Influencing travel behavior in urban areas

A study on the factors of reaching sustainable mobility through travel behavior

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Preface

This report is a result of a long thesis project on the third and fourth semester of master program Urban Planning and Management, in the time between 1st of September 2014 and the 3rd of June 2015. The reference style used is the Harvard method.

The aim of this report has been to investigate which factors are determinant when changing travel behavior. The main context of this project has been the Smart Mobility project in Aarhus.

A special thanks is given to my supervisor, Enza Lissandrello, for her guidance, constructive criticism and patience throughout the whole project.

Lastly, I want to thank Gustav Friis, the project manager of the Smart Mobility project in Aarhus, for taking the time to talk to me, introducing me to the project and providing with relevant literature and data.

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1. Introduction and research question

1.1 The importance of sustainable mobility

The core of societies throughout history has been accessibility regarding both economically and socially. The ability to being able to reach people, goods, services and opportunities have been very important. Achieving this access has involved movement, people traveling distances. As societies kept growing and developing, the movement increased in speed. The faster speeds of movement, resulted in more time traveling and now even longer distances.

This created a dependency towards motorized mobility, especially when these forms of mobility promises independence and new reaches. Western societies especially, have almost supported this dependency towards motorized mobilities as patterns of land use have changed, so the need to cover distances are even greater. The infrastructure has at the same time been ready to expand to accommodate this growth in motorized mobility (Lyons 2012).

Urban transport systems now face a number of challenges worldwide. The economic dimensions of the challenges tend to gain most attention. Traffic congestion experienced on city roads and highways, have often been the root for development of many urban transport strategies and policies. The solution tend to be building more infrastructures for car use and not focusing enough on improving sustainable public transport systems.(United Nations 2013)

The twenty-first century marked the century where global sustainability was widely recognized by world leaders and was a highly discussed topic by scientists, journalist, students and citizens (Adams 2006). The mindset has changed, expanding the infrastructure, is now

being seen as both unaffordable and limited in its effectiveness (Lyons 2012).

One of the reasons for this, is that the transportation sector brings along a number of other challenges that do not get fixed by adding more infrastructure. For example, transportation is also responsible for large proportion of the greenhouse gas emissions which is connected to climate change. Likewise, the noise and air pollution generated from transportation, effects the health of the people in cities. Furthermore, accidents on the road are one of the main causes of premature death in many countries and cities. (United Nations 2013)

When talking about sustainability or sustainable development one definition is still getting quoted today and is of one the most used on the matter. The most frequently quoted definition is from the 1987 report Our common future or as it is also known, the Brundtland report. In here the following definition on sustainable development is found (WCED 1987):

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- the concept of **needs**, in particular the essential needs of the world's poor, to which overriding priority should be given; and
- the idea of **limitations** imposed by the state of technology and social organization on the environment's ability to meet present and future needs."

This definition captured two fundamental issues; the problem of an environment in degradation that commonly linked with economic growth and the fact that such growth is needed to lessen poverty. Over time the definition of sustainable development evolved into being framed in three dimensions; environmental, social and economic sustainability. The three dimensions of sustainability have been illustrated in different ways.(Adams 2006)

The concern about sustainable transport is rooted in the growing knowledge on human activities having significant impacts on environmental issues which then can have an effect on economic and social issues. (Litman & Burwell 2006) Transport suffers from serious problems like congestion, pollution, accidents, loss of space in urban spaces and noise. Besides these problems the fact that transport is dependent on oil as resource and is a major energy consumer and is contributing to global warming. (Elzen et al. 2004)

These challenges and consequences on the environment have opened up for the concept of sustainability becoming widely accepted and used in many academic discourses. However, it still seen that measures attempting to change behavior towards a more sustainable way of living are dealing with complex constraints and resistance. The constraints and acceptance of sustainable solutions can vary widely, for example, changing the behavior at people's homes such as recycling more or changing to more energy efficient light bulbs is seen to be adopted by many people. In contrast, sustainable measures aimed towards daily

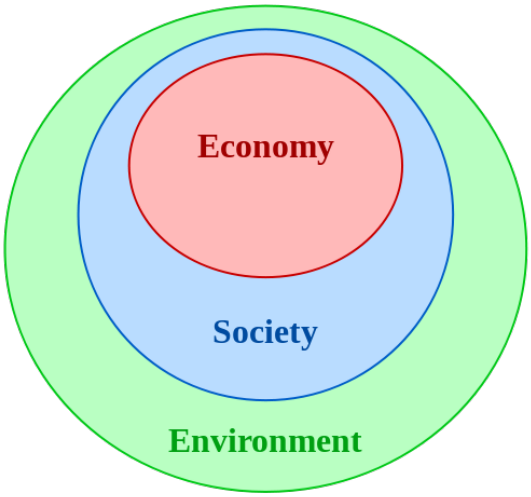


Figure 1.1: diagram that shows the relationship between the three. The idea is that both economy and society are constrained by the environmental limitations. (Adams 2006)

mobility and tourist travel are met with lower levels of acceptance and in the end affect the implementation (Barr & Prillwitz 2011).

A quick search on academic articles or different municipalities through out the world, whether it is Europe, America or Asia, shows that the challenges of sustainability mobility and the desire to solve these problems are a big trend at the moment. The difference in focus and measures in the different cities can be as different as the city names. One city that faces sustainable mobility challenges in the future is Aarhus, the second largest city in Denmark.

The research in this thesis will be based upon the challenges that Aarhus are expected to face in the future.

1.2 Aarhus – future sustainable challenges

This chapter explains the background, challenges and goals for the future mobility planning in Aarhus, thus setting the context for the report.

The city of Aarhus is in the midst of a growth spurt, this is apparent in the many ongoing projects that the city is undergoing. Visiting the town will reveal, among other things, a new harbor front still undergoing construction and the new light rail that will service most of the public transport in and around Aarhus. The population is growing rapidly every year and so are the tourism numbers. The year of 2014 was a record for the city in guests visiting, surpassing 2013 with more than 14%. Is no surprise that Aarhus is being referred as the

capitol of central Jutland. (VisitAarhus.dk 2015)

1.2.1 Background and challenges

The city council in Aarhus decided that in 2010 that municipal had to identify the long-term challenges and the investments demands within the transport area. The reason behind this is that Aarhus expects a significant growth in the traffic and significant problems with the accessibility on the roads. The growth is connected to the economic growth in the society. More people are buying cars because of the welfare is rising and more people are commuting as the workplaces and educations are concentrating in the bigger cities. (Aarhus Municipality 2012)

Probably the main challenge is that Aarhus is expecting a growth in citizens and jobs at around 25% towards year 2030. It is expected that Aarhus will grow with 50.000 workplaces, 75.000 citizens and 10-15.000 education spots. (Aarhus Municipality 2012)

This will create a growth in traffic and it is also expected that more people will buy cars and drive more trips. The forecast are saying that the amount of car trips will grow from 1,3 million a day to around 2,0 million a day towards 2030, this is a growth of 60%. Besides the growth in car transport, the public transport, bicycle trips and walking trips will increase from 1,1 million trips each day to 1,7 million by 2030. (Aarhus Municipality 2012)

Every car today is being used by an average of 1,4 person pr. each car. If the average could be increased to 2,2 person pr. each car then this whole growth in traffic in 2030 could be utilized by the same amount of car trips as today. Aarhus believes that the travel behavior in people has resulted in these habits and that the lack of information on alternative options also has a say in this. (Aarhus Municipality 2012)

Other challenges that Aarhus face is the limited economic resources, which is why it is important to identify the necessary priorities. Especially when Aarhus is a municipal with limited space both in urban and green areas. (Aarhus Municipality 2012)

This model is being used to divide the priorities, so the effort is used correctly and the costs are held at a minimum. As the figure shows, before even thinking about building new infrastructure or improving the existing, the focus goes to the users by influencing the demand for traffic and their choices. (Aarhus Municipality 2012)

This set of priorities, is what started the project “Smart mobility” by Aarhus Municipality. The project is a research and experiment study. Aarhus is attempting to change road users and companies travel behavior by using municipal measures. The measures are primarily soft measures, which can be put in to practice by dialog, information and campaigns. (Aarhus Municipality 2013)

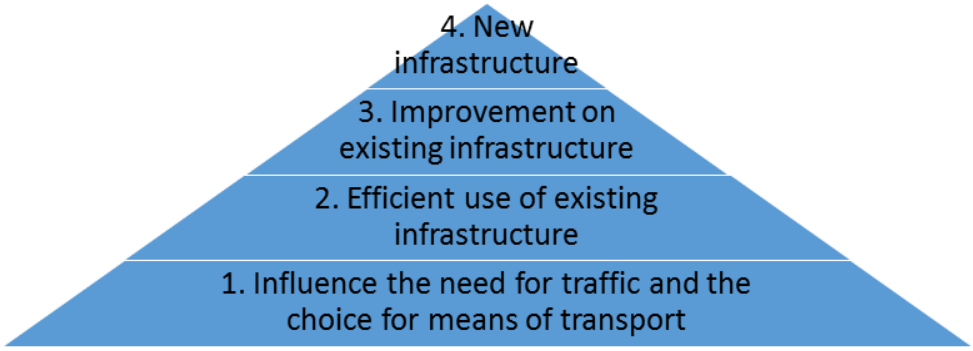


Figure 1.2: Model showing the division in priorities by Aarhus Municipality. (Aarhus Municipality 2012)

The goal with the project is, by changing the travel behavior, to reduce the congestion and improve the accessibility as well as ensuring a sustainable mobility. Aarhus municipality have chosen four focus groups or case areas, that the research will primarily focus on. These are: citizens in a suburban area, citizens in an urban area, young people and a municipal workplace. (Aarhus Municipality 2013)

More specifically, this is done by (Aarhus Municipality 2013):

- Reducing the amount of driving by car
- Increasing the usage of public transport and bicycle
- Increasing the utilization of each vehicle
- Equalizing the traffic load by car during the day or reduce car traffic in peak hours

Gustav Friis, the projectmanager for the Smart Mobility project in Aarhus said that the problem is not necessarily sitting in a car, but it is sitting in a car stuck in traffic that is the problem. The main goal of the Smart Mobility project is to prevent congestion in the present and in the future, and this can be done by various ways, which will be tested throughout this project in Aarhus.

Aarhus wants to change the travel behavior to prepare for the problems that the city is forecasted to meet in the next 15 years. This will be the core of this thesis and therefore leading to the following research question.

1.3 Research question

How can the public administration in Aarhus use mobility management to influence a desired travel behavior?

To help answer the main question the following sub questions are made:

- What is travel behavior and why is this important when talking about mobility?
- Which key factors decide a certain travel behavior and how can this be influenced from one behavior to another?
- What can be learned from how other cities try to manage a change in travel behavior?

The final result of the thesis will be a set of recommendations to Aarhus municipality and other cities that are engaging with changing travel behavior. The recommendations are not specific to the roads, demographic or companies that Aarhus is working with, but the smart mobility project by Aarhus sets the structure of the analysis of this thesis.

2. Methodology

2.1 Research design

In order to answer the main research question, a clear plan for the structure is needed. Figure 2.1 illustrates how the report is approached.

First, the sustainable challenges and problems of the world are presented and acknowledged to create a context for the project, and within these challenges, a local case is selected. The case is Aarhus, which is forecasted to meet these sustainable challenges in the future.

Now that the challenges of the future has been laid, the 1. and 2. sub question are answered, by first, understanding the need for travel behavior in mobility and why it is important. After that, it is necessary to understand which factors can influence travel behavior, if in fact a change is desired.

These two sub questions gives a basic understanding and knowledge to select three relevant case studies, that try to solve the problems in their own way. The review of the three case studies answers the 3. sub question and grants the opportunity to generalize, to a certain degree, a set of recommendations or guidelines for changing travel behavior in general and in relation to Aarhus.

The recommendations answers the main research question by helping the future challenges, which is depicted by the red dotted line.

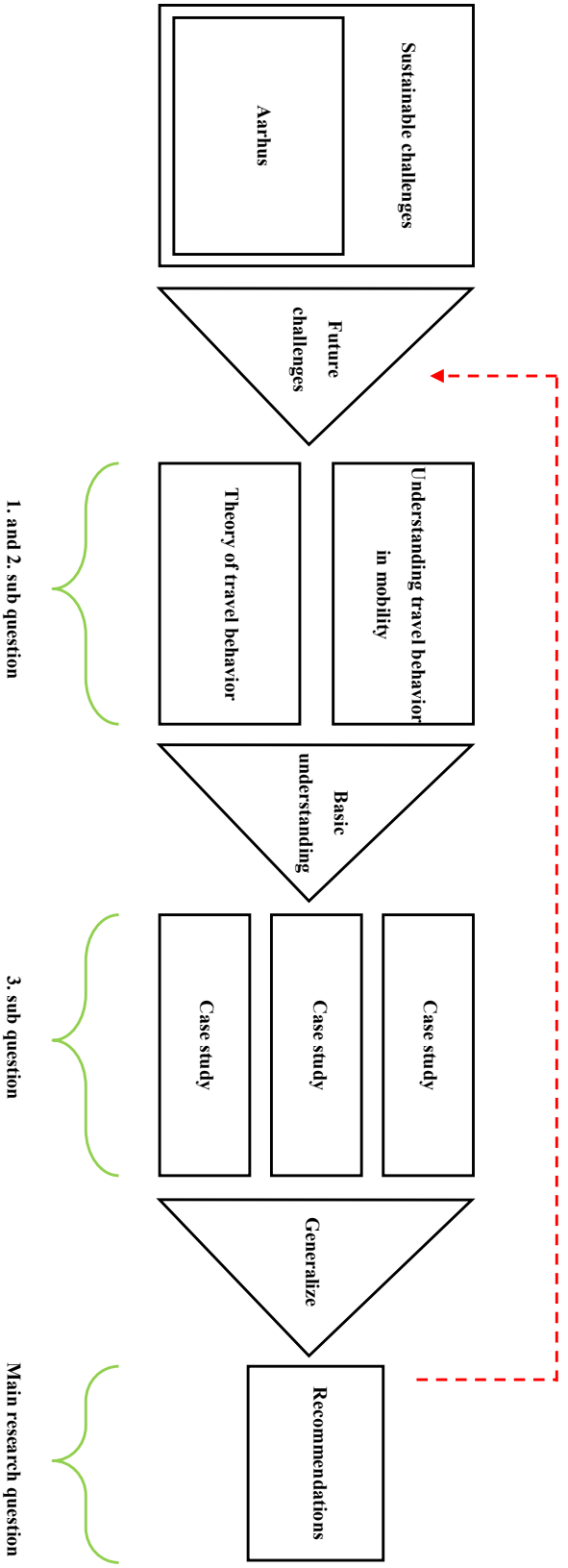


Figure 2.1: Research design (Authors own illustration).

2.2 Research methods

Different methods of research have been used during the writing process to answer the research question and to ensure scientific work and validation of the research. The applied methods are literature reviews and second readings of case studies. In the following sections, it is described how these methods were applied and which limitations occurred when using them.

2.2.1 Literature review

Literature studies have been used to gather the necessary background and theory on the problem. All the literature is secondary data because the field of research on mobilities and travel behavior is already very rich and still growing, so for this research it was not necessary to develop new theory. One thing to be aware of when using others work in literature review, is that it is important that the papers and authors are reliable and trustworthy sources. Another issue, is that the authors can have an hidden agenda or a biased view on the matter, which can color the literature in a certain way.

All of the used literature for the theory chapters are all scientific articles from scientific journals or books from well known researchers in the field, which both gives the validity and credibility of the theory. The articles in the literature is used as secondary data and it is attempted, to gather a range of different authors and sorting the relevant theory out, to avoid it solely being one authors viewpoint. The sorting of the literature reviews are based upon what was most relevant for the research question and best suited in creating the framework to understand the problem.

Other secondary data include data from official documents like the traffic plan obtained from Aarhus municipality's homepage and project description documents from Gustav Friis, the project manager of project in Aarhus. These documents are also considered trustworthy, as the documents comes a public institution like Aarhus municipality. The only challenge here, is that some of the descriptions in the traffic plan can be little vague, but it is a document showing the political future visions and goals for the transport sector, which often include vague and great visions.

2.2.2 Second reading of case studies

A side from literature reviews, three second readings of different case studies have been made. This is done, to gather as much diverse and thorough cases as possible to help better answer the main research question. This method, was also chosen, as the means and resources that it would take to research it empirically would demand a longer period of time.

The cases are all chosen as case studies done by researchers on two criteria. One, this again ensures the quality and credibility of the case study. Two, this also ensures that thorough research has been made and there are data and results gathered from the case study. If a completely new and innovating case study was chosen, then there is a high chance that it is too early in the process to have a significant result and a conclusion.

When working with case studies, and especially in scientific work like this, the question always lies on the degree of generalization. Three case studies have been chosen dealing with different issues on travel behavior: land use/built environment, interventions on habitual car use and changing commuting behavior. This is to have a diverse palette of recommendations to answer the main question and tackle as many challenges as possible, that Aarhus has.

In science, it is often required that a large number of the same study is to be made before it have a generalizing value. So the optimal scenario for this project is either choosing one issue and focusing on that with more cases or finding more cases within the three chosen issues. This is not done in this project, so it has to be noted that the generalization value is limited, if only focused on the case reviews. In the end, the results from the case studies are also discussed with how well it matches the theory, which give more value to the degree of generalizing.

3. Travel behavior in mobilities

SHORT INTRODUCTION TO THE CHAPTER...

3.1 The new mobilities paradigm

The following section deals with the new mobilities paradigm that is being formed in social sciences. It is important to know what defines mobility to fully understand which factors to focus on when addressing the problem.

Theory and research has thus far not been sufficient in examining how various objects enhance peoples movement. It is not that simple dealing with mobility, and with the advancement of the technology and the fact that people are moving more than ever, the way mobility is treated needs a new paradigm. The forming of the new paradigm include work from anthropology, cultural studies, geography, migration studies, science and technology studies, tourism, transport studies and sociology. (Sheller & Urry 2004)

The premise of the new paradigm is that the whole world is on the move and the people on the move are more diverse than ever. Asylum seekers, international students, business people, refugees, backpackers and holiday travelers are just some of the different people on the move and these people occupy airports, buses, ships, trains, roads and sidewalks. In 2006 there were over 700 million legal passengers internationally compared to 1950 where the number was 25 million. The predicted numbers today are even bigger. (Sheller & Urry 2004)

At the same time, the technology, mainly the internet, is rapidly growing. There are now new forms of traveling, 'virtual' and 'imaginative' traveling being combined with physical travels. The technology opens the door for new ways of interacting and communicating while still on the move and enhances new ways of coordination of people, meetings and large events. (Sheller & Urry 2004)

Traditional transport models uses random utility theory to analyze travel-related choices. These models focus highly on physical observable aspects of travel which can be weighted to an expected utility. More specific travel alternatives, e.g. routes, modes and destinations, are seen as 'utility bundles' which can be evaluated on it's physical attributes, e.g. time, distance and price and lastly what socio-economic status or characteristics of the observant. (Wind et al. 2012)

These models have widely been applied in the last 50 years of development, but despite the model's advantages, it is now often criticized by the current transport models for neglecting the new mobilities paradigm. Specifically that there are multiple aspects in mobility and in rationales in analyzing travel behavior. (Wind et al. 2012)

This development and addition of factors shows that mobility is not that easily defined and analyzed as before thought.

"The new mobilities paradigm suggests a set of questions, and methodologies rather than a totalizing or reductive description of the contemporary world." (Sheller & Urry 2004)

This paradigm embraces physical movement such as walking and movement enhancers like technology, bike, buses, cars, trains, planes and ships. Images and information on a local, national and global scale also include as mobility. This embraces one-to-one communication such as mobile phones and many-to-many communication through computers. Mobility studies should include these immobile infrastructures that organize the flow of people, image and information, as well as borders and roads that can limit, channel and regulate peoples movement or anticipated movement. At the same time, it also involves examining the relationship between transportation of people and communicating through messages and information, as this relationship keep converging and overlapping due to the recent digitization. (Sheller & Urry 2004)

"Studies of human mobility at the global level must be brought together with more 'local' concerns about everyday transportation, material cultures, and spatial relations of mobility and immobility, as well as with more 'technological' concerns about mobile information and communication technologies and emerging infrastructure of security and surveillance, including a kind of self-surveillance." (Sheller & Urry, p. 212, 2006)

Therefore mobilities need to be examined not as separate cases but as interdependent factors. Transport researchers tend to investigate simple categories of travel, like commuting, leisure

or business as they were separate factors. Another important mistake that conventional transport research make, is that the time spent traveling is not always dead time that people wish to minimize.

3.2 The emphasis on travel behavior

For many years the main challenge in transport has been congestion and the fact that traffic management could hardly cope. Managing the mobility or the demand gets more and more attention now. The knowledge on the climate challenges turns the focus from congestion to emissions and the threat of energy supply running out only help overshadow the issue of congestion (Lyons 2012).

Alongside this and the change in paradigm and the growing interest in activities and trips by individual travelers in mobility research, emerges now the activity based analysis. The conceptual foundation of the activity based analysis approach is that the choice to change one's location – ergo a trip – derives from a need or demand not satisfactory at the current location. These needs or demands are often physiological, cultural or social and are expressed in a range of activities at different times or places. The changes in travel analysis and modelling leads to complex behavioral patterns. (Schonfelder & Axhausen 2010)

The methodology of the analysis is fundamentally different from the forecasting models which has been predominant until the 1970s. These traditional models see the trip as the only predictor for traffic volumes, neglecting factors like activity demand and individual and environmental circumstances of trip making. The forecasting models, which were developed in the early 1950s, are still used today in transport planning. It is based on analysis of traffic flows on a database. This has given tools for quickly conceptualizing and assessing large-scale infrastructure projects, e.g. motorways. In contrast, the activity based analysis links mobility to human activity patterns, human needs and human interactions and therefore forecast individual travel demands. (Schonfelder & Axhausen 2010)

These factors underlying the analysis are what the theory and mobility researchers call travel behavior.

Since urban life began, observers have been fascinated by the patterns and rhythms of urban life. Especially since the industrialization changed, the scale of what urban life is since the early 19th century. The rapid growth of cities spawned urban problems that made it a necessity to provide urban infrastructure and managing it on a professional level. Two disciplines emerged from this in the 1930s and 1940s, transport planning and traffic engineering. Their main purpose was to provide urban actors with a functional transport system. (Schonfelder & Axhausen 2010)

In the 1950s, social researchers began using large-scale computer based models to narrow the focus of transport planning down to the peak hours of an average workday. The approach was understandable but left the transport planning more and more restrictive as time progressed. To widen the scope of transport planning, research in activity-based approach emerged as the most important tool. In other words, analyzing travel behavior, with its rhythms and interdependencies, and not the isolated trip itself. (Schonfelder & Axhausen 2010)

"Better knowledge of the structures and motives of longitudinal travel behavior has enabled transport policy and planning practice to design better measures to influence travelers according to current transport policy priorities." – (Schonfelder & Axhausen, p. 1, 2010)

In todays transport policies, management, information and counselling play big roles, which is why there is an emphasis on the travelers individual decision making and travel behavior. (Schonfelder & Axhausen 2010)

3.3 Technology fixes vs. behavior change

Advancing and improving technology has always gotten a lot of attention, especially in the transport sector. This section compares technology fixes with behavior change and argues why it is important to change travel behavior if a sustainable mobility is desired.

Transport developments includes three phases that folds out in the existing transport system (Lyons 2012):

- **Vehicles and infrastructure**. The first phase consists of creating/building the infrastructure that facilitates the moving vehicles (railways, roads, waterways). Parallel to this process, is the process of designing and improving the vehicles using the infrastructure. This part of the phase is dominated by science, engineering and technology.
- **Traffic management**. The second phase overlaps with the first, in the way that, the use of the infrastructure has to be as efficient as possible. Maximizing the people or vehicles coming through and minimizing the delay. Technology still remains dominant in this phase by managing the system, optimizing the mechanisms governing the movement of the vehicles and controlling the conflicts between them.
- **Demand management**. If the first two phases are successful, it would likely encourage the use of the transport system. This arises the problem that the demand exceeds supply, even if the infrastructure keeps expanding and the traffic is being managed. The solution for this, is to change the demand itself by either reducing it or influencing how, when and where people use the transport system. Demand management can rely on technology, but it is fundamentally about influencing the decision making process

of the users. The expertise required is suddenly broadened to that of social science, also mentioned in the sections earlier.

These three phases can be applied to different developments in transport as it has evolved from before industrial times to the present day, where movement is found on land as well as air and sea. However, the first two phases will almost always dominate as the primary goal is to provide what the society needs. This dominance in the transport industry and the mindset that technology can resolve all transport challenges, has made room for engineers, scientists, mathematicians and economists to have the upper hand. At theimpinge same time, there is a privatized market where the main profits come from the sale of mobility, and the reduction of transport would be unattractive. Up till now, the voice of transport has had a natural leaning towards that of technology fixes (Lyons 2012).

Technology fixes are appealing to the public because it keep 'things as the are', by improving the services associated with the public's current behavior or mitigating the problems created by transport in ways that do not collide with their lifestyle (Lyons 2012).

The question is then, why a change in behavior is so important these days and what it can do compared to the technology fixes, that promises the comfort of the users not doing much different to achieve the solution. Behavior change is essentially an influence on decisions made by individuals that affects the travel demand.

Figure 3.1 shows a simplistic overview on the comparison of technology fix and behavior change. Both can, in different ways, improve the consumption of transport. For example, technology ensures that a vehicle achieves more kilometers per liter and produces less emissions, and behavior changes like different driving styles or car sharing, can also achieve more kilometers per liters and less emissions, per person (Lyons 2012).

Technology fix	**Behaviour change**
improves efficiency of consumption	improves efficiency of consumption
maintains/encourages consumption	can reduce consumption
supports transport industry	could create a healthier society
is politically palatable	is politically challenging
preserves the automobility regime	challenges the automobility regime

Figure 3.1: Technology fix compared to behavior change. (Lyons 2012)

Technology fixes have the characteristic that it seeks to improve the efficiency of travel rather than reducing movement. This is done in the fields of climate change, energy and congestion. Compared to travel behavior changes, that seeks to solve these problems by traveling less, technology fixes allows people to travel as much or even more, while at the same time trying to remove the negative consequences. However, the two approaches can be connected in a sense, for example, when improving the travel time or fuel efficiency

(technology fix) it can affect the individual living further away from work (behavior change) (Lyons 2012).

One of the biggest contrasts between behavior change and technology fix, is the amount of which the measures are ready for a politically support. Technology fix gives the political message of 'positive things are being done to tackle the problems while you can keep going on with your lives'. On top of that, technology fixes goals are easily definable and understood by most people, as the goals are often showed as improved kilometers per liters or reduced amounts of emissions. Behavior change, on the other hand, comes with the political message of 'in order to tackle the negative problems we require you to make changes in your lives'. This is hard to understand for people as it challenges the freedom to chose their own lifestyle and at the same time, it is a challenge to define how specifically a change in in our own lifestyle would benefit that of others, leading to skepticism (Lyons 2012).

Figure 3.2 illustrates the social dilemma and the importance of changing behavior. When it comes to mobility, people tend to have a more selfish attitude when having to change their own behavior to benefit that of others.

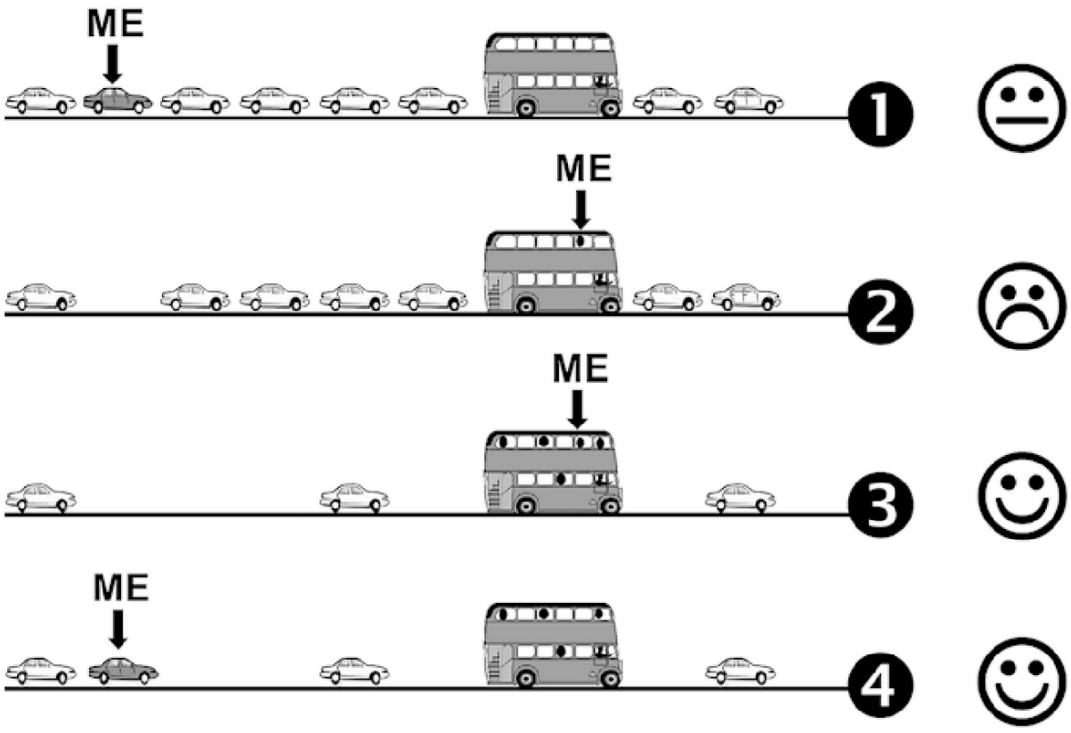


Figure 3.2: Social dilemma of commuting to an urban centre. (Lyons 2012)

The example shows that when people commute to an urban centre they have a choice of either traveling by car or by public transport. It is assumed that both modes of transport

share the same road. Most of the commuters will be met with congestion (situation 1), which is not a positive thing, but at least there is the comfort and privacy of their own car. If the individual chooses to switch to public transportation, the individual will remove one car from the road and thereby marginally reducing the congestion, and at the same time improve the journey for the rest of the commuters by car and public transport (situation 2). This is, in the end, going to be a greater negative cost to the individual, as the he/she is still in a queue and have lost the comfort and privacy of the car at the same time. If all or most of the car users switch to public transport then every commuter would benefit from it (situation 3). Situation 4 shows that the rational car user would stay in the car when realizing that the congestion has improved. The car user here thinks that if others switch and I do not, then I will still gain. This rational way of thinking results in all commuters stuck in traffic and dissatisfied (Lyons 2012).

This social dilemma and challenge requires an intervention for it to be broken. This for example seen with London's congestion charge, where the individual is penalized for selfish behavior and the reward is collective achieved (Lyons 2012).

This is not to say that technology fixes are redundant, rather it shows how important changing travel behavior is. Technology keeps on advancing day by day and research today, tries to combine the two approaches together. However, as mentioned earlier, if a change in behavior is not achieved, then the technology fixes will in fact be redundant. This thesis will focus on travel behavior and not innovating technology fixes, even though they are dependent of each other, but as stated, behavior change is currently the most challenging of the two.

4. Understanding travel behavior

The role of travel behavior in mobilities plays a bigger and much more important role today that ever. A change in behavior is needed to solve the problems of congestion, but before that, the knowledge of how to change behavior is needed. This chapter will focus on explaining the different factors that define certain behaviors in mobilities.

4.1 Factors of travel behavior

Travel behavior research often uses theoretically assumptions implicitly. In most work, there is often one very explicit factor, which is the microeconomic assumption that when the generalized cost of travel falls the more travel will be consumed. Travel, can then be interpreted and measured in a number of ways. Examples could be: number of movements, kilometres travelled (person or vehicle) and minutes of movement (person or vehicle). Because these three factors are not perfectly correlated, it is difficult to state how much a change in one factor of the generalized costs of travel will affect one of the others. (Schonfelder & Axhausen 2010)

The hypothesis here is that travelers trade the costs of travel with the costs of activities during the daily schedule. The costs are defined as the risk and comfort of the time spent on travel or activity, associated expenses and the social content of activities. It can be assumed that travelers would want to minimize these costs from day to day. When looking at longer time horizons travelers have the opportunity to change the travel constraints on a given day, some is voluntarily and others are imposed by others or by the by-product of the traveler's choices. Examples on the choices can be: locations (home, work or education), mobility

tools available (bicycle, car, public transport or plane), network of social contacts and their locations (family, friends, colleagues, churches etc.). (Schonfelder & Axhausen 2010)

Vast literature on transport-mode choice shows that travelers value differently when considering the time needed for a trip, as the level of comfort and risk can be perceived differently from traveler to traveler. Walking tend to be valued in a more negative way than riding the bus or driving a car. Generally a trip is less likely to be chosen when the trip itself will take longer than expected, the costs are perceived as higher because of the unreliability. At the same time, the comfort of a private vehicle is valued higher than travelling by bicycle. (Schonfelder & Axhausen 2010)

Monetary expenses for travel and activity are almost obvious factors within the costs of a daily schedule. It is appropriate to assume that travelers will avoid expenses if the choice is theirs to make. A private vehicle will not give additional cost to an owner, of public transport season tickets, deciding on the transport-mode for the next trip. Cost is a factor when for example the traveler decides whether to buy a season ticket for the month or the year. (Schonfelder & Axhausen 2010)

To a travel behavior analyst the social content can be both familiar or unfamiliar. Social content is here defined as the social signals that a traveler can send or receive by going on a trip or activity. These signals places the traveler in a social space where she or he belongs. The factors here are the social context that leads to the trip (e.g. work or shopping), monetary aspects (wages earned and restaurant bills) and more directly social aspects as the size and composition of the traveling party. In the social context, a travelers' attitude towards risk and variety intertwine because a choice of a new activity or location at a known or new location includes social and monetary risks. Unknown or new locations would be assumed to be linked to the travelers risk aversion. (Schonfelder & Axhausen 2010)

To sum up, the key factors of a travelers daily schedule are: risk aversion and variety seeking, the costs on daily trips and the traveler's social role and network, income, geography and mobility tools.

4.2 The theory of planned behavior

To further understand how the individual actor weigh in factors like cost, restrictions and opportunities perceived in the given social situation and ending up choosing a specific behavior, a theory of action is used. For this report, the Theory of Planned Behavior by Icek Ajzen is used. It has been used frequently in social psychology as one of the main actor theories.

The theory of planned behavior states that when an individual is confronted with the need

of choosing a course of action, the individual then considers the following consequences of available alternatives; weigh the normative expectations of specific individuals or groups; and consider the needed resources and potential restrictions. These are exemplified as the left side of the figure below. These considerations or beliefs are divided in, preferences and restrictions. The preferences are the shaping of attitudes toward the behavior of interest and the restrictions are the subjective norms to the behavior, and the perceived behavioral control. (Bamberg & Schmidt 1999)

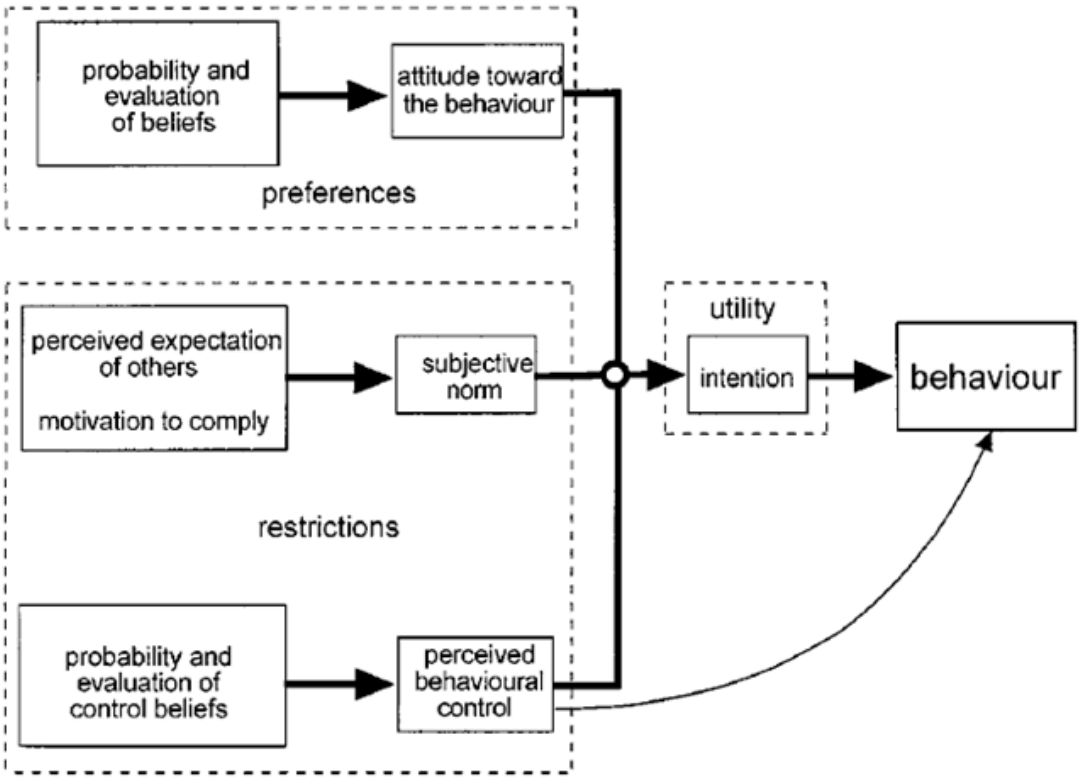


Figure 4.1: Icek Ajzen's theory of planned behavior. (Bamberg & Schmidt 1999)

One point that the theory of planned behavior makes is that the individual's intention to perform a behavior (X intend to do behavior A the next day) is the most immediate and precise predictor of a behavior. Intentions can be an individual's motivation, conscious plan or decision to make a specific behavior. However, performing a behavior is not always entirely under an individual's control, which is why there is a perceived behavioral control, as a second direct determinant for behavior. The perceived behavioral control is the perception that the individual have of whether the behavior is within reach or control, or easy or difficult (Doing behavior A the next day would be possible/impossible). (Bamberg & Schmidt 1999)

The intention itself is determined by subjective norm, the attitude towards the behavior and the perceived behavioral control. The attitude toward the behavior is the individual's

positive or negative evaluation of the behavior (Doing behavior A the next day would be pleasant/unpleasant). The subjective norms is the individual's perception of approval or disapproval from relevant people doing the behavior (Most people think that behavior A is a good thing to do tomorrow). The perceived behavioral control determines both intention and behavior because if the intentions were constant, the effort used to perform the behavior is likely to increase with more perceived behavior control.(Bamberg & Schmidt 1999)

4.3 Thinking in habits when changing travel behavior

Behavior change has in the recent years, become one of the major focus areas within political and intellectual agendas. The UK especially has taken this concept in and implemented this in areas as diverse as public health, energy use and passenger transport. Policy in UK now believe that the citizens must take responsibility and voluntarily change their behavior for substantial change to happen. This way of governing, forms the individual's decision-making while at the same time increasing the available choices for shaping the individual's own life, the idea is therefore to both increase choice and ensure welfare. (Schwanen et al. 2012)

The growing importance of behavior change can be related to two wider developments. The first is the national state generally shifting and re-scaling responsibilities away and towards the individual as an active agent. The second development is the increase in research of behavioral economics, psychology, marketing studies and neuro-sciences. (Schwanen et al. 2012)

Tendencies in governance and policy making and transport research all agree that some level of behavior change is needed to significantly reduce carbon emissions from transport. The ongoing debate is how much behavior change is required and which mechanisms works most effectively. Classic economic instruments like pricing and taxing, urban compaction and transit-oriented development is still highly favored, but soft policy measures and smart choices are beginning to attract more attention. Common for the soft policy measures to change travel behavior is that it runs deeply on being largely individualistic and the premise that the individual chooses, interprets and ascribes meanings to travel patterns. This can be an essential way bringing about change through public policy. (Schwanen et al. 2012)

When talking about changing an individual's behavior, the role of habits in an individual cannot be neglected or excluded. Habits in this context is viewed, as more or less automatic behavior that is acquired by repetition and positive reinforcement. (Schwanen et al. 2012)

An example could be an individual driving a car to work every day, thereby gaining a habit through every day repetition and at the same time receiving the positive reinforcement of the comfort of driving a car and maybe even the shortened travel time it can bring. One of

the main challenges in changing travel behavior is breaking these habits.

The importance of thinking in habits in transport research is increasingly being recognized. The relationship between habits and behavior, is that behavior is understood as an automatically elicited behavior. The presence of specific factors in a context can automatically trigger a behavior; examples can be a specific location that the individual is in, the preceding actions or the presence of certain people. The automated elicited behavior is possible because it is cognitive efficient. This behavior will over time, become habitual when it repeatedly is satisfactory and 'does the job'. The cognitive effort that now goes in to deciding a certain behavior becomes more natural due to the continual positive reinforcement and in the end then turns in to a habit. (Schwanen et al. 2012)

Psychologists emphasize that it is important to break these habits if a behavior change is to happen. The automated behavior needs to be replaced by a reasoned action. This can be done by disrupting either the automated response in an individual or the factors that are triggering the response. By replacing or disrupting a behavior the goal is that, a new habit can come into being. Experiments in transport related work suggests that implementations with a certain intention can weaken exiting habits and possibly facilitate new travel habits. (Schwanen et al. 2012)

Research in transport are working more with these habit-breaking strategies, more specific which factors that influence behavior. For example, studies have been investigating to which degree that car usage habits can be broken by interventions like modifying the cost and benefits of both habitual and alternative behaviors. The interventions can be price reduction on bus travels or changes to the infrastructural conditions like reshaping the size of the road or adding new roads. Some of the experiments have succeeded in bringing a modal shift but the challenge is the unclear long-term effects, which takes more time to show. (Schwanen et al. 2012)

If the lens is turned on the individual, the timing of the habit-breaking intervention can have a say for the change to happen. The interventions might be more effective if a new life event occurs, for example, a new house, a new job or a child is born. At the same time, these life events can enforce the individual's desire to stay with a given habit and not change it, even though an intervention is made. (Schwanen et al. 2012)

4.4 The link between built environment and travel behavior

Urban planners have long been interested in the link between built environment and human behavior, especially in the fields of urban design and transport planning. Former work and research in this, have generally aimed at enhancing the quality of life, improving the system efficiency or reducing environmental impacts. In other words, focusing on the health of the

community rather than individual health of the residents. By understanding how the built environment and behavior work together the outcome might lead a healthy community and residents all together. (Handy et al. 2002)

So what is exactly built environment? Urban planners tend to use a variety of terms to describe it. *Urban design* refers to design and physical elements of a city, this includes both the arrangement and appearance, and is usually focused on the function and appeal of public spaces. *Land use* is the distribution of land across space, this includes locations and density of different activities. These activities grouped in categories such as residential, office, industrial, commercial and other activities. The *transportation system* refers to the physical infrastructure of roads, railroads, bike paths, sidewalks, bridges and so on. Also within this field is the level of service offered, for example bus frequencies.(Handy et al. 2002)

Built environment in this report is defined as combination of urban design, land use and the transportation system, and at the same time encompasses patterns of human activity in the physical environment. The built environment can constantly change; for example a fast change like the drop in the number of pedestrians in a busy street from noon to midnight or slow changes like the deterioration on the exterior of buildings over time.(Handy et al. 2002)

The built environment can then be defined as a multidimensional concept. When looking at the interactions between built environment and travel behavior, certain elements of the built environment are more appropriate to measure at various scales. Research has typically focused either on the scale of a neighborhood or broader regional scales.

Studies suggests at least five dimensions of the built environment(Handy et al. 2002):

1. *Density and intensity of development*. Density is a measure of a amount of activity in an area. It is usually defined as population, employment or buildings in an area and can be measured in people in a certain area or jobs in an area. Density is one of the easiest dimensions of built environment to measure and is therefore widely used.
2. *Mix of land uses*. Land use mix refers to the different land uses within a given area. If the area is a neighborhood it would include not just homes but stores, parks, offices and maybe other land uses. Land use measures are not standardized so different studies measure it differently. One study measured the distance between each house to the nearest store as a measure for mixed land use.
3. *Connectivity of the street network*. This refers to the directness or availability of alternative routes going from A to B within a street network. Measures can be the number of intersections in an area or by the ratio if a straight line is drawn between the two points.
4. *Scale of streets*. Scale is defined as the space along a street as bounded by buildings or things like trees or walls. It is usually described as 'human scale' or 'automobile

scale' and can be measured by looking at the building heights or the distance from the street to the building.

5. *Aesthetic qualities of a place*. These are the qualities that contribute to a place's attractiveness or appeal and is the dimension that is hardest to define. It is more described than measured in research. Examples that contribute to aesthetic quality could be design of buildings, landscaping like trees and shade and the availability of benches and lighting. Places with good aesthetic quality usually have a clear identity and a strong sense of place.

Urban planners often label areas pedestrian friendly if there are relatively high density of development, a mix of land uses, street network with high connectivity, human scale streets and a good aesthetic qualities that makes walking to be more viable and appealing. Oppositely, areas with characteristics that match an automobile friendly area make walking, public transport or other alternatives to the car a significant challenge. (Handy et al. 2002)

The use of walking, cycling and public transport in suburban or rural areas is usually significantly lower than urban areas, the primary mode of transport in these areas is car use. Part of the explanation for this is the built environment of these areas. Areas or neighborhoods with low density and diversity, which is the case for suburban and rural areas, have longer average distances to places. This discourages activities like walking and bicycling compared to the urban neighborhoods, as the potential trip in the proximity of the traveler is reduced. In addition, these areas which encourages car use have fewer public transportation travel opportunities, this results in public transportation stops with longer distances between them.(Vos 2015)

Movements in literature like New Urbanism (in the US), Compact City (in Europe) and transit-oriented development (in the US and later adapted in Europe and Asia) begins to emerge from these problems and are widely getting focus this day today. These movements embrace urban design and planning principles to create public spaces and reduce car use. One of the primary goals is that communities should be designed for pedestrians, public transport and for the car as well. The claim is that by putting the daily activities within walking distance and a set of good streets, sidewalks and paths, will increase walking and decrease driving.(Handy et al. 2002)(Vos 2015)

In recent years, planners, developers and policy makers have wanted to design more compact cities with the mix of land uses to achieve more sustainable urban form. The compact city is difficuelt to implement, but it can help shorten travel distances and thereby lowering emissions, reducing travel costs and improving the quality of life.(United Nations 2013)

The opposite of the compact city, is urban sprawl, which describes low density, dispersed, separated land use activity and car dependent built environments. The urban form are more fragmented and can result in the consumption of resources like farmland and open space. Urban sprawl has a profound influence on travel behavior, in the sense that the spread out

growth, lengthens the trip, but also encourages the use of car.

The transport sector plays a big role in the urban sprawl of cities. As more and more urban transport modes were integrated in the daily life through history, it only accelerated the expansion of the cities outwards. Before the automobile era, distances within the city had to be compact and walking distance friendly, in order to reduce the need to long physical travel. The growth in population and the growth in automobile technology made it easier to travel the long distances. (United Nations 2013)

Density in the urban form is one element, but spatial distribution of population and jobs are also important.

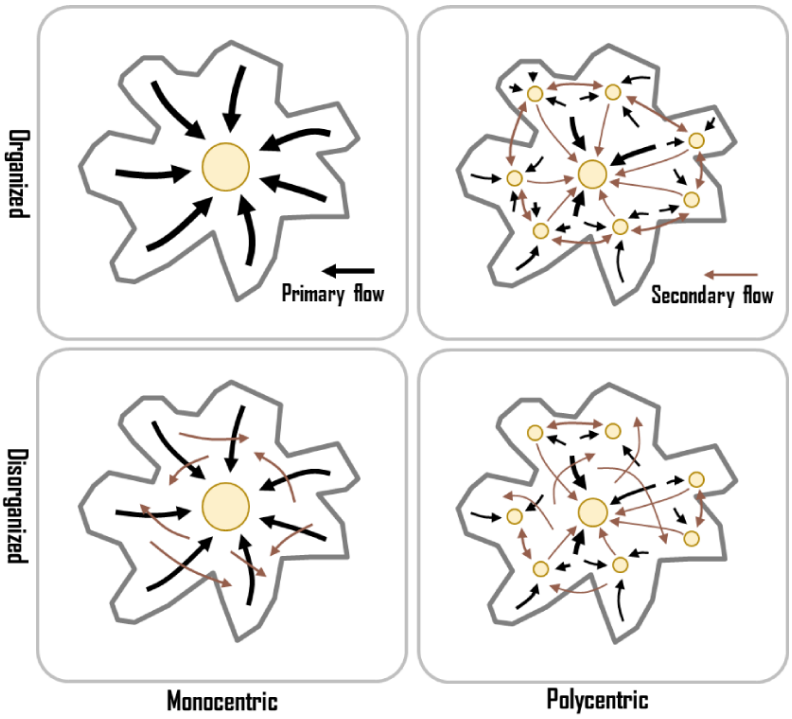


Figure 4.2: Urban form and the spatial pattern of travel flows. (Bertaud 2001)

A monocentric urban form, where the majority of jobs and commercial activities are situated in the city centre and where most of the residential areas reside on the periphery, will produce radial car and public transport trips. This will lead to extreme road congestion when the vehicles near the centre.

A multi centred or polycentric urban form results in more dispersed and cross town travel patterns, which can encourage more flexible forms of mobility, for example private cars. Polycentric regions can host successful public transport networks by using sub centres to

interlink rail services. Suburban centres then effectively become the points for connecting the public transport network.

4.5 Acceptability of transport policy measures

One thing is understanding the different elements of travel behavior in an individual, another thing is actually creating that change in a travel behavior. A way to that is by actively monitoring and planning through transport policies. There are four main types transport policy measures: legal policies, measures changing physical environment, economic policies and informational/educational measures.

The public's negative or positive evaluation of transport policy measures have been investigated to be the attitude toward the policy measure itself, since the evaluation done by the public depends on the expected outcome of the measure. The term acceptability refers to the degree of positive or negative evaluation of the measure. Many researchers point to the fact that public acceptability toward these measure, is crucial if they are to be implemented successfully. (Eriksson 2008)

To understand why certain policy measures get accepted while others do not, it is important to look at which factors trigger acceptability. The attributes of the transport policy measure and the individual's characteristics are important when trying to achieve acceptability.(Eriksson 2008)

Researchers found that attributes like pull measures in a transport policy are perceived as more acceptable than push measures. There is a clear distinction between the relevance of pull and push measures for acceptability. For example, push measures, such as, raising the cost of car use are generally not accepted positively, while pull measures, such as, improving the public transport, are accepted to a larger extent. Measures targeting efficiency are more accepted than the measures focusing on restricting behavior. Studies even show that transport policies combining both push and pull measures have a low level of acceptability.(Eriksson 2008)

As for the role of the individual's characteristics, background characteristics like age, income, education and car use are all important factors for the acceptability of transport policy measures. Attitudinal factors toward the measures have often been found to be more important. Example being, the higher the awareness of the problem, the higher level of acceptability.(Eriksson 2008)

The evaluation of structural changes, like mobility management, is based on four dimensions(Eriksson 2008, p. 16):

- *the extent to which the strategy is perceived to be fair or not (i.e., fairness)*
- *the extent to which the strategy provides the resource without depleting it (i.e., efficiency)*
- *the extent to which the strategy influences freedom of choice (i.e., freedom)*
- *the extent to which the strategy influences the individual (i.e., self-interest)*

4.6 Uncertainty

Common for all the modeling approach and underlying theory is that there is an assumption that decision makers have the ideal knowledge about the data of their choice alternatives. The values of the attributes are locked and the travelers assumed to have perfect knowledge about these attributes. The models relate to choices under conditions of certainty. (Rasouli & Timmermans 2014)

The assumption that the attributes values are certain is not realistic. When travelers leave home, they are not certain about the time of arrival to the intended location, as travel time can fluctuate. When travelers choose public transport, they are not guaranteed a seat. This can vary from day to day. When choosing a place to park, the traveler might face long queues or parking garages being full. A route which is normally never congested might suddenly be struck by an accident or adverse weather conditions that cause significant delays. (Rasouli & Timmermans 2014)

The decision makers or the travelers might then often be faced with conditions of uncertainty when choosing routes, activities, destinations, transport modes, etc. (Rasouli & Timmermans 2014)

5. Reviewing cases on travel behavior

Now that the groundwork for understanding what shapes an individual's travel behavior and which factors plays a role in deciding a behavior has been laid, the lens now turns to more practical examples. The purpose of this chapter is to investigate how the theory works in real life cases. The real life cases/scenarios examples in this chapter will be literature studies on case studies on travel behavior change on different cities. The first part of each case will give a case description explaining the background and reasoning for the experiment. Next will include the results gathered from each of the case studies, and lastly I will give my own discussion on how this fits with the chosen theory in this report and how all this can relate to Aarhus case.

The structure of this chapter is divided in three case reviews. The first two derives from the theory of built environment and changing habits, but these topics are still relevant for Aarhus as well. The last case is about changing commuting behavior and derives from Aarhus having commuters or workers as one of their target groups in their project. The case also bears a resemblance to Aarhus municipality relocating their offices as an experiment.

5.1 Built environment: Comparing Flanders and Netherlands

Flanders in Belgium and the Netherlands have both experienced a increase in car use the past decades, more specific the total distance covered by cars have nearly doubled from 1980 to 2012. This study investigates and compares the influence of land use and mobility policies on travel behavior in the two regions. The Netherlands is a country with a long history of spatial planners intervening in the development of the urban form. In contrast,

Flanders, the northern region of Belgium, have until the end of the twentieth century had limited spatial planning regulations from policy makers in order to encourage people living outside the city.(Vos 2015)

This case study analyzed whether a more active and regulating spatial planning on the built environment as seen in the Netherlands, which have resulted in more clustered land use patterns, have opened for more sustainable travel behavior compared to it's contrast Flanders with the more passive spatial planning regulations. Sustainable travel behavior here meaning reduced car use and shorter daily travel distances.(Vos 2015)

5.1.1 Background: the history of spatial planning and mobility policy

Flanders and the Netherlands at first glance look like fairly similar. They are neighboring regions, partly share a same history, dutch is the language in both regions and the population density is almost the same, 466 inhabitants/km^2 in Flanders and 404 inhabitants/km^2. Even though there are similarities, there is a significant difference in the spatial patterns of both regions.

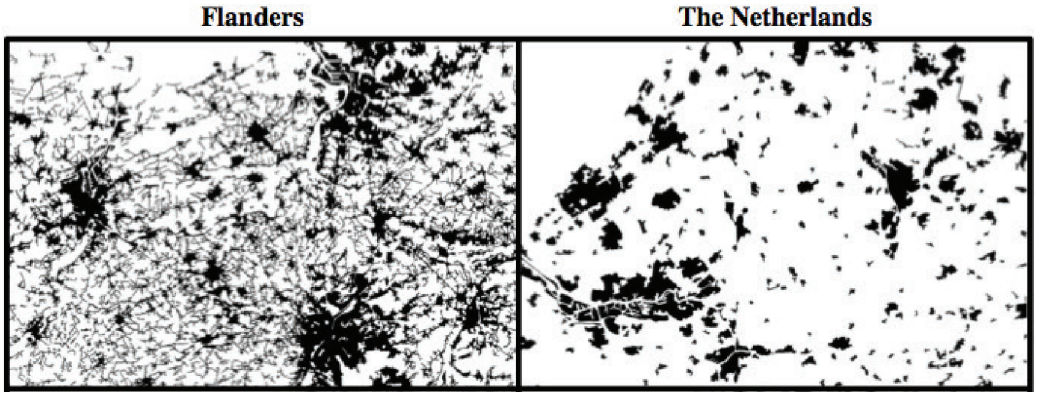


Figure 5.1: Land occupied by infrastructure and buildings in Flanders and the Netherlands. (Vos 2015)

The space occupied by buildings and infrastructure compared to the available amount of land is different. In Flanders buildings and infrastructure take up 26,4% of the land compared to the considerably lower 14,5% in the Netherlands. Part of the explanation why it is higher in Flanders can be the dispersed land use in the region, where the borderlines of city and countryside are hard to draw. The Netherlands, on the other hand, have managed to restrict the spread of the urban development which have resulted in more compact urban areas.(Vos 2015)

Land use in Flanders starts having an important influence on the travel behavior from the

nineteenth century and onward. Belgium was the first country in Europe that experienced the industrial revolution, which caused a growth in employment in the cities. The majority of the workers were poor and did not have the resources to commute, so many of them moved from the countryside to the city. Belgium did not want the cities being overpopulated and unhygienic because of this, so to prevent this, building started for the most densified network of trams and trains that was seen in all of the industrial countries. Laborers were now able to commute easily and more cheap between the countryside and the city with the public transport. (Vos 2015)

Belgium chose an 'anti-urban' policy, which resulted in cheap, efficient and spatially widespread public transportation network, and to hold the regulations on spatial planning limited. The cities then spread outward and generated sub-centers around train and tram stations, which were widely used by employers residing far away from the workplace.(Vos 2015)

The rise of the car after the second world war resulted in the urban sprawl really taking off in Flanders. Combination of laborers earning more income and the mass production of the car made it easier to own a car and reside anywhere on the countryside. All this gave birth to suburban, low density neighborhoods with good accessibility for cars scattered all round the region. The passive spatial planning policies in Flanders only made it easier for the geographical distribution of facilities.(Vos 2015)

Spatial planning or zoning plans in the 1970s pointed out areas, spread around the region, to be residential areas or potential residential areas, based upon expected growth in the population. Other zoning areas like industrial zones were also scattered around almost every municipality. In addition, Flanders allowed construction of dwellings in non residential areas between buildings to 'fill up'.(Vos 2015)

All this resulted in a strong urbanized region where open spaces became hard to find. The available space was being taken by buildings, infrastructure or other activities. This made the city and the countryside fade together.(Vos 2015)

Flanders now use land use policy in a different manner, it is now more focused on urban policy. The region now tries to increase the attractiveness of residential areas in the cities by emphasizing positive things like large supply of jobs, recreation and culture. The mobility plan of Flanders sets a framework for the future of mobility policy. The plan mainly focuses on social aspects of mobility like ensuring accessibility in every place for everybody. Some of the main goals are: accessibility, livability, safety and quality of the environment. By ensuring accessibility for everyone, Flanders pursues to expand the infrastructure and at the same time needs be cheap and with a public transportation network that has to be widespread.(Vos 2015)

The Land use in the Netherlands tells a different story and outcome. The suburbanization

happening in Flanders was held to a minimum in the Netherlands. Industrialization began later in the Netherlands compared to Belgium, so there was a little more time to find a solution for the increasing urban population. The Netherlands took a more systematic approach to the increase in urban population instead of seeing urbanization in the countryside, resulting in a more clustered pattern of land use. Furthermore, the municipalities and housing corporations got financial aid to ensure that urban expansion was structured and organized. Development plans helped large scaled urban expansions and consequently guarded the countryside against urban sprawl.(Vos 2015)

After World War II and the rise of the car the population expected to grow and with it, the risk of urban sprawl grew too. The government in the Netherlands tried to restrict this development of suburbanization in the countryside. The most important method for doing this, was 'concentrated decentralization'. To protect open areas, new urban developments happened in growth centers, mostly placed in the proximity of larger cities. In total 16 growth centers were pointed out to hold the concentration of the growth. The policy was implemented in the 1970s and 1980s and was relatively successful in; restricting urban sprawl, keeping urban developments in the growth centers and maintaining the open spaces free from urban sprawl.(Vos 2015)

The increase in population in the growth centers at the end of the 1980s resulted in an urban exodus from the city centers in larger cities. The growth centers were also criticized for not having varying dwelling types and a weak social cohesion. To prevent the urban exodus from the city centers, the Dutch planning policies tried to concentrate the development in the larger cities, this can be compared concept of 'compact city'. New neighborhoods was to rise at the edges of the existing cities and to protect opens spaces in the countryside, 75% of all dwellings had to be within the existing urban regions.(Vos 2015)

The present policy focus has shifted from compact city to urban network. Urban networks are highly urbanized areas within a network of both small and larger compact cities, each with their own characteristics. It is no longer an individual city, but an urban network that has a complete arrange of dwellings, jobs and other services to the inhabitants. By concentrating these urbanized areas in the network, the purpose is still to prevent urban sprawl.(Vos 2015)

The focus on social aspect of mobility in Flanders, is less visible in the Netherlands mobility plan, instead the focus is on encouraging alternatives to the car. Road and railroads are situated in a number of connecting corridors, and the most important residential areas, jobs and airports are placed along these corridors. In contrast to Flanders, the Netherlands focuses not to expand the infrastructure but seeks to optimize the existing to transport more people.(Vos 2015)

5.1.2 Results: Travel behavior in Flanders and the Netherlands

It appears that the Flemings and the Dutch have different travel mode choices, see figure 5.3, especially in bicycle and car use. The figure shows that the car in Flanders is used for more than 60% of all the types of trips, compared to the car use in the Netherlands, which lies below 50% for the different trips. Bicycle use is significantly lower in Flanders than in the Netherlands for all types of trips. Another thing to notice is that all public transport are higher in the Netherlands than in Flanders. One that stands out is the difference in the public transportation for commuting, where the difference in number is doubled between Netherlands and Flanders. (Vos 2015)

To sum it up, the use of car in Flanders is easily the most dominating whether it is for commuting, leisure or shopping. The Netherlands, on the other hand, even though the car still is the most used, it all seem to be more evened out, especially on the alternatives to the car, compared to Flanders. Travel mode choice is therefore more sustainable in the Netherlands than in Flanders. (Vos 2015)

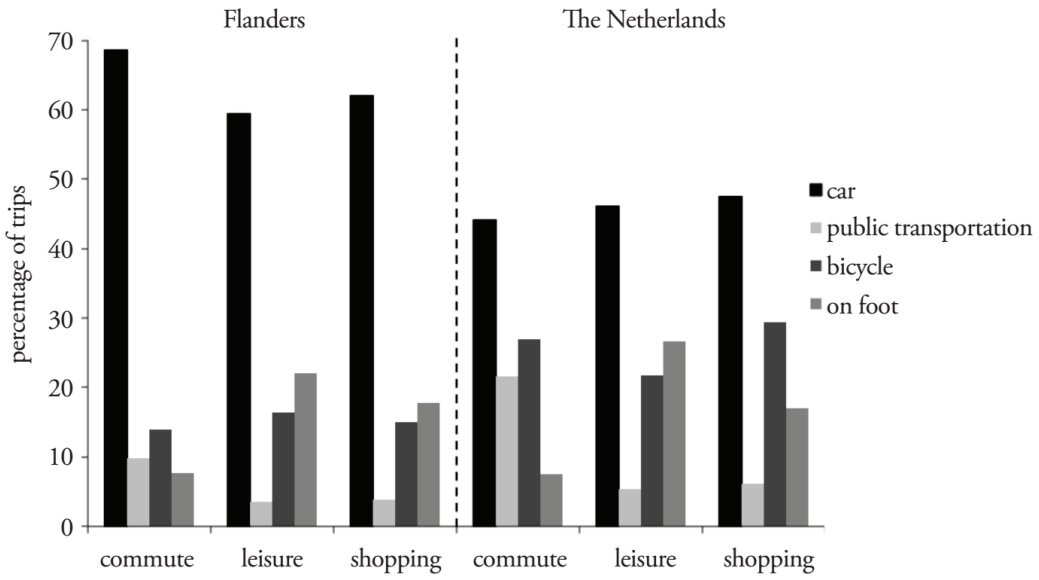


Figure 5.2: Travel mode choice for different types of trips in Flanders and the Netherlands. (Vos 2015)

Some factors might explain why the numbers are as they are. The higher bicycle use in the Netherlands can be due to the differences in the mobility policy and the culture itself. Even though, compared to most Europeans, the Flemings bicycle quite frequently, the bicycle use in the Netherlands is different, it almost seem like a way of life and is deep rooted in the culture. (Vos 2015)

As for the higher public transportation numbers in the Netherlands, this can be explained by the implementation of workplaces in the proximity of major railway stations. The high density development near public transportation have resulted in increased use of this. Highly educated people tend to get more specialized jobs, which are often situated in high density areas. A clustering of these jobs near public transportation might then increase the use of these for commuting. This seem to be the case in the Netherlands. (Vos 2015)

Another explanation for the high usage of the public transportation can be that the Netherlands focuses more in optimizing the public transportation than keep expanding it. For some people, a limited number of public transport but with high quality, frequency and capacity might be more attractive than the opposite. Furthermore, since urban sprawl is limited and people tend to live more dense areas, the public transportation is easier to organize compared to countryside where the availability of public transportation is limited. (Vos 2015)

There are also noticeable differences, see figure 6.3, in how the travel behavior is according to where people resides, more specifically the level of urbanization of the residential area. Car use and public transportation in the Netherlands show logical numbers when looking from large cities to countryside, public transportation use decreases when moving further to the countryside and car use increases instead. (Vos 2015)

Walking is highest in large cities and in Flanders walking decreases when the level of urbanization decreases as well. Large cities simply have more pedestrians walking, while countrysides have the smallest amount. Public transportation is no competition for bicycle use, since Flemings use public transportation significantly less then the Dutch, unless it is in large cities, where public transportation is at it's highest. One thing to notice, is the travel behavior in the Flemish countryside where the people here travel more with car alternatives, except for walking, and less by car than the small cities. This can partly be explained by the widespread of the public transportation system. Even though it is not frequently used as in the Netherlands, people living in the countryside have it more available because of the spread. (Vos 2015)

	Car	Public transportation (bus, tram, metro/train)	Bicycle	On foot
Flanders				
Large city	48.1	12.1 (10.5 / 1.6)	13.4	26.4
Regional city	55.5	6.6 (4.2 / 2.4)	18.5	19.4
Suburb	64.1	6.0 (4.0 / 2.0)	14.9	15.0
Small city	67.6	4.6 (2.0 / 2.6)	12.2	15.6
Countryside	65.5	5.4 (3.6 / 1.8)	16.4	12.7
The Netherlands				
Large city	30.6	29.1 (18.9 / 10.2)	19.1	21.1
Regional city	39.2	16.2 (4.1 / 12.1)	27.4	17.2
Suburb	47.1	12.1 (5.7 / 6.4)	23.5	17.4
Small city	44.5	8.1 (1.3 / 6.8)	29.0	18.4
Countryside	50.1	8.0 (3.9 / 4.1)	25.3	16.6
Growth center	45.6	20.1 (6.5 / 13.6)	19.6	14.7

Figure 5.3: The modal split in percentage in different residential areas. (Vos 2015)

5.2 Attitudinal factors, habits and transport policy measures

This case study has four empirical studies. Study I, aimed to interrupt and reduce habitual car use by deliberate interventions and to examine the factor of moral motivation, for example personal norm. Study II examines which factors are important for the acceptability of three mobility management measures: raised tax on fossil fuel, an information campaign and improved public transportation. Study III follow up on study II and examines the acceptability of single and combined transport policy measures. Lastly study IV examines travel behavioral adaptations, more specifically, how the expected car use reduction behavior can be a response mobility management measures like improved transportation and tax raise on fossil fuel.

5.2.1 Study I: Interrupting habitual car use

To investigate whether an invention could encourage people to reduce car use, the importance of habit strength in cars and moral motivation for a reduction was examined. Three hypotheses were formulated to help the investigation.(Eriksson 2008)

The first hypothesis was about whether the intervention would be successful in interrupting the habitual car use. It insisted that relationship between car habits and car use would weaken, and at the same time, the relationship between car use and personal norm would

strengthen from the intervention.(Eriksson 2008)

The second hypothesis stated that there will be no change in the relationship between car habits and personal norm. Since habits are developed over a longer period of time, the short amount of time being interrupted, would seem unlikely to succeed. Note, that attempts are only made to interrupt habit and not strengthen the motivation to reduce car use.(Eriksson 2008)

The third hypothesis imposed that the size of car use reduction would be greater for individuals that have a strong car habit and a strong personal norm at the same time. The reasoning behind this, is that the intervention would only influence individuals with strong car habits and the only car users who would reduce their car use, will be people with high motivation to reduce it. (Eriksson 2008)

The different hypotheses were tested in an experiment with 71 car users in Sweden. The people were recruited by telephone and was asked to do an pre-intervention questionnaire and a diary of the car use one week before and after.(Eriksson 2008)

Results showed that the control and experimental groups did not differ in personal norm, car habit strength or car use before the intervention. Personal norm was more related to car use than car habit strength after the intervention compared to pre intervention, which fitted the first hypothesis. Furthermore, as hypothesis 2 stated, the interventions did not influence the strength of car habit and personal norm. The final results revealed a significant interaction between intervention, car habit strength and personal norm. Results indicated that individuals with strong car habits and strong powerful norms reduced their car use after the intervention. (Eriksson 2008)

5.2.2 Study II: Acceptability of mobility management measures

The general public's acceptance of transport policy measures are important for the political feasibility and for how effective a measure can be. It can be hard to distinguish between which measures will be received in a positive way and which ones will not. For example, there is high acceptability for pull measures, while push measures are often seen as unacceptable. Previous research has shown that general environmental beliefs as well as policy specific beliefs is important for the acceptability of a measur (Eriksson 2008).

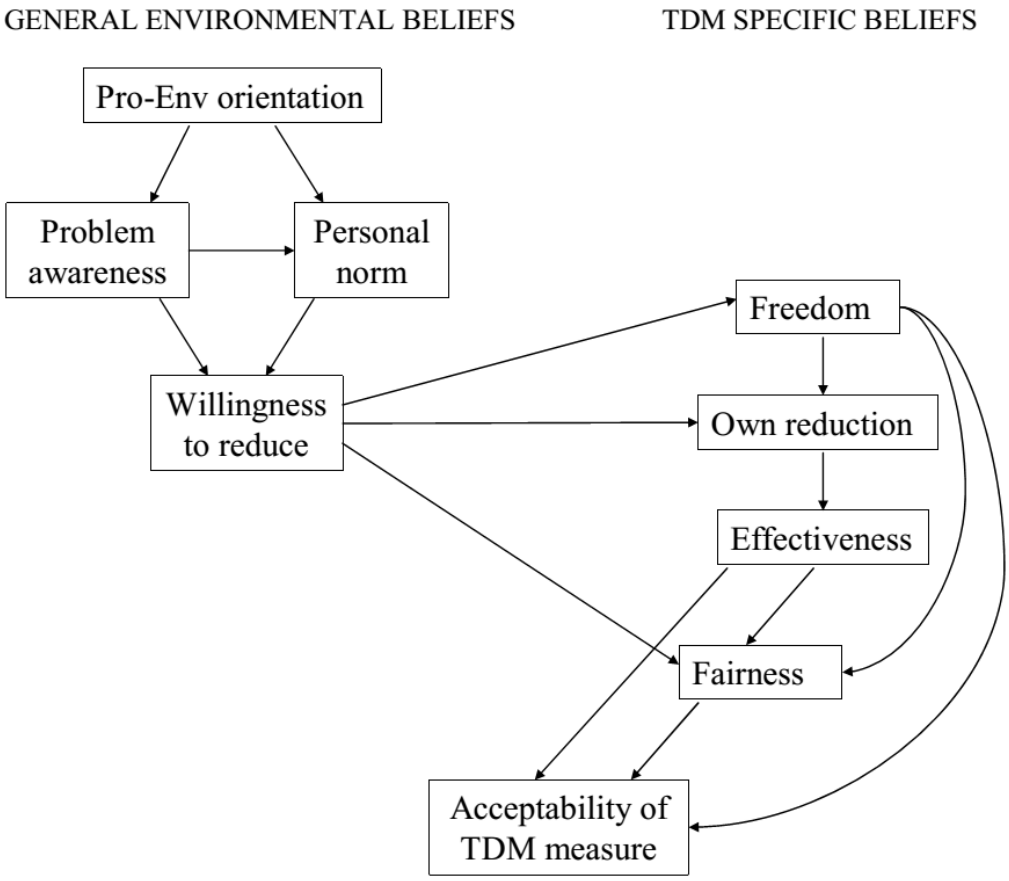


Figure 5.4: A model of factors predicting the acceptability of travel demand measures (TDM). (Eriksson 2008)

The aim of this study was to test the factors of acceptability in the model seen in figure 5.4. The first part of the model links people's pro-environmental orientation, awareness of the problem and personal norm to the willingness to reduce car use. These factors, categorized as environmental beliefs, are then linked to a range of policy specific beliefs, which shows the extent of which the travel demand management (TDM) measures are expected to influence different beliefs like the freedom to choose the travel mode, their own reduction of car use, the perceived effectiveness, perceived fairness and in the end, their acceptability of the measure (Eriksson 2008).

This model was tested in relation to three different measures: information campaigns, improved public transport and increased tax on fuel. This was done by a questionnaire randomly sent to 4000 citizens in four Swedish municipalities. The questions covered background characteristics and all the environmental beliefs (Eriksson 2008).

The measures were described as three different scenarios and was to be evaluated on different

dimensions (Eriksson 2008):

- The degree of which the measures were perceived as fair (fairness)
- The amount of driving distance that they expected others to reduce if the measures were implemented (effectiveness)
- The amount of driving distance they expected to reduce their own car use if the measures were implemented (own reduction)
- How much the measures influence the freedom to choose travel mode (freedom)
- Whether the respondent was in favor or against the measures (acceptability)

The results of this study showed that improved public transport was generally perceived as acceptable, information campaigns was perceived as neither acceptable or unacceptable, and the raised tax on fuel was perceived to be unacceptable. Pro-environmental and problem awareness were both related to personal norm, which was associated with the willingness to reduce car use. The travel demand management specific beliefs acted as a mediator between the environmental beliefs and acceptability, in particular the belief of fairness. On the other hand, personal norm resulted to be directly related to the acceptability of raised fuel tax and information campaigns, while problem awareness resulted in being related to the acceptability of improving public transport. This study confirms that the general environmental beliefs can be used for evaluation of travel demand management measures and the different specific beliefs of TDM are important for the public's acceptability (Eriksson 2008).

5.2.3 Study III: Combining measures

A way to overcome the challenges of implementing push measures, is by advocating a combination of measures, for example public transport together with pricing measures. In this study, the acceptability of single and packaged transport policy is examined. A model, compared to the one in study II, was made with environmental beliefs and policy specific beliefs as the predictors of acceptability. According to this model, pro-environmental orientation, problem awareness, peoples personal norm and their willingness to reduce negative environmental consequences of car use are tied with effectiveness, the perceived fairness and in the end acceptability. It was also examined whether awareness for the problems or personal norms had a direct linkage with acceptability (Eriksson 2008).

This model was tested with three single transport policy measures: raised tax on fuel, improving public transport and subsidies to renewable fuel, and with two packages of measures: raised tax on fuel to improve public transport and raised tax on fuel to help subsidize renewable fuel (Eriksson 2008).

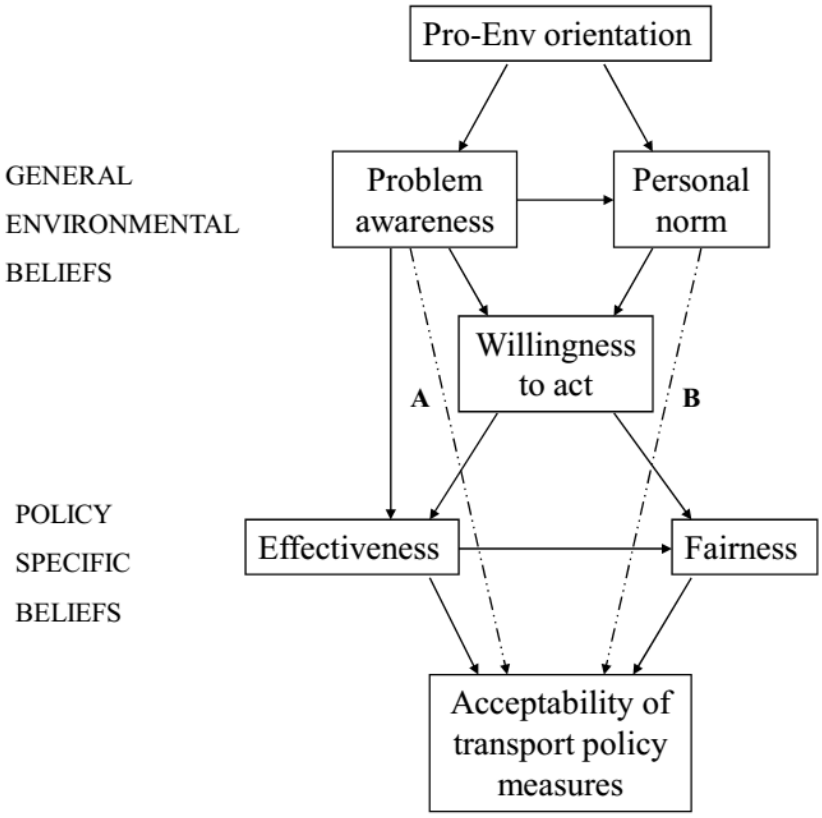


Figure 5.5: Proposed model predicting acceptability of transport policy measures including the original model as A and B). (Eriksson 2008)

Based on the results gathered in the previous study, it is expected that a direct relation between problem awareness and acceptability for pull measures is found, this is shown as line A in figure 5.5. Is also expected a direct relation between personal norm and acceptability for push measures, this is shown as line B in figure 5.5. If the package of measures, including the one with a combination of pull and push measure, is perceived as effective, fair and acceptable, it is expected as a direct relation between problem awareness and acceptability. If the packages, however, are perceived as ineffective, unfair and not acceptable, it is expected a direct relation between personal norm and acceptability (Eriksson 2008).

The results showed that pull measures were seen as acceptable and the push measure was seen as unacceptable. The packages with one pull and one push measure were seen as a mix, although slightly more ineffective, unfair and unacceptable. Regarding looking for a predictor of acceptability, the model of A and B showed that they were better than the other model, except for the package including raising tax and subsidizing renewable fuel (Eriksson 2008).

In summary, the results was in line with study II, as general environmental beliefs and policy specific beliefs were still important for people accepting single and combined transport policy measures. Personal norm was most important for push measures and the combined packages, while problem awareness was most important for pull measures (Eriksson 2008).

5.2.4 Study IV: Car use reduction with travel demand management measures

Since travel demand management measures can change travel behavior, it is important to look at the behavioral effects of these measures. The aim of study IV, is to examine the expected car use reduction when implementing three structural TDM measures. The three measures are: improving public transport, raising tax on fuel and a combination of the two (Eriksson 2008).

The study had three goals. First, regarding the expected car use reduction, it expected that the combined measure will have a larger reduction than measures examined individually. No difference in the two individual measures was to be expected. Second, regarding the applied car reducing strategies. Different strategies tend to be favored depending on the travel purpose, travel length and TDM measure. It is expected here, that more efficient car use and travel mode changes will be the most chosen strategies. Third, regarding the important factors for an expected car use reduction. It is anticipated that, the motivation to reduce car use of the users combined with the perceived personal impact of the measures will be vital for how much the users will reduce car use in response to the implementation of the measures (Eriksson 2008).

Results in this study showed that the combined measure of raising tax and improving public transport led to a larger car use reduction, a 28% reduction compared to that of 19% for improving public transport and 21% for raising tax on fuel. Although this is not a great difference in numbers, it could indicate a need to implement combined TDM measures rather than individual. Furthermore, efficient car use and travel mode changes were chosen most as car use reduction strategies. In the car diaries, changing the travel mode was chosen for around 80% of the trips in response to raising tax and the combined measure. On an annual basis, the favored car reducing strategies were, in order of most popular: trip chaining, change travel mode, car pooling and the least favored strategies were changing destination and refraining from traveling (Eriksson 2008).

5.3 Commuting: Impact on relocating workplace for commuters

As mentioned earlier in the report, accessible mixed-use suburban centres can reduce car use dependency and encourage sustainable mobility. This case study test this theory by analyzing a relocation of a workplace to such a centre in the inner suburbs of Lisbon,

Portugal and which impacts it has on the commuting behavior. More specifically, the study analyzes the travel behavior of workers before and after a relocation to mixed-use and transit-oriented area (Vale 2013).

To test this, three hypothesis are proposed concerning the impacts of employment relocation on commuting (Vale 2013):

- If the relocation significantly decreases the travel distance of the worker, the travel time will decrease as well. In this case, if the commuting time remains within the critical time, the worker might change to a more sustainable mode of transport, if available. The worker might also maintain the same mode of transportation after the relocation.
- If the relocation significantly increases the travel distance of the worker, the travel time will increase as well. In this case, there is a chance that the worker will continue or start commuting by car, in order to maintain the critical travel time.
- If the relocation has a small impact on travel distance, the change will only be seen marginally. In this case, if the commuting time stays around the same level, then the likelihood for the worker to change the commuting mode is small.

The mixed-use centre is located to the east of Lisbon and include a new metro line, train station, a road bridge and improvements on the existing road. This site is therefore very accessible by private and public transport. The area also have good conditions for parking, as available parking spaces can handle 75% of the workers (Vale 2013).

The commuting patterns of the workers in this study is to some extent comparable with workers commuting in the Lisbon Metropolitan area, where the majority commutes 10-20 km and the commute time is 16-30 min. each way. After the relocation, the majority of test subjects commuted 16-30 min, compared to before where the time was over 30 min. The results differ from the Lisbon Metropolitan area when looking at the number of car users, where the study's average is 58,6% compared to Lisbon's 45,0%. This suggests that the relocation increased the distance and car commuters (Vale 2013).

Commuting pattern	Before		After	
	Number	%	Number	%
Travel mode				
Walk	15	5.3	3	1.1
Cycle	0	0.0	0	0.0
Public transport	112	39.3	78	27.4
Car/motorcycle	136	47.7	167	58.6
Car and PT	22	7.7	37	13.0
Travel time				
Less than 15 min	68	23.9	44	15.4
16–30 min	85	29.8	113	39.6
31–60 min	96	33.7	91	31.9
More than 60 min	36	12.6	37	13.0
Travel distance				
Less than 5 km	–	–	30	10.5
5–10 km	–	–	47	16.5
10–20 km	–	–	82	28.8
20–30 km	–	–	55	19.3
More than 30 km	–	–	71	24.9
Total	285	100.0	285	100.0

Figure 5.6: The commuting pattern before and after relocation. (Vale 2013)

Workers who lived in nearby areas were the ones whose commuting decreased the most in distance, as the relocation brought the workplace closer to them. Those living outside the city, also benefited from the move, which is partly explained by the city's ring roads that connect the suburbs. The commuting distance increased the most for the workers living at the opposite end of the city, as the travel distance now consisted of crossing the entire city for their daily commute. As for travel mode, the relocation showed substantial car use inertia for the daily commuting, regardless the place of residence. Furthermore, the amount of active and public transport users decreased (Vale 2013).

The results suggests that the workers adapt to the new situation, when met with a new workplace. This is done by tweaking the commuting mode to maintain a certain travel time that they find acceptable. Travel distance is a clear factor when choosing private transport for commuting. The significant increase in travel distance, significantly increased the likelihood of using the car to reduce travel time. Strangely the opposite is not true in this case study. A stability or decrease in travel distance does not result in a decrease in car use. This suggests that there is an acceptable time of commuting, but not necessarily a minimum ideal time that could encourage workers to commute with more sustainable mobility (Vale 2013).

This shows that commuting time is insensitive to shorter travel distances, while it is clearly sensitive to an increase in distance. So when the commuting time is unaffected, it must mean that the workers change their patterns to a faster mode of transport, but only if the increase in distance surpasses their commuting tolerance (Vale 2013).

5.4 Lessons learned

Sustainable mobility is one the topics today that fills the field of urban planning the most because of the growing awareness on the pollution, climate change and urban problems like congestion. Solving these problems almost include reducing car use or in general change the travel behavior of the people. One of the trends at the moment, looking at spatial planning and land use, is the concept of the compact city, which almost always gets mentioned. The concept of having everything at a walking distance and reducing car use seems to be the near perfect solution at the moment. This leads to questioning whether this case study of Flanders and the Netherlands already has a bias agenda when comparing the two regions. When describing and comparing the history of the active spatial planning in the Netherlands and the lack of it in Flanders, it almost feels like a lesson in which one is the best, solely on the emphasis being put on the negative and positive aspects of the two.

The results gathered in this study matches well with the theory, that the built environment of a city or neighborhood can in fact influence travel behavior in it's inhabitants. The Netherlands showed by active and deliberately planning for an desired urban form can encourage certain travel behavior in people. This also shows that people choose a certain travel behavior by evaluating the consequences and what is the most benefiting for their travel. If the distances are too far or if the public transport is not efficient enough, the most positive option often tends to be the car. This shows the power of a strategic built environment and land use in a city.

The second case study showed that the strength of habitual car use is possible to be reduced through travel demand management measures or interventions. At the same time, it was important to know which measures would get accepted by the car users. Travel demand management specific beliefs like freedom, own reduction, effectiveness and fairness can act as a mediator for environmental beliefs and acceptability. General environmental beliefs can be used for evaluation of travel demand management measures.

By combining more TDM measures at once, the car use can be reduced even further than single measures. The favored car reducing strategies that people chose on the background of TDM measures are trip chaining, change travel mode, car pooling and the least favored strategies were changing destination and refraining from traveling

The last lesson learned, involved relocating a workplace to change travel behavior. The

lesson here is that it requires more than just relocating to a suburban mixed-use location close to the city center. Commuters tend to adapt to new situations when met with a new workplace. They will maintain the travel time at a certain level at all costs, if the travel time increases, the mode of transport will change to that of a faster one, to make up for it.

6. Recommendations

So what can the city of Aarhus benefit from this information about the importance of urban form and built environment when it is one of the oldest cities in Denmark and already has a deep rooted foundation of urban form already. Aarhus is currently in a developing state and have almost completely built a new harbor front, and to accommodate the growing number of people expected in the future, new regions or densified urban areas are being built. By strategic and smart planning these areas, Aarhus can influence these new areas to a desired travel behavior.

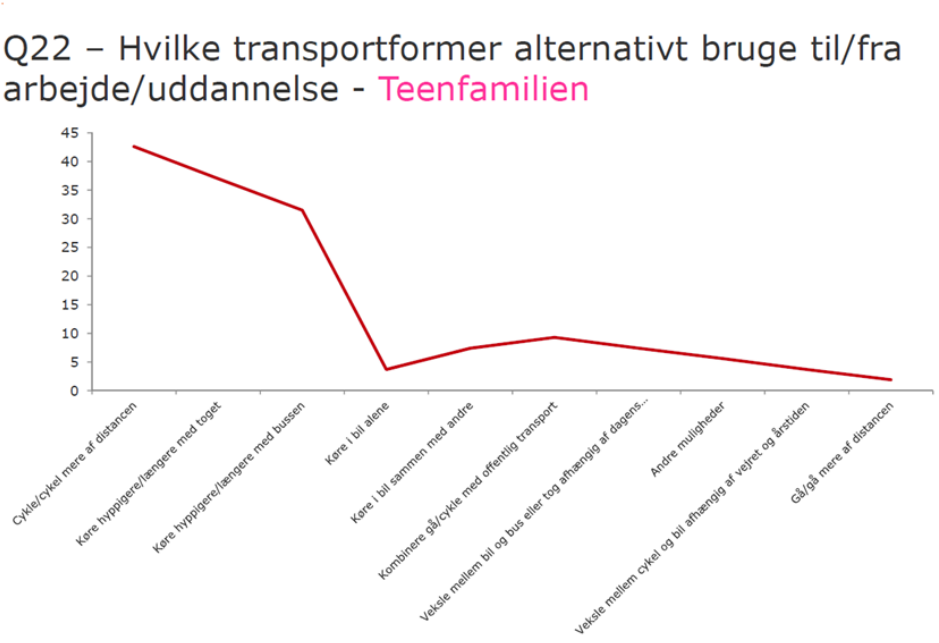
Aarhus has always been the center of mid Jutland and many people commute to work and school from the neighboring cities. The case of Flanders and the Netherlands showed that having high quality and efficient public transportation system and by placing important destinations near the stops, can have a great effect on the use of public transportation. The more people commuting on public transportation, the less people commuting by car, as shown in the case. Aarhus is also currently optimizing their public transportation network greatly by introducing a lightrail system, both within the urban city of Aarhus and to the neighboring cities. As mentioned in the theory of planned behavior, if this lightrail system encourages a positive attitude in the individual's mind or if it changes the norm of transportation in the city, then Aarhus could be moving toward more sustainable mobility.

Statistics done by Aarhus Municipality for the smart mobility project, reveals that 42-48% of the dwellings in the city of Aarhus have a car and 89% of the dwellings own a well functioning bicycle. Comparing the numbers of Aarhus with the travel choices of Flanders and the Netherlands for large cities, as this case defines large cities as being cities with more than 100.000 inhabitants, quickly shows that car use in Aarhus some what similar to the percentage of Flanders. If the Netherlands, in this case, is the result that is to be strived for,

Aarhus has room for improvement. If the forecast in population growth in Aarhus comes to realization, the number could end getting even higher, if not Aarhus actively plans ahead.

Examining the three tabels of the teen family, children family and elderly, one thing worth noticing, is that a high percentage of every asked group would be willing to bicycle more. It seems to not matter which age group or family situation, the bicycle is chosen as a good alternative. Explanation as to why people answer bicycle, could also be the health and fitness craze or that the problems of sustainability and climate change are more in the media. Regardless, there is a potential for Aarhus harvesting this information, as one of their goals is to get more people on sustainable transportation.

Another noticeably thing, is that the elderly seem more willing to use the public transportation than the families with teens and children. The reason could be activities related to having children, for example driving them to school or sports before leaving for work. As the case of the Netherlands showed, if the quality and efficiency of the public transportation are good and if the workplace and children's school are in the same urban area, the potential could be there for public transportation.



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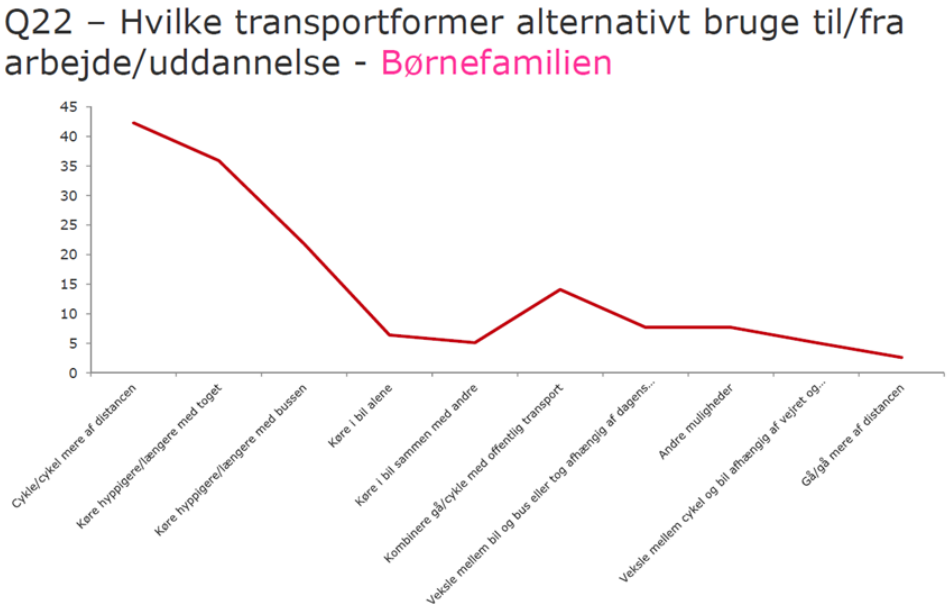

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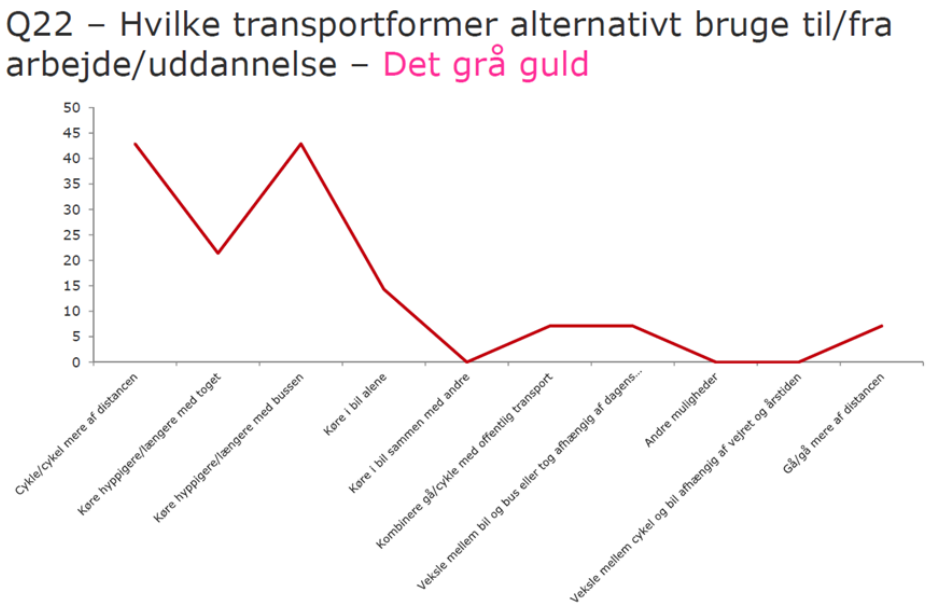

Figure 6.3:

Another thing that Aarhus can benefit from the case studies, is the knowledge of when people are accepting of the measures, that are planned. Aarhus has a range of demographic groups that they want to target, this includes elderly, workers, young people and families. The different people's environmental beliefs and TDM beliefs are important for the acceptability of the measures. The range of different target groups in Aarhus, might possibly have differnt beliefs. For example, the environmental belief for young people can be opposite that of an elderly person. It is important to keep in mind, who and which measures are coming out to specific people. This should be done before even combining different TDM measures to reduce car use.

The interesting thing about the Lisbon case, was that a section of Aarhus municipality recently, as an experiment, tried to move their workplace, to see if it benefited travel behavior. The Lisbon case showed that it was not successful in changing behavior, as the workers adapted when the travel timer increased. This was only one case and probably not generalizing for every relocation of workplaces happening in Aarhus or other places. But one thing to keep in mind, is that the commuting time is insensitive to shorter travel distances, while it is sensitive to an increase in distance. The recommendation here, is that when wanting to change travel behavior by relocating a workplace, it is important that accessibility are sufficient for car transport, bicycle and public. If the accessibility is sufficient, then the travel time is sufficient, resulting in workers more likely to switch to slower modes of transport when the travel time remains the same or shorter.

7. Conclusion

There is a paradigm shift in the way that mobilities are looked at today. It is no longer enough just planning with an overview and using traffic models. More fields are getting included in planning mobilities, especially the field of social science.

This gives room for the emphasis on changing travel behavior, which has become more and more important in the present solutions, if a sustainable mobility system is wanted. Travel behavior are the patterns and rhythms of people's decision when traveling, especially important is which mode of transport is being used. If there is not a focus on travel behavior, then technology will take over and encourage people to drive longer, which does not fix the problem of congestion. Travel behavior is needed if the future problems of congestion is to be fixed.

There are numerous factors that can decide a certain travel behavior, and at the same time there are numerous that have the potential to influence travel behavior. People tend to weigh the negative consequences when choosing a certain travel behavior and usually picks the one with least amount of negative consequences. Factors that can influence that decision can be how the built environment is (for example how good the infrastructure are or how close to your destinations are), different mobility management measures can also actively influence a behavior.

There are many fields that cities can try to alter the travel behavior. The three cases reviewed in this report deals with, the built environment, interrupting habits by interventions and relocating a workplace to change travel behavior.

The city of Aarhus can use mobility management to influence behavior in different ways.

The case of Flanders and the Netherlands showed that by having an active spatial planning and designing the city a certain way, the specific travel behavior almost comes natural to people. Aarhus can also customize specific measures targeted at specific people, as the habits and beliefs of people are different. Lastly, Aarhus can ensure that the accessibility of the infrastructure including the road network and public transport are of sufficient quality that the positive aspects and short travel time, can influence the travel behavior to a more sustainable behavior

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