total amount of needed commuting trips per week.

A lot of the respondents presumably worked at the academic hospital UMCG, this place is really well connected to all the Park and Ride locations via public transport. This is why here, intermodal commuting options can compete with monomodal car usage. To stimulate intermodal travel in cities around the world it is important to have well-functioning mobility chains in which interchanging is efficient and seamless like in Groningen. Although, not all workplaces are as well connected to the intermodal mobility system as the UMCG. Improving the connectivity of this system, by adding lines from Park and Ride locations towards other important workplace destinations is likely to further stimulate intermodal travel in Groningen and other cities alike.

Not only the solid embeddedness of the UMCG in the public transport network leads to an abundance of intermodal commuting, but mobility policy at the workplace also turned out to be an important determinant in this study. Large shares of the intermodal commuters reported that their employer does not offer free parking, has showering facilities and actively stimulated Park and Ride usage. As already stated in the theoretical framework, such policies can stimulate intermodal travel and usage of 'green' -and active- modes (Hamre and Buehler, 2014). Furthermore, the largest share of the intermodal commuters in the sample reported that the amount of mobility related benefits received was independent of the transport mode that they chose. This can also stimulate intermodal commuting as employees are not pushed in one direction. The freedom to choose a preferred combination of transport modes for the intermodal commute is as such retained. If intermodal commuting is to be further stimulated, city governments should aim to partner up with local employers, as mobility policy at the employer is important in determining travel demand. 'Groningen Bereikbaar' is a great example of such a regional public-private mobility partnership.

5.3 The effect of instrumental, affective and symbolic determinants on intermodal commuting

To study the effect of instrumental, affective and symbolic determinants on the choice for commuting intermodally, descriptive analysis of Likert-type questions was done. The variables that played the largest role in stimulating the choice for intermodal commuting options were identified. From this analysis, it became apparent that for the intermodal commuters in the sample most of the determinants were seen as relatively unimportant in their commuting style of choice. The UMCG employees feeling 'forced' to use intermodal commuting options is partly causing these overall low scores.

Three determinants, however, were seen as relatively important. These determinants were '*Flexibility*', *'autonomy'* and *'proximity of a transit stop to the workplace'*. To the intermodal commuters in the sample, these determinants were thus the qualities that made them mostly choose for either a Park and Bike of a Park and Ride commute. The combination of a car with highly frequent public transport or with a bike indeed makes for a highly flexible intermodal trip. *The proximity of public transport* to the workplace adds to this flexibility and facilitates short travel times, which is considered the most important determinant in trip satisfaction for public transport (KIM, 2019). '*Autonomy'* was also regarded as an important determinant in stimulating intermodal commuting. As existing literature attributed feelings of autonomy mostly to car use (e.g. Clauss and Döppe, 2016), this is probably also the case in this study as the sample consisted mostly of Park & Bike and Park & Ride users. However, the more frequent public transport operates, the more likely it is that feelings of *autonomy* are evoked. This is because commuters have more freedom and control in determining their arrival to- and departure from work. Bike usage, on the other hand, can also contribute greatly to feelings of *autonomy* as long as there is a well-functioning network of cycling infrastructure in place that ensures a safe and smooth trip.

5.4 To what extent can amenities at multimodal hubs facilitate intermodal commuting?

As interchanging is integral to intermodal travel, this study highlights the importance of interchange locations or multimodal hubs. Academic literature shows that interchanging is a weak link in travel with public transport because it adds to unreliability (Brons and Rietveld, 2010) and because waiting time lengthens the travelers' experienced travel time more than travel time spent in vehicles (Van Nes et al., 2014). Reducing waiting time by improving departure frequency, or adding amenities so waiting time can become productive and pleasant, might stimulate intermodal commuting.

In this study, respondents were asked what amenities and improvements would make them choose to make more intermodal commuting trips. As a large share of the respondents' total amount of commuting trips is already intermodal, the suggested improvements scored all low in the sense that they leaned to the side of extra amenities not being effective in stimulating intermodal commuters to make more intermodal commuting trips. The results indicate, however, that investing in affordability and frequency of departures has better chances to further stimulate intermodal commuting. These findings correspond with those of the Dutch KIM (Knowledge Institute for Mobility policy) who, in their 2019 report, state that short travel time and low cost of travel are in every person's interest. The more niche a suggested amenity is, the fewer people will be inclined to make more intermodal trips when this amenity is to be realized on the multimodal hub.

5.5 Answering the main research question and implications for policy

This study was guided by the following main research question: To what extent do the various determinants of travel mode choice play a role in stimulating intermodal commuting? This is answered through the answering of the five secondary research questions. However, for clarity an answer to the main research question is formulated here.

The results of the study underline the importance of progressive mobility policies of employers, as well as public transport systems and cycling infrastructure that connect multimodal hubs to workplaces, in stimulating intermodal commuting. This is true for Park & Bike and Park & Ride combinations specifically. Herein, it is important to ensure a public transport system that operates on a highly frequent basis. This can add to the levels of *autonomy* and *flexibility* that commuters experience while using intermodal travel options, as high frequency of departures gives people more freedom to choose when to travel to and from work. Providing highly frequent public transport also helps in reducing waiting time while interchanging between modes. Because literature shows that waiting time and interchanging are experienced negatively by travelers, decreasing waiting time on interchange locations can help stimulate intermodal commuting. Extra amenities at multimodal hubs do not seem to be effective in stimulating intermodal travel. Results indicate that investing in affordability and frequency of departures has better chances to further stimulate intermodal commuting.

In cities around the world, urban policymakers and infrastructure planners who wish to stimulate intermodal commuting should aim to realize high quality public transport- and cycling networks that connect multimodal hubs at the cities edges, to spatial clusters where many people work. By providing such infrastructural networks, intermodal commuting options become faster, easier and more reliable. Then these ways of commuting become viable when compared to the traditional monomodal commute by car. When, simultaneously, large employers stimulate 'green' mode usage, people are more likely to reinvent their commuting habits and switch to intermodal options. The results presented in this study indicate this. Thus, urban policymakers should also work with employers in the region to stimulate travel policies that favor 'green' mode use above car use. Policies that can achieve this should incorporate aspects as introducing paid parking at the workplace, limiting available parking space, making travel benefits independent of mode choice and providing facilities for showering and changing clothes as to stimulate the use of active modes. By stimulating intermodal commuting, cities around the world can reduce congestion, free up parking spaces, decrease carbon emissions and increase livability.

5.6 Reflection

5.6.1 The SARS-CoV-2 pandemic

The results of the study are heavily influenced by the SARS-CoV-2 pandemic. Because of the enforced 1,5 meter social distancing rule, the choice was made to mostly recruit respondents by spreading flyers on Park and Ride locations. This resulted in a sample that was not as diverse in respect to their intermodal commuting behavior as was originally aimed.

An interesting finding was the relative high share of Park and Bike users as compared to Park and Ride users. This is also due to the 'intelligent lockdown'. The use of collective modes of transport was discouraged during this period. Private modes of transport, such as cars and bikes, were still quite safe to use as their usage is much more unlikely to contribute to the spreading of the virus. Despite the 'intelligent lockdown', which requires people to work from their homes, usage of the bike in the Netherlands even increased during this period (NVP, 2020. See also figure 7). Park & Bike thus remained relatively popular during the 'intelligent lockdown' while the popularity of public transport and Park & Ride dwindled.

Another variable in the context during the period of data collection also heavily influenced further results of the study is the fact that the sample consists mostly of healthcare professionals presumably working at the academic hospital UMCG. As explained earlier this is also due to the intelligent lockdown in which everyone is advised to work from home as much as possible and public transport is only available for people with 'vital' professions. The UMCG is known for its progressive mobility policy, in which the use of active modes and park and ride is encouraged. The UMCG also has limited parking space and prioritizes access to parking for patients (RTV Noord, 2015). This is done by making parking at the hospital much more expensive for employees than using the abundant Park & Ride locations around the city. Because of this policy, employees are more or less forced to commute intermodally.

The combination of these circumstances; the 'intelligent lockdown' and the UMCG's progressive mobility policy, caused overrepresentation of UMCG employees in the sample. This resulted in the finding that a large share of the respondents' total amount of commuting trips is already intermodal. This finding, in turn, heavily influenced further results on the effects of the various determinants of travel mode choice on the 'choice' for intermodal commuting options. Needless to state, this study would probably have yielded different results if not for the SARS-CoV-2 pandemic. Because the sample is not representative of the whole population of intermodal commuters in the Groningen region, the presented findings cannot be generalized. The use of this study in informing mobility-related urban policy is as such also limited.

5.6.2 Choices made during the study

An effect of the small sample size is that the results of the ordinal regression- and descriptive analyses are not very well-defined. When certain patterns exist within a population that is being researched, these patterns are more likely to unfold when the sample is larger or more representative of the whole population. Thus, when more time and resources would have been invested in data collection, then the ordinal regression analysis would probably have yielded more telling and interesting results. The same goes for the analysis of the Likert-type questions. Because of the small sample size, the observed differences in the effects of the various variables on intermodal commuting were generally small.

In regard to the research design of this study, some different choices could have been made that would strengthen the analysis of the data. For example, in this study the choice was made to test the effect of amenities at multimodal hubs on stimulating intermodal commuting using descriptive statistical analysis of Likert-type questions. When, instead, the choice was made to use a different style of inquiry, it would have been possible to incorporate the questions about amenities at multimodal hubs in the ordinal regression model. This would have improved the analytical rigor in answering the related research question, as statistical tests are a more reliable method of analysis than interpretation of the compiled result of answers to Likert-type questions.

The broad theoretical approach that was used to approach the research questions has resulted in a comprehensive overview of the factors that influence intermodal commuting behavior. Yet, this broad theoretical scope may also have caused a lack of analytical depth. Narrowing the theoretical scope might open up opportunities for more in-depth statistical analyses.

However deliberately chosen, the phenomenon of intermodal commuting in general was also broad as a form of travel behavior to study. As described in this thesis, intermodal commuting manifests itself in many different forms. By choosing such a broad phenomenon to study, the presented results become less accurate as some determinants may be more important than others for specific forms of intermodal commuting. By further narrowing down the phenomenon under study, to for example only ‘park and bike’, more accurate results on the effect of the determinants of travel mode choice on this form of intermodal commuting might be produced.

5.7 Recommendations for further study

Providing solid intermodal infrastructure networks with seamless interchanging will remain important to keep our cities accessible and clean as well as to reduce carbon emissions. This study took a holistic theoretical approach in researching why people choose for intermodal commuting options. A lot of different determinants were taken into account; from classic instrumental determinants such as travel time to mobility-related policy at the workplace. Other scholars could use a similar framework to study the determinants of choice for intermodal travel mode choice in a quantitative study that does produce a representative sample. Then, findings can be generalized over larger populations, which will give urban planners and policymakers more reliable advice on how to stimulate intermodal travel in cities around the world. The used theoretical scope might also be applied in studies that concentrate on one more specific form of intermodal travel, such as Bike-Train-Bike trips. It would also be interesting to perform a similar study in a different city and compare the results.

Further, narrowing the theoretical scope might be of interest for researching the determinants of intermodal travel. By focusing on only a part of the conceptual model used in this study, scholars are able to dive deeper into the mechanisms of one of the determinants of intermodal travel. It would, for example be interesting to only study the effect of mobility related policies at the workplace on intermodal commuting behavior. A comparative approach, in which the effect of various mobility related policies at the workplace on intermodal commuting are tested and compared, would make for an interesting research project.

Another interesting topic of further study would be the effect of MaaS (mobility as a service) on stimulating intermodal travel. By integrating information and ticketing systems, MaaS has the potential to make intermodal commuting easier and more reliable.

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Appendix A: The questionnaire

Enquête intermodaal reizen via hubs

Introductie:

Ter afronding van mijn masterstudie 'Environmental and Infrastructure Planning' (planologie) aan de Rijksuniversiteit Groningen doe ik onderzoek naar intermodale woon-werk reizen via hubs in de omgeving van Groningen. Fijn dat u bij wilt dragen aan dit onderzoek!

Intermodaal reizen betekent reizen van A naar B met gebruik van meerdere vervoermiddelen door over te stappen. Een voorbeeld van intermodaal reizen is: reizen via een P+R; eerst met de auto en dan verder met de bus/trein. Ook reizen met het OV zijn vaak intermodaal. Veel mensen gaan bijvoorbeeld naar het station met de fiets en leggen de laatste kilometer te voet af naar hun eindbestemming. Wandelen telt in dit onderzoek alleen mee als vervoerwijze, wanneer er meer dan 5 minuten achter elkaar gelopen wordt als onderdeel van de woon-werk reis.

Ik kan me goed voorstellen dat uw huidige reispatronen heel anders zijn dan normaal als gevolg van het coronavirus en de maatregelen hieromtrent. In deze enquête kom ik graag meer te weten over uw manier van verplaatsen in de situatie vóór het coronavirus.

Uw deelname aan dit onderzoek is volledig anoniem. De antwoorden die u geeft zijn na het invullen niet meer terug te herleiden naar u als persoon. U kunt altijd stoppen met de enquête door de pagina weg te klikken. Het invullen van de enquête duurt ongeveer 10 minuten. Voor vragen over dit onderzoek kunt u mailen naar l.j.schaafsma@student.rug.nl

-Luuk Schaafsma

Begin Enquête
***Pagina 1**: Controlevragen*

Werkt u in de stad Groningen?
O Ja O Nee

Reist u meerdere keren per maand intermodaal* van uw huis naar uw werk?

**Intermodaal reizen betekent 'met meerdere vervoermiddelen van A naar B'. Wandelen telt in dit onderzoek alleen mee als vervoermiddel, wanneer er meer dan 5 minuten achter elkaar gelopen wordt als onderdeel van de woon-werk reis.*

O Ja O Nee

Via welke overstaplocatie/hub reist u meestal? (bijvoorbeeld Station Zuidhorn, P+R Haren of de bushalte Boltbrug in Ten Boer)
…….

Hoe vaak reist u via deze overstaplocatie?

O minder dan 1 keer per week O 3 keer per week
O 1 keer per week O 4 keer per week
O 2 keer per week O 5 keer per week of vaker

**Met meerdere vervoermiddelen van A naar B reizen door over te stappen. Wandelen telt ook als vervoermiddel, mits er 5 minuten of langer gelopen wordt als onderdeel van de woon-werk reis.*

Pagina 2*: vragen over intermodaal reisgedrag*

Hoe vaak per week reist u naar Groningen om te werken?

O minder dan 1 keer per week	O 3 keer per week
O 1 keer per week	O 4 keer per week
O 2 keer per week	O 5 keer per week of vaker

Hoe vaak is gemiddeld uw woon-werk reis intermodaal*?
**Met meerdere vervoermiddelen van A naar B reizen door over te stappen. Wandelen telt ook als vervoermiddel, mits er 5 minuten of langer gelopen wordt als onderdeel van de woon-werk reis.*

O minder dan 1 keer per week	O 3 keer per week
O 1 keer per week	O 4 keer per week
O 2 keer per week	O 5 keer per week of vaker

Wat zijn de 4 cijfers van de postcode van uw werkadres?
….

Hoe ziet uw intermodale woon-werk reis er meestal uit?

Eerste deel van de reis:
O Wandelen
O Fiets/e-bike
O Auto

Tweede deel van de reis:
O Bus
O Trein
O Wandelen
O Fiets

Derde deel van de reis:
O Wandelen
O Fiets/e-bike
O Niet van toepassing

Hoe reist u naar uw werk wanneer u niet voor een intermodale optie kiest?
O Met de auto
O Op de fiets
O Op de e-bike/speed pedelec
O Op de brommer
O Met de bus (uw woon en werklocatie liggen beiden vlakbij een bushalte)
O Met de trein (uw woon en werklocatie liggen beiden vlakbij een treinstation)

Pagina 3: *vragen over het belang van verschillende variabelen bij de keuze voor de meest gebruikte intermodale optie*

In hoeverre bent u het eens met de volgende stellingen?
-Helemaal mee oneens -mee oneens -neutraal -mee eens -helemaal mee eens

- De lage reiskosten van mijn intermodale reis is een belangrijke reden dat ik op die manier naar mijn werk reis.
- De korte reistijd bij mijn intermodale reis is een belangrijke reden dat ik op die manier naar mijn werk reis.
- De hoge frequentie van het vertrek/aankomst van bussen is een belangrijke reden dat ik voor een intermodale woon-werk reis kies.
- De nabijheid van bus/treinstations bij mijn **werk**adres is een belangrijke reden dat ik voor een intermodale woon-werk reis kies.
- De nabijheid van bus/treinstations bij mijn **woon**adres is een belangrijke reden dat ik voor een intermodale woon-werk reis kies.
- De hoge mate van privacy die ik tijdens mijn reis ervaar is een belangrijke reden dat ik voor een intermodale woon-werkreis kies.
- Hoe leuk ik intermodaal reizen vind is een belangrijke reden dat ik voor een intermodale woon-werkreis kies.
- Lagere CO_2-uitstoot is een belangrijke reden dat ik voor een intermodale woon-werkreis kies
- De hoge gebruiksvriendelijkheid van deze manier van reizen is een belangrijke reden dat ik voor een intermodale woon-werkreis kies.
- De mogelijkheid om tijdens het reizen andere dingen te doen is een belangrijke reden dat ik voor een intermodale woon-werkreis kies.
- De invloed van mijn keuze op de bereikbaarheid van Groningen is een belangrijke reden dat ik voor een intermodale woon-werkreis kies.
- De hoge mate van ontspanning die ik tijdens mijn woon-werkreis ervaar is een belangrijke reden dat ik voor een intermodale woon-werkreis kies.
- Het financiële voordeel als gevolg van regelingen bij mijn werkgever is een belangrijke reden dat ik voor een intermodale woon-werkreis kies.
- Goede informatievoorziening tijdens de reis (over bijvoorbeeld aankomst en vertrektijden is een belangrijke reden dat ik voor een intermodale woon-werkreis kies.

In hoeverre bent u het eens met de volgende stellingen?
-Helemaal mee oneens -mee oneens -neutraal -mee eens -helemaal mee eens

- Milieubewuste keuzes maken is een belangrijk onderdeel van mijn identiteit.
- Ik vind het belangrijk dat anderen mij zien als een milieubewust persoon.
- Autorijden is een belangrijk onderdeel van mijn identiteit.
- Ik zie auto’s als een statussymbool.
- Sportieve keuzes maken is een belangrijk onderdeel van mijn identiteit.
- Ik vind het belangrijk dat anderen mij zien als een sportief persoon.

Pagina 4: *vragen over het mobiliteitsbeleid van de werkgever*

Kunt u gratis uw auto parkeren bij uw werkgever?
O Ja   O Nee

Worden uw reiskosten voor uw woon-werkreis met de **auto** vergoed?
O Nee O Deels O Volledig

Worden uw reiskosten voor uw woon-werkreis met het **OV** vergoed?
O Nee O Deels O Volledig

Wanneer krijgt u de hoogste reiskostenvergoeding voor uw woon-werk reis?
O Als ik met het OV reis
O Als ik met de auto reis
O Als ik met de fiets/e-bike/speed pedelec reis
O Mijn reiskosten met het OV en met de auto worden in gelijke mate vergoed
O Mijn reiskostenvergoeding is niet afhankelijk van welk vervoermiddel ik kies.

Zijn er bij uw werkgever faciliteiten om te douchen en om te kleden?
O Ja   O Nee

Wordt P+R gebruik gestimuleerd door uw werkgever?
O Ja   O Nee

Pagina 5*: vragen over de overstaplocatie/hub.*

Sommige overstaplocaties/hubs hebben extra faciliteiten zoals een kiosk, een watertappunt, dynamische informatievoorziening over vertrektijden en gratis wifi. Maken deze faciliteiten het voor u aantrekkelijker om intermodaal te reizen?

O Ja   O Nee   O De overstaplocatie die ik regelmatig gebruik heeft deze faciliteiten niet

Reist u vaker intermodaal naar uw werk sinds er op ‘uw’ overstaplocatie/hub extra faciliteiten zijn toegevoegd? (Bijvoorbeeld een kiosk, een watertappunt, dynamische informatievoorziening over vertrektijden en gratis wifi)

O Ja   O Nee   O Niet van toepassing

In hoeverre zou u vaker intermodaal naar uw werk reizen als er op ‘uw’ overstaplocatie:
-geen effect -neutraal -Dit zou eraan kunnen bijdragen dat ik vaker intermodaal reis -‘Mijn’ overstaplocatie heeft deze faciliteit al

- Een kiosk was?
- Kluizen waren om bestelde pakketjes op te halen?
- Oplaadpalen waren voor elektrische auto’s?
- Oplaadpalen waren voor elektrische fietsen?
- Een verwarmde wachtruimte was?
- Een verwarmde wachtruimte met werkplekken was?

- De bussen vaker reden?
- De busritten goedkoper waren?
- De treinen vaker reden
- De treinreis goedkoper was
- Gratis wifi was?
- Er een kinderopvang aanwezig was?

Pagina 6: *Vragen over de life situation*

Wat is uw geboortedatum?
(DD-MM-JJJJ)

Wat is uw geslacht?
O Vrouw   O Man

Wat zijn de vier cijfers van uw postcode?
….

Wat is uw hoogst voltooide opleiding?
O Basisonderwijs/ lager onderwijs
O Lager beroepsonderwijs of vglo, lavo, mavo, mulo, vmbo
O Middelbaar beroepsonderwijs of havo, atheneum, gymnasium, mms, hbs
O Hoger beroepsonderwijs, universiteit
O Andere opleiding
O Geen opleiding voltooid

Uit hoeveel personen bestaat uw huishouden (uzelf meegerekend)?
…personen

Bestaat uw huishouden uit (stiefkind, pleegkind e.d. tellen als kinderen):
O Eén persoon
O Echtpaar/vaste partners
O Echtpaar/vaste partners met thuiswonend(e) kind(eren)
O Echtpaar/ vaste partners met thuiswonend(e) kind(eren) en ander(en)
O Echtpaar/ vaste partners met ander(en)
O Eén ouder met thuiswonend(e) kind(eren)
O Eén ouder met thuiswonend(e) kind(eren) en met ander(en))

Heeft u een autorijbewijs?
O Ja   O Nee

Hoeveel auto's zijn er in uw huishouden aanwezig?
….

Hoe hoog is uw netto besteedbaar jaarinkomen?
O tot 20.000 euro
O 20.000 tot 34.000 euro

O Meer dan 34.000 euro
O Dat wil ik liever niet invullen

Einde enquête.

Hartelijk dank voor uw bijdrage!

Appendix B: The flyer used for promotion

university of groningen / faculty of spatial sciences

Hoi!

Mijn naam is Luuk Schaafsma. Ter afronding van mijn masterstudie 'Environmental and Infrastructure Planning' (planologie) aan de Rijksuniversiteit Groningen doe ik onderzoek naar intermodale woon-werk reizen via P+R locaties in de omgeving van Groningen.

U zou mij hierbij enorm helpen door mijn enquête in te vullen. Dat kan door de QR code hiernaast te scannen met uw smartphone of door onderstaande link in te typen in uw browser.

Alvast bedankt!

https://groningenbereikbaar.typeform.com/to/veWMkQ