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The influence of environmental concerns and land use patterns on the individual travel behaviour of suburban residents: a comparative study between Haarlem and Groningen

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Abstract

Trends regarding suburbanisation have resulted in high car dependency among suburban residents and have led to promotion of use of automobiles for commuting. As a result, atmospheric concentrations of greenhouse gases and pollution particles have increased progressively. A thorough understanding of the factors that drive individual travel behaviour is essential to designing effective policy interventions aimed at achieving a shift towards more sustainable and less polluting travel patterns. Although literature suggests that raised concerns about the environment and land use patterns influence travel behaviour, the extent to which these factors influence individual travel behaviour remains uncertain.

This study aims to contribute to the understanding of individual travel behaviour by using quantitative empirical data and analysis. In order to reveal universal social patterns, a comparative method is used to separate results that are more general from the context laden environment. The research question is defined as follows: *To what extent do environmental concerns and land use patterns influence individual travel behaviour of daily commuting suburban residents of Haarlem and Groningen?*

A sample of 271 suburban residents from Haarlem and Groningen has been analysed using binary logistic regression and linear regression. Only very limited influence of environmental concerns on individual travel behaviour is found. The regression models show that multiple land use dimensions contribute to explaining individual travel behaviour. For instance, density plays an interesting role in explaining use of motorised vehicles and bicycles for commuting and in explaining teleworking.

Suggestions for future work include collecting more data and experimenting with other types of analysis. Also a greater focus on land use patterns could produce interesting findings that account more for the extent to which land use patterns influence travel behaviour.

Keywords: *Suburbanisation, car dependency, commuting, transport policy, land use policy, individual travel behaviour, environmental concerns, land use patterns.*

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CO_2	Carbon dioxide formula	8
CBS	Centraal Bureau voor de Statistiek	8
IPCC	Intergovernmental Panel on Climate Change	8
ITB	Individual Travel Behaviour	9
EC	Environmental Concerns	9
LU	Land Use patterns	10
Covid-19	Corona Virus Disease 2019	33
SPSS	Statistical Package for the Social Sciences	38
NEA	Nationale Enquête Arbeidsomstandigheden	38
Sig.	Significance probability	46
B	Unstandardized beta, B coefficient	46
Exp(B)	Exponentiation of the B coefficient	46

Introduction

During the 20th and 21st century atmospheric concentrations of greenhouse gases have increased progressively due to human activities (Solomon et al., 2009). The most harmful greenhouse gas with regards to global warming, CO_2, is emitted by transport (Santos, 2017). If global warming, fuelled by CO_2 emissions, exceeds the safety threshold of +2°C determined by the Intergovernmental Panel on Climate Change (2014), then the consequences could be catastrophic. For instance, animal species become extinct, parts of the world will suffer from severe drought and other parts will flood (IPCC, 2014).

Over the years, the use of automobiles for transportation has increased (Antrop, 2004). While in various regions CO_2 emissions from other sectors such as industry and agriculture are generally decreasing, those from transport have continued to increase (European Commission, 2016). According to the Dutch central statistical office (Centraal Bureau voor de Statistiek) in the Netherlands, road traffic is responsible for 18,2% of greenhouse gas emissions (CBS, 2018[a]). A large share of road traffic within the Netherlands consist of suburban population. Within the Netherlands, trends regarding suburbanisation have resulted in high car dependency among suburban residents (Bontje, 2001). Dutch suburban residents thus contribute considerably to, for example, CO_2 emissions.

Furthermore, automobiles and other road traffic have major health impacts. Air pollution is one of the important determinants of health that is negatively affected by transportation patterns (Hosking et al., 2011; Raza et al., 2018). In the Netherlands over 15% of the particulate matter (PM) emissions is emitted by road traffic (Centraal Bureau voor de Statistiek, CBS, 2017). PM emissions are of high risk for human health, as PM penetrates deeply into the human body (Marshall, 2013). In 2009 it was found that within the Netherlands around 3000 people die prematurely as a result of short-term exposure to particulates (Priemus & Schutte-Postma, 2009). Tackling environmental issues such as climate change and air pollution is thus one of the most important challenges for governments of this time. For the transport sector, or more specific, road traffic, emissions are still increasing. Reducing emissions in transport is more costly than in other sectors, as transport still heavily relies on fossil fuels and clean transport technologies are costly (Santos, 2017). In 2014, the Netherlands and its economy depend for 90% on fossil fuels, with the highest dependence regarding the energy sector and the transport sector (Den Brinker, 2014). Additionally, even though it has been proved that the emissions have effect on public health and environmental issues, suburbanisation and the corresponding car dependence is still a growing phenomenon in the world. Achieving a reduction in emissions and pollution will thus not be possible via technical progress alone; it requires a substantial behavioural change of individuals as well (Roberts et al., 2018). Such a behavioural change is of extra importance with regards to car-dependent suburban individuals. Gaining understanding of individual behaviour is becoming increasingly important. As a result, among others, transport geographers and policy makers have become interested in understanding individual travel decision making (Dawkins et al., 2018; Roberts et al., 2018).

A thorough understanding of the factors that drive individual behaviour is essential to designing effective policy interventions (Roberts et al., 2018). It is becoming increasingly recognised that rational and purposeful arguments alone are insufficient to explain why most measures to restrict car use do not lead to change (Anable, 2005). One topic of discussion in this regard is the extent to which individual environmental concerns can motivate changes in behaviour (Roberts et al., 2018). Increasingly, the body of literature on travel mode choice or individual travel behaviour and psychological factors is expanding (Anable, 2005; Roberts et al., 2018; Steg et al., 2001; Van Acker et al., 2007). For example, Anable (2005) has applied the theory of planned behaviour (TPB) to explore attitude-behaviour relations, clustering day trip travellers with potential for travel mode switching. Steg et al. (2001) investigated the motives for car use and found that, in addition to instrumental reasoned motives such as travel cost, travel time an safety, motives that have to do with the symbolic function of a car also influence car use of an individual. Despite the growing attention from academics to this topic, the understanding of the factors driving individual travel behaviour remains limited. Within the body of literature regarding travel behaviour travel mode choice, modal choice and (individual) travel behaviour are used interchangeably. For this research, the term "individual travel behaviour", abbreviated as "ITB" in this work, will be used. ITB is used because travel behaviour of individuals involves more than just mode choice.

In order to tackle environmental issues as climate change and air pollution, it is important that peoples' concerns about the environment are raised. This raised awareness might contribute to changing their behaviour (Soltani et al., 2019). Raised concerns about the environment are termed environmental concerns (Roberts et al., 2018), which, are referred here as 'EC variables'. Evidence suggests that environmental concerns have a great influence on individual travel behaviour. The study of Roberts et al. (2018) is an example of a study which has attempted to evaluate the extent to which individual environmental concerns can motivate travel behaviour habits that are more environmentally friendly. Although Roberts et al. (2018) found evidence that confirms the relation, other literature that has investigated this relationship is pessimistic (e.g. Susilo et al., 2012). Additionally, the research of Roberts et al. (2018) and Gifford, (2011) suggests that people do express concern about climate change, however this rarely brings about change towards more sustainable behaviours.

Whilst some research has been carried out on individual environmental concerns motivating behavioural change, few studies have been found which investigate the extent to which environmental concerns influence ITB. The studies of Roberts et al. (2018), Soltani et al. (2019) and Susilo et al. (2012) carried out research on the relation between environmental concerns and ITB. These studies have shown differences in findings. As the relative importance of environmental concerns for ITB and commuting choices has been subject to considerable contrariety and, only few studies have investigated this relation, this indicates that there is a relative paucity on the existence of this relation. Therefore, this research aims to tackle this research gap by investigating environmental concerns as a factor driving individual travel behaviour using quantitative empirical data and analysis.

In addition to environmental concerns, other factors have been found that might influence ITB. Land use patterns and ITB have been the subject of many studies. Factors such as density and diversity are part of land use patterns. However, the extent to which land use patterns influence travel behaviour of individuals is debated. For example, Van Acker et al. (2007) argue that living in a high-density and mixed-use neighbourhood is associated with fewer motorised vehicle trips and shorter travel- distances and times. However, their study has been unable to demonstrate this relation. Other studies such as the study of Van Wee & Hoorn (2004) did find that the relative impact of land use on travel behaviour is important. Although research has been carried out on land use patterns and ITB, the results are conflicting. The scientific understanding of this relation thus remains limited. Therefore, this research aims to tackle also this research gap by investigating land use patterns as a factor driving individual travel behaviour using quantitative empirical data and analysis. Throughout this research variables that measure land use patterns are referred to as ‘LU variables’.

This research thus attempts to contribute to the understanding of ITB by combining environmental concerns (EC variables) and land use patterns (LU variables) as variables that might influence ITB. This research focuses on the travel behaviour of suburban residents that usually commute daily to work. The combination of these aforementioned variables has not yet been investigated. This research will take place in the context of the Netherlands and will compare suburban population of two Dutch cities Haarlem and Groningen. This research attempts to add to the understanding of the complexity of travel behaviour of commuters in order to facilitate a modal change away from car. A focus on the suburban, car dependent population is most suited. Therefore, the corresponding central research question thus is the following:

To what extent do environmental concerns and land use patterns influence individual travel behaviour of daily commuting suburban residents of Haarlem and Groningen?

This question will be answered making use of the following sub-questions:

1. Is the travel behaviour of daily commuting suburban respondents of Haarlem and Groningen changing towards travel behaviour patterns that are more sustainable, due to environmental concerns?
2. How did the 'EC variables' and 'LU variables' play a role in the individual travel behaviour of the daily commuting suburban residents of Haarlem and Groningen?

The results of this study can be valuable for governments looking to add tools to their climate change policy toolbox in an effort to change travel behaviours of commuters in order to tackle environmental issues (Roberts et al., 2018). These policy tools are meant to reduce the impacts of deleterious human activity (Palmer, 2018). As Anable (2005) states, it is widely recognised that addressing unsustainable travel behaviour requires a thorough understanding of travel behaviour and the reasons for, for example, choosing one mode of transport over another. The main goal of this paper with respect to societal relevance is contributing to solutions for environmental issues as climate change and air pollution.

This research is divided in 7 parts. The first section of this paper will examine existing theories in the field of environmental concerns, land use patterns and ITB. The second section discusses the methodology used for this study. The third section presents the findings of the study, in the context of the theory. As a first step, the samples of Haarlem and Groningen will be compared. Comparable available data of the Netherlands as a whole will be used as a frame of reference. Thereafter the data will be statistically analysed. The paper ends with discussion, conclusion and reflection.

Theory

Within this theory chapter relevant theories are presented and reviewed. This chapter is divided in multiple sections. The first section discusses the implications of suburbanisation and car dependency trends. The second section discusses theories regarding travel behaviour. The second section is divided in subsections, involving the concept of ITB and commuting, types of factors that influence ITB, theory on the relation between ITB and environmental concerns and theory on the relation between ITB and land use patterns. Within the third section existing ITB policies linked to environmental concerns are discussed, while the fourth section discusses land use concepts aimed at influencing ITB.

2.1 Implications of suburbanisation and car dependency

Within Europe, the second half of the twentieth century is particularly viewed as a period of suburbanisation. Suburbanisation regards the movement of the resident population from the inner cities into the surrounding areas (Kilper, 2018). Especially since the 1960s, the European urban landscape has been transformed by decentralising forces. Between 1970 and 1975, the main trends in the Netherlands regarded a great population loss for larger cities and a fast growth rate in urbanised rural and especially suburban municipalities (Bontje, 2001).

In both the Netherlands and Europe, the trends regarding decentralisation and suburbanisation came with other trends, for example regarding mobility. One of these mobility trends was the increase in car traffic (Bontje, 2001). Already in the 1950s, the spatial context of cities and regions in the western world have been adapted and shaped in order to facilitate the daily use of automobiles (Wiersma et al., 2016). The availability of cars has fostered further decentralisation and urban sprawl (Motte-Baumvol et al., 2009). The residential and employment density rates have remained considerably high within Europe's urban cores (Riguelle et al., 2007). Therefore, especially the suburban areas have been shaped for the facilitation of cars.

Suburban residents are usually equipped with a family house, garden and a car, and are living car-dependent lifestyles (Hesse & Siedentop, 2018). As aforementioned, until today, low-density suburban environments are associated with higher car use in both Europe and the US (Schwanen & Mokhtarian, 2005). The car, that has gained a central role in mobility, has further contributed to the transformation of these areas. The structuring of suburban areas around the mobility that the car permits has resulted in, among other things, longer commuting distances for suburban areas (Berger, 2004) and less availability of alternative forms of transport (Motte-

Baumvol et al., 2009). Especially the spatial conditions, that have been co-determined by increasing use of automobiles, have resulted in the Dutch society being dependent on cars (Wiersma et al., 2016). Suburbs are limiting travel choices, as all options but the automobile option are physically designed out (Cervero & Gorham, 1995). In contrast, factors regarding modern life requirements only play a very limited role with regards to car dependency (Wiersma et al., 2016).

Car dependency is often defined as the lack of travel mode alternatives due to higher time, effort or financial cost factors (Jeekel, 2013; Wiersma et al., 2016). Travel behaviour is not always related to car dependency. People can choose to use a car while other travel modes are available at comparable efforts. Nevertheless, the assuming of car use as the dominant mode in decisions on transport, infrastructure and land use results in car dependency, even if other modes are available. For example, lacking information about alternative travel modes can result in car dependency in such a situation (Wiersma et al., 2016). Especially people with daily returning mobility patterns such as commuting in a car-oriented environment such as suburbs will need a car on a daily basis and tend to own it (Wiersma et al., 2017).

As aforementioned, trends of decentralisation have influenced travel patterns in the Netherlands. Decentralisation has resulted in 'criss-cross' travel patterns in urban areas. The daily trips, such as commuting trips, are no longer for the largest part between suburbs and the city. Travel patterns have shifted towards city-to-city and suburb-to-suburb characterised patterns (Bontje, 2001). The strong concentration of jobs in the city centre has disappeared and have become polycentric instead of monocentric. Dutch urban areas now have several employment areas. As a result, commuting patterns have become tangential instead of radial (Schwanen et al., 2001). Due to employment density rates still being considerably high, radial commuting patterns continue to exist (Riguelle et al., 2007). The shift towards increasingly polycentric areas, where suburban residents are employed in suburban areas, has the same effect as suburbanisation with regards to the promotion of use of automobiles for commuting (Schwanen et al., 2001).

The rise of suburbs and corresponding car dependency has dramatically added to the environmental footprint of the average household. Since a number of years, one has become aware of climate change harming and threatening the planet and its inhabitants (Cervero et al., 2018). Environmental concerns have raised doubts about the role of the car in contemporary mobility (Motte-Baumvol et al., 2009). According to Cervero et al. (2018), areas dependent on cars consume substantially more land, fossil fuels, and natural habitat than areas that are more compact and oriented towards multimodal based travelling. Car dependent areas also tend to produce substantially more pollution. Such problems caused by urban transport are due to the dependence on fossil fuels of private vehicles such as cars (Cervero et al., 2018). Indirect effects of pollution damage health and cause problems related to asthma, bronchitis, leukaemia and lung disease (Banister, 2008). Adding to the environmental benefits, moving away from car dependency can thus have public health benefits as well. Additionally, the increase in walking, biking, and other physical activity such a shift results in has benefits for health as well (Cervero et al., 2018).

From an environmental perspective, car dependency is a large contributor to climate change (Cervero et al., 2018). As aforementioned, the most harming greenhouse gas causing climate change, CO_2, is heavily emitted by automobiles and other road traffic (Santos, 2017). Attempts in improving natural environments through changes in urban structures must at some level contribute to reducing the dependence on cars and fossil fuels (Cervero et al., 2018). Yet, car dependence and the increased decentralisation of cities are processes which are difficult to reverse (Banister, 2008). Additionally, although the concept of sustainability has become widely accepted in many academic discourses over the past years, measures aimed at behavioural change towards a more sustainable way of living are facing constraints and resistance. Especially sustainability measures related to daily travel behaviour of individuals face much lower levels of acceptance, despite the contribution of travelling to climate change (Prillwitz & Barr, 2011). However, such acceptance is required. Technology can, at best, make a substantial contribution to reducing the rate at which fossil fuels are consumed for travelling. The underlying growth in transport means that other actions, such as behavioural changes, are required to reduce problems caused by transport (Banister, 2000). In order to stimulate intense car users to travel with other modes such as public transport, many (policy) efforts are required (Steg, 2003).

Spatial measures advocated to attempt to reduce the use of automobiles include, among other measures, the compact city concept, high residential and employment densities, mixed land use and the availability of public transport (Wiersma et al., 2017). Such measures trigger a shift in travel mode use towards modes that are more sustainable. Bertolini & Le Clercq (2003) suggest that more sustainable travel behaviour can be reached if people, by not using a car, can perform the same or a greater number of activities:

(a) without travelling,

(b) by walking or cycling,

(c) by using public transport,

(d) or by the more efficient use of cars or use of cleaner cars.

Such a shift in travel behaviour towards patterns that are more sustainable has implications for both transport and land-use policy. Within their study, Bertolini & Le Clercq (2003) have presented a schematically illustration which displays implications of the suggested changes in travel behaviour. An adapted version of this illustration is presented in figure 2.1. The terminology of the figure has been adapted in order to match the terminology used within this research.

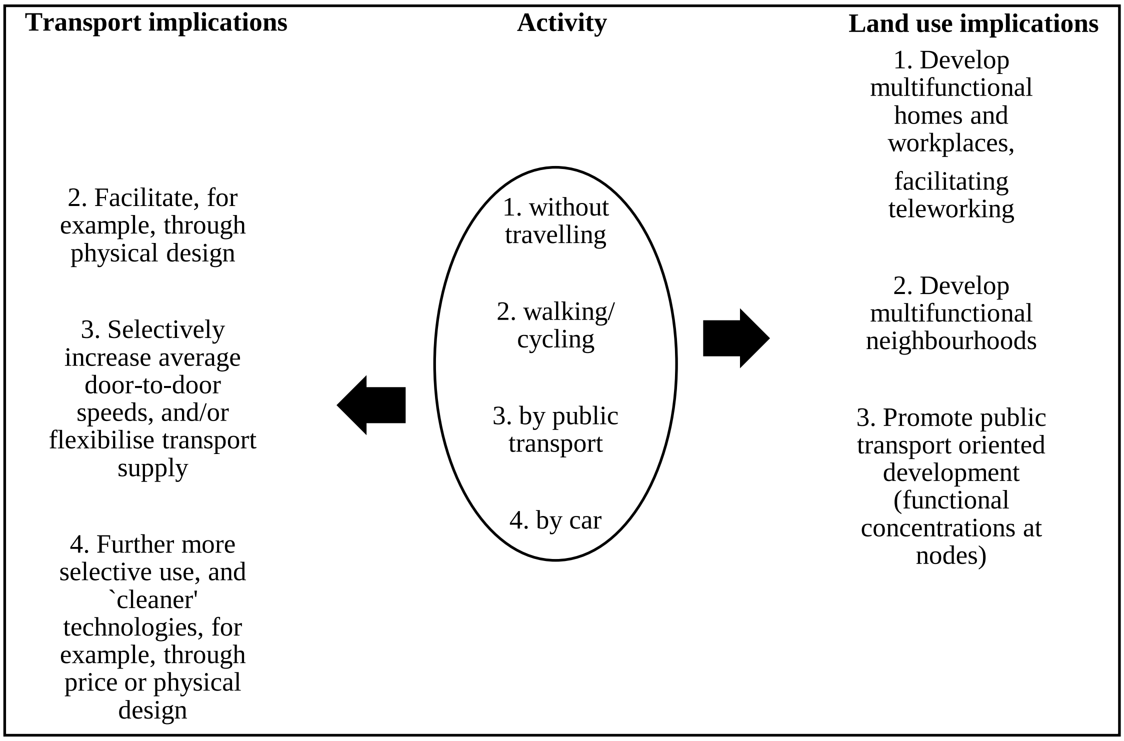


Figure X: Policy implications of sustainable urban mobility patterns. After Bertolini & Le Clercq (2003)

As can be seen in figure 2.1, both transport implications and land use implications affect the physical design. Such physical measures are considered to be highly effective policy measures with the aim of discouraging care use of individuals (Bertolini & Le Clercq, 2003). However, as society has become more complex, travel behaviour and its relation to factors such as land use are also likely to have become more complex (Maat et al., 2005). Additionally, it has become apparent that travel behaviour has a complex relation with situational and personal factors (Prillwitz & Barr, 2011). While the implications suggested by Bertolini & Le Clercq

(2003) are a good starting point for transport policy makers aiming for a reduction in car use, a more thorough understanding of travel behaviour and other strategies might be required in order to realise the desired shift towards more sustainable patterns of travel behaviour.

2.2 Individual travel behaviour

2.2.1 Individual travel behaviour of commuters

Travelling happens for various reasons. People travel mainly because they want to participate in activities at different locations (Van Wee et al., 2002). Accessibility is indicated by the possibilities for travelling. Accessibility regards the number and the diversity of locations for different type of activities that can be reached (Bertolini & Le Clercq, 2003). Activities such as work and recreation are among the possible motivations for travelling (Van Wee et al., 2002). The behaviour of an individual with regards to travel patterns is called travel behaviour. Travel behaviour is about personal behaviour and usually focuses on individuals (Brög et al., 2009). Studying travel behaviour gives insights into the choices that individuals make about their daily travel (Clifton & Handy, 2003). These insights regard to daily individual choices (Calastri et al., 2018). The concept of travel behaviour usually is associated with travel mode choices. As stated by Anable (2009), a detailed understanding of travel behaviour is connected to the reasons for choosing one travel mode over another. However, ITB as a concept involves more than just choosing one mode over another. It involves combination choices of different travel modes (Dawkins et al., 2018), the choices in destinations (Calastri et al., 2018), the distance travelled (Schwanen et al., 2001), the number of trips, the moment of travel (day) and the timing of travel (peak) (Hamer et al., 1991). For this research that focuses on a commuting population, some of the aforementioned aspects are less applicable than others. Gaining understanding of the ITB concept in the broadest sense is important. It is widely recognised that for addressing unsustainable patterns of travel a thorough understanding of travel behaviour is required (Anable, 2009).

Out of the dimensions of ITB discussed above, mode choice for commuting might be the dimension of travel behaviour that has been studied most thoroughly (e.g. Banister, 2011[b]; Calastri et al., 2019; Schwanen et al., 2001; Schwanen & Mokhtarian, 2005; Vale, 2013). A study that has investigated ITB in the Dutch context and has focused on another aspect of travel behaviour is the study of Hamer et al. (1991). Hamer et al. (1991) have studied teleworking in the Netherlands and the corresponding changes in travel behaviour. They found that teleworking has resulted in a significant decrease in the total number of trips by commuters.

Additionally, they found a decrease in peak hour traffic by car and a decrease in trips made by household members of the teleworkers (Hamer et al., 1991).

According to literature, ITB of commuters is critically influenced by the distance of the commute (Banister, 2011[b]; Vale, 2013). However, the findings of Vale (2013) suggest that a decrease in commuting distance is not enough to trigger a change towards travel modes that are more sustainable in comparison to cars. Evidence provided by Calastri et al. (2019) shows that out of all trips, people are most willing to change ITB regarding commuting purposed trips. This willingness results in gaining a thorough understanding of ITB of commuters specifically being very valuable. Changes in the behaviour of commuters can contribute greatly to the tackling of environmental issues such as climate change and air pollution.

2.2.2 Attitudes, demographics and infrastructure

Since the emerging popularity of ITB as research topic, analyses have made it possible to differentiate people's subjective and objective situations and to determine the opportunities for travel behaviour change to environmental-friendly modes (Brög et al., 2009). Early research on ITB have attempted to identify the characteristics of people open to change in their travel behaviour (e.g. Steg & Vlek, 2009). More recently, there has been an increasing interest in the nature and source of car-oriented attitudes, resulting in the application of psychology to the study of mode choice (e.g. Steg et al., 2001; Hunecke et al., 2007).

Conceptualisations of the nature and source of attitudes contribute to the understanding of individuals' barriers to change (Anable, 2005). Psychological theories, such as the Theory of Planned Behaviour have been applied to explain ITB by personal factors rather than preferences for different transport modes (Gardner & Abraham, 2010; Hunecke et al., 2007). This theory regards attitude, subjective norm, perceived behavioural control, and intention as predictors of behaviour in general (Ajzen, 1991). Hunecke et al. (2007) argue that such theory offers an adequate theoretical framework to explain ITB. Applications of the theory on travel behaviour provide strong empirical support and the theory is comprehensive due to the use of only four predictors. However, further attitudinal factors influencing ITB can be identified that are not measured by this theory. According to Hunecke et al. (2007), two types of personal factors are relevant for ITB. Sociodemographic factors, such as age or employment status, determine individual options and necessities. Attitudinal factors, such as values, norms and attitudes, affect preferences. Steg et al. (2001) reveal that symbolic attitudes as pleasure, excitement, prestige and social comparison are as relevant as time, financial cost and driving conditions for using a car. Additionally, it is suggested that such motives might even be most important for travel mode choice (Anable, 2005). Yet, Roberts et al. (2018) found that ITB is more likely to be influenced by personal context based on sociodemographic factors and convenience than attitudes.

Another element that plays a role in ITB are infrastructural factors. Infrastructural factors determine behavioural options, as a specific infrastructure type such as public transport has to exist within the environment of an individual in order to be used by that individual (Hunecke et al., 2007). Such infrastructural factors do overlap with factors such as convenience. When the required infrastructure for a certain mode is difficult to reach, convenience often takes over. This is also reflected in the disparities between the attitudes and the behaviours of an individual that have been found. Ajzen and Fishbein (1977) found low correspondence between attitudinal and behavioural entities, while high correspondence needs to be ensured in order to predict behaviour from attitudes. This also has been demonstrated empirically within the environmental context by Oskamp et al. (1991) and Gardner & Abraham (2008). The importance of contextual factors can weaken the relation between attitudes and behaviour (Roberts et al., Kline, 1988). However, based on the review above it is suggested that according to ITB literature, attitudes influence ITB. Additionally, it is suggested that infrastructural factors and sociodemographic factors influence ITB according to ITB literature.

2.2.3 ITB and environmental concerns

As mentioned above, it is suggested that according to the ITB literature, attitudes influence ITB. In order to tackle environmental issues such as climate change and air pollution, it is important that peoples' concerns about the environment are raised. According to Soltani et al. (2019), raised awareness might contribute to changing ITB for the benefit of the environment. Soltani et al. (2019) argue that understandings and evaluations of the influences on issues of the environment and society that is reached through environmental knowledge can lead to a subsequent change in one's behaviour. Environmental knowledge is the level of knowledge one has of negative human effects on the environment and the environment itself (Ergen et al., 2015). Among these negative effects and environmental problems are for instance global warming, air pollution or the loss of biodiversity (Steg & Vlek, 2009; Soltani & Sharifi, 2017; Soltani et al. 2019). Roberts et al. (2018) define this awareness towards the environment differently. The term environmental concerns is used, which is defined as the reflection of how one feels about the environment and the way that one is predicated to behave with regard to it. Such awareness, understanding, evaluations or environmental concerns are all attitudes. As aforementioned, such attitudes that are found to influence ITB. Winter & Kroger (2004) state that such attitudes might be among the most important factors contributing to the mitigation of all types of negative environmental impacts.

A limited amount of studies has been found which have investigated the extent to which environmental concerns influence individual travel behaviour. The study of Soltani et al. (2019) has affirmed the value of environmental awareness for encouraging more environmentally sustainable travel behaviours amongst students. However, this study has focused on a specific type of commuting and population. As Soltani et al. (2019) have focused on students commuting between home and campuses, the results of the study are not general.

The study by Roberts et al. (2018) has attempted to evaluate the extent to which environmental concerns can motivate individual behavioural change with regards to commuting choice. They also have been able to demonstrate a significant relation between environmental concerns and the choice of commuting mode as an aspect of ITB. Roberts et al. (2018) state that their results suggest that environmental concerns have an important influence on commuting mode choice. Another study that has investigated this relation only has found a limited effect of environmental concerns on travel behaviour. Within this study by Anable (2005), the respondents have been divided into car owning and non-car owning respondents. The car owning respondents are clustered into the following groups: malcontented motorists, complacent car addicts, die hard drivers and aspiring environmentalists. The non-car owning respondents are clustered into car-less crusaders and reluctant riders. Anable (2005) has found some influence from environmental concerns and attitudes on ITB for all groups.

Nevertheless, other literature is more pessimistic with regards to this relationship. According to Gifford (2011) the public expressing concern about climate change rarely brings about change towards more sustainable behaviour. This is in line with the disparities between attitudes and behaviour of an individual as found by Ajzen & Fishbein (1977). Although Anable (2005), Soltani et al. (2019) and Roberts et al. (2018) have been able to demonstrate a relation between environmental concerns and ITB, Roberts et al. (2018) also found that individual behaviours are more likely to be influenced by personal context, such as sociodemographic and infrastructural factors regarding ones living environment, than by environmental concerns. Furthermore, the study by Susilo et al. (2012) found that the environmental views of the respondents did not necessarily match their travel behaviour and in some cases even contradicted. Susilo et al. (2012) have investigated the influence of environmental attitudes and urban design features on individual travel patterns in sustainable neighbourhoods in the UK and therefore the design of the study is comparable to the design of the present study. Nevertheless, Susilo et al. (2012) measure urban design features, which is only a modest component within the concept of land use patterns that is used for this research. Based on the aforementioned, it is suggested that the influence of environmental concerns on ITB is contested.

Within this research, attitudes with regards to the environment and its effects on ITB will be investigated. However, it is thus important to also include infrastructural and sociodemographic factors within the study. As aforementioned, the different studies regarding this topic make use of different terms to describe attitudes regarding the environment. Soltani et al. (2019) have used multiple terms to describe the understandings and evaluations of the influences on issues of the environment one has. One example of these terms is ‘environmental awareness’. Roberts et al. (2018) also have used of multiple terms for describing attitudes regarding the environment. The term ‘environmental concerns’ has been used most often by Roberts et al. (2018). Franzen and Vogl (2013) note that environmental knowledge is an irreplaceable component of the environmental concern. This implies that the terms used by Soltani et al. (2019) and Roberts et al. (2018) overlap and can be used interchangeably. The interchangeability of these terms also means that findings related to the terms can be interpreted in the same way. This also applies to ‘environmental views’ (Susilo et al., 2012) and ‘environmental attitudes’ (Anable, 2005). For this research, the changes in attitude to tackle environmental issues by individuals are called here ‘environmental concerns’ (EC), based on the study of Roberts et al. (2018).

2.2.4 ITB and land use patterns

As aforementioned, the personal context of someone influences ITB. Personal context is, among others, defined by the spatial characteristics of the residential environment and sociodemographic characteristics. Such characteristics are components of the land use patterns container concept (Vale, 2013). The impact of land use patterns on ITB has been the subject of many studies (e.g. Banister, 2011[a]; Cervero et al., 2009; Ewing & Cervero, 2001; Ewing & Cervero, 2010; Maat et al., 2005; Vale, 2013; Vale et al., 2018; Van Acker et al., 2007; Van Wee & Hoorn; 2004). Within the literature, land use is usually divided within dimensions of patterns (e.g. Cervero & Kockelman, 1997; Cervero et al., 2009; Ewing & Cervero, 2001; Ewing & Cervero, 2010). The original set of dimensions have been the designated as the three Ds of the built environment (Vale et al., 2018). These three dimensions regard density, diversity and design (Cervero and Kockelman, 1997). Later, the ‘3 Ds’ have been extended to five Ds (Vale et al., 2018). The ‘5 Ds’ also incorporate the dimensions destination accessibility and distance to transit (Cervero et al., 2009; Ewing & Cervero, 2001). An extensive division of the dimensions has been presented by Ewing & Cervero (2010), which identified domains presented as the '7 Ds'. All domains together are the following: (1) density, (2), diversity or mixed use, (3) design (e.g. conditions for walking and cycling), (4) destination accessibility, (5) distance to public transport, (6) demand management, and (7) demographics. This study explores 5 variables: design, distance to public transport, destination accessibility, density and demographics. The adapted definitions of these variables are discussed in the methodology chapter.

Within other research, density is usually measured as the variable of interest per unit of area. These variables of interest include for example population, dwelling units, addresses or building floor area. Diversity concerns the number of different land uses within a given area. Low values of diversity indicate single-use environments, while higher values indicate land uses that are more varied. Street network characteristics are measured through design. Design can be measured as availability of sidewalks and cycle paths; average street widths; number of pedestrian crossings or through other physical variables that differentiate areas that are pedestrian or cycler oriented from areas that are oriented towards car (Ewing & Cervero, 2010). The ease of access to, for example, city centres is measured trough destination accessibility. Often this concerns the distance to the city centre or the central business district, classified as regional accessibility. Local accessibility would be measured through the distance to the closest store (Handy, 1993). Distance to public transport is usually measured through the length of the shortest routes to the nearest public transport nodes. Alternatively, it can be measured as density of public transport lines, distance between the public transport stops, or even the number of stops or stations per unit area (Ewing & Cervero, 2010). Demand management includes measures that manage the demand of travel, such as pricing, parking and access control and congestion charging. Such measures could promote the use of the car (investment in roads, free parking) or constrain the use of the car by investment in, for example, public transport (Banister, 2011a). The focus for the dimension of demographics is on individuals and their characteristics (Vale, 2013). Variables such as age, gender, household size, level of education, marital status, health and employment status are among the commonly used variables for demographics (Anable, 2005; Roberts et al., 2018; Ryan & Wretstrand, 2019; Soltani et al., 2019; Steg, 2003; Van Acker et al., 2007). It can be argued that land use patterns include both infrastructural factors and sociodemographic factors.

The '7 Ds' as proposed by Ewing & Cervero (2010) have been used by several studies (e.g. Kapp & Malizia, 2015; Renne, 2013; Renne et al., 2016; Vale, 2013; Vale, 2015; Vale et al., 2018; Zhang & Zhang, 2015). Nevertheless, often only a selection of dimensions is applied. For example, within the study of Vale (2015) the dimensions of demographics and demand management are left out, as these two dimensions are not explicit built environment dimensions. Density has been measured by the number of residents within a buffer zone and the diversity dimension has been measured trough the degree of functional mix. Design has been measured using multiple variables. One of these variables is the number of free-standing bicycle paths within a buffer zone. Destination accessibility has been measured trough the accessibility by car, e.g. the distance from the closest highway access. Distance to public transport also has been measured using multiple variables, for example the number of train stations within 20 minutes of travelling. Vale (2015) has combined the '7 Ds' with transit-oriented development literature in order to evaluate and classify different station areas within Lisbon in three different aspects: land use, transportation, and conditions for walking. The study by Zhang & Zhang (2015) is an example that only applies the '3 Ds'. While the '7 Ds' of Ewing & Cervero (2010) are discussed within the study, only density, diversity and design have been taken into account as land use variables. Within this study, density is measured trough the population density. Population density concerns the persons per acre of a residential land use area. Zhang & Zhang (2015) have measured diversity using the land use mix entropy index, which distinguished between residential, commercial, office, industrial, and civic land use types. A larger value indicates a higher level of mixed land use pattern in the area. The design dimension has been measured as street density, which is the number of feet of street centreline per acre. Zhang & Zhang (2015) found that raising population and street densities and raising mixed use contribute noticeable to reducing the vehicle miles travelled.

Usually research regarding land use patterns focuses on the influence of the place of residence, the point of origin for travelling. However, land use characteristics of other locations are of importance as well. The abovementioned study of Vale (2015) has analysed the land use characteristics of station areas. Other locations of importance are destinations. Vale (2013) investigated the influence of land use patterns regarding work locations, the destination of a commute, on travel behaviour. The findings by Vale (2013) suggest that diverse and multimodal accessible work locations reduce car usage. Besides the study by Vale (2013), little is known about the influence of destination land use patterns on ITB. However, even within well-studied origin-oriented literature, the relative importance of land use patterns with regards to ITB is debated. Van Acker et al. (2007) argue that living in a high-density and mixed-use neighbourhood is associated with fewer motorised vehicle trips. However, their analysis showed only limited effects of land use patterns as density and diversity. It was found that a combination of demographics (e.g. age, number of people in the household, number of young children, marital status) and a combination of socioeconomic characteristics (e.g. number of cars, income, job status) influence ITB most. However, Van Acker et al. (2007) did not include demographics within land use patterns. Instead, they added demographics to a socioeconomic dimension that has been differentiated from land use patterns. Additionally, the focus of this research is not solely on commuting trips, but on all trips. Within the study of Maat et al. (2005), they argue that the limited effects of land use on ITB they have found fall short of the expectations. They argue that this is caused by assumptions concerning the relations between land use and ITB. An example of such an assumption is ignoring of the fact that compact urbanisation, which, among other things, implies intensive land-use patterns such as high density and mixed use, may result in people choosing more remote destinations. Maat et al. (2005) do note that land use still offers some potential for influencing ITB. However, they indicate that in more complex societies, such relationships increase in complexity as well. The potential for influencing ITB has been demonstrated by Van Wee & Hoorn (2004). Van Wee & Hoorn (2004) have found that the relative impact of land use on travel behaviour is important. This study was aimed at showing the possible effects of land-use policies on ITB regarding overall passenger transport. Additionally, Ewing & Cervero (2010) found that the dimensions of land use influence travel patterns. Yet, not every abovementioned demonstrated relation is of the same strength. Ewing & Cervero (2010) noted that density has a relatively weak relation with travel. In contrast, design variables are strong predictors for travel mode choice, especially for walking (Ewing & Cervero, 2010). Thus, within the literature on travel behaviour, the relative importance of land use patterns on ITB remains debated.

2.3 Environmental concerns and land use patterns: policy implications

Desiring a shift towards travel behaviour that is more sustainable has policy implications. The physical measures as proposed by Betolini & Le Clercq (2003) are considered to be highly effective transport-policy measures with the aim of discouraging care use of individuals. However, as the literature suggests that environmental concerns and land use patterns influence ITB, policies linked to environmental concerns and land use patterns will be discussed within this sub-section.

2.3.1 Environmental concerns and policies

The aforementioned effects of environmental concerns on ITB have potential to find their way into policies targeted at making travel choices more sustainable. In order to reduce unsustainable travelling, attitudes towards the environment can be influenced via advertising campaigns, provision of information (Roberts et al., 2018) or social marketing (Barr & Prillwitz, 2012). It is often assumed that crucial information regarding alternative travel modes (e.g. walking, cycling and public transport) has been readily available. Nevertheless, the Organisation for Economic Cooperation and Development (2004) found through surveys that this information does not reach the target audience. At this time, people are required to enquire for such information (OECD, 2004). Approaches such as influencing through advertising or provision of information are called 'soft' measures. These 'soft' measures have challenged the assumption that modal shift is only possible through 'hard' measures. 'Hard' measures are system based or regulative, such as changes in land use policy (Brög et al., 2009). Hunecke et al. (2007) argues that policy makers can legitimise the application of soft policy measures, as ITB is not only affected by infrastructural factors or sociodemographic characteristics that are difficult to change, but also by changeable attitudinal variables. In order to design such 'soft' policy measures, it is necessary to gain better understanding of the motivations of the users of different travel modes (Hunecke et al., 2007). The study by Brög et al. (2009) showed that 'soft' measures can activate large potentials for travel behaviour change, often on the same scale as 'hard' measures. Looking back at the implications as presented by Bertolini & Le Clercq (2003), most suggested measures concern 'hard' measures. Although the promotion of cleaner technologies through price incentives is considered a soft measure, Bertolini & Le Clercq (2003) did not take measures into account that are related to environmental concerns.

As it was found that psychological and attitudinal factors such as environmental concerns influence commuting mode choices to a certain extent, this can be exploited by policy makers, as these policy makers need to persuade commuters to make choices that are more environmentally friendly (Roberts et al., 2018). A thorough understanding of the influence of environmental concerns on ITB contributes to the effectiveness of such 'soft' policy measures.

2.3.2 Land use concepts of planning and design aimed to influence ITB

The aforementioned effects of land use patterns on ITB have found their way into diverse concepts of planning and design. Land use concepts on the local level concern, among other things, the scale of land use diversity, density and the extent to which developments are concentrated into nodes. Notions on land use patterns regarding the neighbourhood level are concerned with urban design related to movement, such as pedestrian-friendly and bicycle-friendly designs. An example of such a concept is the compact city (Maat et al., 2005). The main principle in the theory of compact cities is that of high-density (residential) development close to the core of a city. Among others, Geurs & Van Wee (2006) claim that the concept of compact cities results in everyday travel patterns of individuals that are the least energy-intense. Therefore, the compact city concept contributes to reducing greenhouse gas emissions (Holden & Linnerud, 2011). This concept is in line with the aforementioned findings that have confirmed that land use patterns such as density influence ITB to a certain extent.

Within the Netherlands, the compact-city policy is has been included in national spatial planning policies and has been implemented in many cities (Maat et al., 2005). Since the 1990s, the concept of the compact city is included as a basic principle of Dutch urban planning (Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, 1991). In concrete terms, this means that compact, high-density and mixed use designs have been encouraged. A mismatch between the locations of jobs and residential areas results in commuting over longer distances. However, spatial balance regarding residential areas and jobs does not guarantee that people will choose jobs and residential areas that are close together (Maat et al., 2005). Albeit the compact city concept already has been a basic principle of Dutch urban planning, its effectiveness remains, in accordance with the effect of land use patterns on ITB, debated.

Other planning concepts that relate to land use and ITB are urban networks, provision of facilities for slow travel modes as walking and cycling, discouraging of motorised travel mode use through designs that reduce vehicle speeds and new urbanism (Maat et al., 2005). Urban networks are an adaptation of the compact city concept that aims at concentrating new jobs and residential developments near existing and potential public transport nodes and highway intersections (Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, 2004). Concepts of urban design regarding the layout of urban areas are believed to be able to influence the travel patterns by affecting the attractiveness of different travel modes as well. New urbanism, another land use concept, is a combination of the aforementioned that is mostly advocated for in the US. It regards neighbourhoods that are diverse, compact, and mixed. Additionally, new urbanism aims to provide an environment that pleasant, comfortable, and safe for pedestrians, as well as the provision of alternatives for car use (Maat et al., 2005). New urbanism has been criticized for being part of the suburban problem. Its solutions are accused of relying too much on design to generate desired patterns of behaviour (Marshall, 2013). For both the compact city and new urbanism it applies that the contribution of compact urban designs in order to reduce unsustainable travel might not be as straightforward as is suggested by advocates of the concepts. However, when the limited contribution to sustainable travel patterns is combined with other positive effects regarding residential preferences, congestion, safety, and financial aspects, the potential of both concepts remains (Maat et al., 2005).

Another recent land use concept aimed at influencing ITB is the concept of Transit-Oriented Development (TOD). Research regarding TOD is often linked to land use patterns and the '7 Ds' (e.g. Renne et al., 2016; Vale, 2013; Vale, 2015). In the 2000s, TOD has become an increasingly popular model for urban planning (Renne et al., 2016). New construction and redevelopment around public transport nodes is seen as a promising tool for controlling suburbanisation and corresponding car dependence. TOD is intended to reduce car travel by increasing the multimodal access conditions of the city, considering public transport as the key transportation infrastructure (Cervero et al., 2004). Physical characteristics of TOD concern mixed-use, relatively high urban density and high-quality conditions for walking with public transport nodes within walking distance (Vale, 2015). A critique towards TOD is that universal TOD models are too often embraced uncritically and emulated as perceived best practice (Bertolini et al., 2012).

The implications as suggested by Bertolini & Le Clercq (2003) do overlap with these land use concepts. In order to promote public transport, they suggested transit-oriented development with, for example, functional concentrations at public transport nodes. Additionally, they advocated for mixed use (development of multifunctional neighbourhoods), facilitating walking and cycling through design and discouraging of car use through design. The discussed land use concepts thus match the policy implications of sustainable urban mobility patterns as suggested by Bertolini & Le Clercq (2003).

Considering the above, it is suggested that the extent to which existing land use concepts contribute to sustainable travel patterns is unsure. Although the contribution of the abovementioned concepts remains unsure, it was found that land use patterns influence travel behaviour to a certain extent (e.g. Ewing & Cervero, 2010). A thorough understanding of the influence of environmental concerns on ITB contributes to the effectiveness of such concepts and policy measures to be more effective.

2.4 Hypotheses

Previous research has shown that attitudes such as environmental concerns influence ITB (e.g. Roberts et al., 2018; Soltani et al., 2019). It has also previously been observed that land use patterns (e.g. density, diversity, design, demographics) are thus factors that influence travel behaviour of individuals (e.g. Ewing & Cervero, 2010; Van Wee & Hoorn, 2004). Additionally, it has been found that ITB of commuters are influenced by the distance of the commute (Banister, 2011[b]; Vale, 2013). Based on the literature review, this research has three theoretical hypotheses, which are tested by comparing and applying binary logistic regression and linear regression. The first hypothesis is that suburban residents of Haarlem and Groningen are making a change towards sustainable travel patterns due to environmental concerns. The second hypothesis that is tested is that suburban residents of Haarlem and Groningen with environmental concerns are more likely to make environmentally friendly choices with regards to commuting behaviour, compared to individuals that do not have concerns. Put differently, the second hypothesis is that a there is a relation between the EC variables and the ITB variables. The last hypothesis is that land use patterns influence the likelihood of choosing for travel options that are environmentally sustainable. In other words, the third hypothesis is that there is a relation between the LU variables and the ITB variables. The expected direction of the possible relations between the separate EC and LU variables and ITB variables are presented in appendix 1. In addition to the theoretical hypotheses, methodological null hypotheses and alternative hypotheses are used for analysing the regression models. The methodological hypotheses are presented in the results section.

The aforementioned factors are presented in the explanatory conceptual model (figure 2.2). The conceptual model is the basis for the methodological choices and statistical analysis of this research. In addition to the included variables, a comparison will be made. The place of residence of respondents is included in order to compare Haarlem and Groningen. This research includes a field study among the residents living in suburbs. The variables included within the conceptual model and the method of analysis will be further explained in the methodology section.

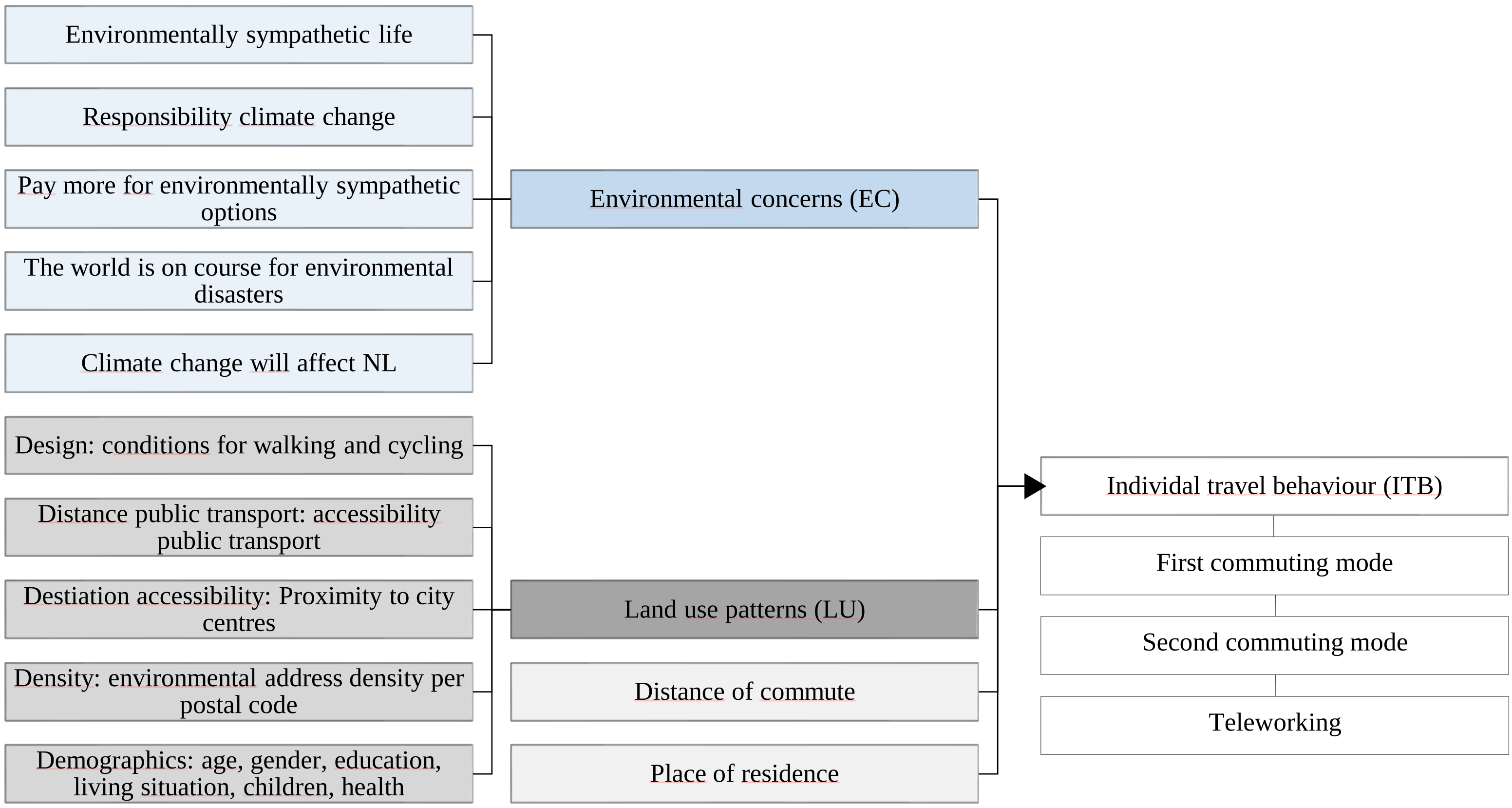


Figure 2.2: Conceptual model

Methodology

In order to understand how environmental concerns and land use patterns influence individual travel behaviour of daily commuting of suburban residents of Haarlem and Groningen and to answer the research question and sub-questions, a quantitative approach is used in this investigation. The benefit of a quantitative approach is that the results between models can be compared. Comparative analysis is a broad term that includes quantitative comparison of social entities that is based on, for example, geographical lines (Ember, 1991). The universal social patterns this study has attempted to reveal are difficult to determine in social research. Therefore, a comparative method is used to separate results that are more general from the context laden environment (Mills et al., 2006). The quantitative approach involves statistical analysis with multiple regression models. Within this third chapter the selection of respondents and data collection process are discussed, thereafter the variable selection and explanations are discussed and finally data management and methods of analysis are discussed.

For this research a quantitative statistical comparison of the social entities of Haarlem and Groningen in the form of a cross-regional comparison is done. This chapter is divided into two sections. The first section regards the case study protocol. Within this section the case studies and context are described. The second section concerns the data preparation and methods of analysis. Within this section the data, questionnaire and methods of analysis are described.

3.1 Case study protocol

The unit of analysis, or the case, is determined by defining spatial boundary, theoretical scope, and timeframe (Yin,2003). The country of analysis is the Netherlands, with the literal spatial boundaries being the suburbs of Haarlem and Groningen. Haarlem and Groningen are both provincial capitals with around 200.000 inhabitants (Eurostat, 2020). The cities Haarlem and Groningen and their location within the Netherlands are presented in figure 3.1.

Figure 3.1: Haarlem and Groningen

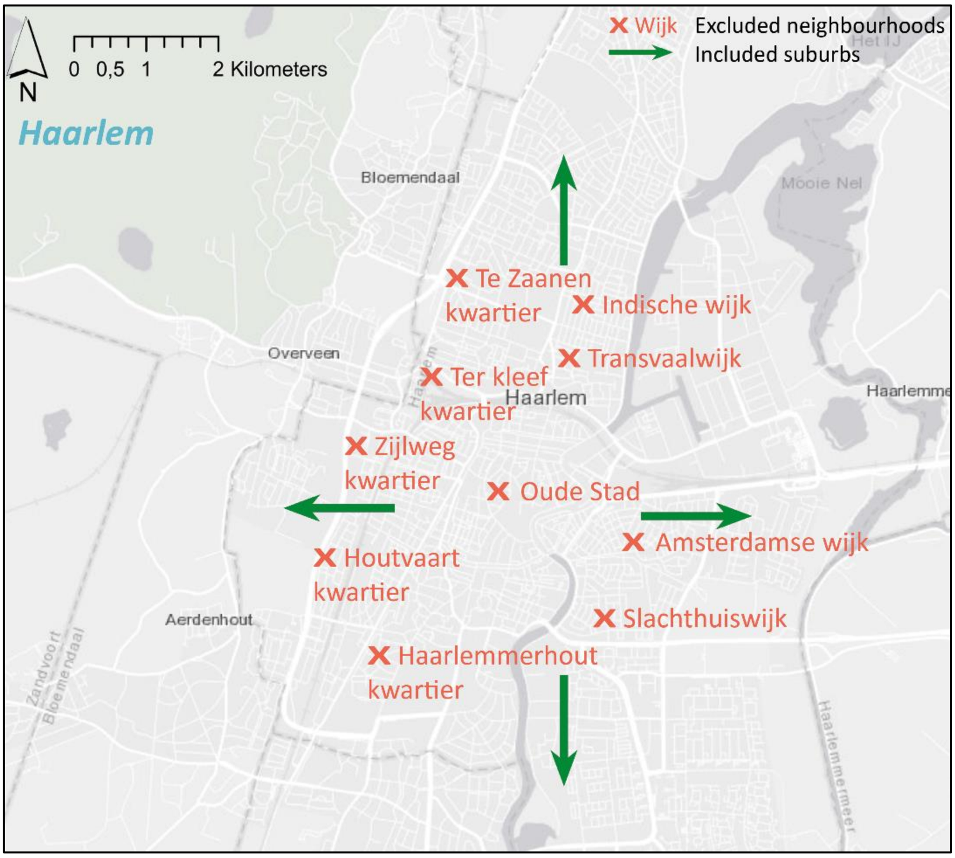
The selected suburbs are defined based on the Dutch definition of a suburb. Suburbs are often defined as low-density, sprawling, often city detached, car-oriented areas that consists of single-family homes (Schwartz, 1980). However, this definition does not cover Dutch suburbs. In Dutch, the term suburb has two translations, and thus two different definitions. The first translation of suburb is 'buitenwijk'. This type of suburbs is defined as recent, monofunctional city neighbourhoods with one-family-houses in green surroundings (Droogleever Fortuijn & Karsten, 1989). The second translation of suburb is 'voorstad'. This second type of suburbs is defined as administratively independent urban residential areas outside of the big city, which culturally and economically depend on the big city (Jonge, 1962). Examples of the first type of suburbs are the Bijlmermeer in Amsterdam and Lunetten in Utrecht (Blauw, 1985). In the case of Haarlem and Groningen, comparable neighbourhoods are Schalkwijk in Haarlem and

Vinkhuizen in Groningen (Gemeente Groningen, 2020; Gemeente Haarlem, 2020). An urban area is defined as a suburb of the second type if the area is located in the 'stadsgewest' (city region) of the city. Examples of the second type of suburbs of Haarlem and Groningen are Heemstede, a second type suburb of Haarlem and Bedum, a second type suburb of Groningen (CBS, 2015). In Dutch, neighbourhood has two translations as well, namely: 'wijk' and 'buurt'. Usually, neighbourhoods of the first type consists out of several neighbourhoods of the second type. Second type neighbourhoods are thus of a lower scale. An example within Groningen is the Oosterparkwijk neighbourhood, which consists out of several lower scale neighbourhoods such as the Oosterparkbuurt (Gemeente Groningen, 2020).

As in both Haarlem and Groningen a lot of neighbourhoods exist, and especially a lot of 'buurten', only the neighbourhoods that are regarded as non-suburban are listed (Gemeente Haarlem, 2020; Gemeente Haarlem, 2020). These excluded neighbourhoods are neighbourhoods that are adjacent to the city centres. The excluded neighbourhoods and included towns are listed in Table 3.1 and presented in figure 3.2.

Suburbs	Haarlem	Groningen
Excluded neighbourhoods Other neighbourhoods are included (Type 1: buitenwijken, part of city)	Oude Stad Zijlwegkwartier Haarlemmerhoutkwartier Houtvaartkwartier Amsterdamse wijk Slachthuiswijk Ter Kleefkwartier Te Zaanenkwartier Transvaalwijk Indische wijk	Binnenstad Schilders- en Zeeheldenwijk Korrewegwijk Oosterparkwijk Oranjewijk Oosterpoortwijk Tuinwijk Northern part of Herewegwijk Eastern part of Stadsparkwijk
Included suburbs (Type 2: voorsteden, part of city region)	Beverwijk Bloemendaal Castricum Haarlemmerliede Spaarnwoude Heemskerk Heemstede Uitgeest Velsen Zandvoort	Bedum Ten Boer Haren Leek Marum Noordenveld Tynaarlo Winsum Zuidhorn
Other included areas	People who feel that they live in a suburb dependent on Haarlem or Groningen that, for example, isn't included in the official city regions are included as well	

Table 3.1: Suburb selection



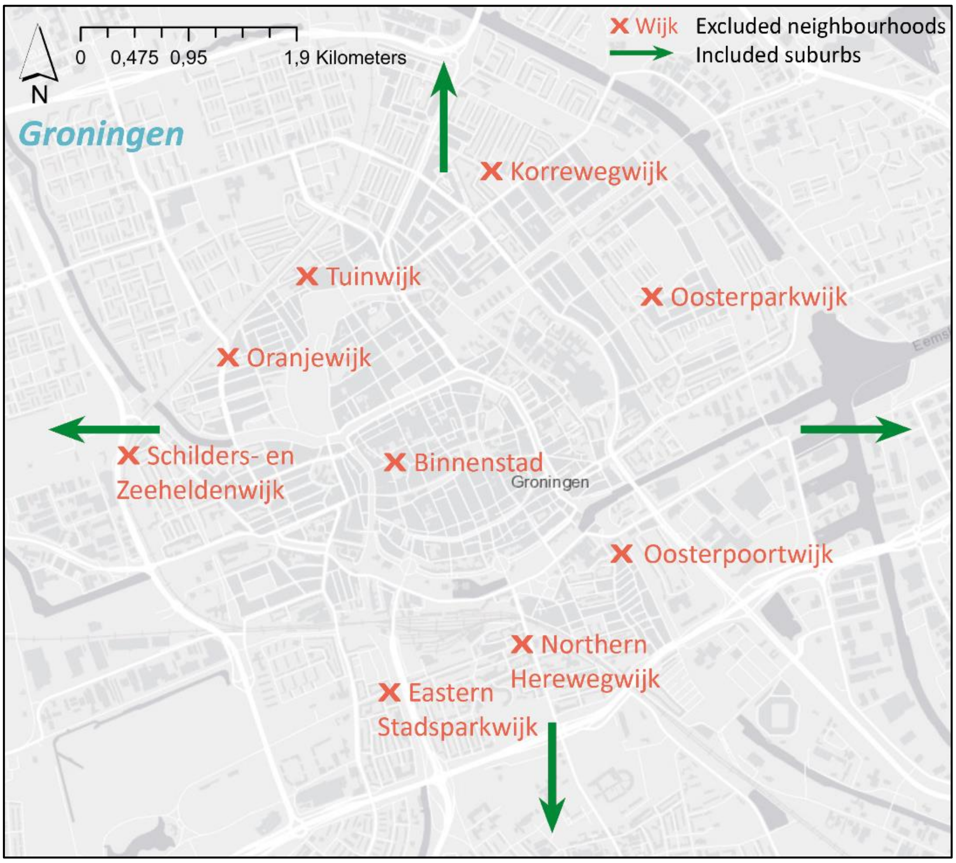


Figure 3.2: Excluded neighbourhoods and included suburbs

The data has been gathered among the usually daily commuting population of Haarlem and Groningen making use of a questionnaire. The design of the questionnaires has been based on existing research. The questions included within the questionnaire have been adopted from multiple researches (Hamer et al., 1991; Roberts et al., 2018; Schwanen et al., 2001; Vale, 2013; Van Acker et al., 2007). Some questions required adaptation. The questionnaire design can be found in appendix 2. Although the targeted population of suburban, daily commuting residents living around Haarlem and Groningen is relatively specific, the data collection process has been successful. Due to recent events (Covid-19), possibilities for collecting respondents have been limited. The data has been collected making use of an online questionnaire and a total amount of 271 respondents have filled in the questionnaire. These respondents within the relevant population were contacted and provided with a participance web-address through e-mail, Facebook and websites of neighbourhood associations. It has to be taken into account that questionnaires are not always filled in seriously. However, when filling in an online questionnaire, respondents are not tempted to 'impress' the pollster. For example, it is less likely respondents will fill in a higher number for income without direct contact to a pollster (Lunsford & Lunsford, 1995).

The sample is collected as a convenience sample. Convenience sampling is a type of sampling in which respondents are sampled because they are 'convenient' sources of data, the primary selection criterion relates to the ease of obtaining a sample (Lavrakas, 2008). The criticism of this technique is that bias is introduced into the sample, as volunteers may not be representative of the population. Volunteers often have a strong opinion they like to show off, therefore a random sample is preferred in order to avoid this bias (Lunsford & Lunsford, 1995). Due to the limited scope of this study and unavailability of the means to conduct a random sample, the bias remains unmanaged. Quota sampling, an approach that includes taking a very tailored sample that's in proportion to some characteristic or trait of a population, is an alternative to manage the bias (Lunsford & Lunsford, 1995). However, this type of sampling is difficult to apply to a population that is this specific. Additionally, the limited possibilities for collecting respondents due to recent events (Covid-19) has resulted in convenience sampling being the best option available.

3.2 Methods of analysis

The main variables for this study are environmental concerns, land use patterns and individual travel behaviour. The variables measuring environmental concerns are referred to as 'EC variables' and the variables measuring land use patterns are referred to as 'LU variables' throughout this study. The variables measuring individual travel behaviour are termed 'ITB variables' throughout this study. The latter are entered into the regression models as the dependent variable. The models consists of the factors that were found by previous research as control variables, EC variables and LU variables. The ITB variables are entered into the models as the dependent variable. The relations between the variables are presented in figure 3.3.

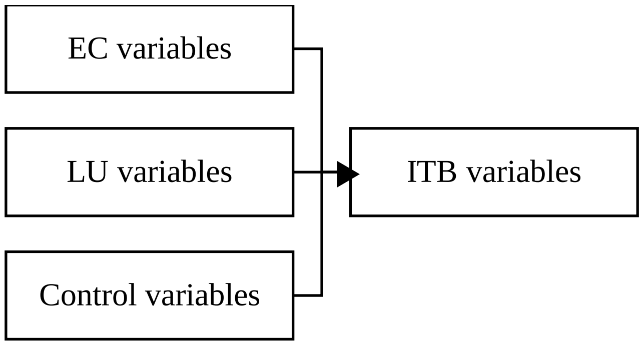


Figure 3.3: Relations between variables

The variables were based on the following researches. The questions regarding ITB are based on Schwanen et al. (2001) and Hamer et al. (1991), the questions regarding environmental concerns are based on the study by Roberts et al. (2018) and the questions regarding land use patterns are based on Ewing & Cervero (2010) and Van Acker et al. (2007).

The ITB variables within this research are adapted from Schwanen et al. (2001). Schwanen et al. (2001) used two travel behaviour characteristics as dependent variables: modal choice and distance travelled. Schwanen et al. (2001) divide individual travel behaviour into two aspects, modal choice and distance travelled. As this research focuses on daily commuters and only commuting trips are analysed, only modal choice will be taken into account. Schwanen et al. (2001) have distinguished five travel modes: walking, cycling, public transport, private car and other. In order to make the categories more inclusive, private car is changed into 'motorised vehicles', including scooters, motorcycles, taxis and cars. The category 'electric vehicles' includes electric cars and scooters but excludes the electric bike. The electric bike is included as a separate category, as electric bike ownership and use within the Netherlands has rapidly increased over the last decade (Plazier, 2018). The distinction between electric vehicles and non-electric vehicles is of relevance as the choice for commuting with electric vehicles is more environmentally friendly than motorised vehicles (Nanaki et al., 2016).

Within this research, two dependent variables measure the travel mode aspect of ITB. One variable focuses on the first most used travel mode, while the other focuses on the second most used travel mode. Second most used travel mode has been added, as Dutch commuters do not always use the same travel mode for the commuting. Additionally, commuting is often multimodal. For a multimodal commute usually two different travel modes are used (Heinen & Bohte, 2014). In case of multimodality, the first travel mode is the mode with which the longest distance is covered when commuting, and the second travel mode is the mode with which the second longest distance is covered. As aforementioned, the article of Schwanen et al. (2001) does not focus on commuting trips only but focuses on all the kilometres travelled by an individual. Within this study, the distance travelled will only be taken into account for individual travel behaviour indirectly by measuring the amount of days respondents work from home (teleworking). People telework for various reasons, but teleworking is found to result in a decrease in the number of commuting trips and can therefore be considered as an aspect of ITB (Hamer et al., 1991). One dependent variable, as shown in table 3.2, measures this aspect of ITB. Hence, three dependent variables are used in the analysis.

Dependent variable	Definition	Scale
First travel mode	First most used travel mode for commuting	Nominal, - Motorised vehicles (cars, motorcycles, scooters and taxis) - Bicycle - Public transport - Electric bike - Walking - Electric vehicles (electric car, electric scooters)
Second travel mode	First most used travel mode for commuting	Nominal, - Motorised vehicles (cars, motorcycles, scooters and taxis) - Bicycle - Public transport - Electric bike - Walking - Electric vehicles (electric car, electric scooters) - Same as first
Teleworking	Days of the week working from home	Ratio, number of days (0-5)

Table 3.2: ITB variables, adapted from Schwanen et al. (2001); Hamer et al., (1991)

Roberts et al. (2018) measured environmental concerns making use of indicators. Together these behavioural and attitudinal indicators measure environmental concerns. Within the study of Roberts et al. (2018) the indicators are divided into behaviours and attitudes. The behaviour indicators measure environmental concerns indirectly by addressing for example switching lights off and taking own bags for shopping. Attitude indicators measure environmental concerns more directly. For this research, five attitude indicators are adopted. Only attitude indicator questions are included where a positive answer (agree) indicates that someone has environmental concerns, in order to simplify the analysis. The indicators that are included as variables measuring environmental concerns are the EC variables. The EC variables are presented in table 3.3.

Variable	Definition	Scale
Own life	Respondent leads an environmentally sympathetic life	Ordinal, extent of agreement, 5-point scale
Own responsibility	Own behaviour contributes to climate change	Binary, agree or disagree
Pay more	Prepared to pay more or put in more effort for environmentally sympathetic products or options	Ordinal, extent of agreement, 5-point scale
Disaster	The world is on course for environmental disasters related issues such as climate change or air pollution	Binary, agree or disagree
30 years	Climate change will affect NL in next 30 years	Binary, agree or disagree

Table 3.3: EC variables, adapted from Roberts et al. (2018)

In order to avoid an overestimation of the psychological EC variables, socio-demographic and infrastructural variables are included in the analysis as well (Hunecke et al., 2007). These regard the LU variables and control variables. As land use patterns is a container concept, this variable will be divided in land use components. These components are based on the 7 Ds. As aforementioned, these Ds have been introduced by Cervero & Kockelman (1997), Cervero et al. (2009), Ewing & Cervero (2001) and Ewing & Cervero (2010). As aforementioned, these 7 Ds are, as noted by Ewing & Cervero (2010), the following: (1) density, (2) diversity/mixed use, (3) design (including parking, and conditions for walking and cycling), (4) destination accessibility (proximity to city centres and network connectivity), (5) distance to public transport (the accessibility of public transport), (6) demand management, and (7) demographics. Diversity, design and destination accessibility are viewed as particularly important for explaining ITB (Van Acker et al., 2007). Distance to public transport is found to influence ITB by Roberts et al. (2018), Soltani et al. (2019) and Anable (2005). Density, design, destination accessibility, distance to public transport and demographics are therefore included in this study. The demographics that are adapted are also found to influence ITB by other studies. The selection of the demographic variables is based on Anable (2005), Roberts et al. (2018), Ryan & Wretstrand, (2019), Soltani et al. (2019), Steg (2003) and Van Acker et al. (2007) and include the following: Age in years; Gender; Education; Living situation; Children in the household; Health. The adopted components are presented in table 3.4.

Variable	Definition (adapted)	Scale
Design	Conditions for walking and cycling, satisfaction on availability and accessibility of cycle paths	Ordinal, extent of agreement, 5-point scale
Public transport	The accessibility of public transport, distance to public transport	Ratio, minutes travel time
Destination accessibility	Proximity to city centres and network connectivity, distance to nearest city centre	Ratio, minutes travel time
Density/1000	Environmental address density per postal code, divided by 1000	Ratio, average number of addresses per km² (circle with a radius of one km) divided by 1000
Demographics	Age	Ratio, years
	Gender	Nominal, man, woman or other
	Highest completed education	Nominal, High school, MBO, HBO, University
	Living situation	Nominal, single, living together or married
	Number of children in the household	Ratio, number of children
	Perceived own health	Ordinal, extent of agreement, 5-point scale

Table 3.4: LU variables, adapted from Ewing & Cervero (2010); Van Acker et al. (2007)

Next to the EC and LU variables, the commuting distance will be included as control variable. As found by Vale (2013) and Zhao & Zhang (2018), the distance of the commute has effect on car use and travel mode choice. The last variable that will be included in the analysis is the place of residence. This in order to facilitate the city comparison. Within the questionnaire, additional questions have been asked. These questions regard if a respondent has changed its travel behaviour and if the respondent has changed its travel behaviour due to environmental concerns. This in order to establish if the sample consists of respondents who have changed and respondents who have not made a change. These ‘change variables’ measure if respondents have consciously changed their travel behaviour because of environmental concerns. The further analysis measures if environmental concerns unconsciously influence ITB or if environmental concerns influence ITB regardless of changes. This is relevant, as ITB is driven by intention, which in turn is shaped by attitudes as environmental concerns (Azjen & Fishbein, 1997). The attitude–behaviour relationship is not a direct one, people are less willing to change their behaviour when this is costly, inconvenient, or if personal contribution can’t make much difference (Oskamp et al., 1991). Conscious changes in ITB due to environmental concerns are therefore expected to be infrequent. However, unconscious influence of environmental concerns on ITB might exist more frequent. Respondents can use a travel mode that is relatively environmentally friendly, such as public transport, but think a change to a mode that is even more environmentally friendly is too much of an effort. Also, it could be the case that someone always has commuted using a sustainable travel mode consciously due to environmental concerns and therefore has not shifted towards travel modes that are more sustainable. In such cases, environmental concerns do influence travel mode choice, disregarding changes.

Data management and analysis were performed using SPSS 26.0. As a first step of analysis the frequencies for both of the samples are compared to the Netherlands using CBS and NEA data. The comparison between samples is done in order to gain first insights in the data. The data for the Netherlands is used as a frame of reference. The results for the change variables are analysed as well, in order to determine if respondents have already changed ITB due to the environment. Thereafter, the statistical analysis was done. To analyse the data Binary Logistic Regression and Linear Regression were used. These methods are suited to model the relation between a quantitative response variable and one or more explanatory variables (Moore & McCabe, 2006). In order to test the relation between the EC and LU variables and individual travel behaviour regression analyses have been done.

3.3 Data preparation

As aforementioned, the dependent variable ITB, has been measured using three sub-variables, which are the 1) first travel mode (nominal) 2) Second travel mode (nominal) and 3) Teleworking (ratio). Consequently, three models would have run. However, the amount of cases has been insufficient for the preferred multinomial logistic regression. In order to perform the analysis the categories of 'First travel mode' and 'Second travel mode' have been recoded into dummy variables that have been used for Binary Logistic Regression models. Six binary logistic regression models have been run for 'First travel mode', six binary logistic regression models have been run for 'Second travel mode' and one linear regression model has been run for 'Teleworking'. In order to run a linear regression, independent nominal and ordinal variables have to be recoded into dummies. Categories have been merged to create a dummy variable for the control variables. All different categories of the EC variables have been recoded into dummies. An overview of the recoded variables is presented in table 3.5. After general analysis, the differences between the cases will be further analysed. The next section will discuss the results of the analyses and starts with an overview of the models.

Dummies	Recoding type	Value description
Place of residence	Binary to dummy	1: Haarlem, 'success' 0: Groningen
Own life	Ordinal to multiple dummies	For every extent of agreement category (5-point scale) 1: category does apply, 'success' 0: category does not apply Reference category: neutral
Pay more	Ordinal to multiple dummies	For every extent of agreement category (5-point scale) 1: category does apply, 'success' 2: category does not apply Reference category: neutral
Gender	Binary to dummy	1: woman, 'success' 0: man
Education	Nominal to dummy	1: higher educated, 'success' 0: not higher educated
Living situation	Nominal to dummy	1: living together or married, 'success' 0: single
Own health	Ordinal to dummy	Based on extent of agreement (5-point scale) 1: agree, health is good, 'success' 0: neutral or disagree, health is not good

Table 3.5: Dummy recoding scheme

Results

Within this fourth chapter the results of the analyses are discussed. This chapter is divided in four sections. The first section concerns the results of the 'change variables', as well as a comparison of the samples and the Netherlands. The second section concerns the statistical analysis of model A.1 till model C. The last section, section 4.3, regards a further comparison. This section discusses model A.3.2. A guide for the models is presented in table 4.1.

Model	Dependent variable	Original variables used	Dummy variables used	Entry method
Model A.1 Binary logistic regression	Motorised vehicles first, dummy variable for the motorised vehicles category of the variable first travel mode	All independent	None of the independent	Enter
Model A.2 Binary logistic regression	Bicycle first, dummy variable for the bicycle category of the variable first travel mode	All independent	None of the independent	Enter
Model A.3 Binary logistic Regression	Public transport first, dummy variable for the public transport category of the variable first travel mode	All independent	None of the independent	Enter
Model A.4 Binary logistic regression	Electric bike first, dummy variable for the public transport category of the variable first travel mode	All independent	None of the independent	Enter
Model B.1 Binary logistic regression	Motorised vehicles second, dummy variable for the motorised vehicles category of the variable second travel mode	All independent	None of the independent	Enter
Model B.2 Binary logistic	Walking second, dummy variable for	All independent	None of the independent	Enter

regression	the walking category of the variable second travel mode			
Model C Linear regression	Teleworking, days	Distance commute Own responsibility Disaster 30 years Design Public transport Destination accessibility Density Age Children	Place of residence Own life Pay more Gender Education Living situation Own health	Enter
Model A.3.2 Binary logistic regression	Public transport first, dummy variable for the public transport category of the variable first travel mode	All independent	None of the independent	Forward: LR

Table 4.1: Model guide

The second section, section 4.2, is divided into three sub-sections. Within every sub-section a different dependent variable is discussed. Some dependent variables required multiple models, as the categories of these variables have been recoded into dummies. Within the first sub-section the results of model A.1, A.2, A.3 and A.4 are discussed. The corresponding dependent variable is 'First travel mode.' The second sub-section discusses model B.1 and B.2 and the corresponding variable 'Second travel mode', while the last sub-section discusses model C, which corresponds with the variable 'Teleworking'.

4.1 Change variables and sample comparison

This section focuses on the sample as a whole and the two city samples. First the samples will be briefly described. Within the Haarlem sample of 125 respondents, 21,6% has indicated to be a man, while 78,4% has indicated to be a woman. The mean age of the respondents is 41,7 years, the mean commuting distance is 22,19 kilometres. The Haarlem respondents telework on average ,76 days per week. Within the Groningen sample of 146 respondents, 33,6% has indicated to be a man, while 66,4% has indicated to be a woman. The mean age of the respondents is 42,9 years, the mean commuting distance is 20,74 kilometres. The Groningen respondents telework on average ,42 days per week. Out of all respondents from Haarlem, 7,2% has indicated to have changed the most used travel mode in the past 5 years due to environmental concerns. For Groningen this is 8,2%. Within the Haarlem sample, 2,4% percent of the respondents has indicated to have changed the number of days per week one teleworks due to environmental concerns. Within the Groningen sample, none of the respondents have indicated to have changed this number due to environmental concerns. These variables regarding changes are also analysed for the whole sample in order to answer if the daily commuting suburban respondents of Haarlem and Groningen are changing towards travel behaviour patterns that are more sustainable due to environmental concerns, which is the first research question.

In order to establish if the sample consists of respondents who have changed and respondents who have not made a change due to environmental concerns, the 'change variables' are analysed. The 'change variables' are not included in the models but will be used as a first step of analysis. The respondents were presented four questions about changes in ITB: 1) if they have changed the most used travel mode in the past five years; 2) if they have changed the most used travel mode in the past five years due to environmental concerns; 3) if they have changed the average weekly number of days they telework and 4) if they have changed the average weekly number of days they telework due to environmental concerns. As can be seen in figure 4.1, within the total sample of 271 daily commuters in Haarlem and Groningen, 100 respondents

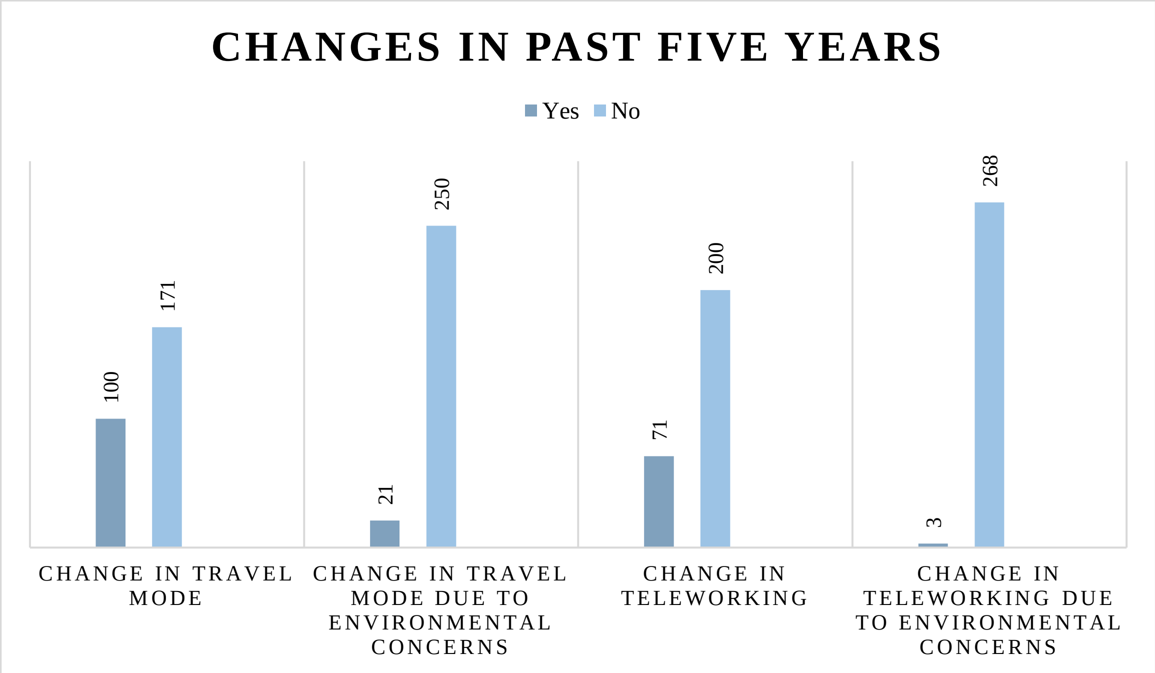


Figure 4.1: Sample results: Changes within sample

have indicated that they have changed their most used travel mode travel mode in the past five years, of which 21 have indicated to have made this change due to environmental concerns. For teleworking these numbers are considerably lower. Within the sample, 71 have indicated to have changed the amount of days they telework, while only three respondents have indicated to have done this due to environmental concerns. These results indicate that within the sample respondents that consciously have changed their travel behaviour are included, as well as respondents who haven't made a conscious change. The first hypothesis can thus be accepted: some respondents from Haarlem and Groningen are making a change towards travel behaviour patterns that are more sustainable due to environmental concerns. This information does not rule out that environmental concerns influences travel behaviour such as mode choice unconsciously or without having made a change as well, which will be tested in section 4.2.

The ITB variables are three variables that measure travel behaviour in terms of most used travel modes, second most used travel modes and teleworking. These variables are the dependent variables in the regression models. Additionally, these variables are suited for a comparison of the sample results with travel behaviour in the Netherlands. It should be noted that these results only apply to this study's samples of Haarlem and Groningen and do not apply to the total commuting population of Haarlem and Groningen. While data on Dutch travel behaviour is available, the CBS does not have suited data available that describes ITB for the population of the included cities. Nevertheless, such a comparison provides insight in the gathered data.

As the data is available, it is possible to compare the distribution of first most used travel modes within the samples to the distribution of most used travel modes of the Netherlands. The sample distributions are based on the results of the variable 'First travel mode' and the Dutch distribution is based on the national numbers published by the CBS (2016). As can be seen in figure 4.2, the results differ not only between the samples and the Netherlands, but also between the samples themselves. It can be noted that the use of both the electric bike and the bicycle as first travel mode is considerably higher within the Groningen sample than within the Haarlem sample and within the Netherlands. Within the sample of Groningen, the use of bicycles and electric bikes together adds up to 50,7%, which is considerably higher than the use of motorised vehicles. Within the Netherlands, motorised vehicles are clearly the most popular travel modes for commuting. This difference might be explained by the fact that, relatively, nowhere in the world more people use a bicycle than in the city of Groningen. According to Groningen fietsstad (2020), about 60% of all movements in Groningen a bicycle is used. Another striking result is the popularity of public transport within the Haarlem sample in comparison to the Groningen sample and the Netherlands. While the overall use of public transport is increasing in the whole of the Netherlands, the growth concentrates in the Randstad and especially within the Amsterdam region (OVPro, 2020). As Haarlem is part of the Amsterdam Metropolitan Area, this could be an explanation for the difference (Gemeente Haarlem, 2020[b]).

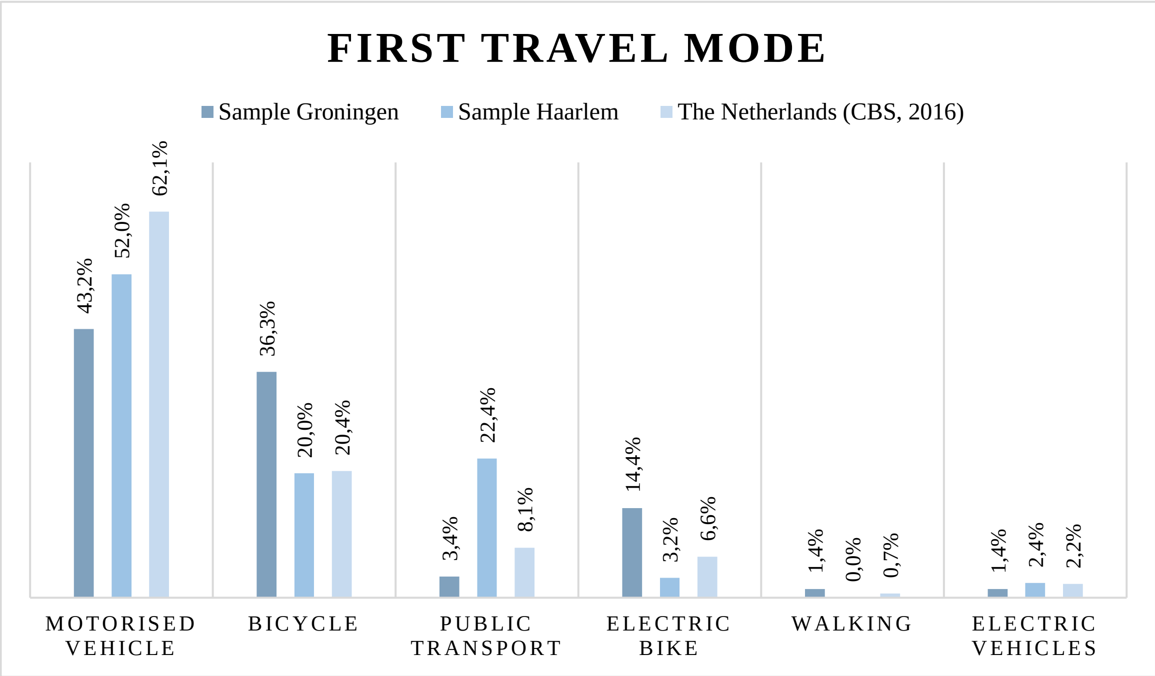


Figure 4.2: Sample results: First most used travel modes, compared to the Netherlands (CBS, 2016)

While data on the Dutch distribution of the first travel modes is available, the CBS does not provide data on the distribution of the second most used travel modes within the Netherlands. Therefore, is impossible to compare the distribution of second most used travel modes within the samples to the distribution of second most used travel modes of the Netherlands. Nevertheless, it is possible to do a comparison among the samples. The sample distributions are presented in figure 4.3. It can be noted that the differences appear to be less present than is the case for first most used travel modes. Electric bike and walking appear to be more popular as second most used travel mode within the Groningen sample, while public transport appears to be more popular as second most used travel mode within the Haarlem sample.

The last ITB variable concerns the number of days respondents telework in a week. It is possible to compare sample results of teleworking within the samples to teleworking figures of the Netherlands, provided by the Nationale Enquête Arbeidsomstandigheden, which translates to the National Survey of Working Conditions (NEA, 2019). What is striking about the results, as presented in figure 4.4, is that within the Groningen sample respondents tend to telework considerably less days a week than within the Haarlem sample and within the Netherlands. Within the next section the differences between the samples will be statistically analysed and combined with the expected influence of the EC variables and LU variables.

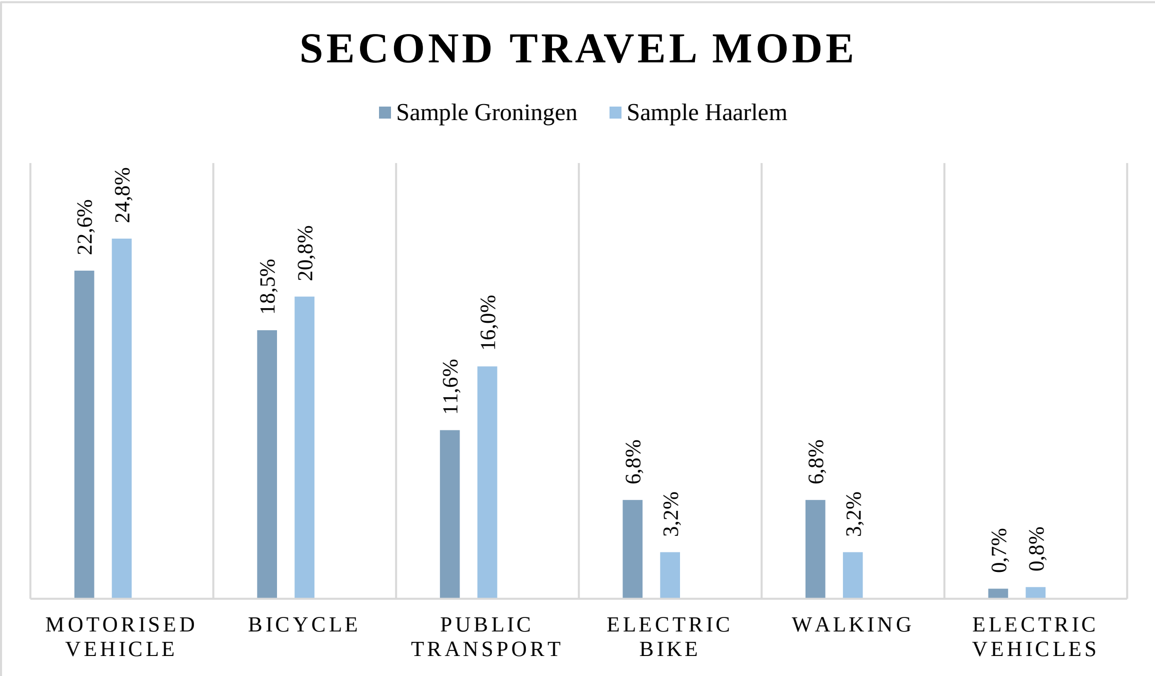


Figure 4.3: Sample results: Second most used travel modes

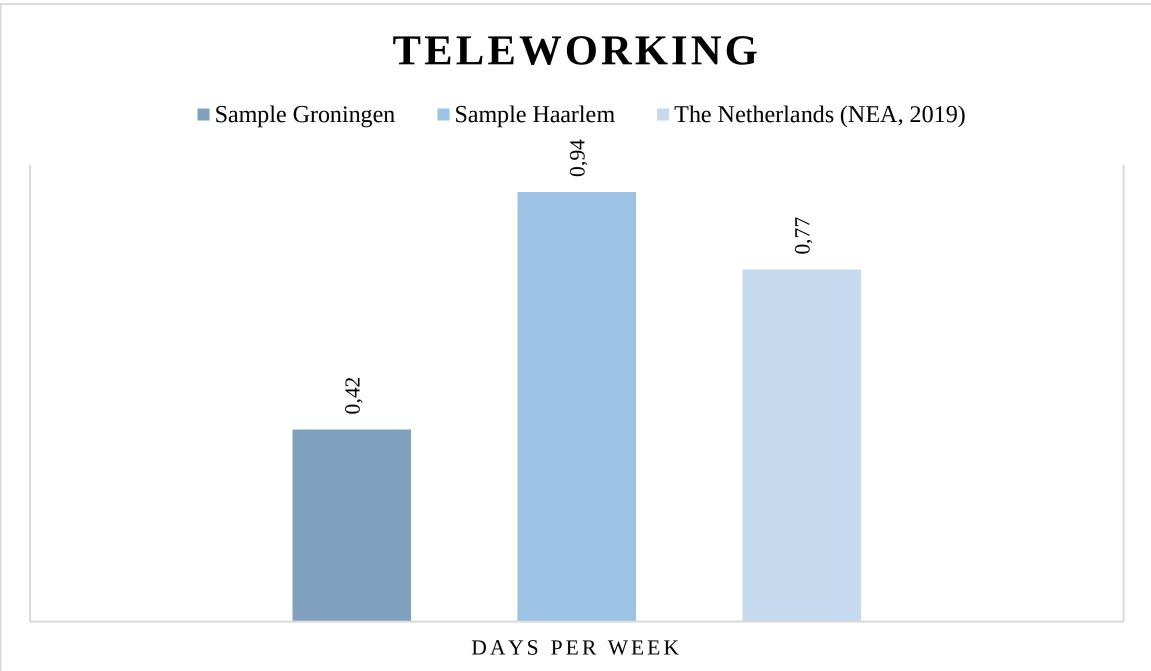


Figure 4.4: Teleworking, days per week compared to the Netherlands (NEA, 2019)

4.2 Statistical analysis

The effect that will be tested is that the 'EC variables' and the 'LU variables' influences ITB of the daily commuting population of Haarlem and Groningen. As mentioned, the second hypothesis that is tested is that suburban residents of Haarlem and Groningen with environmental concerns are more likely to make environmentally friendly choices with regards to commuting behaviour, compared to individuals that do not have concerns. The third hypothesis is that there is a relation between land use patterns and the likelihood of choosing for options that are environmentally sustainable. The (methodical) null hypotheses (H0) for all logistic regression models is that in the population no relation exists between the EC and LU variables and ITB. In other words, in the population all regression coefficients are equal to 0. For the linear regression model, the null hypothesis (H0) is that in the population, no linear relation exists between ITB on the one hand and the EC and LU variables on the other hand. Put differently, the null hypotheses is that all regression coefficients are equal to zero. The alternative hypotheses (H1) for all models is that there is a relation between the EC and LU variables and ITB. For all models a 95% confidence interval is used.

4.2.1 Model A.1, A.2, A.3 and A.4

Model A.1

The result of the binary regression analysis on model A.1 is a satisfying ,000 significance of the model. Interpretation of the outcomes is thus valuable. The Nagelkerke value of ,303 is relatively low in comparison to the other models. However, interpretation of this model is fair. Relations between the dependent and the independent variables for model A.1 are presented in table 4.2.

TABLE 4.2 Model A.1

Motorised vehicles first:	B	Sig.	Exp(B)
Model		,000	
Place of residence	,523	,147	1,687
Distance commute	,042	,000	1,043
Own life (EC)	,085	,676	1,089
Own responsibility (EC)	-,561	,087	,571
Pay more (EC)	,322	,050	1,380
Disaster (EC)	,511	,159	1,667
30 years (EC)	-,593	,226	,553
Design (LU)	-,068	,898	,934
Public transport (LU)	-,029	,385	,972
Destination accessibility (LU)	-,038	,112	,962
Density/1000 (LU)	-,544	,005	,581

Age (LU)	-,031	,013	,970
Gender (LU)	,080	,806	1,083
Education (LU)	-,215	,242	,806
Living situation (LU)	-,057	,790	,945
Children (LU)	,102	,431	1,107
Own health (LU)	-,020	,866	,980

Nagelkerke: ,303

One of the EC variables has a significant relation with using a motorised vehicle most often for commuting. This is in line with the expectation that environmental concerns influence travel behaviour. The B-value for the EC variable 'Pay more' is positive and the Exp(B)-value is higher than one. If someone indicates to be prepared to pay more for environmentally friendly products or options it is 1,380 times more likely that someone has indicated to use a motorised vehicle most often for commuting. This positive relation is an interesting one, as motorised vehicles are among the least environmentally sympathetic options with regards to ITB (Anable, 2005). However, low-income groups tend to make less use of a car (Steg, 2003) and people with lower incomes are probably less prepared to pay more for environmentally friendly products or options due to a lower budget. Although a relation is found between an EC variable and ITB for this model, the direction of the relation is not in line with the second theoretical hypothesis.

Two of the LU variables have a significant relation with using a motorised vehicle most often for commuting, which is in line with the expectation that land use patterns influence travel behaviour. The outcome for 'Age' is significant, the B-value for 'Age' is negative and the Exp(B)-value is lower than one. The chance that someone indicates to use a motorised vehicle most often for commuting decreases with age. This does not correspond with the literature, as according to Steg (2003) younger people usually make less use of cars than older age groups. The outcome for 'Density' is significant as well. The B-value for 'Density' is negative and the Exp(B)-value is lower than one. The chance that someone indicates to use a motorised vehicle most often for commuting decreases with the address density of the living environment, so a negative relation between 'Density' and the chance on using a motorised vehicle most often exists. The latter is striking, as less dense areas, such as suburbs, are associated with higher car use (Schwanen & Mokhtarian, 2005; Van Acker et al., 2007). As both the EC and LU variables influence ITB for this model, the null hypothesis can be rejected.

Lastly, the outcome for the control variable 'Distance commute' is significant, so interpretation of this outcome is valuable. There is a positive relation between 'Distance commute' and the chance on using a motorised vehicle most often, the chance that someone indicates to use a motorised vehicle most often for commuting increases with the distance of the commute. This is in line with other sources, as according to the CBS (2016) car use increases with the length of a commute. There is no significant difference between Haarlem and Groningen with regards to the chance on using a motorised vehicle most often for commuting.

Model A.2

The result of the binary regression analysis on model A.2 is a satisfying ,000 significance of the model. The Nagelkerke value of ,532 is relatively high in comparison to the other models. Relations between the dependent and the independent variables for model A.2 are presented in table 4.3.

TABLE 4.3 Model A.2

Bicycle first:	B	Sig.	Exp(B)
Model		,000	
Place of residence	-,674	,138	,510
Distance commute	-,203	,000	,816
Own life (EC)	,091	,713	1,096
Own responsibility (EC)	,085	,839	1,089
Pay more (EC)	-,258	,215	,773
Disaster (EC)	-,647	,158	,524
30 years (EC)	,347	,595	1,415
Design (LU)	1,788	,040	5,979
Public transport (LU)	-,005	,905	,995
Destination accessibility (LU)	,045	,175	1,046
Density/1000 (LU)	,528	,035	1,695
Age (LU)	,027	,092	1,027
Gender (LU)	-,242	,563	,785
Education (LU)	,241	,279	1,273
Living situation (LU)	,370	,179	1,448
Children (LU)	-,009	,957	,991
Own health (LU)	-,031	,837	,970

Nagelkerke: ,532

None of the EC variables has a significant relation with using a bicycle most often for commuting, which is not in line with the second theoretical hypothesis. Additionally, the null hypothesis cannot be rejected for this model. Nevertheless, two of the LU variables have a significant relation with using a bicycle most often for commuting. First, the outcome for ‘Design’ is significant. The B-value for ‘Design’ is positive and the Exp(B)-value is higher than one. These values mean that if someone has indicated to be satisfied with the design and availability of footpaths and cycle lanes within their living environment, it is 5,979 times more likely that someone has indicated to use a bicycle most often for commuting. Second, the outcome for 'Density' is significant, so interpretation of this outcome is valuable as well. The chance that someone indicates to use a bicycle most often for commuting decreases according to the density of the living environment. These results are in line with the literature, as Schwanen & Mokhtarian (2005) found that availability of appropriate infrastructure and areas with higher densities are associated with higher use of bicycles.

Finally, the outcome for the control variable 'Distance commute' is significant as well. The chance that someone indicates to use a bicycle more often for commuting decreases with the increasing distance of the commute. This largely corresponds with the numbers of the CBS (2016), although the CBS indicates that for the shortest distances (0,1-1 km) bicycle use is lower than one category above. No significant difference has been demonstrated between Haarlem and Groningen with regards to the chance on using a bicycle most often for commuting.

Model A.3

The result of the binary regression analysis on model A.3 is significant using a 95% confidence interval (,000). The Nagelkerke value of ,334 is relatively low in comparison to the other models. However, interpretation of this model is fair. Relations between the dependent and the independent variables for model A.3 are presented in table 4.4.

TABLE 4.4 Model A.3

Public transport first:	B	Sig.	Exp(B)
Model		,000	
Place of residence	2,480	,000	11,941
Distance commute	,022	,001	1,022
Own life (EC)	-,064	,847	,938
Own responsibility (EC)	,937	,098	2,551
Pay more (EC)	-,254	,344	,776
Disaster (EC)	-,640	,267	,527
30 years (EC)	,697	,410	2,007
Design (LU)	,198	,789	1,219
Public transport (LU)	-,062	,364	,940
Destination accessibility (LU)	,051	,129	1,052
Density/1000 (LU)	,446	,059	1,561
Age (LU)	-,038	,045	,962
Gender (LU)	,356	,490	1,428

Education (LU)	,575	,062	1,777
Living situation (LU)	-,112	,694	,894
Children (LU)	-,098	,662	,907
Own health (LU)	,132	,477	1,142

Nagelkerke: ,334

None of the EC variables has a significant relation with using public transport most often for commuting, which is not in line with the second theoretical hypothesis. Additionally, the null hypothesis cannot be rejected for this model. Nevertheless, one of the LU variables has a significant relation with using public transport most often for commuting. The outcome for ‘Age’ is significant, the B-value is negative and the Exp(B)-value is lower than one. The chance that someone indicates to use public transport most often for commuting thus decreases with age. This is in line with other sources, as according to the CBS (2018[b]) younger people tend to make use of public transport more often than older people do. Additionally, the outcome for the control variable ‘Distance commute’ is significant. There is a positive relation between ‘Distance commute’ and the chance on using public transport most often, the chance that someone indicates to use public transport most often for commuting increases with the distance of the commute. This result is in line with the theory. Accordingly, the CBS (2016) also found that public transport usually is used for longer distance trips.

Interestingly, this model was the only one that highlighted differences between Haarlem and Groningen with regards to public transport use are significant. Residents of Haarlem and the surrounding area are 11,941 times more likely to use public transport for commuting compared to Groningen. This model thus qualifies for further comparison.

Model A.4

The result of the binary regression analysis on model A.4 is significant using a 95% confidence interval (,000). The Nagelkerke value of ,458 is relatively high in comparison to the other models. Relations between the dependent and the independent variables for model A.4 are presented in table 4.5.

TABLE 4.5 Model A.4

Electric bike first:	B	Sig.	Exp(B)
Model		,000	
Place of residence	-1,342	,072	,261
Distance commute	-,136	,007	,873
Own life (EC)	-,101	,780	,904

Own responsibility (EC)	,115	,870	1,122
Pay more (EC)	,224	,492	1,251
Disaster (EC)	,314	,639	1,369
30 years (EC)	1,711	,182	5,537
Design (LU)	-1,742	,061	,175
Public transport (LU)	,144	,005	1,155
Destination accessibility (LU)	,052	,310	1,053
Density (LU)	-,365	,445	,694
Age (LU)	,109	,001	1,115
Gender (LU)	-,664	,288	,515
Education (LU)	-,155	,640	,957
Living situation (LU)	-,145	,771	,865
Children (LU)	-,081	,745	,922
Own health (LU)	,018	,937	1,018

Nagelkerke: ,458

None of the EC variables has a significant relation with using and electric bike most often for commuting, which is not in line with the second theoretical hypothesis. Additionally, the null hypothesis cannot be rejected for this model. Nevertheless, one of the LU variables has a significant relation with using an electric bike most often for commuting. The outcome for 'Public transport' is significant, the B-value is positive and the Exp(B)-value is higher than one. The chance that someone indicates to use an electric bike most often for commuting increases with the distance of one's home to the nearest public transport node. This implies that low connectivity to the public transport network leads to higher use of electric bikes. However, Plazier (2018) found no evidence for current or potential substitution of electric bikes for public transport use. Substitution for a travel mode depends on the level of use. Plazier (2018) might not have found evidence for substitution as the use of public transport in Dutch rural areas is relatively low, while bicycle use is high. Nevertheless, the current study found that greater distances to the public transport network leads to higher use of electric bikes.

The outcome for 'Distance commute' is significant and the relation is negative. The chance that someone indicates to use an electric bike most often for commuting decreases with the distance of the commute, which corresponds with the number found by the CBS (2016). For this model, no significant difference between Haarlem and Groningen with regards to the chance on using an electric bike most often for commuting exists.

Excluded models

The significance levels of the models for the dummy variables of ‘Walking first’ and ‘Electric vehicles’ are above ,050 and are therefore insignificant (resp. ,130 and ,610). As these models are insignificant, the interpretation of the models is of no value.

4.2.2 Model B.1 and B.2

Model B.1

The result of the binary regression analysis on model B.1 is significant using a 95% confidence interval (,011). The Nagelkerke value of ,227 is relatively low in comparison to the other models. However, interpretation of this model is fair. Relations between the dependent and the independent variables for model B.1 are presented in table 4.6.

TABLE 4.6 Model B.1

Motorised vehicles second:	B	Sig.	Exp(B)
Model		,011	
Place of residence	,620	,184	1,859
Distance commute	-,039	,005	,961
Own life (EC)	,408	,102	1,504
Own responsibility (EC)	-,436	,268	,646
Pay more (EC)	-,251	,246	,778
Disaster (EC)	-,430	,327	,650
30 years (EC)	,976	,130	,012
Design (LU)	,645	,329	1,906
Public transport (LU)	,051	,153	1,052
Destination accessibility (LU)	,033	,294	1,034
Density/1000 (LU)	,166	,484	1,181
Age (LU)	,021	,174	1,022
Gender (LU)	-1,007	,012	,365
Education (LU)	,206	,337	1,228
Living situation (LU)	,523	,053	1,687
Children (LU)	,183	,244	1,200
Own health (LU)	-,143	,377	,867

Nagelkerke: ,227

No significant relations between the EC variables and using motorised vehicles second most often for commuting, which is not in line with the second theoretical hypothesis. The null hypothesis thus cannot be rejected for this model. However, one of the LU variables, ‘Gender’ has a negative significant relation with using motorised vehicles second most often for commuting. This is in line with the third theoretical hypothesis, which states that that land use patterns influence travel behaviour. Women are ,365 times more likely to use a motorised vehicle as a second mode for commuting. This can be turned around in order to simplify interpretation. The result implies that if someone indicates to be a man, it is 2,739 times more likely that someone has indicated to use a motorised vehicle second most for commuting than if someone indicates to be a woman. Men choose motorised vehicles more as the second choice for commuting more often than women do. This seems in line with the findings of Soltani et al. (2019), who found that women are more likely to act in a sustainable way than men.

Finally, the outcome for 'Distance commute' is significant which implies that the chance that someone indicates to use a motorised vehicle as the second mode for commuting decreases with increasing distance of the commute. Short commuting distances increase the chance on using a motorised vehicle second most often. There is no significant difference between Haarlem and Groningen with regards to the chance on using motorised vehicles second most often for commuting.

Model B.2

The result of the binary regression analysis on model B.2 is a ,006 significance of the model. The Nagelkerke value of ,405 is on the higher side in comparison to the other models. Relations between the dependent and the independent variables for model B.2 are presented in table 4.7.

TABLE 4.7 Model B.2

Walking second:	B	Sig.	Exp(B)
Model		,006	
Place of residence	-,943	,328	,389
Distance commute	-,544	,005	,580
Own life (EC)	,335	,512	,715
Own responsibility (EC)	,051	,952	1,052
Pay more (EC)	,872	,065	2,392
Disaster (EC)	2,451	0,60	11,605
30 years (EC)	-1,702	,187	,182
Design (LU)	20,336	,998	678854583,9
Public transport (LU)	-,068	,655	,934
Destination accessibility (LU)	,078	,274	1,081
Density/1000 (LU)	,160	,770	1,173
Age (LU)	,021	,508	1,021
Gender (LU)	,016	,984	1,016
Education (LU)	,206	,608	1,229
Living situation (LU)	-,544	,341	,580
Children (LU)	,300	,361	1,349
Own health (LU)	,102	,751	1,108

Nagelkerke: ,415

None of the EC variables or LU variables have a significant relation with walking second most often when commuting, which is not in line with the second and third theoretical hypothesis. The null hypothesis can thus not be rejected for this model. However, one of the control variables has a relation with walking second most often when commuting. The outcome for 'Distance commute' is significant, so interpretation of this outcome is valuable. The chance that someone indicates to walk as second mode for commuting decreases with the distance of the commute. The direction of this relation is in line with the literature. The CBS (2016) also found that usually people only walk for short distance trips. For this model, no significant difference between Haarlem and Groningen was found regarding the chance someone walks most often for commuting exists.

Excluded models

The significance levels of the models for the dummy variables of 'Bicycle second', 'Public transport second', 'Electric bike second' and 'Electric vehicles second' are above ,050 and are therefore insignificant (resp. ,117; ,232; ,076 and ,182). As these models are insignificant, the interpretation of the models is of no value. These results mean that the included independent variables do not explain the dependent variable.

4.2.3 Model C

Model C

For model C the dependent variable is the number of days one teleworks. The result of the linear regression analysis on model C is a ,003 significance of the model. The R-Squared of ,165 or explained variation of 16,5% is quite low. However, this is an attempt to predict human behaviour. Campesato (2020) states that R-squared values for such attempts are typically lower than 50%. Additionally, regardless of the R-squared value, the significant coefficients describe the mean change in the dependent variable for one unit of change within the independent variable when other dependent variables are constant, which is valuable information (Campesato, 2020). Relations between the dependent and the independent variables for model C are presented in table 4.8.

TABLE 4.8 Model C

Teleworking:	B	t	Sig.
Model			,003
Place of residence	,244	1,694	,091
Distance commute	,005	2,452	,015
Own life (EC):			

Strongly agree	,114	,415	,678
Agree	,087	,603	,547
Disagree	-,139	-,753	,452
Strongly disagree	,522	1,143	,254
Own responsibility (EC)	-,289	-2,078	,039
Pay more (EC)			
Strongly agree	,314	1,516	,131
Agree	,182	1,252	,212
Disagree	,011	,061	,951
Strongly disagree	-,426	-1,340	,181
Disaster (EC)	,014	,099	,921
30 years (EC)	-,027	-,144	,886
Design (LU)	-,288	-1,394	,165
Public transport (LU)	,046	3,469	,001
Destination accessibility (LU)	,007	,770	,442
Density/1000 (LU)	,156	2,078	,039
Age (LU)	,009	1,740	,083
Gender (LU)	-,245	-1,906	,058
Education (LU)	,085	,603	,547
Living situation (LU)	,000	,002	,999
Children (LU)	,011	,213	,832
Own health (LU)	-,096	-,680	,497

R-Squared: ,165

One of the EC variables has a significant relation with the number of days one teleworks. This is in line with the expectation that environmental concerns influence travel behaviour. The dummy for 'Own responsibility' is significant and the B-value is negative, so for the population it can be assumed that on average people who believe that their own behaviour contributes to climate change work ,289 days less from home than people who do not believe this (the reference category for this dummy). This contradicts the second theoretical hypothesis of this research, as it was expected that people who have environmental concerns make less trips. Teleworking is promoted as a way to reduce environmentally harmful trips with motorised vehicles (Banister, 2000). As the largest share of the respondents use motorised vehicles for commuting, the results show that the majority of the trips are harmful for the environment.

In addition to the EC variable, two of the LU variables have a significant relation with the number of days one teleworks. The outcome for 'Public transport' is significant and the B-value for 'Public transport' is positive. Consequently, for the population it can be assumed that on average 10 minutes extra travel time to the closest public transport node increases the number of days someone works from home with almost half a day (,460). This is the most important variable for explaining the average amount of days one works from home. This outcome suggests that for the population, on average, people living in environments that are less accessible to public transport tend to work more days from home. The outcome for ‘Density’ is significant as well. As the B-value for ‘Density’ is positive, it can be assumed for the population that on average, if the address density of a living environment increases with 10.000, the number of days someone works from home increases by more than one and day and a half (1,560). The null hypothesis can be rejected for this model.

Finally, ‘Distance’ has a significant relation with teleworking. Extra commuting distance of 100 km increases the number of days someone works from home with half a day (,500). People of the suburban population of Haarlem and Groningen that have to travel further to their job, work more days from home compared to the ones that travel shorter distances. Regarding the amount of days people are working from home per week, no significant difference between Haarlem and Groningen exists.

4.3 Further comparison

Binary regression analysis has revealed that a significant difference between the ITB of residents from Haarlem and Groningen exists, concerning the use of public transport for commuting. This section concerns a further comparison in order to separate results that are more general from the context laden environment (Mills et al., 2006). Such a comparison is only done for the results of model A.3, as only for this model a significant difference in ITB between the two cities has been established.

In order to perform the comparison, model A.3 is performed again, excluding the ‘Place of residence’ variable. Instead, the data file is split, so the regression will be executed for the Haarlem sample and the Groningen sample separately. The results of the Groningen model cannot be interpreted as the final solution for the binary regression analysis after the maximum iterations could not be found. The results of the Haarlem model cannot be interpreted as well, as with a significance level of ,229 the model is insignificant. As all regressions have been executed using ‘Enter’ as method of entry, the regression has been repeated using ‘Forward: LR’ in order to roll out a usable outcome. This entry method is chosen as the plausibility ratio (LR) is often recommended as criterion for selection (Sieben & Linssen, 2009). For the Haarlem model this entry method does not make a difference. However, for the Groningen model it does. The results for the Groningen model (Model A.3.2) are presented in table 4.9.

TABLE 4.9 Model A.3.2

Public transport first Groningen:	B	Sig.	Exp(B)
Model		,004	
Distance commute	,028	,001	1,022
Age	-,115	,065	,891

Nagelkerke: ,279

The results imply that the chance that someone indicates to walk second most for commuting increases with the distance of the commute for the population of Groningen. As shown in table 4.9, the only variable that significantly explains using public transport most often for the population of Groningen is ‘Distance commute’. The variable ‘Age’ is included in the model, as although the contribution of the variable by itself is insignificant, it does contribute to the significance of the model. If age is not taken into account, the effect of the distance of the commute diminishes, although minimal. Looking back at model A.3, the contribution of ‘Distance commute’ (,001) and ‘Age’ (,045) are significant, which corresponds with the results of model A.3.2. However, for model A.3 the contribution of ‘Place of residence’ is most significant. For Haarlem, none of the included variables explain using public transport most often significantly. This comparison has revealed that the effect of the distance of the commute on public transport use is context laden, as it only applies to the population of Groningen. The high use of public transport of the population living in and around Haarlem is influenced by other factors that are not taken into account, for instance quality, frequency and connectivity of public transport within the region.

Discussion

The results have been presented and discussed briefly within the result section. Within this section, the results are discussed more thoroughly, focusing on the overview. In order to do this, the data will be summarised using the conceptual model as presented in the theory section.

5.1 Relations regarding environmental concerns

For only two models, model A.1 and model C, a relation between one of the EC variables and a variable measuring ITB has been found. As mentioned, the results show that being prepared to pay more for products or options that are more environmentally friendly has a positive relation with using car most often for commuting. Feeling responsible for contributing to climate change with personal actions has a negative relation with the amount of days per week that one teleworks. Both relations do indicate that EC variables influence travel behaviour of individuals. However, the directions of the relations are contradictive to the hypothesis. The second hypothesis that has been tested implies that residents with environmental concerns are more likely to make environmental-friendly choices with regards to commuting behaviour, compared to individuals that do not have these concerns. As suggested by Anable (2005), motorised vehicles are among the least environmentally sympathetic options among travel modes used for commuting. Nevertheless, being prepared to pay a higher price for products or travel options that are more environmentally friendly show environmental concerns but might also indicate one's financial resources. Within this thesis, income has not been measured, but it might have influenced this result. As previously mentioned, low-income groups tend to make less use of cars (Steg, 2003). Such lower income groups might be less prepared to pay more for environmentally friendly products or options due to less availability of financial resources. Although the hypothesis can be rejected, the found relation is explainable. The relation found might be no evidence of environmental concerns influencing ITB but is probably explained by the availability of financial resources. A variable measuring one's financial resources could have controlled for this effect. Such control variables can be used in order to purify observed relationships among the variables of interest (Spector & Brannick, 2010). Control variables can reveal if this particular EC variable influences ITB, or if this EC variable and the use of motorised vehicles are both influenced by the availability of financial resources. Nevertheless, it is questioned whether inclusion of control variables leads to more or less accurate interpretation of results. In order to contribute to an investigation, control variables should receive full attention and should be given a firs-class role within the investigation (Spector & Brannick, 2010).

The results show that residents of Haarlem and Groningen that feel responsible for contributing to climate change by their personal actions tend to work less days from home. As aforementioned, teleworking is promoted as a way to reduce environmentally harmful trips with motorised vehicles (Banister, 2000). In that respect, this result is contradictory with regards to the hypothesis. It is a more environmental-friendly choice, regarding ITB, to make fewer commuting trips by teleworking more days a week. Residents of Haarlem and Groningen that feel responsible for contributing to climate change do not make this choice. However, acknowledging responsibility with regards to climate change does not automatically imply that one thinks of climate change as a problem. People choose to telework or not for various reasons, such as avoidance of peak hour traffic. Additionally, not every type of work is suitable for teleworking (Hamer et al., 1991). Variables that measure reasons for teleworking and suitability of the type of work of respondents would have been able to control for these effects.

Taking the abovementioned into account, the effects of the EC variables on ITB can be classified as very limited. Additionally, the effects found are contradictive to the hypothesis. The first hypothesis, regarding that residents of Haarlem and Groningen with environmental concerns are more likely to make environmental-friendly choices with regards to commuting behaviour in comparison to residents that do not have these concerns, can thus be rejected. Although some respondents have indicated to have changed their travel behaviour due to environmental concerns, the results of the analysis suggest that environmental concerns are not initiating a change towards travel behaviour that is more environmentally friendly. This is in line with other studies that have investigated this effect. For example, Susilo et al. (2012) found that the environmental views of the respondents did not match or even contradicted their travel behaviour. The low correspondence between attitudinal and behavioural entities, as found by Ajzen and Fishbein (1977), appears to apply to the attitudinal entity environmental concerns and the behavioural entity ITB. Looking back at the conceptual model (figure 2.2), the relation between environmental concerns and ITB does not exist. Nevertheless, the other variables included in the conceptual model seem to play a greater role in explaining travel behaviour.

5.2 Relations regarding land use patterns

Relations between the LU variables and variables measuring ITB are found in every model, except for model B.2. This suggests that the third hypothesis, which implies that the seven dimensions of land use patterns influence ITB of residents of Haarlem and Groningen, can be accepted. Relations with the LU variable ‘Density’ are found in most models, including model A.1 (motorised vehicles first), model A.2 (bicycle first) and model C (teleworking). While the chance on using motorised vehicles most often for commuting decreases as the density of the living environment increases, the chance on using a bicycle most often for commuting and the days one teleworks increase as the density of a living environment increases. The density of a living environment thus influences if a resident of Haarlem and Groningen chooses a motorised vehicle or a bicycle for commuting. As aforementioned, living environments with lower densities are associated with higher car use and living environments with higher densities are associated with higher use of bicycles (Schwanen & Mokhtarian, 2005). Additionally, neighbourhoods with higher densities are related to lower levels of car ownership among residents, which has a positive effect on using a bicycle for commuting (Heinen et al., 2010).

However, usually low-density living environments are situated at the edges of a city, while high-density living environments tend to be close to a city centre (Griffith, 1981). For model A.1 and model A.2, a relation between the control variable measuring the distance of the commute and using a motorised vehicle most often or a bicycle most often for commuting has been found as well. The chance one uses a motorised vehicle most often increases with the distance of the commute, while the chance one uses a bicycle most often increases for shorter commuting distances. Density might influence the travel mode choice regarding motorised vehicles and bicycles only due to the typical location of areas with a certain density. For model C, this is different. The amount of days per week someone works from home increases with the density of the neighbourhood someone lives in, while the amount of days per week someone teleworks also increases with the distance of the commute. High density might thus not automatically imply that the commuting distance is shorter. Ewing & Cervero (2010) argue that the effect of density on travel behaviour is partly due to better walking conditions, shorter distances to public transport nodes, and less availability of (free) parking within high-dense neighbourhoods. The LU variable density thus seems to play a role in explaining ITB. However, the distance of the commute contributes more to the explanation of travel mode choice for both models than the density of the living environment does.

Relations with another LU variable that was found in multiple models regards the demographics dimension. Relations with variables measuring demographics are found in model A.1, A.3 and model B.1. For model A.1 and A.3, age influences the travel mode choice. The chance on using motorised vehicles most often for commuting decreases with the age of someone. As aforementioned, usually younger people use cars less often than older age groups do (Steg, 2003). The chance on using public transport most often decreases with age as well, which is in line with the numbers of the CBS (2018[b]). Younger people tend to use both motorised vehicles and public transport more often for commuting. For model B.1, gender influences the second most used travel mode for commuting. Men choose motorised vehicles more as the second choice for commuting more often than women do. Demographics influence commuting mode choice. However, gender only has a relation with using motorised vehicles second most often for commuting, which is rather specific. Age seems to have more influence on ITB, but the relation with motorised vehicles is contradictive with regards to existing literature. Additionally, demographic variables measuring level of education, living situation, number of children in the household and perceived health do not influence ITB. Therefore, the relation of land use dimension and ITB remains limited.

The last relation between a LU variable and ITB that is found in multiple models regards the distance to public transport. Relations with the variable measuring the distance to the nearest public transport node are found in model A.4 and model C. Both relations are positive, implying that the chance on using electric bikes for commuting and the amount of days one teleworks increase with the distance to the nearest public transport node. It is striking that the distance to public transport influences the use of electric bikes but does not influence the use of public transport. As aforementioned, it seems that low connectivity to the public transport network leads to higher use of electric bikes. This is an interesting finding, as existing literature found no evidence for the electric bike being substitution for public transport (Plazier, 2018). This relation is very interesting, as such an insight is of high usability for policymakers. For model C, the distance to public transport is the most important variable for explaining the average amount of days one works from home. Larger distances to public transport nodes usually imply overall larger travel distances (Ewing & Cervero, 2010). People who telework on a regular basis tend to commute for a longer time on non-teleworking workdays than people who do not telework regularly (Elldér, 2017). The effect of larger distances to public transport nodes on teleworking might thus be explained by the overall distance of the commute of these teleworkers.

The last LU variable that has a relation with ITB is design. This relation only is found for model A.2. One's satisfaction with the design and availability of footpaths and cycle lanes within their living environment, increases the chance on using a bicycle most often for commuting. As aforementioned, this relation is in line with the literature. The availability of appropriate infrastructure is associated with higher use of bicycles (Schwanen & Mokhtarian, 2005). This information is of high usability for policymakers that want to stimulate non-motorised travelling. Although this variable does not contribute to other models, this relation is of importance due to the high usability. Overall, the contribution of the different LU variables seems diffuse. Nevertheless, multiple LU variables contribute to explaining multiple ITB variables. For some LU variables no relations with ITB have been found. Despite, due to the overall influence of LU variables the second hypothesis can be accepted.

5.3 Relations regarding the control variable: distance

The distance of the commute has been added to the model as a control variable in order to purify observed relationships among the abovementioned variables of interest (Spector & Brannick, 2010). A relation between this variable and variables measuring ITB has been observed for every model. For model B.2, the distance of the commute is the only variable that explains walking second most often for commuting. Although the distance of the commute does not always contribute most to explaining the dependent variable, the variable is of great importance for explaining ITB. Additionally, regarding the further comparison of Haarlem and Groningen concerning the use of public transport most often for commuting, the distance of the commute is the only variable that explains the use of public transport among the suburban residents of Groningen. However, the variable does not explain the use of public transport for commuting among the suburban residents of Haarlem, as none of the included variables do.

In summary, the effects of the EC variables, LU variables and control variable on ITB vary greatly. Firstly, the effect of the EC variables on ITB is limited to non-existent. In other words, environmental concerns do not influence travel behaviour with regards to commuting of the suburban residents of Haarlem and Groningen. Secondly, an effect of the LU variables on ITB does exist. Land use patterns do influence travel behaviour of suburban residents of Haarlem and Groningen with regards to commuting. Lastly, the distance of the commute heavily influences ITB of suburban residents of Haarlem and Groningen.

Conclusion

This research investigated to what extent environmental concerns and land use patterns influence travel behaviour of the suburban residents of Haarlem and Groningen that commute daily. This paper argued that a relation between environmental concerns, land use patterns and the travel behaviour of the individual suburban residents of Haarlem and Groningen exists. To date there has been little agreement on the existence of the relation between environmental concerns and travel behaviour. This study has found that generally environmental concerns have very limited or no influence on ITB of the suburban residents of Haarlem and Groningen. Within the existing literature regarding land use patterns, the extent to which land use patterns influence ITB has been subject of debate. The results of this study regarding this relation are not convincing enough to end this debate, as the influence of the different LU variables varies greatly. The key results of this study are the findings regarding the influence of land use patterns on travel behaviour. For instance, density plays an interesting role in explaining use of motorised vehicles for commuting, use of bicycles for commuting and teleworking. Other important result are the influence of design on bicycle use and the influence of the distance to public transport on use of electric bikes. Although Brög et al. (2009) argued that 'soft' measures have the potential to be the solution in order to achieve modal shift, the results of this study highlight the importance of 'hard' measures such as changes in land use policy. The results of this study provide insights for 'soft' measures regarding environmental concerns; however it needs additional data collection and analysis.

Taken together, these findings do not support strong recommendations to reducing car use by fully focussing on changes in land use policy. Interestingly, the findings regarding density and design and the corresponding use of cars and bicycles might contribute to a reasonable approach to tackle the issue. The aforementioned implications for transport and land use policy as suggested by Bertolini & Le Clercq (2003) and other land use concepts, such as the compact city, new urbanism and transit-oriented development, do fit these findings and therefore do not have to be written off.

The generalisability of the results of this study is subject to certain limitations. For instance, the sample size of 271 respondents did not allow for multinomial regression. Applying binary logistic regression to dummies of the nominal variables has been a solution for this problem, but multinomial regression remains first choice. It would be interesting to collect more data and experiment with other types of analysis, among which multinomial regression. Another limitation of this study is that the sample has not been collected randomly. The developments around Covid-19 within the timeframe of this study makes these findings less generalisable. The respondents were quarantined during the data collection process and thus did not commute. This might have influenced the questionnaire responses. Nevertheless, in order to minimise bias, respondents have been asked to answer as they would have before the developments around Covid-19. In spite of its limitations, the study certainly adds to our understanding of ITB in relation to environmental concerns and land use patterns.

This study adds to the growing body of research that investigates the influence of attitudinal factors as environmental concerns and socio-demographic and infrastructural factors as land use patterns. While the influence of environmental concerns is negligible, land use patterns do influence travel behaviour of individuals. Especially the latter would be a fruitful area for further work. A greater focus on land use patterns could produce interesting findings that account more for the extent to which land use patterns influence ITB. In summary, this study thus contributes to the understanding of individual travel behaviour with regards to environmental concerns and land use patterns, but to a limited extent. Some major findings of this study regarding land use patterns suggest several courses of action for transport policy makers. The effect of 'soft' measures has been insufficiently substantiated to replace 'hard' measures, but the potential for co-action of both type of measures remains.

Reflection

Although this thesis has been written in an interesting period of time, during the global outbreak of Covid-19, the options for collection of data were limited, the data collection process was rather smoothly. Due to the period of quarantine, people had more time and seemed to be more prepared to help a student out by filling in a questionnaire. This part of the overall process went well.

Nevertheless, some parts of the process were less successful. Although people were prepared to respond to a questionnaire, the research design required a very large number of respondents. In hindsight, it would have been better if the research design didn't require that many respondents, as it would have been impossible to gather enough respondents within the given timeframe.

Although an alternative statistical method has been used for the analysis, the results are still of high value. The alternative method brought about changes related to the interpretation of the results, but the type of test is not inferior to the test that was supposed to be used according to the research design. As the test has been performed correctly, the results found by the study are convincing.

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Appendix 1: Expected relations

Independent	Dependent	Direction	Effect relation	Literature
All EC variables	Motorised vehicles (dummy first and second commuting mode)	Negative	Having environmental concerns (affirmative answer on EC variable question) leads to lower chance on use of motorised vehicles	e.g. Roberts et al. (2018), Anable (2005) Motorised vehicles are least sustainable (Anable, 2005)
All EC variables	Bicycle, public transport, electric bike, walking, electric vehicles (dummies first and second commuting mode)	Positive	Having environmental concerns leads to higher chance on use of bicycle, public transport, electric bike and electric vehicles and higher chance on walking	e.g. Roberts et al. (2018), Anable (2005) Motorised vehicles are least sustainable (Anable, 2005)
All EC variables	Teleworking, days per week	Positive	Having environmental concerns leads to more days teleworking per week	Teleworking reduces environmentally harmful trips (Banister, 2000)
Design (LU)	Bicycle, electric bike, walking (dummies first and second commuting mode)	Positive	Good conditions for walking and cycling lead to higher chance on use of bicycle, electric bike and walking	Schwanen & Mokhtarian (2005)
Design (LU)	All other dummies first and second commuting mode	Negative	Good conditions for walking and cycling might lead to lower chance on use of all commuting modes other than bicycle, electric bike and walking	
Distance to public transport (LU)	Public transport (dummy first and second commuting mode)	Negative	Higher distance to public transport nodes leads to lower chance on use of public transport	Ewing & Cervero (2010)
Distance to public transport (LU)	All other dummies first and second commuting mode	Positive	Higher distance to public transport nodes might lead to higher chance on use of all commuting modes other than public transport	

Destination accessibility (LU)	Motorised vehicles (dummy first and second commuting mode)	Positive	Higher distance to city centres leads to higher chance on use of motorised vehicles	Ewing & Cevero (2010)
Destination accessibility (LU)	Walking (dummy first and second commuting mode)	Negative	Higher distance to city centre leads to lower chance on walking	Ewing & Cervero (2010)
Destination accessibility (LU)	All other dummies first and second commuting mode	Negative	Higher distance to city centre might lead to lower chance on use of all commuting modes other than motorised vehicles	
Density (LU)	Motorised vehicles, electric vehicles (dummies first and second commuting mode)	Negative	Higher density leads to lower chance on use of motorised vehicles and electric vehicles	e.g. Van Acker et al. (2007)
Density (LU)	Bicycle, walking, electric bike (dummies first and second commuting mode)	Positive	Higher density leads to higher chance on use of bicycle, walking and electric bike	Schwanen & Mokhtarian (2005)
Density (LU)	Public transport (dummy first and second commuting mode)	Positive	Higher density leads to higher chance on use of public transport	Ewing & Cervero (2010)
Demographics: Age (LU)	Motorised vehicles (dummy first and second commuting mode)	Positive	Higher age leads to higher chance on use of motorised vehicles	Steg (2003)
Demographics: Age (LU)	All other dummies first and second commuting mode	Negative	Higher age might lead to lower chance on use of all commuting modes other than motorised vehicles	
Demographics: Gender (LU)	Motorised vehicles (dummy first and second commuting mode)	Negative	Being a woman leads to lower chance on use of motorised vehicles	Women are more likely to act in a sustainable way (Soltani et al., 2019)
Demographics: Gender (LU)	Bicycle, public transport, electric bike, walking, electric vehicles (dummies first and second commuting mode)	Positive	Being a woman leads to higher chance on use of bicycle, public transport, electric bike and electric vehicles and higher chance on walking	Women are more likely to act in a sustainable way (Soltani et al., 2019)

Demographics: Gender (LU)	Teleworking, days per week	Positive	Being a woman leads to more days teleworking per week	Teleworking reduces environmentally harmful trips (Banister, 2000), Women are more likely to act in a sustainable way (Soltani et al., 2019)
Demographics: Education (LU)	Motorised vehicles (dummy first and second commuting mode)	Positive	Higher education leads to higher chance on use of motorised vehicles	Roberts et al. (2018), Van Acker et al. (2007)
Demographics: Education (LU)	All other dummies first and second commuting mode	Negative	Higher education might lead to lower chance on use of all commuting modes other than motorised vehicles	
Demographics: Living situation (LU)	Motorised vehicles (dummy first and second commuting mode)	Negative	Being single or living together leads to lower chance on use of motorised vehicles	Car use is lower among singles and couples living together than among married couples or households with children (Van Acker et al., 2007)
Demographics: Living situation (LU)	Public transport (dummy first and second commuting mode)	Positive	Being single or living together leads to higher chance on use of public transport	Use of public transport is higher among singles and couples living together than among married couples or households with children (Van Acker et al., 2007)
Demographics: Living situation (LU)	All other dummies first and second commuting mode	Positive	Being single or living together might lead to higher chance on use of all commuting modes other than motorised vehicles and public transport	
Demographics: Children (LU)	Motorised vehicles (dummy first and	Positive	Higher number of children leads to higher	Car ownership is higher among

	second commuting mode)		chance on use of motorised vehicles	households with children (Van Acker et al., 2007)
Demographics: Children (LU)	All other dummies first and second commuting mode	Negative	Higher number of children might lead to lower chance on use of all commuting modes other than motorised vehicles	
Demographics: Own health (LU)	Motorised vehicles (dummy first and second commuting mode)	Negative	Higher perceived health leads to lower chance on use of motorised vehicles	Ryan & Wretstrand (2019)
Demographics: Own health (LU)	Public transport (dummy first and second commuting mode)	Positive	Higher perceived health leads to higher chance on use of public transport	Ryan & Wretstrand (2019)
Demographics: Own health (LU)	All other dummies first and second commuting mode		Higher perceived health might lead to higher chance on use of all commuting modes other than motorised vehicles and public transport	

Appendix 2: Questionnaire

1. Where do you live?
   A. Around or in Haarlem
   B. Around or in Groningen

2. What is your postal code? (1234AB)

3. What is your age?

4. What is your gender?
   A. Man
   B. Woman
   C. Different

5. What is your highest education achieved?
   A. High school
   B. MBO
   C. HBO
   D. University

6. What is your living situation?
   A. Single
   B. Married or partnership
   C. Living together

7. How many children do you have within your household?

8. Extent of agreement: I consider my health to be good.
   A. Strongly agree
   B. Agree
   C. Neutral
   D. Disagree
   E. Strongly disagree

9. Which travel mode do you use most often for your commute to work? (if multimodal, with which travel mode do you travel the longest distance)
   A. Walking
   B. Bicycle
   C. Public transport
   D. Electric bike
   E. Motorised vehicles
   F. Electric vehicles

10. Which travel mode do you use second most often for your commute to work?
    A. Walking
    B. Bicycle
    C. Public transport
    D. Electric bike
    E. Motorised vehicles
    F. Electric vehicles
    G. I always use the same travel mode

11. How many days a week do you telework on average? (If you don't work at home, enter 0)

12. What is (approximately) the distance from your commute to work in kilometres? (The distance from your home to your work location)

13. I consider the distance from my home to my work location to be large
    A. Agree
    B. Disagree

14. I am satisfied with the availability and accessibility of footpaths and cycle paths in my neighbourhood.
    A. Agree
    B. Disagree

15. In how many minutes do you walk (approximately) to the nearest public transport node in your living area?

16. I am satisfied with the availability and distance to public transport from my home.
    A. Agree
    B. Disagree

17. In how many minutes do you cycle (approximately) to the nearest city centre?

18. I am satisfied with the distance to the nearest city centre from my home.
    A. Agree
    B. Disagree

19. Have you changed the travel mode you use most often for your commute in the past 5 years?
    A. Yes
    B. No

20. Have you changed the travel mode you use most often for your commute in the past 5 years due to environmental concerns?
    A. Yes
    B. No

21. Have you changed the number of days you telework in the past 5 years?
    A. Yes
    B. No

22. Have you changed the number of days you work from home in the past 5 years due to environmental concerns?
    A. Yes
    B. No

23. Extent of agreement: I lead an environmentally friendly life.
    A. Strongly agree
    B. Agree
    C. Neutral
    D. Disagree
    E. Strongly disagree

24. My own behaviour contributes to climate change.
    A. Agree
    B. Disagree

25. Extent of agreement: I am willing to choose more environmentally friendly options or products, even if this takes more effort or costs me more money.
    A. Strongly agree
    B. Agree
    C. Neutral
    D. Disagree
    E. Strongly disagree

26. The world is on course for environmental disasters, related to for example climate change or air pollution.
    A. Agree
    B. Disagree

27. Climate change will have negative consequences for the Netherlands in the next 30 years.
    A. Agree
    B. Disagree