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Ex-ante appraisal of cycling policies:

Towards a holistic framework for social cost-benefit analysis

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Abstract

Cycling is gaining attention as a healthy, efficient and sustainable alternative to meet the mobility needs of urban areas. Many cities around the world are therefore increasing their funding to greatly expand their cycling infrastructure. Fast cycle routes (or bicycle highways) represent the prominent example of this development. However, the costs and the benefits of these projects have hardly been assessed in ex-ante appraisal, potentially leading to inefficient allocations of resources. This research combines the existing knowledge on cycling and transport evaluation to develop a holistic framework for social cost-benefit analysis and applies this on an illustrative case study. In line with previous preliminary findings, the results confirm that cycling projects are economically efficient. The results show (in line with previous studies) that cycling has indeed high social benefits. However, the current ability to make economic assessment are very much limited to the current methodologies which are not yet fully developed for cycling. Moreover, holistic approaches entail a high level of complexity in the definition of the scope and the identification of effects. In addition, evaluators need to make multiple assumptions as causality cannot be directly established. This is also part of the limitation of ex-ante appraisals and therefore the use of scenarios and conservative values appear to be ideal approach to incorporate uncertainty. The implications for environmental governance are that SCBA can be a useful tool for learning, especially if integrated early in the decision-making process. In spite of this, the risk is that the tool may be used politically to steer the attention to the assumptions and lose the focus on actual sustainability issues. The research concludes with a discussion on the applicability of the method, knowledge gaps and current opportunities and limitations.

Key words: | social cost-benefit analysis | cycling | transport | evaluation

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Abbreviations

CBA: Cost-Benefit Analysis
CBS: Centraal Bureau voor de Statistiek
CPB: Centraal Planbureau Economische Beleidsanalyse
B/C: Benefit-to-cost ratio
EU: European Union
WTP: Willingness-to-pay
OEI: Overzicht Effecten Infrastructuur
PBL: Planbureau voor de Leefomgeving
SCBA: Social Cost-Benefit Analysis

Key concepts

- **Mobility and transport:** both mobility and transport refer to the physical movement of goods and they are both associated with the social, economic and political processes. Mobility however highlights the social dimension of being mobile, including driving forces and the experience associated with it at a personal level. Transport, on the other hand is the activity (or process) of moving something or someone from a point to another (Schiefelbusch, 2010).

- **Cycling policies:** Bicycle or cycling policies are defined in this research as set of actions, rules or guidelines adopted or issued by a (public or private) organisation with the intention to achieve an outcome on bicycle use.

- **Appraisal:** consists in the process of evaluating a policy with intent to assess a particular condition (efficiency, effectiveness etc.). The difference with "evaluate" is that the latter is used in a retrospective sense, referring to the process of reviewing (ex-post) a project performance (Campbell & Brown, 2016)

- **Pressures:** direct or indirect effects of transport choices.

- **Effects:** to changes to an independent variable as a result of a policy response (or intervention). When an effect exceeds a certain level, this has an impact on society, the environment and the economy

- **Externalities** occur when an actor (individual, firm or group of people) impose uncompensated costs or benefits to another actor (Romijn & Renes, 2013).

- **Impacts** (of transport): long-term transformation of a broader set of variables belonging to one or more system as a result of pressures of transport choices.

- **Social cost benefit analysis:** SCBA can be defined as an *important tool for the a priori assessment of welfare effects of alternative policy options by listing and monetizing all the (important) impacts that can be measured with a certain degree of accuracy* (van Wee & Borjesson, 2015; Romijn & Renes, 2013). The theoretical foundations of SCBA are grounded in economic theory, particularly in the discipline of welfare economics. In general, SCBA is used to estimate the sum of the willingness-to-pay of all individuals in a society for the changes in utility resulting from the implementation of a measure (Romijn & Renes, 2013). This includes a systematic listing of all the impacts as benefits and costs and assigning a value expressed in a particular currency.

- **Willingness-to-pay (WTP):** together with the willingness-to-accept (WTA), it is a measures of human preference. WTP represents the amount that society (the aggregation of all individuals) is willing to sacrifice to procure a benefit or avoid something undesirable (Pearce et al., 2006).

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1. Introduction

1.1. Background problem

The exponential growth of world population, the technological progress and the rise in material well-being of the last century has been unprecedented in human history (Brown, 2009; Steffen et al., 2011). However, the impact of human activity on the environment is altering the equilibrium of many natural processes on a global scale. Above all, man-induced global warming and climate change are causing extreme weather events, sea-level rise and other natural catastrophes, which represent a direct threat to our social and economic structures (Brown, 2009). The magnitude of this perturbation is so considerable that some scholars suggest that the planet has entered a new geological epoch: The Anthropocene (Steffen et al., 2011). In this uncertain context, multiple transitions in multiple domains and at different levels of human society are needed to adjust our current pattern of development (Rotmans et al., 2001).

In the last decades, the concept of *sustainable development (SD)* has become part of the common language (Banister, 2005). This was first defined by the Brundtland report as the *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987, p. 41). The underlying normative principle is that the improvement of our quality of life should not come at the expenses of the environment and erode the resource base for future generations. This can be narrowed down to the reconciliation of three dimensions: the social, the environmental and the economic. Concerns on the state of the global environment have brought together leaders of the world in order to negotiate a common strategy to mitigate the impact of harmful economic activities, cut down CO2 emissions and foster a more inclusive economic development. On 1st January 2016, 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development officially came into force. The aim is to promote a new course of development which includes not only environmental protection but also education, health and job creation (Sachs, 2012; UN, 2016). Although the SDGs are not legally binding, national governments are expected to steer public and private investments to achieve those goals.

In this context, the sustainable development of cities has a prominent role. More than 50% of the human population lives in urbanized areas and this number is expected to reach 70% by 2050 (Gerland et al., 2014). In the European Union, already 73% of the population more than 85% of the GDP is concentrated in urban areas (EEA, 2013). Hence, cities represent the core of economic and social development but also a place where a number of pressing issues and challenges are emerging. Among these, of paramount importance is the performance of the transport system to sustain cities' economic development, social cohesion and environmental quality (Meyer & Miller, 2001). By enabling the exchange of goods, transport fosters economic development, job creation and it allows access to fundamental services such healthcare, education and leisure (van Wee, 2011). However, increasing car use, coupled with rapid urbanisation, has reached a point that makes its present form unsustainable (Banister, 2005). The long-term consequences of mass-motorisation have, in fact, generated substantial environmental, economic and social costs that are unevenly distributed among social groups and place a heavy burden on future generations (Gärling et al, 2014; Meyer & Miller, 2001; Banister, 2005; Brown, 2009).

Attention is recently shifting towards non-motorised forms of transportation such as walking and cycling as an inexpensive, healthy and equitable solutions to meet the increasing demand for mobility (Bertolini & Le Clerq, 2003; Cervero, 2005; van Wee, 2015). Active transportation is defined by this research as the use of transport means that involve physical efforts to be propelled. Cycling, in particular offers an efficient alternative to the private car since the majority of the trips occur between 3 and 5km in cities and therefore could be potentially shifted on the two wheels (EEA, 2013). The bicycle also meets the definition of sustainable transport mode as it allows *"basic access needs of individuals and societies to be met safely and in manner consistent with human and ecosystem health, and with equity between generations"* (Litman, 2011 p.3). Moreover, investments on cycling infrastructure in the Netherlands, Denmark and Germany have emerged as a cost-effective strategy to promote independent mobility among children, foster social inclusion and improve the quality of life in cities (Pucher & Buehler, 2008; Pucher & Buehler, 2012; Gössling & Choi, 2015). Although cycling cannot be the solution to all transport-related issues, it can complement the existing mobility systems in a sustainable way.

1.2. Ex-ante appraisal of cycling policies

In light of these benefits, many cities are increasing their re-design and planning efforts to promote bicycle use (Hutton, 2013). A recent example are the investments in fast cycle routes, also known as "*bicycle highways*" as means to encourage medium to long distance commuting by bicycle (ECF, 2016). However, the capital investment for this type of infrastructure is often high, up to € 1,9 million per kilometre (ibid.), rising concerns regarding efficient allocation of resources. A growing academic literature is therefore focusing on how cycling policies can be assessed in ex-ante appraisal (Elvik, 2000; Weigand, 2008; Kahlmeier et al., 2014; Börjesson & Eliasson, 2012; van Wee & Börjesson, 2015; Litman, 2016).

Appraisal can be described as the process of evaluating (i.e. attaching a value to) a policy with intent to assess a particular condition (efficiency, effectiveness, etc.) before its implementation (Campbell & Brown, 2016). Policy evaluation is defined by Wildavsky (1987) as *"speaking the truth to power"* by determining *"the desirability of different courses of action and presenting this information to decision-makers in a comprehensive and useful form"* (Meyer & Miller, 2001). The desirability is determined by the difference between strength and weaknesses of alternative polices. Policy evaluation is generally divided between two traditions: the rational-analytical and the argumentative tradition. The rational-analytical approach to evaluation is generally seen as neutral and free from psychological, cultural and linguistic influence. Moreover, it works systematically by defining an optimum by measuring the distance between the effects of a policy and the optimum. This approach stems from economic theory and advocates for a positivist and *"scientifically guided"* approach as a systematic problem solving process which consists of sequential and predetermined stages (Andrews, 2007).

One of the main tools to appraise transport policies is social cost-benefit analysis (SCBA). This is a systematic and straightforward method to assess and compare the benefits and the costs of different policy (or project) alternatives by assigning a monetary value (Boardman et al., 2011). The difference between social cost-benefit analysis and the standard cost-benefit analysis (CBA) is that the analysis focuses on all the externalities[1] that have an impact on the aggregated welfare, including environmental and social effects. A bicycle policy

[1] Externalities occur when an actor (individual, firm or group of people) impose uncompensated costs or benefits to another actor (Romijn & Renes, 2013). For example, if a transport system produces uncompensated air pollution and the environmental damages, a welfare loss occurs. This type of externality is defined as negative externality.

or project is therefore appraised for its *"social efficiency"* that is the amount of increase or decrease in the total social welfare[2]. Efficiency can be broadly defined as *"a situation in which resources, such as land, labour, and capital, are deployed in their highest valued uses in terms of the goods and services they create"* (Boardman et al., 2011; p. 27). Although a positive benefit-to-cost (B/C) ratio is not a formal requirement[3], SCBA is explicitly required to access many national and international funding systems, playing a central role in spatial and transport planning (Beukers et al., 2009; Sartori et al., 2015).

In general, SCBA is used to appraise large-scale infrastructure project at regional or national level and entailing a large budget. The implementation of bicycle plans, on the other hand, requires relatively little money and (most of the time) consist in small cumulative improvements that do not generally justify the use of SCBA[4] (Wee & Börjesson, 2015). Although relatively inexpensive compared to the budget required for the same infrastructure for cars and public transport, heavy investments on cycling infrastructure may also may result in unforeseen and unintended consequences that are sub-optimal in the long-term (Hutton, 2013). The bicycle traffic jams and the problem of theft in Amsterdam also underline how *"too much of a good thing"* may also bring social costs[5].

1.3. Knowledge gaps and research aim

Despite the increasing attention on cycling, relatively little knowledge is present in the policy evaluation domain in which several knowledge gaps emerge (Handy et al., 2014; van Wee & Borjesson).

At the present time, no specific framework for the appraisal of the effects of cycling policies in ex-ante has been yet proposed. The current available literature builds the analysis on the basis of the problem definition but do not provide a clear theoretical foundation for the selection of the effects to assess and monetize. In particular, evaluators incur in substantial methodological difficulties to forecast and model the effects of cycling policies since the factors that contribute to bicycle use are poorly understood (van Wee & Borjesson, 2015; Elvik & Rune, 2000). Therefore, predicting the outcome of bicycle policies is not as straightforward (Ortùzar et al., 2000). This is an important knowledge gap as understanding the determinants of bicycle use is fundamental for SCBA because it allows to 1) anticipate the effects of cycling policies 2) determine the magnitude of the benefits and the costs 3) revealing interactions between socio-economic characteristics and the willingness-to-pay (WTP)[6] (Rietveld & Daniel, 2004; Litman, 2016). This has also been underlined by few preliminary empirical case studies present in which the determinants of bicycle use, together with forecasting techniques, are mentioned as one of the main problems to determine the magnitude of the effects (Elvik,

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[2] The aggregation of all individual utilities in a society is defined as "social welfare" and a policy that increases the total social welfare is defined as welfare-increasing (Romijn & Renes, 2013). The aggregation of all individual utilities in a society is thus defined as "social welfare" and a policy that increases the total social welfare is defined as welfare-increasing. "An individual's utility is the degree to which his preferences are met" (ibid., p. 46). The utility of an individual is influenced by choices and these concern the allocation of scarce resources. The assumption is that individuals will try to maximise their utility by making choices that *"deliver them a relatively high level of utility in relation to the resources spent*" (ibid. p.46).

[3] Interview SRA2, (2016)

[4] Interview VU1, (2016)

[5] Interview P1 (2016).

[6] together with the willingness-to-accept (WTA), it is a measures of human preference. WTP represents the amount that society (the aggregation of all individuals) is willing to sacrifice to procure a benefit or avoid something undesirable (Pearce et al., 2006).

2000; Sælensminde, 2004). The scientific literature on these determinants is still at its infancy and fragmented across multiple journals belonging to different disciplines. Rietveld & Daniel (2004) have first proposed a simple theoretical framework, however this has largely focused on cycling as a rational activity carried out by utility maximizer individuals and left out other important "soft variables" such as the travel experience that seems to be a particularly important[7] factor when choosing the bicycle (Heinen et al., 2010). Finally, the mechanisms of interaction between implementation of a policy and effects have only been marginally addressed (Handy et al., 2014).

Secondly, evaluation research on cycling has also mainly focused on the assessment of a limited range of specific policies' effects, such as health or environmental effects (see Rabl and Nazelle, 2012), but hardly tried to combine the knowledge with other fields to address multiple effects. This is another important knowledge gap for SCBA evaluators as the effects of cycling policies relate to multiple domains (health, environment, economy and society) simultaneously at different levels (from local to global) and with different magnitude over time (Macmillan et al., 2014). In the absence of a general framework that addresses the broader spectrum of social, economic and environmental impacts, it is argued that certain effects that are relevant in the context of sustainable development may be overlooked and not counted in the final balance (Hüging et al., 2014). Holistic approaches are increasingly recognised as an ideal approach to address multiple interconnected issues simultaneously and therefore improve the quality of the assessment, as well as the outcome of the implementation (Hüging et al., 2014; Liu et al., 2009). However, this has not yet been done in practices particularly for cycling.

Hence, the main research goal is to propose a theoretical framework for the ex-ante appraisal of bicycle policies from a holistic perspective by conducting a systematic literature on the determinants of bicycle use, the role of policies in affecting transport choices, thereby filling an extensive knowledge gap. In addition, by applying this framework on an illustrative case study, this research aims to identify advantages, limitations and further knowledge gaps of the use of SCBA from this perspective. The selection criteria of the case study are provided in the "Methodology" (chapter 3).

1.4. Research question

The main research question of this MSc. Thesis is:

How can the effects of cycling policies be appraised in ex-ante assessment from a holistic perspective?

This main question is answered by the following sub-questions:

1. *What are the determinants of bicycle use?*
2. *What are the effects of bicycle policies?*
3. *How can such effects be appraised from a holistic perspective?*
4. *What are the main benefits and the costs of investing in fast cycle routes by applying this perspective?*

[7] Interviews UvA1 (2016), VU1 (2016).

5. *What are the opportunities and limitations can be identified in the application of this approach to social cost-benefit analysis?*

1.5. Scientific relevance

The development of frameworks that combines multiple perspectives is considered paramount to study complex challenges such as mobility (Perri 6 et al. 2003). Until now, SCBA has been the almost exclusive domain of economics, leaving out inputs from sociology, natural sciences and other disciplines. This reductionist approach overlooks critical interactions between transport and its social and environmental implications (ibid.). For example, the focus on travel time or better flow measured for its economic implications has often reinforced mobility solutions based on the private car leading to a largely unsustainable development of the transport system (Meyer & Miller, 2001; Banister, 2005; Brown, 2009).
This transdisciplinary and holistic approach also lays at the core of the M.Sc. program "Sustainable Development" at Utrecht University which tries to connect theories, frameworks and disciplines in order to understand the interactions between nature and society (de Vries, 2015). Moreover, this research is also relevant for the field of "Environmental Governance" as the framework is mainly thought to be used by policy analysts and researchers in the field of public policy in order to better support better the decision-making in choosing more efficient solutions. In addition, the political implications of the research have been outlined in the discussion (chapter 5 section 2). This research is also relevant as it tries to expand and integrate the existing knowledge on bicycle use and cycling policies, especially on the determinants and their relation with policy which is fundamental for SCBA. Finally, this research contributes to the transport and policy evaluation literature in which the number of empirical studies where SCBA has been applied to appraise cycling policies is scarce. Many case studies available also belong to the so-called "grey literature", meaning that they have been carried out by private consultancy companies and other advocacy groups where assumptions are not clearly stated and the selection of effects is not often scientifically sound (van Wee & Borjesson, 2015). Finally, a case study on fast cycle routes is yet missing in the literature and this would be, to the knowledge of the researcher, the first empirical one.

1.6. Societal relevance

Although cycling is increasingly recognized as tool for a more inclusive social and economic development in cities, bicycle mobility tends to be highly politicised and poorly funded (Koglin and Rye, 2014; Koglin, 2015). Cycling therefore tend to rank low in the political agenda in many countries around the world. In this situation, to reveal the social costs and benefits of cycling infrastructure investments may increase the attention towards this sustainable transport mode. Previous preliminary economic studies underline, in fact, the high social benefit of this mode of transport if compared to its relative low costs (Kahlmeier et al., 2014). However, the absence of suitable instruments to assess bicycle mobility measures' costs, benefits and overall impacts is considered a significant factor limiting their implementation (Hüging et al., 2014). Conversely, in those bicycle centric countries such as the Netherlands and Denmark, where larger, more expensive and resource intensive projects are going to be implemented, the need for such tools is also becoming relevant to assess that (public/private) funds are being spent efficiently (van Wee & Borjesson, 2015). In addition, it has become essential to take into consideration an extended time horizon, to make linkages between local and global effects and identify boundaries and links between environmental effects and human activities.

SCBA can therefore play an important role in reducing complexity and uncertainty in the decision-making. In particular, the increasing interest in the complex interplay between social, environmental and economic effects, the need to identify how policies yield different distribution of costs and benefits among various target groups and the challenge of finding a balance between policy alternatives that are satisfactory not only in terms of problem solving but also efficient in terms of allocation of resources (Runhaar et al., 2006)

This framework can therefore be used for the ex-ante appraisal of urban and non-urban bicycle infrastructure. It can be adapted for the evaluation of new facilities or upgrades of existing infrastructure. Moreover, its flexible design allows to assess both small to large projects as well as non-cycling related projects. The target group for the use of this tool varies from transport planners to transport economists and policy consultants. In addition, this can be used for other purposes such as a conceptual framework for research projects and as a guideline for the public administration to structure an integrated evaluation process.

1.7. Research framework

The research unfolds following three main steps (see figure 1):

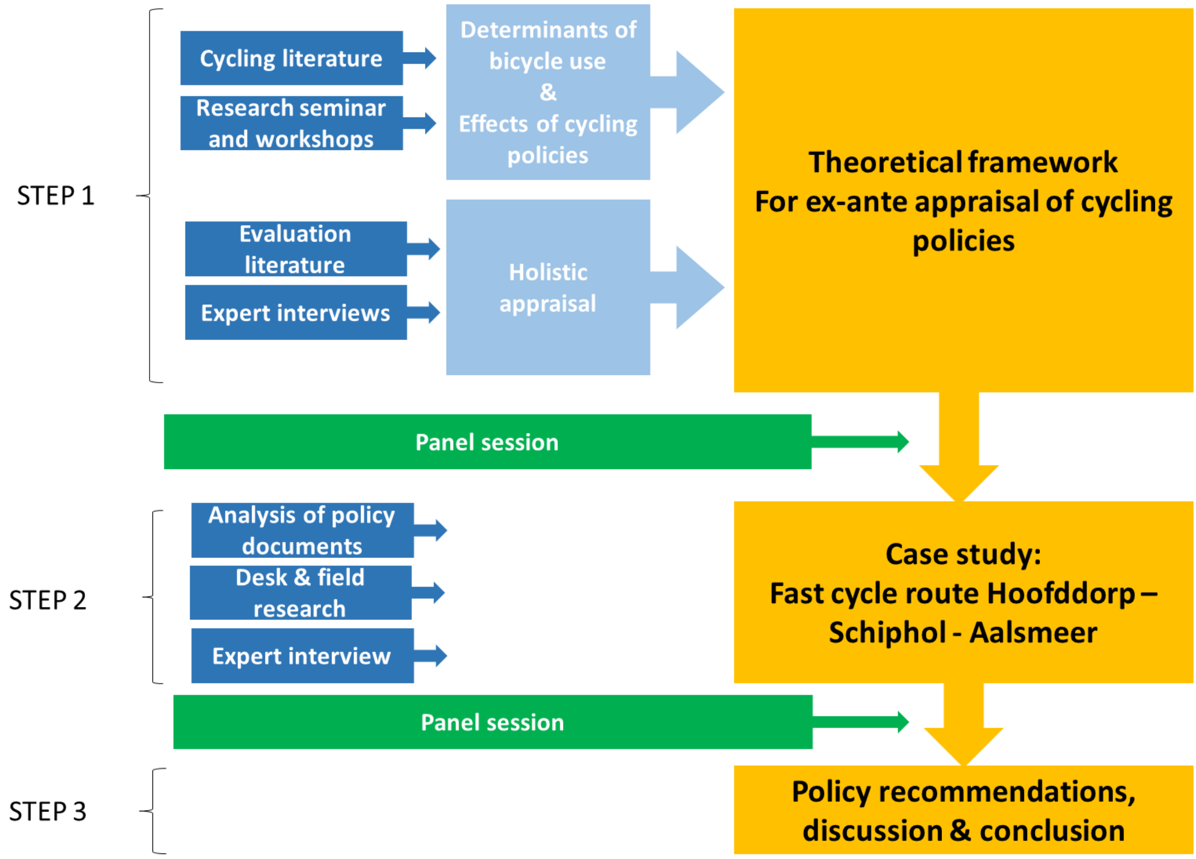


Figure 1 - Research Framework

In the first step, desk research has been carried out to identify relevant literature on cycling literature, transport economics and sustainability appraisal. This has been combined with the evaluation literature to develop a theoretical framework for the appraisal of cycling policies (data collection in chapter 3.3). A research seminar, workshops and several conferences have been attended to further deepen the understanding on SCBA and cycling policies (see Appendix E, F). In addition, the framework has been validated during two times by a panel of experts including academics, practitioners, policy-makers and few other selected participants with relevant knowledge on cycling (se Appendix A).

In the second step, the framework developed has been applied on a case study with the purpose to identify further strengths and weaknesses (chapter 4). The case study has been reviewed during a final panel session with policy-makers and conclusions have been drawn (Appendix A).

The research ends with several points of discussion (chapter 5). First of all, a discussion on the overall advantages of the framework. Secondly, the limitation of the holistic approach, a limitation on welfare economics. Thirdly, a discussion on SCBA applied to cycling policies. Finally, a discussion on the political use and implications.

1.8. Research scope and strategy

In line with Verschuren and Doorewaard (2010) and O'Neill (2013) to make a useful, realistic, feasible, clear and informative contribution to research and the advancement of society, the following choices have been made:

In the development of the theoretical framework, this research opts for breadth instead of depth. This is also in line with the idea of holism which entails a broad perspective on multiple disciplines. As a result, a comprehensive literature review has been conducted in combination with the support and guidance of experts to formulate the framework (see chapter 3 and Appendix A, B, C). Moreover, the research touches broadly on many aspects to avoids to deal with concepts that belong to specific disciplines. For example, the topic of transportation is a highly complex field addressed by multiple disciplines ranging from economics, planning and engineering. In addition, being cycling a relatively new topic of research, the approach to study cycling needs to borrow concepts, ideas and theories from different disciplines. This approach has also downsides (Verschuren & Doorewaard, 2010). In particular, going broad means scarifying details for a far-reaching understanding of the topic. Nevertheless, this thesis provides clear information on the theoretical components. Another demarcation has been done regarding the theoretical underpinnings of welfare economics and demand analysis that have only been marginally addressed. For example, the role of preferences and elasticity have not been treated in details. The aim of this thesis is not to provide a more accurate method to estimate the monetary value of a project as it is out of the scope of this MSc. program in Environmental Governance.

For the case study, on the other hand, an in-depth and "empirically-oriented" approach has been followed. In light of the research question and the holistic approach, the method used is SCBA. This method includes all the effects that have an impact on society as whole and therefore it is ideal to address complex issues such as mobility programs (Pearce et al., 2006). Although SCBA is not the only appraisal tool, this is addressed by this research as it is considered[8] the least value-laden and the most straightforward way to assess and compare different alternatives (ibid.). Its application requires multiple data sources, including access to policy documents and the input from multiple government agencies and stakeholders (Appendix B, C, D). This research also used a mix of quantitative and qualitative methods to collect and analyse data (see chapter 3). In order to make the research feasible, the case study has been chosen on the basis of data, resource and time availability and feasibility as well for its scientific relevance (more in chapter 3). In the case-study the SCBA has been applied according to the framework proposed and both the output and the

[8] Interview TU1 (2016).

application of such method have been object of discussion (chapter 5). Although this case study was not initially included in the research proposal, it has been considered fundamental to identify potential strengths, knowledge gaps, weaknesses and limitations.

Finally, the social costs and benefits of the projects have been calculated of different outputs (or scenarios) of a single alternative. This stretches the concept of SCBA which in theory should base the analysis on multiple alternatives (Campbell & Brown, 2016). This contrasts with the reality of the decision-making in which most decisions hardly consider different alternatives (Chapter 5). Although this did not alter the purpose of this research as the main research question rather asks how the costs and the benefits of cycling can be appraised from a holistic perspective, it is a relevant point addressed in the discussion.

2. Theoretical Framework

2.1. Determinants of bicycle use

The concept of transport is defined in this research as the activity of moving something (or someone) from a point to another one by means of a transport mode (car, bicycle, train etc.). Mobility, on the other hand, underlines *"the social dimension of being mobile"*, including its driving forces (Schiefelbusch, 2010, p. 201). These driving forces can be understood *"needs"*[9] (Kristensen, 2004) and categorised between primary (or material needs) and secondary (or non-material needs). While the first refers to the need to access goods, services, leisure and jobs, the second describes the non-material need to visit family, friends, build social relations. These two needs translate into desire for mobility which is expressed through markets as demand or supply of transport (Ravetz, 2000). The term used in transport economics is *"derived demand",* meaning that people do not travel for the sake of travelling but as a *"derivative of buying or seeking some other service or commodity"* (Meyer & Mahlon, 1997). Mobility is therefore considered as a rational activity carried out by individuals as utility maximizers, necessitated by factors external to them and shaped by the generalised costs of transport (ibid.).

However, this perspective has largely left out the induced demand which is the activity of travelling just for the pleasure of travelling for its experience or as *"part of life"* (Wiersma et al., 2016) (Figure 2). The experience of mobility can be described as the set of emotions, sensual stimulations and perceptions (Schiefelbusch, 2010). This dimension is also gaining attention in the appraisal of transport projects as an increasing number of studies show how this "soft dimension" of mobility plays a great role when it comes to bicycle use (Heinen et al., 2010; Schiefelbusch, 2010; Handy et al., 2014).

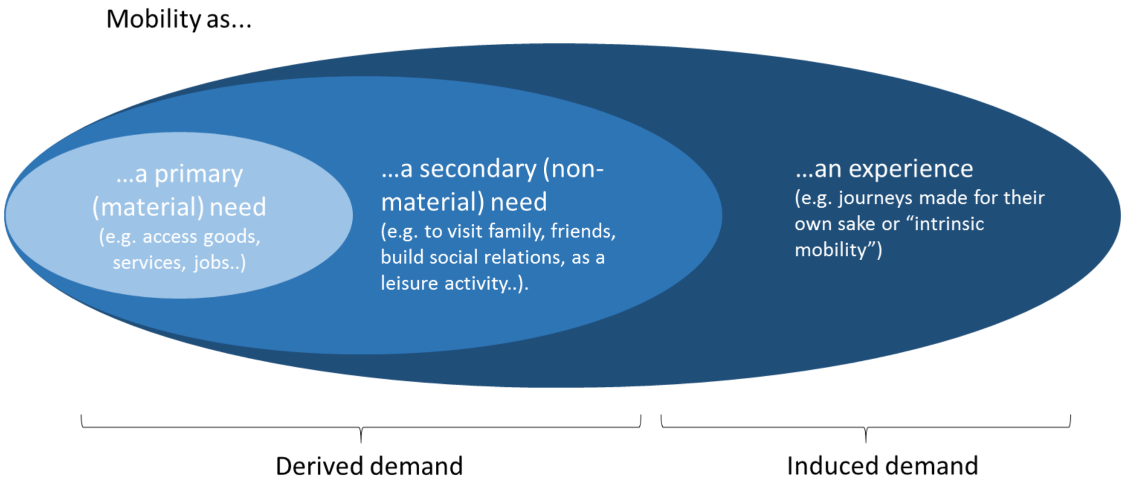


Figure 2 - Drivers of mobility (adapted from Schiefelbusch, 2010)

The fulfilment of mobility needs leads to demand for mobility which, in turn, translates into transport mode choices such as walking, cycling, driving (Schiefelbusch, 2010).

[9] Needs differ from trip purposes as they underline a higher purpose or desire.

Cycling or bicycle use refers to the activity of using a bicycle to access mobility and meet individual needs. Bicycle use can be expressed in terms of number of users, trips, distance cycled, average speed, purpose and modal split (see Table 1 for the indicators).

Data	Indicator
Users	Number of people using their bicycle
Trips	Number of trips taken by bicycle /day or year and the number of return trips on the same infrastructure
Distance	Km/day or year
Speed	Average speed
Purpose	Utilitarian or recreational
Modal split	Share of total daily trips with other modes
Ownership	Bikes / inhabitants

Table 1 - Bicycle use indicators

The decision to cycle (and therefore the "amount" of cycling or *Q*) is determined by individual features and other several endogenous and exogenous factors (Rietveld & Daniel, 2004). At an exogenous level, the climate, the landscape, the built environment, the political and cultural context, and the social, economic and technological trends affect both bicycle use and the magnitude of the effect of cycling policies (Heinen et al., 2010; Pucher & Bueheler, 2012); Handy & Xing, 2012; Litman, 2016). These cannot be influenced directly by individuals or policy interventions (Heinen et al., 2010). Endogenous factors affect bicycle use both directly and indirectly. Bicycle use, as individual choice, is directly determined by individual features and indirectly by the generalised costs of different modes (Rietveld & Daniel, 2004). Cycling policies intervene as an exogenous factor and affect mobility choices by leveraging on the different costs of mobility to encourage (or discourage) more bicycle use (or give priority to other modes) (ibid.). Moreover, cycling is also induced by the experience of travelling and by the intrinsic utility that is derived by its use (Schiefelbusch, 2010). All these factors are to be understood as dynamic (change over time) and their interaction determines the magnitude of bicycle use (Rietveld & Daniel, 2004). These variables are described below.

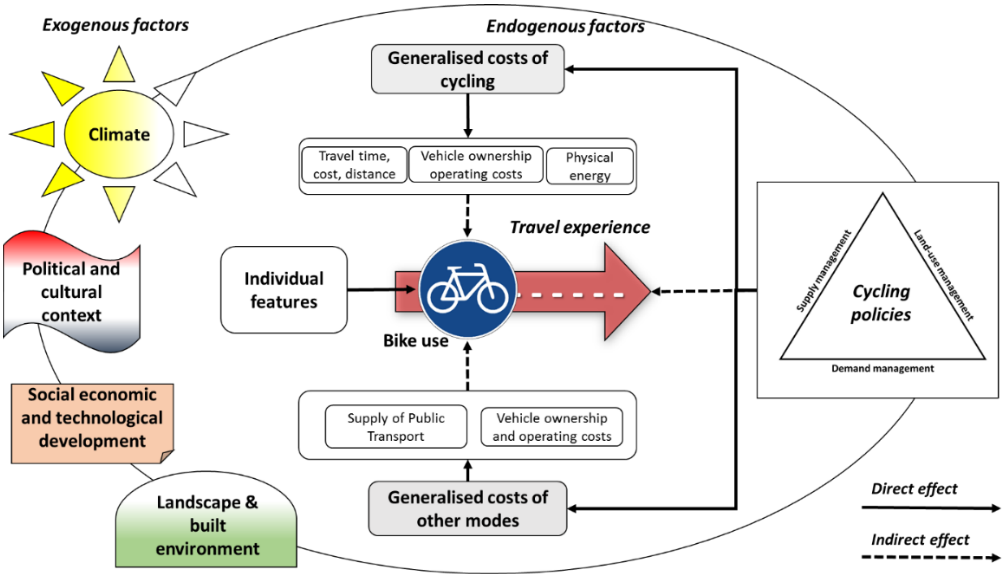


Figure 3 - Determinants of bicycle use

2.1.1. Endogenous factors

Individual features

The individual features identified from the literature are mainly age, gender, income, activity/occupation, location of residence, physical ability, education, cultural background and political preferences; values and beliefs (Rietveld & Daniel, 2004; Hunt & Abraham, 2007; Heinen et al., 2010; Handy & Xing, 2012). For example, *age* has an impact on the physical status of people and it is linked to physical ability and energy. Young people may have more energy than older people therefore might be more prone to use their bicycles for daily trips. Gender might play a role on the perception of risk. Women and children, for example, are found to have a higher perception of risk compared to men (Rietveld & Daniel, 2004). Higher levels of income might shift preferences towards better, faster and more comfortable transport modes as cycling could be considered as an *"inferior good"*[10]*.* This negative interaction between bicycle use and income does not seem to take place in countries such as the Netherlands as cycling may be part of the cultural background of people and part of the general political-cultural context (Pucher & Buehler, 2012). *Different jobs / occupations* or activities might require different means to commute and, depending on the *location of residence*, an individual might more or less prone to use the bicycle to commute.

Generalised costs of transport

Another classic feature of economic analyses and transport modelling are the (non-)monetary generalised costs of transports (Rietveld & Daniel, 2004). These are also more simply defined as the aggregated price level (*P*) (Oum et al., 1997). Among the monetary costs, bicycle ownership and maintenance (or operating) costs. Although bicycle use (unless rented) comes with no costs, e-bikes need to be recharged and it may be required to pay parking costs. Among the non-monetary costs, *travel time* to get from A to B is considered one of the main attributes of route choice (Börjesson & Eliasson, 2012; Hunt & Abraham, 2007; Wardman et al., 2007). *Travel distance* corresponds to the "acceptable" maximum travel distance with a mode. This values also depends on the type of built environment, type of bicycle and the spatial distribution of origin and destinations. This value needs therefore to be calibrated by using local data. *Physical energy* may also be considered part of the total cost of travel as cyclists might factor landscape in their mode choice the amount of effort to be put into cycling. Lower physical energy might also reduce the distance travelled and it is influenced by age, gender and level of exercise. Individuals may compare these costs with those of motorised vehicles (adding mandatory insurance, fuel, parking costs and tolls) and public transportation (fare costs, distance to the stop and frequency).

Travel experience

Bicycle use goes beyond solely (comparative) economic and physical motivations but also includes aspects of *travel experience* (Schiefelbusch, 2010). Travel experience refers to all the qualitative attributes of the trips, meaning all the sensual impressions that can be obtained through all senses (visual, audible etc.). These are caused both by elements of the surrounding environment and the experience produced by the use of the vehicle. These seems to play an important role when it comes to cycling as *"emotional concerns"* such as safety risk or comfort are cited as one of the main reasons not cycle (Pucher & Buehler, 2012; Heinen et al., 2010).

[10] A good that decreases in demand when the level of income increases (Oum et al., 1997)

The travel experience belongs to the individual perception of the travel and can only be indirectly influenced by policy interventions, as everyone's travel experience is different. For example, *comfort* may be linked to the general perception of safety. This concept can be understood as comprising all issues related to the passenger physical accommodation during the journey, such as design and quality of the cycling infrastructure. Moreover, climate and landscape may play a role in the value assigned to comfort. The (perceived or real) *risk of injury* is the concern of being injured may change depending on the degree of interaction between motorised vehicles. The (perceived or real) *risk of theft* might be determined by the presence or absence of bicycle parking facilities, the type of bicycle used and the type of environment. Travelling produces *entertainment and stimulation* by generating sensual impressions and experiences which may be perceived as valuable (Schiefelbusch, 2010). Travelling with a mode of transport may also provide an *occasion for other activities* such as the ability to listen to music, read or do other activities while travelling. Certain modes may allow a different degree of flexibility and give the possibility to stop for shopping, coffee or interact with people. *Communication and contact possibility* are also important determinants. The ability to exchange verbal and non-verbal communication signals and the level of social interaction may also produce different experiences with different modes of transport influencing the choice. Contact possibilities are also studied in sociological studies and they are defined as the *"exposure to (social and spatial) diversity"* (UvA1; Boterman and Musterd, 2015).

These factors are summarised in the table below (Table 2).

Endogenous factors	Indicator	Source
Individual features	Age	Rietveld & Daniel (2004); Hunt & Abraham (2007); Heinen et al. (2010); Handy & Xing, (2012); Pucher & Buehler (2012)
	Gender	
	Income	
	Activity / occupation	
	Location of residence	
	Physical ability	
	Education / cultural background	
	Values and beliefs	
	Political preferences	
Generalised costs of transport modes	Vehicle ownership and operating costs	Rietveld & Daniel (2004); Wardman et al., (2007); Heinen et al. (2010); Pucher & Buehler (2012)
	Travel costs	
	Travel time	
	Travel distance	
	Physical energy	
	Supply of public transport	
	Public transport costs	
Travel experience	Comfort	Schiefelbusch (2010) Heinen et al. (2010); Pucher & Buehler (2012) Boterman & Muster (2015)
	Risk of injury	
	Risk of theft	
	Entertainment & stimulation	
	Communication and contact possibility	

Table 2 - List of endogenous factors

2.1.2. Exogenous factors

The *climate* conditions such as extreme heat and humidity highly affect the propensity to cycle. Moreover, the time of the day might impact visibility and therefore the general perception of safety. *Social, technological and economic development* refer to the level of economic activity and trade (GDP), population growth, the activity of financial markets and price of energy, transport development, rate of technological improvement (Dom, 1999; Kristensen, 2004). Globalization of the economy and more complex life styles may lead to more dynamic mobility patterns and higher demand for mobility (Cervero, 2005; Wiersma et al., 2016). The overall economic situation of a country, financial markets and fluctuation of oil prices may put pressure on income, hence leading to different transport choices. *Landscape* refers to the natural environment such as the presence of steep slopes discourages the use of bikes compared to flat areas. *The built environment* is comprised by all those characteristics of a city such as size, density and the work and settlement distribution. Land-use influences the number of activities and people located in the same area and the way the move in the area. There is, for example, a great difference between urban and rural area due to the proximity of destinations which may affect bicycle use. Finally, *political and cultural context* may take the form of encouragement. If cycling is seen as a normal way to get places, residents may be more inclined to cycle themselves (Heinen et al., 2010). Political and public *support* is also an exogenous factor that plays a role in policy-making for cycling (Koglin, 2015).

These are summarized in the table 3 below:

Factor	Indicator	Source
Climate	Type of climate Weather conditions	EEA (1999) Kristensen (2004) Cervero (2005) Heinen et al. (2010) Pucher & Buehler (2012) Handy & Xing (2012); Koglin (2015) Litman (2016) Wiersma et al. (2016)
Landscape	Type of landscape Land use	
Built environment	City size Population density Degree of urbanisation Presence of amenity Presence of infrastructure	
Political and cultural context	Degree of support for cycling policies (Public and Cultural background Political will	
Social, economic and technological development	Economic development Population development Income Market price of energy Technological improvement	

Table 3 - Exogenous factors

2.1.3. Cycling policies

Bicycle or cycling policies are defined in this research as a set of actions, rules or guidelines adopted or issued by (public or private) organisation with the intention to achieve an outcome on bicycle use.

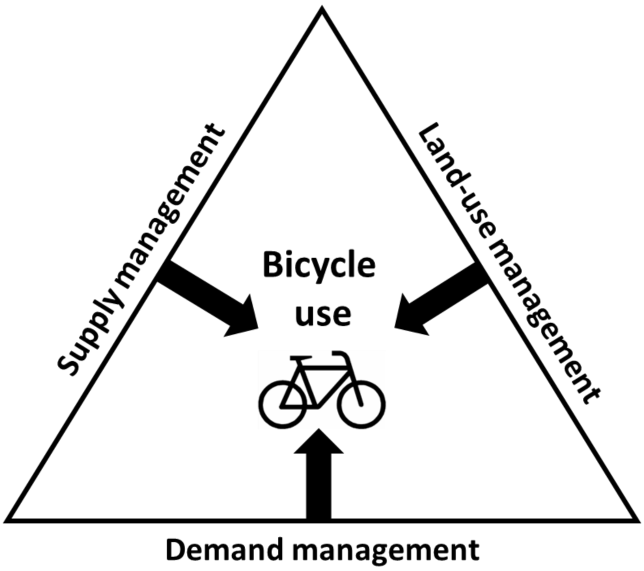


Figure 4 - Representation of cycling policies

These political actions are *“triggered by (the societal perception of) impacts and attempt to prevent, eliminate, compensate, reduce or adapt to them and them and their consequences”* (Omann et al., 2009, p. 25). For example, the increasing number of victims on the roads among cyclists is likely to trigger a policy intervention to increase bicyclists’ safety or lower car speeds. Cycling policies can be classified between: supply management, demand management and land-use management.

Supply management entails adding (or removing) facilities or making physical and operational changes (i.e. expand the supply of bicycle paths and other facilities) to encourage (or discourage) the use of a particular mode of transport (Meyer & Miller, 2001). *Demand management* aims at “*influencing the intensity, time and spatial distribution of transport demand for the purpose of reducing the impact of traffic or enhancing mobility options”* (ibid., p.11). Finally, *land-use management* refers to the linkage between territorial development and transport and therefore it has an important link with bicycle use. These measure can be independent or combined depending on the case. A few examples of interventions are listed in Table 4.

Type of policy	Example of interventions	Source
Supply management	Implementation, expansion or upgrade of physical infrastructure Traffic management improvement Road (re)design Predestinations	Meyer & Miller (2001) Pucher & Buehler (2012) Litman (2016) SRA2 (2016)
Demand management	Traffic laws (Non-)monetary incentives	

	Education & communication programs Integration with public transport Bike sharing systems	PNH1 (2016)
Land-use management	Densification Promotion of mixed-functions Location efficient development	

Table 4 - Types of policies and example of interventions (based on Meyer & Miller, 2001)

2.2. Effects of cycling policies

Before describing the outcome of different cycling policies, an elucidation on the concept of "effect" is provided. Effects are described as changes to an independent variable attributable to a (policy) intervention (Moran et al., 2008). Effects may be distinguished between direct, indirect and internal and external (Romijn & Renes, 2013; Oum et al., 1997). The difference between these is explained in sections 2.2.1 and 2.2.2 below. The mechanisms of interaction between the implementation of a policy and the effects produced are explained by micro economic theory and transport economics (see Oum et al, 1997). The assumption is that individuals act as rational agents, complete information and ordered preferences.

2.2.1. Direct and Indirect effects

The effect of a policy is defined as "direct" when it is immediately linked to the implementation of a policy. According to Rietveld & Daniel (2004) and the model proposed in section 2.1, the quantity of bicycle use (*Q)* cannot be directly influenced by the policy as transport decisions are only directly influenced by the individual and his preferences. Policy have however a direct effect on *P* of different modes and partially on the travel experience (Rietveld & Daniel, 2004). Comfort, risk of injury and risk of theft, although they belong to the sphere of the experience of travel, can be treated as part of the costs of travel (van Ginkel, 2004). This is because infrastructural projects by improving the quality of the asphalt and make specific operational changes can increase the overall level of comfort of using a bicycle (ibid.). On the other hand, variables, such as contact possibilities, cannot be influenced directly as may only be effected by the increase in the number of travellers (ibid.). *Supply management* policies for example increase or decrease *P* by expanding or reducing the supply of infrastructure and other facilities, *demand management*, on the other hand, may decrease the *P* of a mode by subsidizing the use of a mode (Meyer & Miller, 2001). While, *land-use policies* also affect the price levels by encouraging land-use changes that increase the proximity of destinations (ibid.).

"Indirect effects" are, on the other hand, the outcome resulting from the change of in price level due to the implementation of a policy (Romijn & Renes, 2013). the lower the generalised costs of a mode (P) the higher the demand for that particular mode will be and the utility derived (Oum et al., 1997). Hence, following Figure 5, interventions that increase the supply ($S_0 \rightarrow S_1$), the generalised costs of a cycling are reduced ($P_0 \rightarrow P_1$) and the quantity of travel increases ($Q_0 \rightarrow Q_1$). The increase in the Q demanded, however, does not happen immediately but it usually there is a latency between the price change and the increase in the quantity demanded that needs to be accounted (Elvik, 2000).

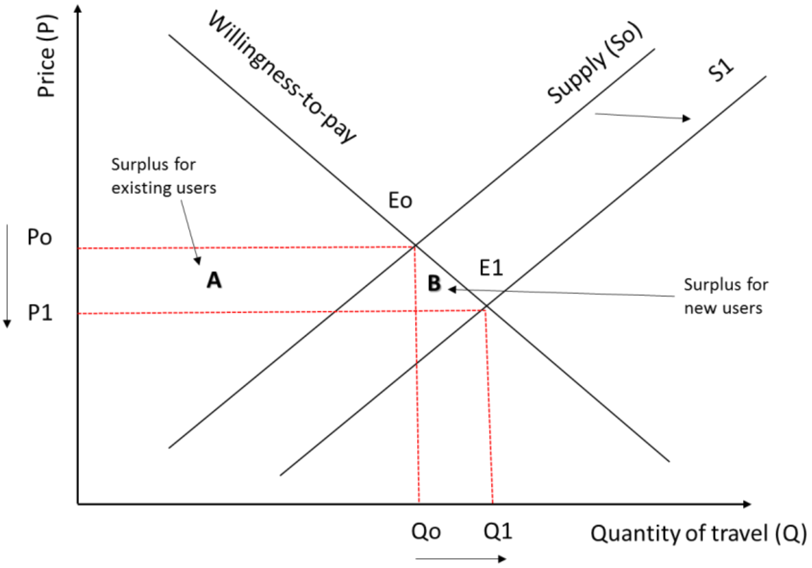
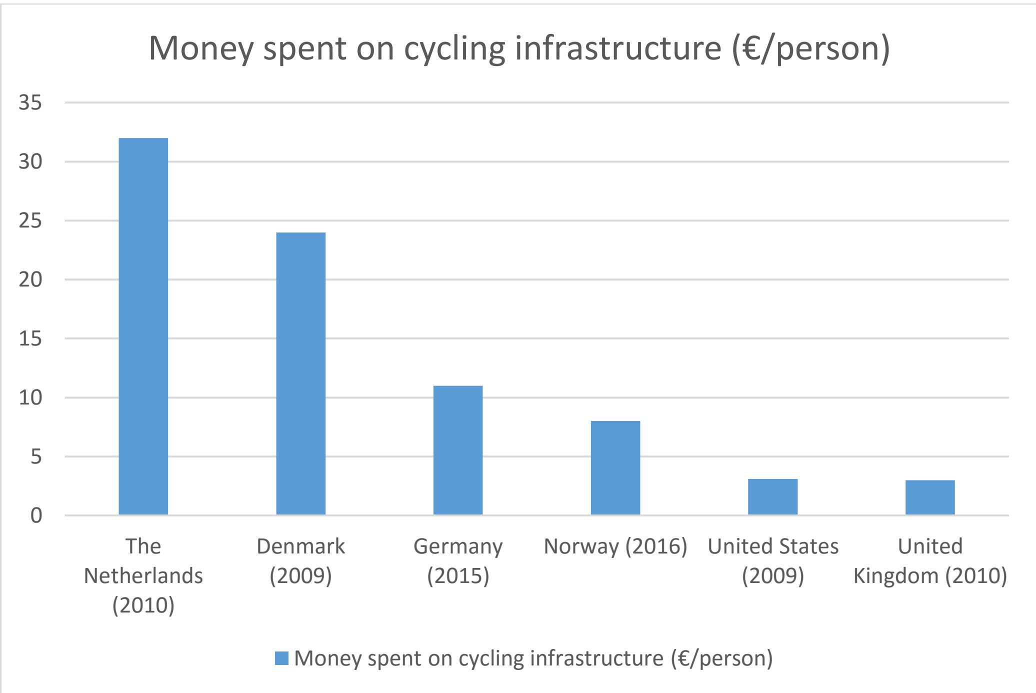


Figure 5 - Example of intervention that increases the supply (S) assuming a linear demand curve (WTP)

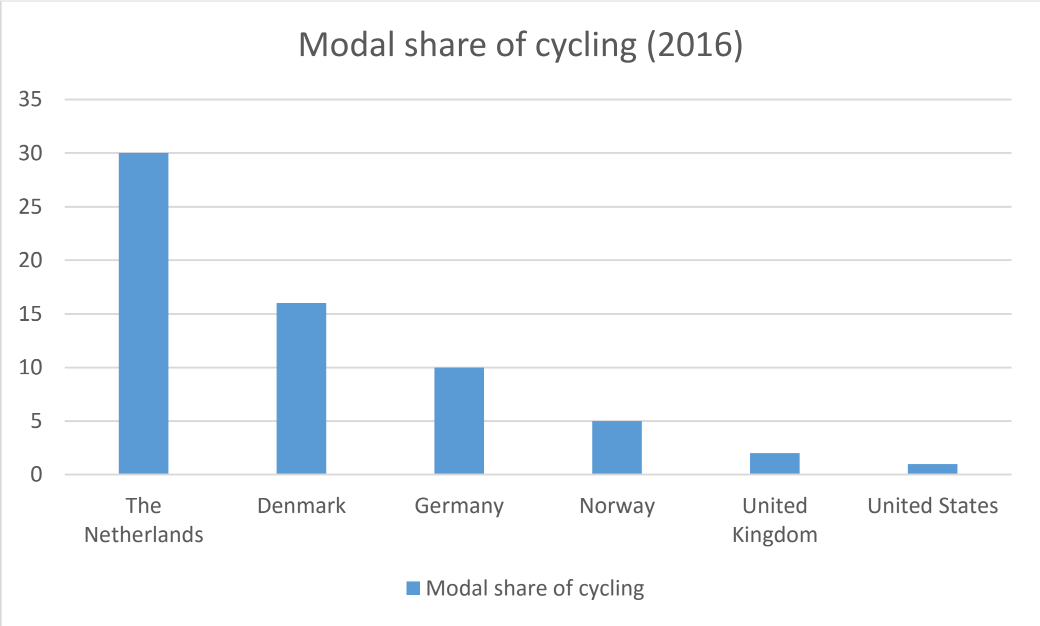
Following this some examples are proposed for each type of policy are proposed.

Supply management

Cycling infrastructure is usually considered the backbone of a strong bicycle culture. The presence of a network of bicycle paths, lanes and bicycle tracks and safe junctions is correlated with a higher share of cycling (Barnes & Thompson, 2006; Pucher and Buehler, 2008). People are in fact found to be more willing to cycling if they have their own dedicated infrastructure that connects them safely, directly and easily to places (Heinen et al, 2010; Dill & Voros, 2007). Spending per capita on cycling projects may be an indication of this (see bar charts below).



Bar Chart 1 - Per capita spending on cycling infrastructure (ECF, 2016a; Pucher & Buehler, 2012; DCE, 2009; German Federal Ministry of the Environment; 2015)



Bar Chart 2 - Modal share of cycling in EU countries (ECF, 2016a)

Conversely, increasing the *P* of other modes by reducing their supply of infrastructure, the *Q* for other modes is reduced (Meyer & Miller, 2001). For example, reducing the number of car lanes and the removal of on-street parking may increase the generalised costs of other modes, negatively affecting their use and increase the propensity to use the bicycle instead. This is also an important measure as *"the attractiveness of cycling is inversely linked to the attractiveness of car driving and measures to re-designate car lanes and car parking are both psychologically important to support cyclist identities and physically necessary to accommodate growing cyclists' populations"* (Gössling and Choi, 2015).

Demand management

Demand management aims at influencing the intensity, time and spatial distribution of transport demand mainly by increasing or decreasing *P* and the perception of different modes of transport with the intention of reducing the volume, intensity of certain modes and enhance other mobility options (Meyer & Miller, 2001). Mandatory *laws or other types of traffic laws* (together with the threat of penalty) that impose a certain requirement or behaviour on cyclists might impact the use of bike. For example, imposing helmet to cyclists may reduce head injuries but also increase the generalised costs of bicycle use and decrease the overall utility gained from cycling to discomfort. This has been particularly the case of the helmet law in Western Australia and New Zealand where the number of bicyclists have dropped after the introduction of the mandatory law Road Accident Prevention Research Unit (1999). Moreover, the demand might be influenced by introducing measures to lower the price level such as (non-)monetary incentives and other forms of payment to use the bicycle

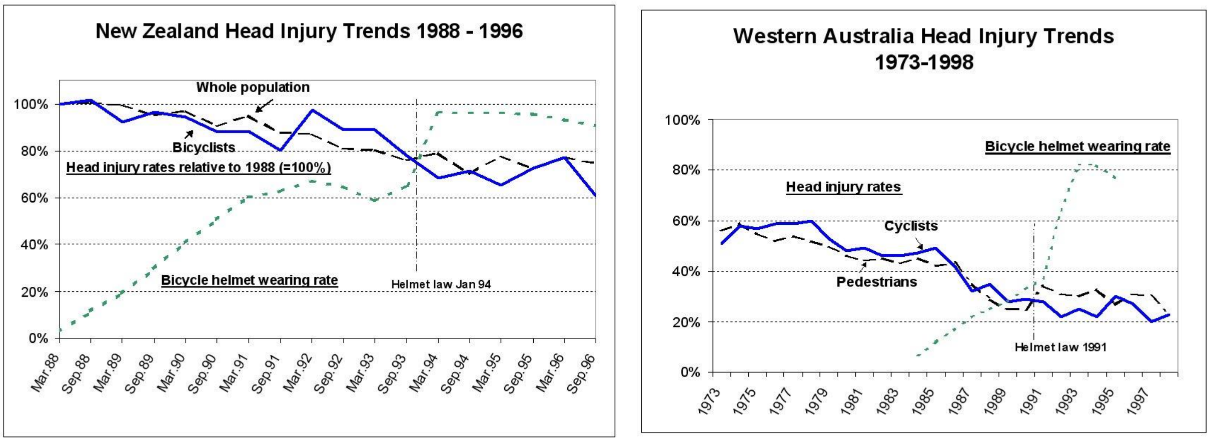


Figure 6 - Road Accident Prevention Research Unit (1999)

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Land-use management

Containing urban growth or reducing urban sprawl can be the strategy to increase bicycle use as more compact communities produce shorter trips (Litman, 2011; Sherlock, 1991). Moreover, promote densification and land use mixes strongly correlate with the use of active modes of transport (Handy & Xing, 2012). Although this type of measure is not thoroughly addressed in this research, evidences shows that this can be very effective when combined with the other interventions previously described (Litman, 2016).

2.2.2. Internal and External Effects

The changes in quantity of bicycle use as a result of the implementation of a policy produces multiple effects both to the user and to society that can translate into costs or benefits (Litman, 2016).

These effects are *"internal",* if these are internalised by the user. For example, shifting to bicycle use may determine an additional cost of bicycle ownership. "*External"* (or externality), when these cannot be passed on to any existing market (Romijn & Renes, 2013). External effects can either bring a cost or a benefit to society (welfare effect). For example, increasing bicycle use may increase health conditions, well-being and bring longer life expectancy (Kahlmeier et al., 2014). Reducing car-use may also bring substantial positive externalities in terms of reduction of air pollution, noise, GHG effects, decreased land and building acidification. Environmental benefits may also reduce health risks and reinforce positive benefits of health benefits (Rajé & Saffrey, 2016). Less cars, means less traffic and more pleasant environment. Depending on the extent of any substitution between car and cycle trips, increases in bicycle trips have the potential to reduce road maintenance costs, as bicycles produce only insignificant wear and tear on roads (Krizek, 2007).

According to Litman (2016) several factors might affect the magnitude of these effects (see Table 5). The degree of improvement may have different outcomes on the experience of travel in terms of comfort and perception of safety. Moreover, the number of potential users determine the likelihood of infrastructure to be used. The amount increase is the main measure to quantify in physical units the costs and the benefits of the policies (ibid.). As previously discussed, the exogenous factors may externally influence the magnitude of the effect of a policy. Last but not least, addressing trip purposes is also of great importance to estimate the magnitude of the effects. For example, if cyclists use their bicycles for recreational purposes, external benefits such as travel time savings or health benefits are internalised because their accounted at the moment of choosing the bicycle as transport mode (Oum et al., 1997). Therefore, they are not counted as external benefits. This also rises a fundamental paradox that is highlighted in the discussion (Chapter 5).

Type of policy	Factors affecting their magnitude
Supply management approach & Demand management	Degree of improvement Number of potential users Amount increase in cycling Purpose of the trip Exogenous factors
Land use impact	Degree that a policy or project supports land use planning objectives Exogenous factors

Table 5 - Factors affecting the magnitude of the effects of policies

2.3. Holistic appraisal of the effects of cycling policies

The main interest in this thesis is all those direct or indirect external effects that may increase or decrease the aggregate welfare of society. Since the effects of cycling belong to multiple domains, a holistic framework is introduced in this section. Before explaining the framework, a definition of holistic is provided.

2.3.1. Definition of Holistic

Ravetz (2000) proposes several main criteria that should be present in a holistic framework. These can be narrowed down to:

- Extended time horizons
- Extended spatial (or physical) horizon
- Extended causal chains
- Extended sectoral (or system) boundaries
- Extended value system

Extended time and spatial horizons imply making linkages between individual and its community in the next few weeks or years and the world where future generations will live in (ibid.). Bossel (1999) underlines this by introducing the concept of horizon of attention[11] that must not be smaller than the horizon of responsibility (Bell & Morse). This because what may be perceived as a benefit immediately may translate into costs in the future and vice versa.

[11] The *horizon of responsibility* is the closest in terms of time and space and it is where individuals care the most and are willing to give up advantages (time and resources) to take some responsibility. This implies a certain degree of commitment to preserve or improve the systems. The *horizon of attention*, on the other hand, comprises all systems whose development are of some interest to the actors. This does not imply any specific commitment but it is within a certain degree of concern (or just curiosity) of the individual. Finally, the *horizon of influence* which stretches over all systems in space and time that are ultimately affected by humans' choices.

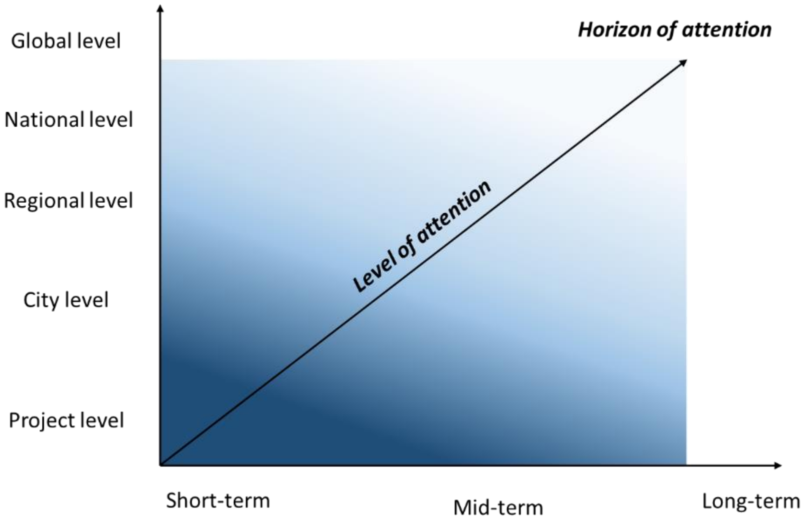


Figure 7 - Temporal and spatial horizon

Translated to practice, this means that the appraisal should account for both short-term and long-term effects of policies and contextualise them from local to global. The level of attention should therefore increase to account for the longest time horizon and the wider geographical scope. In general, the *geographical scope* of the project should coincide with the area over which the effect of a policy will be felt. This is generally wider than the physical intervention as this may affect mobility patterns in the surroundings. Moreover, other levels such as the regional, the national and the global should also be included whenever possible (Ravetz, 2000).

The appraisal must also include an *extended perspective on the causal mechanisms* between bicycle use and its effects in multiple domains: economic, social and environmental. The conceptualisation that is proposed in this research derives from the International Institute for Sustainable Development (IISD, 1999). This is based on the idea that the earth-system behaves like a complex system characterised by multiple interconnected elements or (sub-)systems (Moran et al., 2008). Within this perspective, Bossel (1999) has proposed three major systems, natural, support and human systems that belong to a complex system defined as the "Anthroposphere" (see a representation in Figure 8).

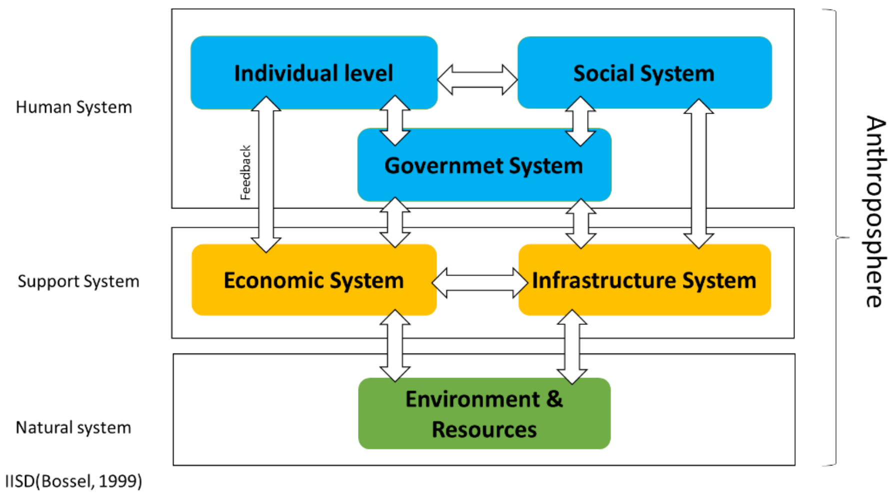


Figure 8 - The six major systems of the anthroposphere and their major relationships

Each system is composed by one or more sub-systems that interact with each other. At the fundamental level lays the *natural system*, this represents the stock of renewable, and non-renewable resources of material, energy and bio-systems, including the capacity to absorb waste and regenerate new resources. At a meso-level, *the support system* bridges the human system with the natural system allowing exchange of information between the two systems[12]. Here, the (soft and hard) infrastructure and the economic subsystem are located at a strategic location. The physical and organisational structures that allow and facilitate the exchange of people, goods, services, data and information, and it is essential *"to enable, sustain or enhance societal living conditions"* (Fulmer, 2009). Narrowed down to the urban context, the term refers to all those services operated at the municipal or regional level such as the road and railway infrastructure, the broadband, the electrical grid and the sewer system. These are defined as "hard infrastructure". While other services such as schools, parks, hospitals etc. belong to the, so called, "soft infrastructure". At the *"very top"*, the *human system* represents the dimension in which social interactions occur. It includes the single individual as unit, society and its governing structures. These dimensions and their subsystems represent the structure upon which human society is based, develops and depends.

Extended value system means that the appraisal must include ethical consideration such as distributive issues of policy intervention between different target groups and between different generations. A policy or a project might, in fact, benefit the current generation but place a heavy burden on future generations, preventing them to maintain the same or improve their level of welfare. For example, certain cycling policies and projects may favour specific target groups such as younger people who may gain more benefits than older people or individuals with disabilities. Policies may therefore account for distributive issues and weather a policy actually bring benefits to the larger community or to a small restricted group. In addition, a project should also be assessed not only for its technical and economic feasibility but also for its social and political feasibility (Feitelson & Salomon, 2004).

2.3.2. Appraisal building blocks

The ideal approach to appraise cycling policies in ex-ante is to follow the linear rational-analytical approach. This entails five main building blocks

Problem analysis

In the first step, the *problem analysis* forms the basis to identify the effects and consists of two main steps. First, the context of the problem and the reason for the intervention is outlined. Secondly, the type of intervention is described with a clarification of the purpose and how it is supposed to tackle the problem (Romijn & Renes, 2013). For cycling policies, this consist in the identification of the type of cycling policy (supply, demand or land-use management) and the specification of the intended effects of the policy.

Geographical and temporal scope

Information on the geographical delimitation of cycling policies is not present in the literature, this has therefore been based on literature of other transport modes (Meyer & Miller, 2001) and expanded to include the definition of holistic. Ideally, it starts from the project level, that is the area in which the policy will be implemented and then the analysis scales up to the local

[12] The support system is located in the middle as it is assumed that in complex societies, individuals do not access directly natural resources but they access them through markets or by means of infrastructure (railway, cargos etc).

and regional level till the national and global one depending on the size of the project. Several criteria on how to define different level have been proposed below (Table 6).

Level	Description	Delimitation data
Project level	Area of the physical intervention. This is addressed for its technical information such as cost of the infrastructure (and maintenance), quality, carrying capacity and present and future use (current number of trips and future number of trips).	Total length in km (for cycle path / routes)
		Total area in m2 (for bicycle parking facilities)
Local level	Area in which the mobility choices might be directly and indirectly affected by the intervention. This area might be inside or outside urban areas and include multiple sources of origin and destinations of mobility.	Average maximum distance cycled per trip (km/trip) or amount of bicycle trips per distance classes
		Average speed (km/h)
		Average time spent cycling per trip (minutes/trip)
		Origin and destination of bicycle trips in the area
		Type of bicycle and share of that bicycle (normal bike, e-bikes, speed pedelec)
		Trip purposes (utilitarian, sport or recreational)
Regional Level	Area in which mobility patterns might be influenced indirectly by choices at the local level. Conversely, the area where certain economic, social or environmental developments might affect mobility choices at the local level.	Delimitation depends on the location of the intervention and size.
National & global level	Accounted whenever the project may substantially contribute to fight/contribute to climate change or have an impact on the economic, social, environmental situation at the national or global level.	The size of the project, the amount of (financial) resources needed to implement the project, the type of emissions avoided.

Table 6 - Geographical scope for cycling policies

Time scope depends on the size of the project. Small intervention such as an improvement of an existing bicycle path might be analysed for short-term effects. Wang et al (2010) suggests that a time frame of 10 to 30 years might be ideal. Other projects such as the construction of important connections as bridges or big facilities might require to predict longer time scope[13] such as a generation from now (50 to 100 years).

[13] Interview P4 (2016).

Impact model

In the third, the effects of the policy alternatives are described, categorized according to different systems as outlined in the theoretical framework (Figure 8) and explained by means of an impact model. An impact model is a conceptual model where the direct and indirect effects are identified. In addition, direct and indirect effects can also be distinguished between "intended" if they are expected or are part of the main / sub-goal or unintended if they have not been foreseen at the moment of their formulation. These sub-systems can be described as in table 7 below:

Sub-Systems	Elements	Description
Human System	Individual level	Individuals in their single unit of analysis.
	Social	The aggregation of all individuals in society
	Government	The central government and government agencies
Support System	Economic	The market forces and its actors at different levels
	Infrastructure	Soft infrastructure such as public services (schools, parks and hospitals), hard infrastructure such as road system, power grid, dikes (etc.). This dimension refers to the physical attributes of the infrastructure.
Natural System	Environment & Resources	The environment is both the physical and biological environment with its resources, species and the climate.

Table 7 - Anthroposphere and its systems

Moreover, a classification between costs and benefits is performed. In general, costs (either one-off, recurring, fixed or variable) are related to the financial resources needed to implement, monitor and maintain the project or the externalities that are produced on society. Benefits, on the other hand, can be described as the desirable effects of a project, where "desirable" suggests a positive externality that increases well-being of individuals at the aggregate level (Meyer & Miller, 2001). Finally, potential sources of biased have to be identified among the exogenous factors (as in 2.1.2).

Estimate of bicycle use

In fourth, estimates of bicycle use as result of the intervention have to be performed. This is a fundamental step in the appraisal as knowing what would be the modal share as a result of a policy intervention it is necessary to calculate the magnitude of the effects in physical units (Elvik, 2000; Meyer & Miller, 2001). Transportation demand analysis techniques range from complex to simple estimations. Some models are based on economic theory and consumer behaviour; others are simplified demand estimation techniques which are based on trend analysis (Meyer & Miller, 2001). Currently, demand analysis techniques and models for cycling are in an embryonal stage and the transport elasticity of cycling is yet not known (Litman, 2016). Trend analyses and survey techniques are therefore suggested as an approach to estimate the propensity to cycle if people had certain conditions fulfilled, such as an improved connection to reach their destination (Ortùzar et al., 2000). Since causality cannot be established directly, to incorporate uncertainty, the use of scenarios and conservative estimates is recommended (Litman, 2016; Koster, 2016).

Valuation of costs and benefits

Finally, to perform financial analyses such as CBA or SCBA, the effects of the intervention and the alternatives have to be valued in monetary terms. Since many effects of cycling are intangible and not traded in markets, especially those affecting the quality of life and the environment, indirect methods can be used (as Pearce et al., 2006; Boardman et al., 2011; Campbell & Brown, 2016). These can broadly be divided into three main methods, which are revealed preference methods, stated preference studies and benefit transfers. These are generally explained in this section and then more precisely in the following part where the effects of cycling are addressed. Because many effects cannot be measured directly and their value is largely estimated, it is utterly important to be transparent on the assumption to ensure validity.

Revealed preference methods are based on observed behaviors, where individuals reveal their preferences without having to be asked (Boardman et al., 2011). These methods estimate willingness to pay for changes in provision of non-market goods through survey approach (Pearce et al., 2006). For example, in choice experiments hypothetical situation is presented in the form of a survey in which respondents are required to choose between several alternatives, thereby revealing their hypothetical preference. *Stated preference* methods are indirect methods in which individuals disclose their preferences through actual choices (Boardman et al., 2011). Shadow prices, also called *"benefit transfers",* are used when it is impossible to reflect the social value. For example, the use of damage cost to calculate the value of pollutants or the value of statistical life for health effects.

3. Methodology

This chapter elaborates on the methodology used to conduct the research on the case study. First of all, the selection for the case study is justified and the selection criteria are explained. Secondly, the method and the steps of social cost-benefit analysis (SCBA) are described. In third, the data collection strategy, sources and their elaboration are illustrated.

3.1. Case study selection and description

3.1.1. Selection criteria

As outlined in the introduction, this research applies the framework developed in chapter 2 to appraise the effects on a project in order to identify opportunities, limitations and further knowledge gaps of this approach to cycling. A single in-depth case study has been chosen on the basis of the following criteria.

First of all, data availability and accessibility. Conducting a study on a public projects requires, in fact, access to several data sources which may sometimes be restricted or in phase of elaboration (especially if the project has not yet been implemented) and therefore not publicly available. A research internship at the Stadsregio Amsterdam was opted to improve the accessibility to policy-makers, stakeholders, technical information, policy documents and have a location where to conduct interviews and organise expert panel meetings. This however limited the available scope of options for the case study to projects within the metropolitan area of Amsterdam. Secondly, to classify as "ex-ante" and to make the application of the SCBA framework a valid contribution to society, the project should not have been yet implemented and it should have been in the phase of decision-making (Campbell & Brown, 2016; Verschiren and Dooreward, 2010). This also further restricted the number of choices available to a few regional routes and bridges. Thirdly, to justify the use of SCBA a relatively expensive project has also been selected as in line with Campbell & Brown (2016). In the literature there are no references to a cost baseline for cycling to perform an appraisal. Therefore, employees of the Stadsregio Amsterdam and academics have been asked what, in their opinion[14], would have been an interesting case to assess the costs and the benefits. The emerging idea was that infrastructure more expensive than 5 million euros may be a good candidate for a SCBA, not only for the financial resources needed but also for the amount of material used. Hence, based on this a project above that baseline has been chosen. Finally, to make the research a useful and informative contribution (Verschuren and Dooreward, 2010.), this research opted for a case study on fast cycle routes which is a case that has not yet been analysed in academia[15].

3.1.2. Case study

The illustrative case study identified to apply the framework for SCBA is a fast cycle route that is planned along the N201 Kruisweg in the metropolitan area of Amsterdam between the cities of Hoofddorp, Aalsmeer and Schiphol airport. The aim of the regional policy is to address weak links (poor quality or disconnected cycle paths) in order to improve local accessibility (Stadsregio Amsterdam, 2015)[16].

[14] Interview SRA1 (2016), SRA2 (2016), SRA5 (2016), SRA6 (2016), SRA9 (2016), SRA7 (2016), TU1 (2016), TU2 (2016).

[15] A study is present on the fast cycle route between Nijmegen and Cuijk but performed by a private consultancy company (Decisio, 2013).

[16] Interview SRA1 (2016), SRA2 (2016), SRA4 (2016), SRA6 (2016).

3.2. Fundamentals of Social Cost-Benefit Analysis

To answer the question how to appraise the benefits and the costs of cycling policies from a holistic perspective. The ideal method chosen is social cost-benefit analysis. SCBA is an important tool for the ex-ante assessment of welfare effects of policy decisions by listing and monetizing all the (important) effects that can be measured with a certain degree of accuracy (Campbell & Brown, 2016; Romijn & Renes, 2013). Effects (explained in chapter 2.2) can be classified as costs and benefits and compared. This method includes all the effects that have an impact on society as whole and therefore it is ideal to address complex issues such as mobility programs. Moreover, by applying a discount rate it gives a realistic idea of the value of future benefits (Pearce et al., 2006).

The stages to perform the SCBA are derived from Romijn & Renes (2013) that is the general guidance manual used in the Netherlands and based on the OEI-methodology. Other guidelines have also been consulted, especially Boardman et al. (2011) and Campbell & Brown (2016). These are combined with the appraisal building blocks in order to perform a holistic appraisal specifically tailored to cycling policies. This research conducts seven main steps to appraise the social efficiency of the fast cycle route:

- Problem analysis and description of the policy intervention
- Geographical and temporal delimitation
- Identification of effects
- Estimate of bicycle use and modal shift scenario
- Valuation of costs and benefits
- Results
- Policy recommendations

To obtain the net present value of each effect, discounting is applied. This is because a Euro of today has not the same value of a Euro of tomorrow (Campbell & Brown 2016). The discounting applied for cycling projects is 3% that is considered the standard discount rate for infrastructure projects (Romijn & Renes, 2013) and 5% for health effects of cycling that is the standard suggested by (Kahlmeier et al, 2014). The net benefits of the project have been determined through the formula: social benefits (B) minus social costs (C) equals net social benefits (NSB).

$$NSB = B - C$$

Finally, the costs and the benefits are represented in the ratio B/C. By comparing the costs and the benefits of different alternatives, SCBA helps the decision-making to choose "social efficient" solutions. Finally, the case study ends with the results and policy recommendations. Although the objective of the SCBA to assess whether a measures deliver a positive rate of return and not if the policy will achieve or not the objective, it is also recognised that the *"ability to achieve a policy objective is one of the criteria of the selection of promising options and policy alternatives*" (Romijm & Renes, 2013 p.85-86). These include criteria of technical and legal practicability, economic feasibility, goal-oriented, social and political feasibility. Finally, it is also important to address the question. Romijn & Renes (2013) suggests that the summary or overview should be clear, user-friendly and reproducible. In addition, important unquantified or non-monetised effects should also be included in the results (ibid.). Final insights on the projects are provided.

3.3. Validity & Reliability

To ensure the validity of the results both the triangulation of methods and the triangulation of data sources has been performed. First of all, data has been collected from multiple sources (different statistical databases, analysis of policy documents, general literature review, interview with policy makers and other actors). Secondly, both qualitative and quantitative methods have been used (social cost-benefit analysis, trend analysis, field research). Finally, every stage has been reviewed by a panel of experts and their feedback incorporated. The data related to estimates of bicycle use have been validated by also being able to access traffic model for cycling of the municipality. Data on bicycle use has both used statistical data, previous studies and BikePrint . Moreover, scenarios have been produced to incorporate uncertainty. The case study has a low level of generalizability as the results can be applied only to that very specific context. However, some general conclusion can be drawn in light of the application of the framework. The section below addresses the data collection more into details.

3.4. Data collection

3.4.1. Desk research

In the compilation of the theoretical framework, relevant literature has been identified and selected by using Scopus and Google Scholar. and selected the articles according to citations and year of publications. Some general key words included: “determinants of bicycle use”; “cycling policies”; “holistic appraisal”; “active transportation”; “sustainability appraisal”; “effects of bicycle use”; “effects of cycling policies”; “urban sustainability”. More specific key words for SCBA included: “social cost-benefit analysis”; “benefits and costs of transport”; “evaluation sustainability”; “evaluation of active transport”; “evaluation of cycling policies”. Further articles have been identified through expert consultation[17].

In the case study, the use of SCBA from a holistic perspective entails a high degree of complexity as it requires multiple data sources, multiple skills (modelling techniques, qualitative and quantitative skills of policy analysis) and the cooperation with governments agencies and stakeholders. Hence, together with the literature research, statistical research has been conducted by mainly using CBS StatLine and also databases of the province of North-Holland, Fietsberaad, and the Netherlands Environmental Assessment Agency (PBL). The data collected has been elaborated by means of multiple tools such as Excel, Stella, Biogeme and HEAT Tool and BikePrint. The HEAT Tool is a standard methodology of the World Health Organisation (2014) to calculate the health benefits of walking and cycling. Stella has been used to crate scenarios based on population growth rate used in the estimates on bicycle use. Biogeme has been used to estimate the basic utility function for the value of travel time (explained below in 3.3.4). Finally, the calculation of travel times, delays and the identification has been mainly based on BikePrint. This software elaborates the data from the FIetstelweek national cycling survey that takes place once a year and the first one carried out in 2015.

[17] Interview UvA1 (2016), TU1 (2016), TU2 (2016).

3.4.2. Policy document analysis

A number of policy documents has been analysed (listed in Appendix B). These have been analysed to identify the type of policy intervention, the intended effects (but also unintended effects), costs and other technical information relative to the project. Moreover, these have been integrated with reports, interviews (3.3.3) and other secondary sources (explained in 3.3.4) to gain a complete understanding of the case and the problem under study.

3.4.3. Interviews

A few unstructured qualitative interviews have been conducted both during the formulation of the theoretical framework and the case study (list of people interviewed in Appendix A). In particular, interviews have been conducted, at the beginning, to further identify further knowledge gaps, later, to improve the structure and the scope of the research. The method followed the book from Weiss (1995) on how to "learn from strangers". Interviewees have been informed about the purpose of the interview and the research and, then, recorded (if permission was granted). In other cases, notes have been taken. The totality of the interviews has been conducted in person. The identification of relevant interviewees has been done by looking at their role, position and stake in the project with the help and indication of the Stadsregio Amsterdam. During the analysis of the case study, interviews have been conducted during each step to ensure appropriate triangulation of the data. Because of the internship allowed to work closely together with the Stadsregio employees, there was no need to make semi-structured interviews.

3.4.4. Secondary sources

Along with the desk research, the analysis of policy documents and interviews, this research has further benefit of other secondary sources.

Cyclists' Value of Time seminar

By taking part to a research seminar organised by the Vrij Universiteit Amsterdam, it has been possible to organise a field research in which the cyclists' value of time (VoT) has been directly calculated by means of mode choice experiment. As explained in Chapter 2, The research method applied is a choice experiment. In general, the VoT depends on the willingness-to-pay (WTP) and the utility that individuals gain from a specific choice out of a set of alternatives. Whenever, a person has to decide between alternatives, the one that will maximize his utility will be chosen. The utility deriving from this choice is also assumed to be higher than the utility that could be derived from other available alternative. A survey was performed in which over 300 respondents had to choose their mode of transport between several alternative scenarios, thereby revealing their hypothetical preference. Google Forms on digital devices has been used as empirical data collection tool.

Utilities are estimated by random utility functions, which are formed by an observable part (V_j) that is determined by the connection between an attribute (x_j) and preference (β) and an error-term(ε_j) which is included to account for the unobservable. It is mainly the β that influences the utility positively or negatively for each alternative (Koster, 2016). The complete utility function than can be described by the following formula: $U_j = V_j(\beta, x_j) + \varepsilon_j$. The systematic component V_j itself has the following formulation: $V_j = \sum_{k=1}^{K} \beta_k * x_{jk}$. In this formula *K* stands for the total number of attributes in the model, β_k for the parameter to be estimated concerning attribute *k,* and x_{jk} for the value of attribute *k* for alternative *j*. The data obtained has been analysed by applying the MNL (Multi Nominal Logit) as the basic choice model. MNL is used to determine how an individual chooses among three or more discrete alternatives. The program used for this purpose is Biogeme. It gives estimates for β which than can be used in order to calculate the value of time. For the calculation of the value of time, the derivative of the formula for the calculation of the WTP is used:

$$WTP_j = -\frac{change\ in\ attribute}{change\ in\ cost} = \frac{\frac{\partial\, U}{\partial\, attribute}}{\frac{\partial\, U}{\partial\, Cost}}$$

Four values have been derived, in particular the value of value of time spent travelling, value of waiting time (see Appendix F).

Other activities

In addition to this, several seminars and workshops have been followed to improve both the knowledge on cycling and SCBA (Appendix C). A field trip to the location has also been done as part of the internship to further identify qualitative problem of the route related to the travel experience (Appendix L).

3.4.5. Limitations to the data collection

Due to the breadth of the thesis and SCBA, not all variables have been included in particular most of the individual features are not represented. The valuation of the cycling time, for example, only took into account income, age, occupation and trip purpose. However, off these, only trip purpose has actually been used. In addition, data collection has location bias as it has been performed on another location of Amsterdam. However, according to Koster (2016), the values may not differ dramatically as people on the same area are likely share similar values.

Data collection on other values has also been limited to a few effects and the use of proxies has been necessary. This however is also reflected in the discussion and represents an important limit of SCBA and the holistic approach. Moreover, the study focused mainly on bicycle use but hardly took into account e-bikes and other road users such as public transport.

Another source of limitation has been the language barrier. Although throughout the year a Dutch course has been followed in order to improve read and communication skills. It is yet likely possible that some (more or less) important information might have missed. Both the interviews, desk research and document analysis has been mainly conducted in Dutch, with the exception of expert panel sessions.

Finally, although BikePrint represents an innovative solution to identify origins and destinations of trips as well speed, delays and number of cyclists, it is yet very limited in data and therefore its results can hardly be generalised. However, no other method is currently available to perform such task.

4. Results

4.1. Case study: Fast cycle route Hoofddorp-Aalsmeer

4.1.1. Problem analysis

The infrastructure analysed by this research is a cycle path located in the metropolitan area of Amsterdam between the cities of Hoofddorp and Aalsmeer. According to a local and regional problem analysis the level of bicycle use in the area is low due to the poor quality of the infrastructure that may bring substantial "disutility" to cycling and encourage car travel instead[18](Stadsregio Amsterdam, 2010; Gemeente Haarlemmermeer, 2015b). Traffic counts show, in fact, low levels of bicycle use in relation to the number of people living and working in the area (De Meerlanden, 2008; Gemeente Haarlemmermeer, 2015a). An early qualitative analysis and a large-scale mobility survey among Schiphol employees[19], underline these unattractive conditions as a factor for not cycling (Stadsregio Amsterdam, 2010; SOAB, 2013). In particular, the comfort, the number of intersections and safety concerns are specifically mentioned[20]. Moreover, between 2010 and 2013, the number of workers commuting to the by bicycle Schiphol Area has declined from 3,2% to about 2,6% (SOAB 2010; SOAB 2013). Meanwhile, car use has steadily increased to almost 60% of the totality of the trips (ibid.). This is also the case for those workers living in the neighbouring municipalities where bicycle use has declined in favour of car use (see Appendix H).

Hence, by improving the cycling conditions on the Kruisweg it is believed that there is the potential to substantially increase bicycle use in the area (Stadsregio Amsterdam, 2010; Gemeente Haarlemmermeer, 2015; Gemeente Haarlemmermeer, 2015b). In addition, by encouraging a modal shift to cycling it is also believed[21]to be beneficial to also tackle traffic congestion in the area (Stadsregio Amsterdam, 2010). The N201 Kruisweg is, in fact, an important provincial road that connects Zandvoort to Hilversum and intersects with the A4 between Hoofddorp, Aalsmeer and the Schiphol Airport. Although this is not specifically listed in the "filetop 50[22]", annual travel time measurements and traffic measurement indicates it as one of the busiest road sections of the country (ibid.). Important economic activities are located which attract traffic from the surrounding municipalities causing bottlenecks during morning and evening rush hour (Gemeente Haarlmmermeer, 2015b). Part of this congestion is caused by short trips taking place during morning and evening rush hour due to traffic arriving to and/or departing from Schiphol and its surrounding area (ibid.). In addition, the motorised traffic currently cuts through a number of residential and commercial areas, impacting the quality of life, traffic safety and determining slow traffic also on other provincial and regional roads (Stadsregio Amsterdam, 2010). The noise nuisance also imposes stress on cyclists diminishing the quality of their travel experience (Stadsregio Amsterdam, 2010). The growing traffic also puts pressure on the environment by releasing an increasing number of pollutants in the surrounding environment (see Appendix I).

[18] Interview SRA3 (2016).
[19] The largest group making use of the corridor (Stadsregio Amsterdam, 2010).
[20] Interview SRA2 (2016); F1 (2016); F2 (2016); F3 (2016).
[21] Interview SRA1 (2016); SRA2 (2016); PNH3 (2016).
[22] List of the busiest road sections in the Netherlands

4.1.2. Description of the policy intervention

The proposed intervention aims at encouraging a modal shift to cycling by improving the current cycling conditions. In particular, the construction of a high-quality fast cycle route to connect Hoofddorp, Aalsmeer and Uithoorn (circa 8 km) in order to improve local and regional accessibility to the Schiphol Airport and to other local economic areas by bicycle. The fast cycle route will reuse the old infrastructure, whenever possible, and partially rebuilt on the south of the Kruisweg in order to avoid potential conflicts with motorized traffic. The total number of intersections will be reduced from 5 to 2. In addition, the material used will be upgraded to ensure a higher level of comfort. Together with the physical intervention, a behavioural campaign (demand management approach) will be done in order to encourage people working and living within 15 km to commute to work by bicycle. A special target group of this intervention are the Schiphol employees, which together represent 65000 people. The majority of which commutes with the car.

On the basis of this information, the policy can be classified as "supply management" approach (see Table 4, Chapter 2) with the intended effect of increasing bicycle use by improving the cycling conditions on the Kruisweg.

4.1.3. Geographical and temporal scope

Following the theoretical framework (Table 6, Chapter 2), the area where the intervention may have a direct and indirect effect has been identified and explained below.

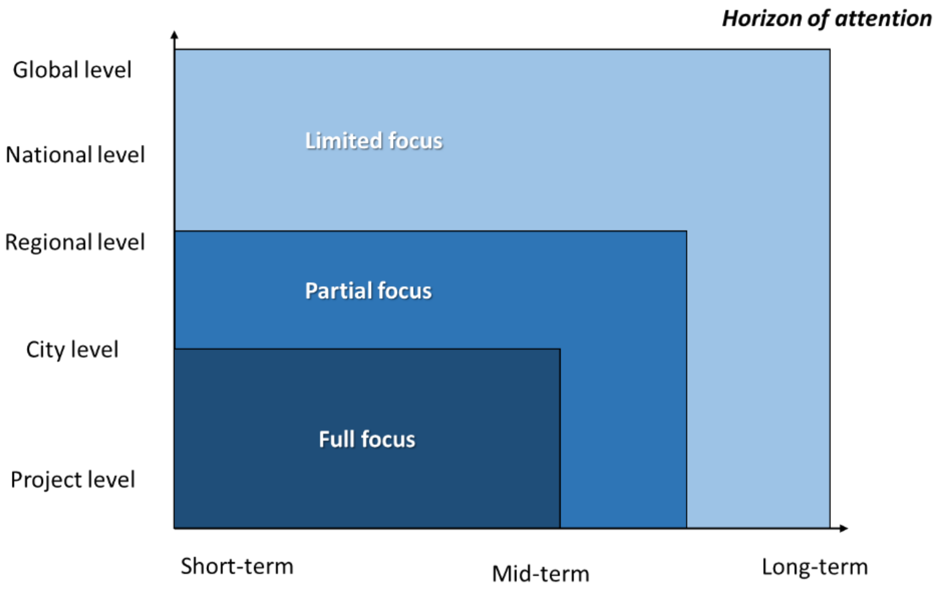


Figure 9- Representation of the horizon of attention of the study

Project level

The project level has been delimited based on the length of the project. This will be located along the N201 Kruisweg for 8 km. This research addresses only the first segment, between van Heuven Goedhartlaan and Fokkerweg (about 4,2 km) stretching between Hoofddorp, Aalsmeer and Schiphol due to data availability. Here traffic models indicate an average of 2800 trips per day (Appendix G). By using data from CBS (2015); OIS (2015) it was possible to estimate the total number of return trips (see Table 8). In addition, a distinction between utilitarian and recreational has based on data of travel purpose CBS (2015).

Data	Variable	Value	Source
Bicycle use	Trips	2800	Appendix G
	Total users	1288	CBS (2015) return trips
	Proportion recreational	112	CBS (2015) trip purpose

Table 8- Data on bicycle use on the Kruisweg

Finally, the use of the *Fietstelweek* data (BikePrint, 2015) allowed to calculate the average bicycle speed, travel time and delays on the stretch analysed (Table 9).

Data	Variable	Value	Source
Cycling travel time data	Travel speed	14 km/h	Traffic analysis with BikePrint (2015) see Appendix J
	Time spent travelling	18 min	
	Waiting time	3 min	
	Parking time	1 min	
	Walking time	Not accounted	

Table 9 - Travel time and speed

These values are in general lower than the Amsterdam region average (around 16km/h) and 4km lower than values on similar roads (around 18/km) due to the number of intersections (Appendix J).

Local level

This level corresponds to the immediate surrounding of the project. This has been defined by determining the origins and the destinations of bicycle trips travelling along the Kruisweg (Figure 10).

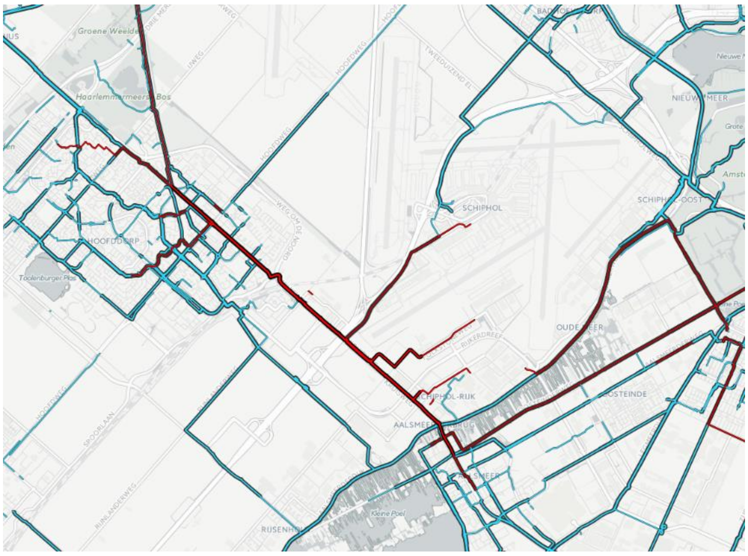


Figure 10 - Origins and destinations (BikePrint, 2015)

The size of the local area has been delimited to 5 km radius on the basis of local trips (CBS, 2015). Within this radius, several residential areas, firms and transport hubs are located. In particular, three towns are situated: Hoofddorp, Aalsmeer and Uithoorn. Five “economic areas” are present with fairly strong diversity of functions: services, industrial, logistics, floriculture and the international airport of Schiphol. In total, the area provides circa 80.000 jobs and more than 140.000 people live there (Gemeente Haarlmmermeer, 2015b).

Within this area, the potential beneficiaries of the project have been identified by looking at the total population (from 12 and 84 years old) who are assumed would use the bicycle most regularly. Moreover, in the Netherlands, bicycle ownership tends to be high with 1.1 bikes/inhabitant (Fietsberaad, 2009). Hence, it is assumed that the population within that age range may likely possess a bicycle. This is the target group that is likely to benefit from having an additional option such as a fast cycle route. Assuming that this modal share will stay constant in the future, following the population dynamics, it is possible to estimate an average total "cyclist population" of about 15,000 cyclists in the area that may benefit in the area of having an additional option (Appendix K). Within this area further information regarding bicycle use has been collected as this is relevant as input for the impact model and the valuation of the effects (see Table 10).

Data	Value	Source
Time spent cycling per day	17 minutes	CBS (2015)
Number of trips (day)	1,5 (return trips) – assumptions based on workers	CBS (2015)
Cycling trip	10 min	CBS (2015)
Average speed	16 km/h	CBS (2015)
Km cycled year	917 km/y	CBS (2015); Decisio (2012)
Days a year utilitarian	274	CBS (2015); Decisio (2012)
Purpose	1 /10 made for recreation	CBS (2015)
Days of cycling for recreation	50	CBS (2015)
Distance	60% of the trips usually take place within 3,5 km. About, 30% of the cyclists cover between 3,5 and 7,5 km per trip. While about 10% cycles between 7,5 and 15 km	CBS (2015)
Modal share Hoofddorp	15	Fietsberaad (2009)
Modal share Aalsmeer	20	Fietsberaad (2009)

Table 10 - Data on bicycle use at the local level

Regional level

The regional level has been partially considered for three main reasons. First of all, one of the underlying motivations for the policy implementation is the assumption that fast cycle routes will partially reduce congestion at the regional level during peak hours by encouraging a model shift at the local level (Stadsregio Amsterdam, 2015). Secondly, the project is also part of the regional policy to create a network of fast cycle routes to increase long-distance commuting for both for recreation and tourism and therefore the implementation of this project may have an effect on the number of recreation trips (ibid). Thirdly, regional economic, social and political development (exogenous factors) may constitute a source of bias of the evaluation and therefore they also need to be addressed.

Beyond this level, namely at the national and global level, the focus has been limited to environmental effects due to the relatively small size of the project.

The table below summarizes these levels:

Levels	Delimitations
Project level	Stretch of the N201 Kruisweg between Van Heuven Goedhartlaan and Fokkerweg (4,2 km) between Aalsmeer and Hoofddorp, connecting to Schiphol International Airport.
Local (or City) level	Radius of 5km from the project level, it includes the cities of Hoofddorp, Aalsmeer and the local economic areas.
Regional level	Partially considered to
National & Global level	Partially considered for some effects

Figure 11 - levels addressed and their delimitation

Temporal scope

It is assumed that the project will be completed in 2020[23]. The limit of the temporal scope is set to 2035 and therefore a frame of 15 years which is considered an extended temporal scope for a 4 km cycle route[24]. Fixing a broader scope might generate additional sources of bias such as: economic, social, political and population trends which cannot be accurately predicted.

4.1.4. Effects identification and impact model

On the basis of the problem analysis and the theoretical framework, it can be assumed that the policy will likely have a direct effect on the generalised price level of bicycle use.

In particular, on the project level, the fast cycle route will reduce travel time and increase safety by reducing the number of intersection from 5 to 2 (Gemeente Haarlemmermeer, 2015). Moreover, the current tiles on the path will be replaced by smooth red asphalt to increase speed and perceived comfort (ibid.). In addition, the construction of a windshield placed along the path will reduce noise from motorised traffic and reduce the effect of wind coming from the west of the country (ibid.). This will also reinforce the overall level of comfort and the increased separation from traffic may reduce the perceived risk of injury (ibid.). On the local and regional level, the project may directly increase the option value for the community living within cycling distance as it provides a high quality and more comfortable connection to cycle between the two cities and the Schiphol area. In addition, the project may become an additional amenity for the community, potentially attracting regional and national bicycle tourism (Stasdregio Amsterdam, 2010). A potential unintended effect is the increased speed of light motorised vehicles such as scooters that are allowed on bicycle paths according to the Dutch traffic laws. This may increase the potential risk of conflict between cyclists and scooters.

By reducing these generalised costs of cycling, the policy is expected to indirectly increase bicycle use both for leisure and recreational purposes and therefore lead to a decrease car use. The increase in bicycle use is linked to physical activity which reduces potential risks of mortality and therefore lead to a prolonged life. Healthier individuals are also less likely to get sick and therefore they increase their overall level of productivity at work. Finally, more people cycling on the bicycle path may lead to more contact possibilities and occasions for social interaction. Increasing bicycle use may lead to a decrease in car use as individuals are less likely to use their car. Less car use determines more private savings that

[23] Assumption based on interviews SRA2 (2016), SRA3 (2016), SRA9 (2016).
[24] Interview TU1 (2016).

are redistributed at the local level. On the national and global level, less car use means less CO_2 being emitted in the atmosphere and therefore lower costs damage costs to mitigate these negative consequences of climate change. In addition, other externalities such as emissions of NO_2, CH_4, and PM_{10} that are dangerous for human health and lead to land acidification are reduced. In addition, the less car use is also leads to lower noise levels at the local level and a quieter environment. Finally, less cars on the road lead to less traffic accidents and less congestion.

- *Prized effects*: the intervention produces a direct cost to the government bodies. These costs include material costs, labour costs, construction costs and maintenance costs. Decreasing car use and increasing bicycle use for both recreation and utilitarian purposes leads to savings that increase local spending. However, these count as redistribution of income and therefore are not counted as external effects. Increasing outbound tourism may, on the other hand, produces a welfare effect in terms of demand for goods and services. Increase in productivity relates to the increased production that is achieved when people are less on sick leave.
- *Non-prized effects:* travel time savings, traffic time reliability, increased comfort and other health and environmental effects are all non-prized effects as they are not traded in markets.

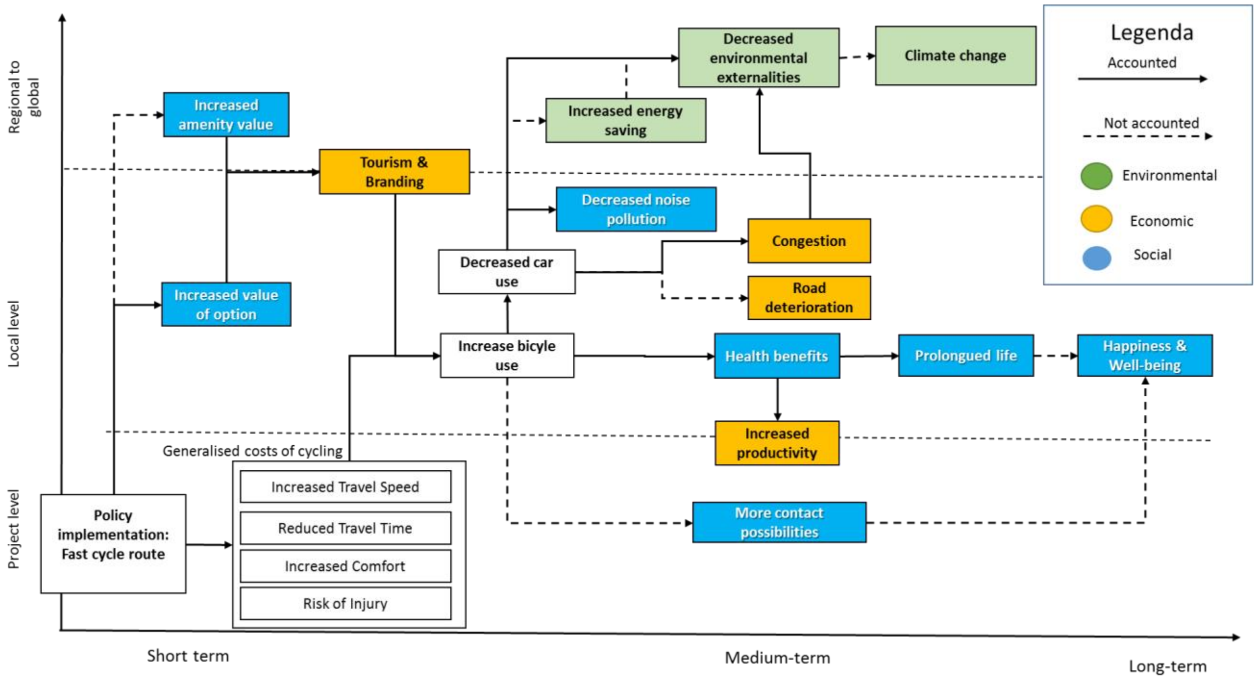


Figure 12 - Impact model

The effects are here expressed as costs and benefits as well as their monetisation method. The first table gives an overview of the type of costs, their measure, monetisation method and source.

Costs			
Type of cost	Measure	***Monetisation***	***Source***
Construction costs	Operations costs (incl. labour)	Direct market price	Gemeente Haarlemmermeer (2015)
Material costs	Price for materials	Direct market price	(ibid.)
Maintenance	Price for materials and operation costs (incl. labour)	Direct market price	(ibid.)

Table 11 - Costs

The second table illustrates the positive effects of the intervention including the measure, monetisation method and source.

Benefits			
Type of benefits	Measure	Monetisation	Source
Travel savings	Annual time saved due to shorter trips	WTP for one-minute cycling (€/min)	Directly estimated (Appendix F); bicycle use data on the project level.
Travel time reliability	Annual time saved due to avoided congestion	WTP for one-minute spent in congestion (1/4 of the travel time savings) (€/min)	Based on KiM (2012) Using values in Appendix F; bicycle use data on the project level.
Improved health	Decreased in mortality rate	VSL (€/reduced risk) and HEAT Tool of the World Health Organisation (Kahlmeier et al., 2014) - €/less mortality risk	Kahlmeier et al. (2014); bicycle use data on the local area.
Increased comfort	Increased in perceived comfort	WTP for one minute in a comfortable route (€/min)	Literature proxy (Van Ginkel, 2014) and bicycle use data on the project level
Prolonged life	Life years gained	VSL(€/years)	Literature proxy: TNO (2012); bicycle use data on the local level.
Option value	Additional km of cycle paths for the community	WTP for additional or more valuable option (€/km)	Literature proxy (Litman, 2016); total length of the cycle path.
Increased productivity	Decrease in sick days' leave	Labour productivity (€/km)	Literature proxy (TNO, 2012); bicycle

			use data on the local level.
Outbound Tourism and branding	Value of recreational (cycling trips)	Direct Market Price (€/trip)	Literature proxy: (Witteveen+Bos, 2012); number of recreational trips
Decreased noise	Abatement costs	Shadow price (€/km)	Literature proxy (Decisio, 2012); number of car trips and km travelled
Decreased air pollution (incl. Climate Change)	Abatement costs	Shadow price (€/km) (€/pollutant converted into €/km)	CBS (2015); de Bruyn et al. (2010); Klein et al. (2009). Korzhenevych et al., (2014) and data on car trips use at the local level

Table 12 - Benefits

Exogenous factors

- **Climate and Landscape.** Both climate and landscape are assumed by this research not to be a factor in impeding bicycle use. The mild climate and the flat landscape are generally ideal for cycling.

- **Political and cultural context.** Being the Netherlands a cycling country, bicycle use is considered part of the culture. Cycling is also an important component of Dutch policy making as it is considered as part of the mobility and accessibility policy and it is also part of health and recreation policy[25].

- **Social economic and technological development.** At the local level, projection show that *population* living in Hoofddorp and Aalsmeer is likely to remain stable between 2010 and 2030 (OIS Amsterdam, 2015; Gemeente Haarlemmermeer, 2015a), hardly affecting the current mobility system. This however does not seem to be the case in the neighboring municipalities. PBL (2013) estimates, in fact, that the conurbation of Amsterdam and part of the Randstad will be interested by a significant population growth (more than 10%) by 2030 and 2040 compared to the 2012 level. *Economically*, the regional level is in a process of economic development. The central location and the proximity to Schiphol international airport makes it a prime location for business establishment both nationally and internationally (Stadsregio Amsterdam, 2010). Despite the financial crisis, the area has kept growing, registering a 2,1% increase in GDP (between 2013 and 2014) compared to 1% of the national average (CBS, 2015). This area is also expected to continue growing in the future (ibid.). The successful economic development is reflected in the florid labour market of the area. The Amstelland-Meerlanden is location with highest jobs density in the Province of Noord-

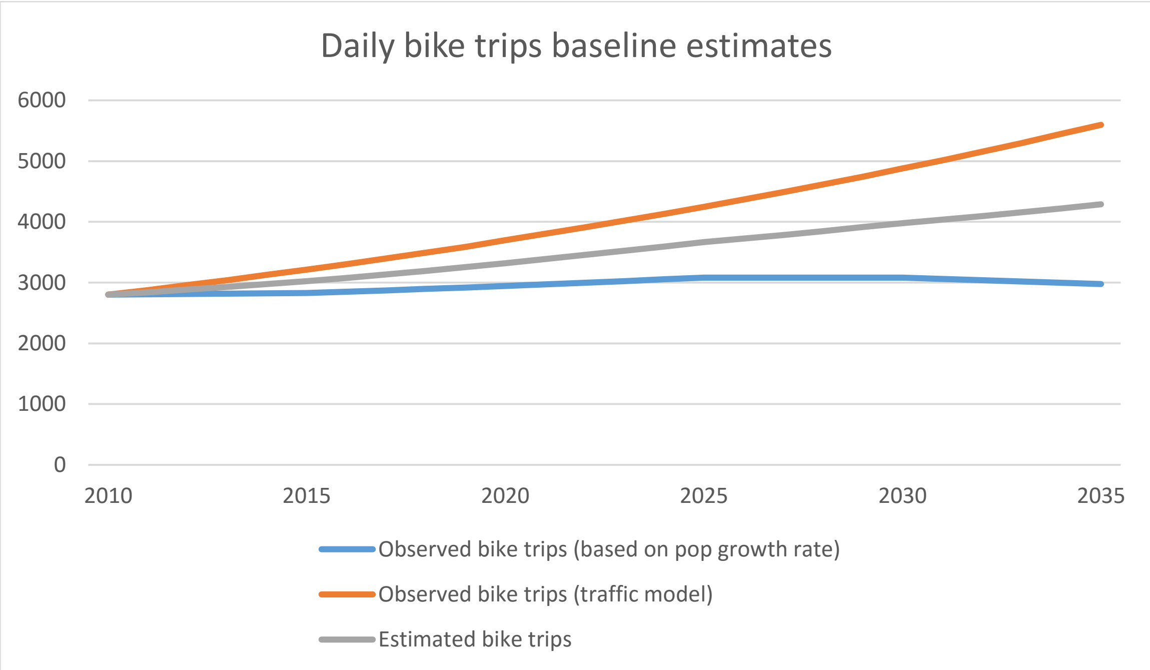
[25] Interview SRA3 (2016).

Holland, second only to Amsterdam, with more than 229.000 jobs (PNH, 2016). Almost half of these are concentrated in the municipality of Haarlemmermeer accounting to almost 119.224 jobs in 2014, 65.000 of which are concentrated in Schiphol (Gemeente Haarlemmermeer, 2015a). This works as a city without inhabitants with a 24-hour economy throughout the year (Stadsregio Amsterdam, 2010). These factors may also lead to an increase in car use, reducing the magnitude of the effect of the policy. In particular, regarding the ability to tackle environmental effects and health benefits. This is underlined by several studies which highlight the increase of car ownership and use both at the national and local level, especially outside main urban centers (CBS, 2012).

- **Built environment.** The area where the policy will be implemented can be categorised as low to medium urbanised and this correlates in general low bicycle use. Moreover, the spatial distribution of origins and destinations contributes to a high reliance on the private car in the area. The Schiphol area remains isolated (due to airport activities) from residential areas. This means that the average home-job travel distance is around 37 km which is higher than the average 18 km of the country (SOAB, 2013).

4.1.5. Estimates of pre-post intervention bicycle use

In this section, future trend in bicycle use have been estimated on the basis of the data identified in section 4.2. According to traffic models the number of daily trips will increase to 3700 in 2020 (see Appendix G). Assuming that the number will grow at the same rate, by 2035, the number of trips per day will reach 5597/day. However, these values are based on strong economic growth scenario and the value is optimistic[26]. Another trend has therefore been re-estimated by calculating the average increased based on the population growth rate of the local population (within the age range able to cycle). An average between these two trends (meaning 4287 trips per day) has been done in order to make a more conservative increase. This value is therefore used as baseline estimate for the number of trips.



Trend 1 - Base trend without intervention

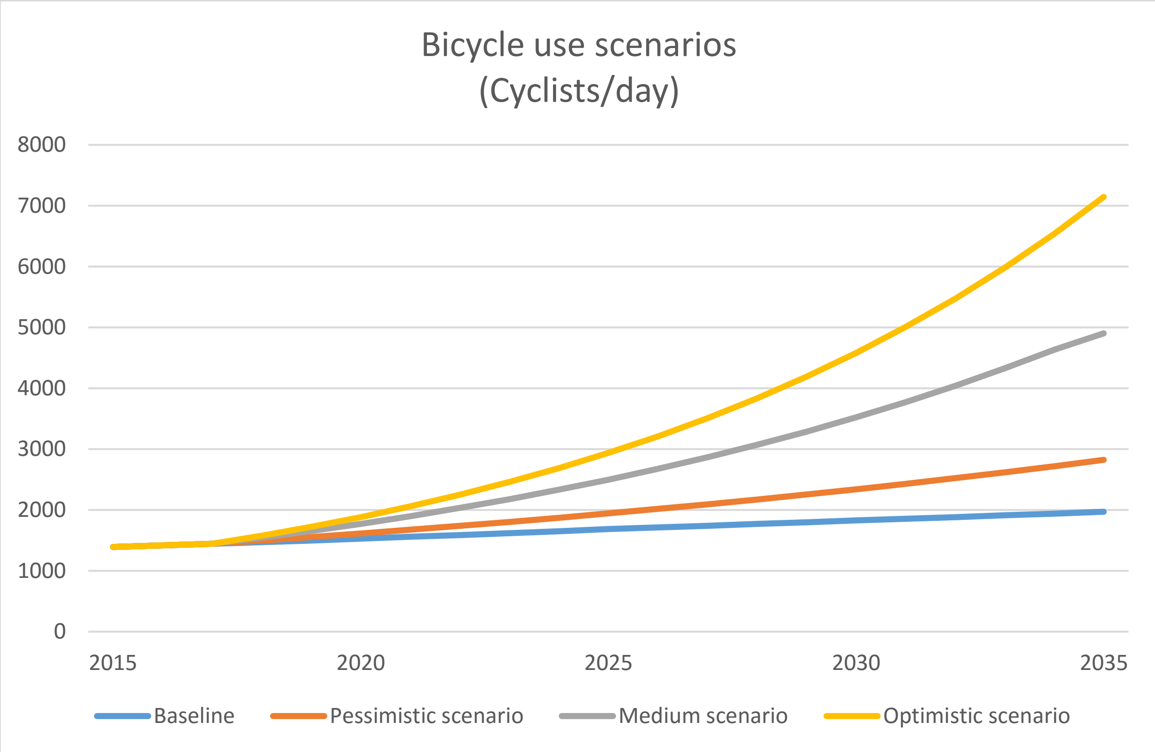
To estimate the magnitude of the effects of the policy, the Schiphol Area has been analysed to identify a potential target group of the policy. The area provides about 65,105 jobs. Most of them (43%) perform office functions and belong to technical staff and security (about 20%) and represent a group that may potentially shift to cycling. Excluding the people living beyond 15 km, this research has calculated the number of people who could potentially be shifted to cycling based on a survey performed by SOAB (2013). A question, in particular, asked what mode of transport Schiphol workers would use if they had better accessibility. Around 9% of the respondents said they would be interested in using their bicycle if they had better conditions (see Appendix H for the employees' mode choice). This equates to around 6000 people[27].

Assuming that the number of employees will remain constant, three scenarios have been developed in which the that the policy will modify the behavior of 25% of the workers (pessimistic scenario) that have expressed their interest, 50% (realistic scenario) and 90% of the workers (optimistic scenario). It is also assumed that the full shift will not be immediate but it will take place within the whole scope period. This is based on the idea that the demand

[26] Interview SRA7 (2016).

[27] More precisely, 5859 of the workers living in the surroundings have expressed their interest.

never adapts immediately to the new level of price but often requires time to fully build up (see theoretical framework chapter 2.2). Constant numbers for employees and modal shift has been intentionally kept constant even if they are likely to increase or decrease, in order to incorporate uncertainty and make more conservative estimates. This leads to the following scenarios (Trend 2).



Trend 2 - Scenarios pessimistic, realistic, and optimistic

4.1.6. Valuation of costs and benefits

In this sections the valuation of the costs and the benefits is performed. First of all, the values that have been directly valued by this research are illustrated, then other values derived from the literature are listed.

4.1.6.1. Direct valuation

Implementation costs of the fast cycle route

	Costs	
Cost (one off construction and materials)	€ 6.594.000	Gemeente Haarlemmermeer (2015)
Maintenance cost/year	1,5% of the total cost a year	Estimated (based on interview with SRA 9, 2016).
Maintenance cost x 15 years	€ 1.483.650	Estimated
Total cost	€ 8.077.650	

Table 13- Table of costs

Travel time savings
It is assumed that as result of the intervention the travel time will be reduced by 6 minutes if cycling increase their speed to 18km/h and have less intersections (see Appendix J for the study results using BikePrint). Table 12 below illustrates the before and after the intervention.

Indicator	Before	After	Difference	
Travel speed	14km/h	18 km/h	+4 km/h	Bikeprint (2015)
Time spent travelling	18 min	14 min	-4 min	Bikeprint (2015)
Waiting time	3 min	1 min	-2 min	Est.
Parking time	1 min	1 min	-	Est.
Walking time	Unknown	Unknown		-
Total time	22 min	16 min	-6 min	Estimated

Table 14 - Travel time change

The value of these variables has been calculated by employing a mode choice experiment as explained in the methodology (3.3.4) and these are summarized in Table 15.

Value of Time	Value utilitarian trip	Value recreational trip	Method
Value of time spent travelling	€ 0,21/min	€0,16/min	See Appendix F
Value of waiting time	€ 0,14/min	€0,10/min	
Value of walking time	€ 0,036/min	€ 0,036/min	
Value of searching time	€ 0,021/min	€ 0,021/min	

Table 15 - Values of cycling time for utilitarian and recreational trips

On the basis of this data, the value for travel time savings has been estimated. Assuming a linear demand function (as in the theoretical framework in chapter 2), current users receive the full benefit. While the "rule of half" has been applied to the new users. Hence, the travel time savings for pessimistic, realistic and optimistic scenarios have been calculated.

Travel time savings		
Pessimistic	**Realistic**	**Optimistic**
€ 1.114.168	€ 1.592.670	€2.109.626

Table 16 - Value of travel time savings

Future travel time reliability
This is the value for avoided future travel time losses due to congestion this is equals to the a fourth of the travel time gain (KiM, 2012). Hence this has been directly derived by the previous value but discounted for recreational trips as they are assumed to fully internalize the value of travel time in due to cycling congestion.

Travel time reliability		
Pessimistic	**Realistic**	**Optimistic**
€ 216.732	€ 310.724	€ 412.269

Table 17 - Travel time reliability

Health benefits

To estimate the value of health benefit, the amount of cycling before and after the observation has been calculated. It has been assumed that the time needed to reach the full shift is 15 years. In addition, only 10% of the population has been excluded from the calculation as it has been calculated that 1/9 of the trips is made for leisure purposes and therefore the benefit is internalized. Moreover, the average mortality rate of the population between 20 and 64 years of age has been used (232,42 deaths 100,000 persons/year) and the average EU value of statistical life (€2.587.000) (Kahlmeier et al., 2014). These value have been used as input in the HEAT tool to calculate the value of the health benefits. These are reported below.

Reduced risk of mortality			
	Pessimistic	**Realistic**	**Optimistic**
Prevented deaths / year	13%	13%	13%
Reduced risk of mortality	0.24	0.82	1.45
Discounted total benefit in 15 years	€ 2.059.000	€ 7.096.000	€ 12.536.000

Table 18 - Value of health benefits of increased cycling

4.1.7. Literature proxies

Other values could not be calculated directly and therefore, proxies from evaluation studies have been used to give a monetary value to other effects.

Effects	Value	Description	Source
Increased comfort	€ 0,06/min for commuting trips € 0,04/min for recreational trips X Minutes spent a year travelling on the new fast cycle route	"Rule of half" for new users.	Van Ginkel (2014)
Option value	€,05[28] X Km of the new fast cycle route	"Rule of half" for people beyond 3,5 km radius.	Litman (2016)

[28] This value has been halved. The book "Transportation Cost and Benefit Analysis" (Litman, 2016) has estimated this value 7cent passenger mile, equals to €2016 0.10/ cyclist km.

	X Potential population able to cycle		
Increased productivity	€0,05 x average km cycled/year	For car driver shifting to cycling	TNO (2012)
Outbound tourism and branding	€1/for recreational trip	Only recreation trips	Witteveen+Bos, (2012)
Prolonged life (Life years)	€0,02 x average km cycled/year	Only new cyclists	TNO (2012)
Sound pollution	€0,01 (value out of urban areas) x average km cycled/year	For car driver shifting to cycling	Decisio (2012)
Air pollution	€0,01 (value outside of urban areas) x average km cycled/year	For car driver shifting to cycling	CBS (2015); de Bruyn et al. (2010); Klein et al. (2009). Korzhenevych et al., (2014) + Appendix I

Table 19 - Other values from the literature

4.2. Discounting

Following the methodology section, a discount rate of 3% has been applied and 5% discount rate for health effects (see theoretical chapter 2).

4.3. Results of the social cost-benefit analysis

Based on the number of additional cyclists from the scenarios and assuming the average distance/time cycled per day will stay constant, the values have been calculated and displayed in the table below and organised in costs and benefits. At the bottom, the net present value has been calculated by subtracting the net social benefits to the total costs. The B/C ratio show the

Benefits	Pessimistic scenario	Realistic scenario	Optimistic scenario
Travel Time Savings	€ 1.114.168	€ 1.592.670	€ 2.109.626
Comfort	€216.732	€310.724	€412.269
Option Value	€875.623	€875.623	€875.623
Productivity	€38.972	€134.294	€237.277
Health	€2.059.000	€7.096.000	€12.536.000
Tourism & Branding	€54.013	€54.013	€54.013
Reliability future traffic	€278.542	€398.167	€527.406
Life years	€15.589	€53.717	€94.910
Sound	€25.877	€44.942	€65.538
Pollution	€7.794	€26.858	€47.455
Total to discount	€2.578.052	€3.365.494	€4.216.216

Discount	€77.341	€100.964	€126.486
Total	€4.559.711	€10.360.530	€16.625.730
Costs			
Construction	€ 6.594.000	€ 6.594.000	€ 6.594.000
Maintenance	€ 1.483.650	€ 1.483.650	€ 1.483.650
Total	€ 8.077.650	€ 8.077.650	€ 8.077.650
Net	€ -3.517.938	€2.282.880	€8.548.080
B/C ratio:	0.56:1	1.2:1	2:1

Table 20 - Summary table of costs and benefits

In the pessimistic scenario the project has a total balance of -3.5 million euros of net losses due to low use of the new infrastructure. While the realistic and optimistic scenario both show relatively high return with 2.2 and 8.5 million social benefits respectively. This means that in 15 years the project is likely to be repaid in terms of increased welfare.

4.4. Policy recommendations

The policy intervention aims at increasing bicycle use in the area by providing a more comfortable and pleasant route with higher quality of asphalt, provide a safer and direct connection. The qualitative analysis conducted (Appendix L) reveals that an intervention is needed given the current state of the cycling connection. The intervention shows technical, economic, political and social feasibility for the following reasons. First of all, it is technically feasible as this has been subject of an engineering study and no technical problem is mentioned (Gemeente Haarlemmermeer, 2015). Secondly, the fast cycle route is both economically viable and feasible. The project is within the budget[29] range of the municipalities involved (see Stadsregio Amsterdam, 2015) and the costs are divided between the different stakeholders (see section 4.2). Moreover, the result of this study shows an overall positive economic balance of about € 2,5 million on average (min -3,5 million, max 8.5 million). Thirdly, the project is politically feasible as both the local and the provincial administrations are in favour of cycling. In particular, local policies have the objective to improve accessibility by putting emphasis on cycling as utilitarian mode (Gemeente Aalsmeer, 2009; Gemeente Haarlemmermeer, 2015b). At the regional level, the objective is to increase cycling in all types of built environment and fast cycle routes are considered[30] as a tool to increase both utilitarian and leisure commuting (Stadsregio Amsterdam, 2015). Moreover, cycling is perceived as a sustainable mode that is also in line with objectives of health and recreational policy[31]. The fast cycle route is also positively perceived by local and regional NGOs, particularly the Fietsersbond (that is the cyclists' union of the Netherlands) and therefore socially feasible[32]. On the basis of this, the judgement over the policy is positive, even in spite of the results of the pessimistic scenario. This is because the study made use of conservative estimates to both

[29] Interview SRA1 (2016) and PNH1 (2016).
[30] Interview SRA1 (2016), SRA3 (2016), SRA4 (2016), SRA5 (2016), SRA 11 (2016), SRA 12 (2016)
[31] Interview SRA2(2016); Interview PNH2(2016)
[32] Interview SRA1 (2016), F1 (2016), F2 (2016), F3 (2016)

calculate the amount of cycling (and their future scenarios) and the valuation of the effects (as explained in the Chapter 2, section 2.3.2).

However, three critical remarks are risen. First of all, the project analysed did not present any alternative and therefore the fast cycle route could only be compared with its own different outcomes. More efficient alternatives could have been tested and compared to this project. For example, maintenance works and improvement in the quality of the asphalt and safety could have been a more efficient and inexpensive solution. Secondly, the policy mainly leverages on the supply side of cycling but does not intervene on the demand for motorised travel. This is a weakness of the policy because there is the likelihood that car traffic will remain constant (or only slightly decrease) despite the lower price level for cycling and therefore the pessimistic scenario may also be realised[33]. It is therefore suggested to also consider measures that discourage car use such as the introduction of yearly parking fees to combine with the behavioural campaign among employees combined with incentives for employees working at the local level. Finally, fast cycle routes as they allow cyclists to go faster, they may encourage scooters to go even faster determining potential risks to cyclists.

[33] Interview VU1 (2016), TU2 (2016).

5. Discussion

5.1. Strengths of the framework and the method

Appraising cycling policies in ex-ante by means of a SCBA appears to be a valuable approach to identify, quantify and communicate in an effective manner the weaknesses and the strengths of cycling projects and policies. Especially, translating the environmental, social and health effects into the language of Euro value may be a straightforward way to inform decision-makers on the social effects of their policies. This has therefore the potential to bring back the political debate on cycling to its economic, social and environmental benefits and costs. Including SCBA at an early stage of the decision-making may also be an important tool for learning and therefore in choosing more efficient solutions. In addition, SCBA as tool for decision-making is geared to address many of the principles of Good Goveranance (2009) such as transparency, efficiency, effectiveness, equity and accountability. Framing the problem, defining alternatives and selecting assumptions underlying the monetization method have to be consensus-oriented, accountable and participatory. By assigning a monetary value to each effect, the benefit and the costs of every project alternative are portrayed in an understandable and clear way for every stakeholder. As a result, SCBA facilitates inclusion to decision-making, it structures the debate on an objective basis and it supports policy-makers in choosing efficient solutions. Since stakeholders have to be taken into account during the process and the assumptions upon which SCBA is based have to be clearly stated (and negotiated), the decision-making becomes more transparent, the intervention economically justified and the outcome legitimate (von Knobloch & Ruffino, 2015).

Tailoring SCBA to a holistic perspective appears to be ideal to address complex problems such as mobility. As introduced at the beginning of this research, cycling relates to multiple domain and therefore these should also be factored in the analysis. By including non-prized effects, it is also possible to factor in the decision also immaterial benefits of this mode such as comfort and health benefits. In addition, the extended geographical and temporal scope may encourage to consider more level of analysis and incorporate feedbacks from the local, regional and national levels. Such as how population dynamics and economic development may influence the outcome of the estimations. Finally, although some scholar rejects the use of SCBA for its ethical principles such as give a monetary value to life or nature and rather support *"story-telling"* instead[34], this research does not a priori exclude the possibility that story-telling and SCBA could not be combined. It is rather underlined the potential of integrating the two to improve the communication and social acceptability of cycling policies. This may also encourage more municipal councils to invest more on cycling policies and therefore achieve a more sustainable transport system that favors a bike and pedestrian friendly environment in cities.

5.2. Limitations of the framework and the method

5.2.1. Limitations of the holistic framework

Addressing urban transport challenges requires system thinking and dealing with complexity. Therefore, holistic approaches seem ideal to address sustainability challenges. This ideal is very much supported by scholars in sustainability science (Ravetz, 2000; de Vries, 2012;

[34] Interview UVA1 (2016), P5 (2016), P6 (2016).

Hüging et al., 2014). However, this research evidences in line with Dror (2008) that *"distilling the essence of complexity"* may involve *"abstruse"* calculations, estimations and simulation that may paradoxically lead to oversimplifications, undermining the very same purpose of this approach. The problem with holistic frameworks and tool start with the definition of *"holistic"* that, similarly to the value-laden concept of *"sustainability",* is *"more of a buzzword than a genuine concept"* (Pearce et al., 2006 p. 213; Redclift, 2005). In the scientific literature, this concept is surrounded by conflicting assumptions, interpretation, values and principles (Redclift, 2005) with theoretical and practical implications. One of the implications in SCBA is the problem with the categorization and the classification of the effects that is needed to avoid double counting.

Effects can, in fact, take many forms as they can either be social, environmental and economic. For example, it may become challenging to separate health benefits of cycling from the increase in the level of exercise and the reduced pollution. Moreover, pollution can be considered a health, environmental and economic effect. Also in this research it appeared also to be an obstacle to exactly classify the effects into a particular category. Establishing a temporal and geographical scope is less straightforward than it might seem. Changing the scope may dramatically increase the complexity of the analysis and a clear boundary (especially) between local and regional effects is cannot be easily determined. Furthermore, municipal councils often do not collect enough data on mobility choices, particularly for cycling, and therefore it becomes difficult to estimate the exact geographic scope of an effect.

Future research should therefore further investigate how to improve the holistic appraisal without increasing complexity. In addition, future studies could also try to investigate what would be an ideal temporal and geographical scope for the appraisal different cycling projects.

5.2.2. Limitations of welfare economics

Although this research did not fully address the concepts of welfare economics in details, several remarks can be made in light of this research.

Welfare economics employs the concept of Pareto efficiency to describe an *"allocation of resources where no alternative allocation can make at least one person better off without making anyone worse off"* (Boardman et al., 2011 p. 21). This means an outcome where everyone is more or less satisfied with the distribution of resources. This is hardly achieved in practice since it is impossible to know everyone's utility function. The larger the project being implemented, the higher the uncertainty to be incorporated. This often translates in the use of averages. However, this often leads to a distorted information due to the inequality of income distribution[35]. High incomes are, in fact, those who gain the most of from SCBA as their willingness-to-pay is generally higher than the average and therefore they tend to be overrepresented if wealth distribution is not taken into account. Thus, it is possible that a policy may yield a positive net benefit to a group and *"bring misery"* to those who bear the costs (Moran et al., 2008).

Another issue concerning welfare economics and sustainability is that often the "social worth" of projects does not always coincides with the "sustainability worth" as environmental and more complex social issues might be underrepresented when the willingness-to-pay is used as method to monetized these effects. This is because individual might not have an adequate perception of the real magnitude of effects' costs and benefits. Moreover, what is

[35] Interview VU1 (2016).

depicted as a benefit for a group might be considered as cost or a burden by another group. For example, the reduction of supply of car lanes might be perceived as costs or a benefits depending if the person is a cyclist or a driver. This therefore leads to equity and fairness issues that have hardly been addressed in this research but they are equally important in the context of sustainable development. In addition, the valuation of the effects largely depends on the many determinants of bicycle use and therefore the range of values can differ dramatically from one person to another.

The approach advanced in this research is to use conservative values both in the valuation and the estimate of bicycle use.

5.2.3. Limitations of SCBA and the evaluation of cycling policies

Time and health benefits and travel time savings seem to be the driving benefit of the fast cycle route analysed according to this methodology. This is also in line with previous findings where health generally represents over 60% of the total benefits (Elvik, 2000; Saelsmide, 2004; Decisio, 2012; Decisio, 2013; Gossling & Choi, 2015; Litman, 2016). See bar chart below.

Figure 13 - Benefit distribution in other SCBAs on cycling

However, other social and psychological effects of bicycle use have been so far "underexposed". Schiefelbusch (2010) mentions for example how transport modes can become a mean to regulate aggression by relieving stress and anxiety. Moreover, increasing bicycle use may increase the level of social interaction, thereby increasing the feeling of community and belonging, leading to more awareness of public space and of living together. Some scholars and other expert interviewed also mention the "networking effect" such as the possibility to make contact with other individuals as the basis for the fulfilment that goes beyond the exchange of goods and services but it becomes an occasion for social interaction and build social capital[36]. This can bring inspiration, vicinity and sense of appreciation (ibid.).

[36] Interviews UvA1 (2016), VU1 (2016), P1 (2016), P2 (2016), P3 (2016), P4 (2016), P5 (2016), P6 (2016)

Finally, another aspect that is rather missed are equity benefits for under age groups such as the possibility for children to access mobility independently.

Further research, should therefore investigate how such effects can be better represented in these types of analyses. A hypothetical example to measure social interaction would be estimating the number of cyclists' crossing each other's' path on the same route per minute or hour and try to give value by means of stated preference methods. Researchers may ask for example to give value to a path that is more or less frequented by cyclists and determine the difference between the values of different cycle paths. This may also contribute to the understanding of route choice.

Another relevant academic issue has been identified while conducting the valuation of health effects and while dealing with the concept of internal and external effects in welfare economics. Although this has not been verified directly, it can be hypothesised that in bicycle-friendly countries[37], where cycling is part of the culture, health benefits are less likely to be internalised by users as they might not represent the main motivation to cycle[38]. On the opposite, in car centric-country, health benefits are usually the main reason motivating bicycle use and there, theoretically, should not be counted as a welfare gain. This clearly a paradox since one cyclist more and a car less in a car-oriented city should actually value the same (or even more).

Finally, the current ability to make economic assessment are very much limited to the current methodologies which are not yet fully developed for cycling. Moreover, to calculate the value of each effect is a time consuming activity that may not be feasible for small projects and therefore the use of proxies from literature becomes almost necessary.

5.2.4. Political implications

The underlying assumption of rational-analytical tools of (and for) decision-making is also that the outcome of the decision-making will also be a rational selection of efficient alternatives (Moran et al., 2008). This "scientifically guided" policy-making system as a systematic problem solving process consisting of sequential and predetermined stages has been criticized by institutionalists. Decision-making is, in fact, depicted as an ambiguous process where the outcome is often unpredictable (Simon, 1957; Kingdon, 1995; Zahariadis, 2007). Thus, providing more knowledge by means of a holistic SCBA may reduce uncertainty and improve learning but it may not decrease the ambiguity of decision-making.

When it comes to bicycle planning, this is even more striking. Although it is generally recognised that the promotion of cycling is a key tool for liveable cities, it continues to be largely marginalised and poorly funded in many cities around the world. The reasons for this are not always "rational" per se. In fact, more complex factors play a role in explaining different investment decisions on cycling programs. For example, Koglin & Rye (2014) and Koglin (2015) point out that different organisational schemes produce power relations that may exert different decision-making outcomes that are marginalising towards cycling.

In addition, SCBA is likely to be used "strategically" rather than "rationally" to support decisions that have already been taken or to contrast decision taken by others. For example, during the period of this research it a project presenting alternatives was not available. In addition, the risk of SCBA is that most of the political debate, instead of being steered onto objective bases, it will be catalyzed towards the assumptions used and loose scope of the

[37] Such as The Netherlands.

[38] And therefore are not internalised.

actual problem. A holistic approach to SCBA may even suffer of a greater risk as even stronger assumptions might be included to calculate effects that do not have monetary values. In addition, many also question SCBA for its ethical considerations such as distributional issues (welfare inequality) and applying a monetary value to human and natural life. In addition, regardless of the completeness of the framework and the level of precision, decision-makers do not actually assign more value to SCBA if the value of an effect (e.g. Value of Time) was calculated in a more sophisticated way, unless this may completely change the results[39]. Thus, it seems that SCBA works as long as the result matches the expectations of the commissioners.

On the other hand, SCBA especially if holistic, if integrated at the early steps of the decision-making could instead provide a useful tool for learning. Further research could therefore investigate at what level and stage of the decision-making SCBA could have a better impact in the selection of alternatives.

[39] Interview TU1 (2016), TU2 (2016)

6. Conclusion

The transition to a sustainable society requires holistic approaches in the way policies are appraised in order to capture complexity and to avoid sub-optimal and unintended externalities. Decisions on transport, in particular, have a large implication for the society, the economy, the environment, and play a fundamental role in individual development. With this in mind, this thesis addressed the question:

"how can the effects of cycling policies be appraised in ex-ante assessment from a holistic perspective?".

The broad scope of SCBA appears to be the ideal tool to evaluate cycling policies as all the external effects have to be taken into account when assessing projects. Moreover, the expression of the effects into monetary costs and the benefits represents an attempt to produce a "value-free" analysis in which everyone can recognize the order of magnitude. However, to be able to appraise the effects of cycling policies, evaluators have to grasp how these effects are produced and what their magnitude is by understanding what determines bicycle use and what are the effects of cycling policies. Very few papers have addressed this question in a systematic way. This research conceptualises bicycle use as influenced by exogenous, endogenous factors. Cycling policies can only directly influence the generalised costs of different modes and indirectly the quantity of travel. Changes in the quantity of cycling generate effects that may impact multiple societal domains. Following system theory, this thesis advanced the idea that evaluators should take into account multiple systems and multiple levels of analysis ranging from short-term to long-term effects at the local to global level. By applying this framework to a case study this research aimed both to identify potential costs and benefits of a project and also to identify potential strengths and weakness of this approach. This study valued directly the value of time, the value of reliability of future travel and the health benefits my making use of existing methodologies and by using the result as input for the SCBA. Other effects required the use of proxies from literature to calculate the costs and the benefits of an illustrative case study. The results show (in line with previous studies) that cycling has indeed high social benefits. However, the current ability to make economic assessment are very much limited to the current methodologies which are not yet fully developed for cycling. Moreover, holistic approaches entail a high level of complexity in the definition of the scope and the identification of effects. In addition, evaluators need to make multiple assumptions as causality cannot be directly established. This is also part of the limitation of ex-ante appraisals and therefore the use of scenarios and conservative values appear to be ideal approach to incorporate uncertainty. The implications for environmental governance are that SCBA can be a useful tool for learning, especially if integrated early in the decision-making process. In spite of this, the risk is that the tool may be used politically to steer the attention to the assumptions and lose the focus on the actual sustainability issues.

7. References

Andrews, C., J. (2007). Rationality in Policy Decision-Making. In Fischer, F., Miller, G. J., & Sidney, M. S. (2007). *Handbook of public policy analysis: theory, politics, and methods*. *Methods*, *125*, 642 S. http://doi.org/10.4135/9781848608054

Banister, D. (2005). *Unsustainable transport: city transport in the new century*. Transport development and sustainability. http://doi.org/10.1016/j.jtrangeo.2006.09.002

Bell, S., & Morse, S. (2003) *Measuring Sustainability: Learning from Doing.* Routledge London.

Bertolini, L., & le Clercq, F. (2003). Urban development without more mobility by car? Lessons from Amsterdam, a multimodal urban region. *Environment and Planning A*, *35*(4), 575–589. http://doi.org/10.1068/a3592

Barnes G., R., & Thompson K., B. (2006). Longitudinal Analysis of Effect of Bicycle Facilities on Commute Mode Share. *Transportation Research Board Business Office.* Transportation Research Board 85th Annual Meeting (Conference). Washington, USA.

Beukers, E., Bertolini, L., & Te Brömmelstroet, M. (2012). Why Cost Benefit Analysis is perceived as a problematic tool for assessment of transport plans: A process perspective. *Transportation Research Part A: Policy and Practice*, *46*(1), 68–78. http://doi.org/10.1016/j.tra.2011.09.004

Boardman, A., E., Greenberg, D., H., Vining, A. & Weimer, D., L. (2011). *Cost-Benefit Analysis: Concepts and Practice*. 2nd Edition. Prentice Hall. New Jersey, USA.

Börjesson, M., & Eliasson, J. (2012). The value of time and external benefits in bicycle appraisal. *Transportation Research Part A: Policy and Practice*, *46*(4), 673–683. http://doi.org/10.1016/j.tra.2012.01.006

Bossel, H. (1999). Indicators for Sustainable Development: Theory, Method, Applications, A Report to the Balaton Group. *Public Health* (Vol. 68). Retrieved from http://www.ulb.ac.be/ceese/STAFF/Tom/bossel.pdf

Bovens, M., Hart, P., Kuipers, S. (2008). The Politics of Policy Evaluation in Moran, M., Rein, M., & Goodin, R. E. (2008). *The Oxford Handbook of Public Policy. Public Policy* (Vol. 1). http://doi.org/10.1093/oxfordhb/9780199548453.001.0001

Boterman, W. R., & Musterd, S. (2015). Cocooning urban life: Exposure to diversity in neighbourhoods, workplaces and transport. *Cities*. http://doi.org/10.1016/j.cities.2015.10.018

Brown, L. (2009). *PLAN B 4.0, Mobilizing to Save Civilization*. *Mobilizing to Save Civilization*. Available at: http://www.worldresourcesforum.org/files/PlanBZusammenfassung.doc. [Accessed 1 Feburari 2016].

Cavill, N., Kahlmeier, S., Rutter, H., Racioppi, F., & Oja, P. (2008). Economic analyses of transport infrastructure and policies including health effects related to cycling and walking: A systematic review. *Transport Policy*, *15*(5), 291–304. http://doi.org/10.1016/j.tranpol.2008.11.001

Cervero, R. (2005). Progress in Coping with Complex Urban Transport Problems in the United States. In Jönson, G., & Tengström, E. (Eds.), *Urban Transport Development: A Complex Issue.* Springer Berlin Heidelberg.

Dror, Y. (2008). Training for Policy Makers in Moran, M., Rein, M., & Goodin, R. E. (2008). *The Oxford Handbook of Public Policy. Public Policy* (Vol. 1). http://doi.org/10.1093/oxfordhb/9780199548453.001.0001

Rauner, A., Mess, F., & Woll, A. (2013). The relationship between physical activity, physical fitness and overweight in adolescents: a systematic review of studies published in or after 2000. *BMC Pediatrics*, *13*, 19. http://doi.org/10.1186/1471-2431-13-19

Rietveld, P., & Daniel, V. (2004). Determinants of bicycle use: Do municipal policies matter? *Transportation Research Part A: Policy and Practice*, 38(7), 531–550. http://doi.org/10.1016/j.tra.2004.05.003

De Vries, B. (2012). *Sustainability Science.* Cambridge Press.

De Vries, B. (2015). Sustainable Development: Integrating Perspective. Lecture. September 2015. Utrecht University. The Netherlands

Dill, J., & Voros, K. (2008). Factors Affecting Bicycling Demand: Initial Survey Findings from the Portland, Oregon, Region. *Transportation Research Record*, 2031(1), 9–17. http://doi.org/10.3141/2031-02

Elvik, R. (2000). Which are the relevant costs and benefits of road safety measures designed for pedestrians and cyclists? *Accident Analysis and Prevention*, *32*(1), 37–45. http://doi.org/10.1016/S0001-4575(99)00046-9

Feitelson, E., & Salomon, I., (2004). The Political Economy of Transport Innovations. In Beuthe, M., Himanen, V., Reggiani, A., Zamparini, L. (Eds.), (2004). *Transport Developments and innovations in an Evolving World*. Springer, Netherlands.

Ferreira, A., Beukers, E., & Brömmelstroet, M. Te. (2012). Accessibility is gold, mobility is not: A proposal for the improvement of Dutch transport-related cost-benefit analysis. *Environment and Planning B: Planning and Design*, *39*(4), 683–697. http://doi.org/10.1068/b38073

Field, C., B. (1997). *Environmental Economics. An Introduction*. (2nd Ed.). McGraw-Hill International Editions.

Fulmer, Jeffrey (2009) 'What in the world is infrastructure?'*. PEI Infrastructure Investor* (July/August): 30–32

Gärling, T., Ettema, D., & Friman, M. (2014). *Handbook of Sustainable Travel*. Springer, Netherlands. http://doi.org/10.1007/978-94-007-7034-8

Gerland, P., Raftery, a. E., Ev Ikova, H., Li, N., Gu, D., Spoorenberg, T., Wilmoth, J. (2014). World population stabilization unlikely this century. *Science*, *346*(6206), 234–237. http://doi.org/10.1126/science.1257469

Giddings, B., Hopwood, B., & O'Brien, G. (2002). Environment, economy and society: Fitting them together into sustainable development. *Sustainable Development*, *10*(4), 187–196. http://doi.org/10.1002/sd.199

Gössling, S., & Choi, A. S. (2015). Transport transitions in Copenhagen: Comparing the cost of cars and bicycles. *Ecological Economics*, *113*, 106–113. http://doi.org/10.1016/j.ecolecon.2015.03.006

Handy, S., van Wee, B., & Kroesen, M. (2014). Promoting Cycling for Transport: Research Needs and Challenges. *Transport Reviews*, 34(1), 4–24. http://doi.org/10.1080/01441647.2013.860204

Handy, S. L., & Xing, Y. (2011). Factors Correlated with Bicycle Commuting: A Study in Six Small U.S. Cities. *International Journal of Sustainable Transportation*, 5(2), 91–110. http://doi.org/10.1080/15568310903514789

Heinen, E., van Wee, B., & Maat, K. (2010). Commuting by Bicycle: An Overview of the Literature*. Transport Reviews*, 30(1), 59–96. http://doi.org/10.1080/01441640903187001

Hendriksen, I., Simons, M., Garre, F. and Hildebrandt, V. (2010). The association between commuter cycling and sickness absence. *Preventative Medicine* 51(2), 132-135

Hüging, H., Glensor, K., & Lah, O. (2014). Need for a Holistic Assessment of Urban Mobility Measures - Review of Existing Methods and Design of a Simplified Approach. In Transportation Research Procedia (Vol. 4, pp. 3–13). http://doi.org/10.1016/j.trpro.2014.11.001

Hunt, J. D., & Abraham, J. E. (2007). Influences on bicycle use. *Transportation*, *34*(4), 453–470. http://doi.org/10.1007/s11116-006-9109-1

Hutton, B. (2013*). Planning Sustainable Transport.* Earthscan from Routledge, Oxon.

Kemp, R., Loorbach, D., & Rotmans, J. (2007). Transition management as a model for managing processes of co-evolution towards sustainable development. *International*

Journal of Sustainable Development & World Ecology, *14*, 1–15. http://doi.org/10.1080/13504500709469709

Klein, J., Hulskotte, J., van Duynhoven, N., & Hensema, a. (2009). Methods for calculating the emissions of transport in the Netherlands. *The Report, Including the Tables in the Excelfile, Can Be Found on: Http://www. Cbs. Nl*, (April). Available at: http://www.cbs.nl/NR/rdonlyres/2880AA1F-F077-45D2-94B5-7663A953EEF0/0/200611methodenrapportverkeereng.pdf. [Accessed 10 August 2016].

Koglin, T., & Rye, T. (2014). The marginalisation of bicycling in Modernist urban transport planning. *Journal of Transport & Health*, *1*(4), 214–222. http://doi.org/10.1016/j.jth.2014.09.006

Koglin, T. (2015). Organisation does matter – planning for cycling in Stockholm and Copenhagen. *Transport Policy*, *39*, 55–62. http://doi.org/10.1016/j.tranpol.2015.02.003

Korzhenevych, A., Dehnen, N., Bröcker, J., Holtkamp, M., Meier, H., Gibson, G., … Cox, V. (2014). Update of the Handbook on External Costs of Transport. *Final Report*, (1), 139. http://doi.org/Ref: ED 57769 - Issue Number 1

Koster, R., P. (2016). Valuation of Cycling Time: Research Seminar at Vrij Universiteit Amsterdam. March-April 2016.

Kristensen, P. (2004). The DPSIR Framework. Available at: http://wwz.ifremer.fr/dce/content/download/69291/913220/file/DPSIR.pdf. [Accsed 3 May 2016].

Krizek, K., Poindexter, G., Barnes, G. and Mogush, P. (2007). Analysing the benefits and costs of bicycle facilities via online guidelines. *Planning Practice & Research*, 22:2, 197-213

Litman, T. (2011). Developing Indicators for Comprehensive and Sustainable Transport Planning, (2005), 10–15. Available at: http://www.vtpi.org/sus_tran_ind.pdf. [Accessed 19 February 2016].

Litman, T. (2016). Evaluating Active Transport Benefits and Costs. Victoria Transport Policy Institute, 134–140. Available at: http://www.vtpi.org/nmt-tdm.pdf. [Accessed 19 February 2016].

Liu, J., Mooney, H., Hull, V., Davis, S. J., Gaskell, J., Hertel, T., … Li, S. (2015). Systems integration for global sustainability. *Science*, 347(6225), 1258832. http://doi.org/10.1126/science.1258832

Macmillan, A., Connor, J., Witten, K., Kearns, R., Rees, D., & Woodward, A. (2014). The societal costs and benefits of commuter bicycling: Simulating the effects of specific policies using system dynamics modeling. *Environmental Health Perspectives*, *122*(4), 335–344. http://doi.org/10.1289/ehp.1307250

Meyer, J., R., & Mahlon, R., S. (1997). Transport Demand the Basic Framework. In Oum, T., H, Dogson., J., S., Hensher, D., A., Morrison, S., A., Nash, C., A., Small, Kenneth., A., Waters II, W., G. (1997). *Transport Economics*. Harwood Academic Publishers.

Meyer M., D., & Miller, E., J. (2001). *Urban Transportation Planning: a decision-oriented approach*. (2nd Ed). McGraw-Hill Higher Education.

Moran, M., Rein, M., & Goodin, R. E. (2008). *The Oxford Handbook of Public Policy. Public Policy* (Vol. 1). http://doi.org/10.1093/oxfordhb/9780199548453.001.0001

Mulley, C., Tyson, R., McCue, P., Rissel, C., & Munro, C. (2013). Valuing active travel: Including the health benefits of sustainable transport in transportation appraisal frameworks. *Research in Transportation Business and Management*, *7*, 27–34. http://doi.org/10.1016/j.rtbm.2013.01.001

Nash, A., C. (1997) Cost-Benefit Analysis of Transport Projects in Oum, T., H, Dogson., J., S., Hensher, D., A., Morrison, S., A., Nash, C., A., Small, Kenneth., A., Waters II, W., G. (1997). *Transport Economics*. Harwood Academic Publishers.

O'Neill, K., Weinthal, E., Marion Suiseeya, K. R., Bernstein, S., Cohn, A., Stone, M. W., & Cashore, B. (2013). Methods and Global Environmental Governance. *Annual Review of Environment and Resources*, 38(1), 441–471. http://doi.org/10.1146/annurev-environ-072811-114530

Omann, I., Stocker, A., & Jager, J. (2009). Climate change as a threat to biodiversity: An application of the DPSIR approach. *Ecological Economics*, *69*(1), 24–31. http://doi.org/10.1016/j.ecolecon.2009.01.003

Ortùzar, J. D. D., Iacobelli, A., & Valeze, C. (2000). Estimating demand for a cycle-waynetwork. *Transportation Research Part A: Policy and Practice*, *34*(5), 353–373. http://doi.org/10.1016/S0965-8564(99)00040-3

Oum, T., H, Dogson., J., S., Hensher, D., A., Morrison, S., A., Nash, C., A., Small, Kenneth., A., Waters II, W., G. (1997). *Transport Economics*. Harwood Academic Publishers.

Perri 6, Leat, D., Seltzer, K., Stoker, G. (2003). *Towards Holistic Governance: The New Reform Agenda*. London: Palgrave.

Pearce, D., Atkinson, G., Mourato, S. (2006). *Cost-Benefit Analysis and the Environment* (Vol. 115). http://doi.org/10.1086/426308

Pucher, J., & Buehler, R. (2008). Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany. *Transport Reviews*, 28(4), 495–528. http://doi.org/10.1080/01441640701806612

Pucher, J., & Buehler, R. (2012). *City cycling*. *The MIT Press*, (November), 1–3. http://doi.org/10.1080/01441647.2013.782592

Ravetz, J. (2000). Integrated assessment for sustainability appraisal in cities and regions. *Environmental Impact Assessment Review*, *20*, 31–64.

Rabl, A., & de Nazelle, A. (2012). Benefits of shift from car to active transport. *Transport Policy*, *19*(1), 121–131. http://doi.org/10.1016/j.tranpol.2011.09.008

Redclift, M. (2005). Sustainable development (1987-2005): An oxymoron comes of age. Sustainable Development, 13(4), 212–227. http://doi.org/10.1002/sd.281

Runhaar, H., Dieperink, C., & Driessen, P. (2006). Policy analysis for sustainable development. *International Journal of Sustainability in Higher Education*, 7(1), 34–56. http://doi.org/10.1108/14676370610639236

Rotmans, J., Kemp, R., & Van Asselt, M. (2001). Emerald Article: More evolution than revolution: transition management in public policy Jan Rotmans, René Kemp, Marjolein van Asselt. *Foresight*, *3*(1), 15–31.

Sælensminde, K. (2004). Cost-benefit analyses of walking and cycling track networks taking into account insecurity, health effects and external costs of motorized traffic. *Transportation Research Part A: Policy and Practice*, *38*(8), 593–606. http://doi.org/10.1016/j.tra.2004.04.003

Sachs, J. D. (2012). From millennium development goals to sustainable development goals. *Lancet*, *379*(9832), 2206–11. http://doi.org/10.1016/S0140-6736(12)60685-0.

Sherlock, H. (1991*), Cities are good for us: the case for close-knit communities, local shops and public transport*. London: Paladin.

Steffen, W., Persson, Å., Deutsch, L., Zalasiewicz, J., Williams, M., Richardson, K., (…) Svedin, U. (2011). The anthropocene: From global change to planetary stewardship. In *Ambio* (Vol. 40, pp. 739–761). http://doi.org/10.1007/s13280-011-0185-x

Schiefelbusch, M. (2010). Rational planning for emotional mobility? The case of public transport development. *Planning Theory*, 9(3), 200–222. http://doi.org/10.1177/1473095209358375

United Nations. (2009). What is good governance. Available at: http://www.unescap.org/sites/default/files/good-governance.pdf. [Accessed 17 February, 2016]

van Wee, B. (2011). *Transport and ethics: Ethics and the evaluation of transport policies and projects*. *Transport and Ethics: Ethics and the Evaluation of Transport Policies and Projects*. http://doi.org/10.4337/9781849809658.00001

van Wee, B. (2014). The Unsustainability of Car Use. In T. Gärling, D. Ettema, & M. Friman (Eds.), *Handbook of Sustainable Travel*. SE - 5 (pp. 69–83). Springer Netherlands. http://doi.org/10.1007/978-94-007-7034-8_5 van Wee, B. (2015). Peak car: The first signs of a shift towards ICT-based activities replacing travel? A discussion paper. Transport Policy, 42, 1–3. http://doi.org/10.1016/j.tranpol.2015.04.002

van Wee, B., & Börjesson, M. (2015). How to make CBA more suitable for evaluating cycling policies. *Transport Policy*, *44*, 117–124. http://doi.org/10.1016/j.tranpol.2015.07.005

van Wee, B., & Roeser, S. (2013). Ethical Theories and the Cost–Benefit Analysis-Based Ex Ante Evaluation of Transport Policies and Plans. *Transport Reviews*, *33*(6), 743–760. http://doi.org/10.1080/01441647.2013.854281

van Ginkel, J. (2014). The value of time and comfort in bicycle appraisal. A stated preference research into the cyclists' valuation of travel time reductions and comfort improvements in the Netherlands. University Twente.

Verschuren, P., & Doorewaard, H. (2010). *Designing a Research Project*. The Hague: Eleven International Publishing. http://doi.org/10.1017/CBO9781107415324.004

Wang, G. (2005). A Cost-Benefit Analysis of Physical Activity Using Bike/Pedestrian Trails. *Health Promotion Practice*, *6*(2), 174–179. http://doi.org/10.1177/1524839903260687

Wardman M., Tight, M., Page, M., (2007). Factors influencing the propensity to cycle to work. Available at: http://eprints.whiterose.ac.uk/2448/1/ [Accessed 19 February 2016].

Weigand, L. (2008). A Review of Literature: The Economic Benefits of Bicycling. Available at: https://www.pdx.edu/ibpi/sites/www.pdx.edu.ibpi/files/Economic%20Benefits%20of%20Bicycling.pdf. [Accessed 5 February 2016].

Weiss, R. S. (1995). Learning from Strangers: The Art and Method of Qualitative Interview Studies. *Contemporary Sociology*, *24*, 420. http://doi.org/10.2307/2076552

Wiersma, J., Bertolini, L., & Straatemeier, T. (2016). How does the spatial context shape conditions for car dependency? An analysis of the differences between and within regions in the Netherlands. *The Journal of Transport and Land Use*, 3, 1–21.

Wildavsky, A. (1987*). Speaking Truth to Power: The Art and Craft of Policy Analysis*. Transaction Publishers, 2md ed. New Brunswick, USA.

World Commission on Environment and Development (WECD), (1987*). Our Common Future.* Oxford paperbacks (Vol. Report of). http://doi.org/10.2307/2621529

Appendix A – Interviewees

University of Amsterdam

UvA1. Researcher in Urban Planning and Social Policy. Personal Interview. 05 May 2016.

Vrij Universiteit Amsterdam

VU1. Researcher in Spatial, Transport and Environmental Economics. Personal Interview. March 2016.

TU Delft

TU1. Transport Economics Researcher. Personal Interview. May 2016.
TU2. Transport and Spatial Economics Researcher. Personal Interview. March 2016.

Stadsregio Amsterdam (Internship period February 2016 – September 2016)

SRA1. Program Manager

SRA2. Advisor/Specialist in infrastructure projects and programmes.

SRA3. Policy officer in infrastructure.

SRA4. Junior Policy Advisor

SRA5. Specialist Public Transport

SRA6. Policy officer in infrastructure

SRA7. Infrastructure Specialist

SRA8. Modelling Specialists

SRA9. Traffic Engineer

SRA10. Traffic Engineer

SRA11. Policy-maker

SRA12. Senior Policy-maker

Provincie Noord-Holland

PNH1. Engineer. Personal Interview. July 2016

PNH2. Policy Officer. Personal Interview. July 2016

Practitioners and expert groups

P1. Founder, Sustainable Amsterdam. Presentation. April 2016.

P2. Founder, VeloMondial. Personal Interview. June 2016.

P3. Policy Advisor, Decisio. Personal Interview. June 2016

P4. Policy Advisor, Decisio. Personal Interview. June 2016

P5. Copenhagenize Design Company. Personal Interview. May 2016.

P6. GIZ Policy Officer. Personal Interview. May 2016.

Local & regional cyclists' unions

F1. Volunteer Fietsersbond Administration. Personal Interview. July 2016

F2. Volunteer Fietsersbond Policy. Personal Interview. July 2016.

F3. Member of Regional Fietsersbond Personal Interview. August 2016

Panel session 1 – May 2016

VU1. Researcher in Spatial, Transport and Environmental Economics. Personal Interview. March 2016.

SRA1. Program Manager

SRA4. Junior Policy Advisor

SRA6. Policy officer in infrastructure

P1. Founder, Sustainable Amsterdam.

P2. Founder, VeloMondial.

P3. Policy Advisor, Decisio.

P6. GIZ Policy Officer.

F2. Volunteer Fietsersbond Policy.

Panel session 2 – July 2016

VU1. Researcher in Spatial, Transport and Environmental Economics. Personal Interview. March 2016.

SRA1. Program Manager

SRA4. Junior Policy Advisor

SRA6. Policy officer in infrastructure

P1. Founder, Sustainable Amsterdam.

P2. Founder, VeloMondial.

P3. Policy Advisor, Decisio.

P6. GIZ Policy Officer.

Appendix B – Government literature & sources

De Meerlanden, (2008). Werkgelegenheidstelling Rapport (2008).

European Environmental Agency (EEA), (1997). Towards a Transport and Environment Reporting Mechanism (TERM) for the EU.

European Environmental Agency (EEA), (2013). A closer look at urban transport – TERM 2013: transport indicators tracking progress towards environmental targets in Europe. Available at: http://www.eea.europa.eu/publications/term-2013. [Accessed 23 February 2016].

Fietsberaad, (2009a). Breed overzicht van de veiligheidsaspecten van fietsers. Available at: http://www.fietsberaad.nl/?lang=nl&repository=Factsheet+verkeersveiligheid+fietsers. [Accessed 5 September 2016].

Gemeente Aalsmeer, (2009). Aalsmeer Traffic and Transport Plan. June 2009.

Gemeente Haarlemmermeer, (2015). Kostenraming Snelfietspad N201-N196 Van Heuven Goedhartlaan – Aalsmeerderderbrug. Ingenieursbureau. March 2015.

Gemeente Haarlemmermeer, (2015a). TRENDRAPPORT: De Staat van Haarlemmermeer n°3. Available at: https://haarlemmermeergemeente.nl/onderzoek/staat-van-haarlemmermeer-3. [Accessed 2 July 2016].

Gemeente Haarlemmermeer, (2015b). Stimuleren fietsgebruik Hoofddorp – Schiphol – Aalsmeer. 30 March 2015.

Gemeente Haarlemmermeer, (2016). Inwonersenquête 2016. Available at: https://haarlemmermeergemeente.nl/onderzoek. [Accessed 17 June 2016].

German Federal Ministry of the Environment, (2015). German National Cycling Policy. Available at: http://www.nationaler-radverkehrsplan.de/. [Accessed 28 July 2016].

Rajé F. & Saffrey, A. (2016). The value of Cycling. Available at: https://www.gov.uk/government/publications/the-value-of-cycling-rapid-evidence-review-of-the-economic-benefits-of-cycling. [Accessed 04 April 2016].

Road Accident Prevention Research Unity, (1999). Department of Western Australia. Available at: http://www.cycle-helmets.com/nz3.doc. [Accessed 19 July 2016].

Romijn G., and Renes, G. (2013). *General Guidance for Cost-Benefit Analysis*. Netherlands Environmental Assessment Agency (PBL); Netherlands Bureau for Economic Policy Analysis (CPBL). The Hague. 2013.

Sartori, D., Catalano, G., Genco, M., Pancotti, C., Sirtori, E., Del Bo, C., (2015). Guide to Cost-Benefit Analysis of Investment Projects Economic appraisal tool for Cohesion Policy 2014-2020.

Stadsregio Amsterdam, (2010). Fiets filevrij! Subsidieaanvraag. Route Hoofddorp – Aalsmeer – Schiphol. 14 September 2010.

Stadsregio Amsterdam, (2015). Investeringsagenda FIETS: investeren in een bereikbare regio (2015). Available at: https://www.stadsregioamsterdam.nl/artikel/20160129-investeringsagenda-fiets-pdf [Accessed 20 March 2016].

Stadsregio Amsterdam, (2016). Voortgangsrapportage Investeringsagenda FIETS (2016). Available at https://www.stadsregioamsterdam.nl/artikel/20160622-voortgangsrapportage-investeringsagenda-fiets [Accessed 26 June 2016].

Kennis Institut voor Mobiliteit (KiM), (2013). De maatschappelijke waarde van kortere en betrouwbaardere reistijden. Available at: https://www.kimnet.nl/publicaties/rapporten/2013/11/18/de-maatschappelijke-waarde-van-kortere-en-betrouwbaardere-reistijden. Accessed [1 September 2016]

Appendix C – Websites & Statistical databases

BikePrint, (2015). Heatmap for cycling. Available at: http://bikeprint.nl/. [Accessed 10 March 2016].

Centraal Bureau voor de Statistiek (CBS), (2012). Personenautobezit van huishuidens en Personen. Available at: https://www.cbs.nl/NR/rdonlyres/69B7DBF3-BA02-4B1F-90D0-40F362C6C4E1/0/2012k1v4p34art.pdf. [Accessed 13 July 2016]

Centraal Bureau voor de Statistiek (CBS), (2015). Mobiliteit van personen (dataset). Available at: http://statline.cbs.nl/Statweb/dome/default.aspx [Accessed 5 June 2016].

Centraal Bureau voor de Statistiek (CBS), (2015a). Vervoer personen en goederen (dataset). Available at: http://statline.cbs.nl/Statweb/dome/default.aspx [Accessed 5 June 2016].

Centraal Bureau voor de Statistiek (CBS), (2015b). Verkeersprestaties motorvoertuigen (dataset). Available at: http://statline.cbs.nl/Statweb/dome/default.aspx [Accessed 5 June 2016].

Centraal Bureau voor de Statistiek (CBS), (2015c). Vervoermiddelen (dataset). Available at: http://statline.cbs.nl/Statweb/dome/default.aspx [Accessed 5 June 2016].

Fietsberaad, (2009). Cycling in the Netherlands. Avaialble at: http://www.fietsberaad.nl/index.cfm?section=kennisbank&lang=nl&kennisbankPage=Fietsgebruik+in+Nederland+algemeen&mode=detail&repository=Cycling+in+the+Netherlands+(NL). [Accessed 3 February 2016].

Fietsberaad, (2010). Fietsgebruik per gemeente. Available at: http://www.fietsberaad.nl/?repository=cijfers+over+fietsgebruik+per+gemeente. [Accessed 9 July 2016].

Kahlmeier, S., Kelly, P., Foster, C., Götschi, T., Cavill, N., Dinsdale, H., & Racioppi. (2014). *Health Economic Assessment Tools (HEAT) for walking and for cycling economic assessment of transport infrastructure*. World Health Organisation. Available at: http://www.euro.who.int/en/health-topics/environment-and-health/Transport-and-health/publications/2011/health-economic-assessment-tools-heat-for-walking-and-for-cycling.-methodology-and-user-guide.-economic-assessment-of-transport-infrastructure-and-polic. [Accessed 18 August 2016].

Netherlands Environmental Assessment Agency (PBL), (2013). Bevolkingsprognose 2013 – 2040. Available at: http://www.pbl.nl/themasites/regionale-bevolkingsprognose/prognoses-in-beeld/bevolking. [Accessed 10 June 2016]

Onderzoek, Informatie en Statistiek (OIS), (2015). Gemeente Amsterdam. Statistiek Stadsregio

Amsterdam (dataset). Available at: http://www.ois.amsterdam.nl/feiten-en-cijfers/. [Accessed 30 March 2016].

Provincie Noord-Holland (PNH), 2016. Databank. Available at: http://noordholland.databank.nl/. [Accessed 13 July 2016].

United Nations (UN), (2016). Sustainable Development Goals. Available at: https://sustainabledevelopment.un.org/. [Accessed 20 March 2016].

Verkeerskunde, (2016). Het geheim van de Fiets Telweek: bevestiging van vermoedens (VK2/2016). Available at: http://www.verkeerskunde.nl/internetartikelen/vakartikelen/het-geheim-van-de-fiets-telweek-bevestiging-van.44160.lynkx. [Accessed 1 September 2016].

World Health Organisation (WHO), (2014). Health Economic Assessment Tool (HEAT).

Appendix D – Other documents (Interest groups, research consultancy reports, papers)

European Cyclists' Federation (2016). Factsheet: Fast Cycling Routes: towards barrier-free Commuting

European Cyclists' Federation (2016a). Cycling facts and figures. Available at: https://ecf.com/resources/cycling-facts-and-figures. [Accessed 2 May 2016].

SOAB (2010). Mobiliteitsonderzoek Schiphol (2010). 26 January 2011.

SOAB (2013). Mobiliteitsonderzoek Schiphol (2013). 26 March 2014.

Decisio (2012). Social cost-benefit analysis of investments in cycling. June 2012. Available at: http://www.fietsberaad.nl/library/repository/bestanden/Decisio_Social%20costs%20and%20benefits%20of%20bicycle_Summary.pdf. Accessed [12 February 2016].

Decisio (2013). MKBA Snelfietsroute Cuijk – Mook – Nijmegen. 17 January 2013.

TNO (2010). Fietsen is groen, gezond en voordelig. Januari 2010

Von Knobloch, K. & Ruffino, P. (2015). Design of a Cost-Benefit Analysis. Assignment in Policy Analysis at Utrecht University. MSc. Sustainable Development (track Environmental Goveranance)

Witteveen+Bos (2011). MKBA-kengetallen voor omgevingskwaliteiten: aanvulling en Actualisering.

Appendix E – Extra activities

Seminars

S1. Research Seminar: Value of Cycling Time. Vrij Universiteit Amsterdam. February 2016

Workshops

W1. CIVITAS Training: Cycling 2.0. 08 April 2016

W2. MKBA Informatie sessie1. Stadsregio Amsterdam. March 2016

W3. MKBA Informatie sessie2. Stadsregio Amsterdam. June 2016

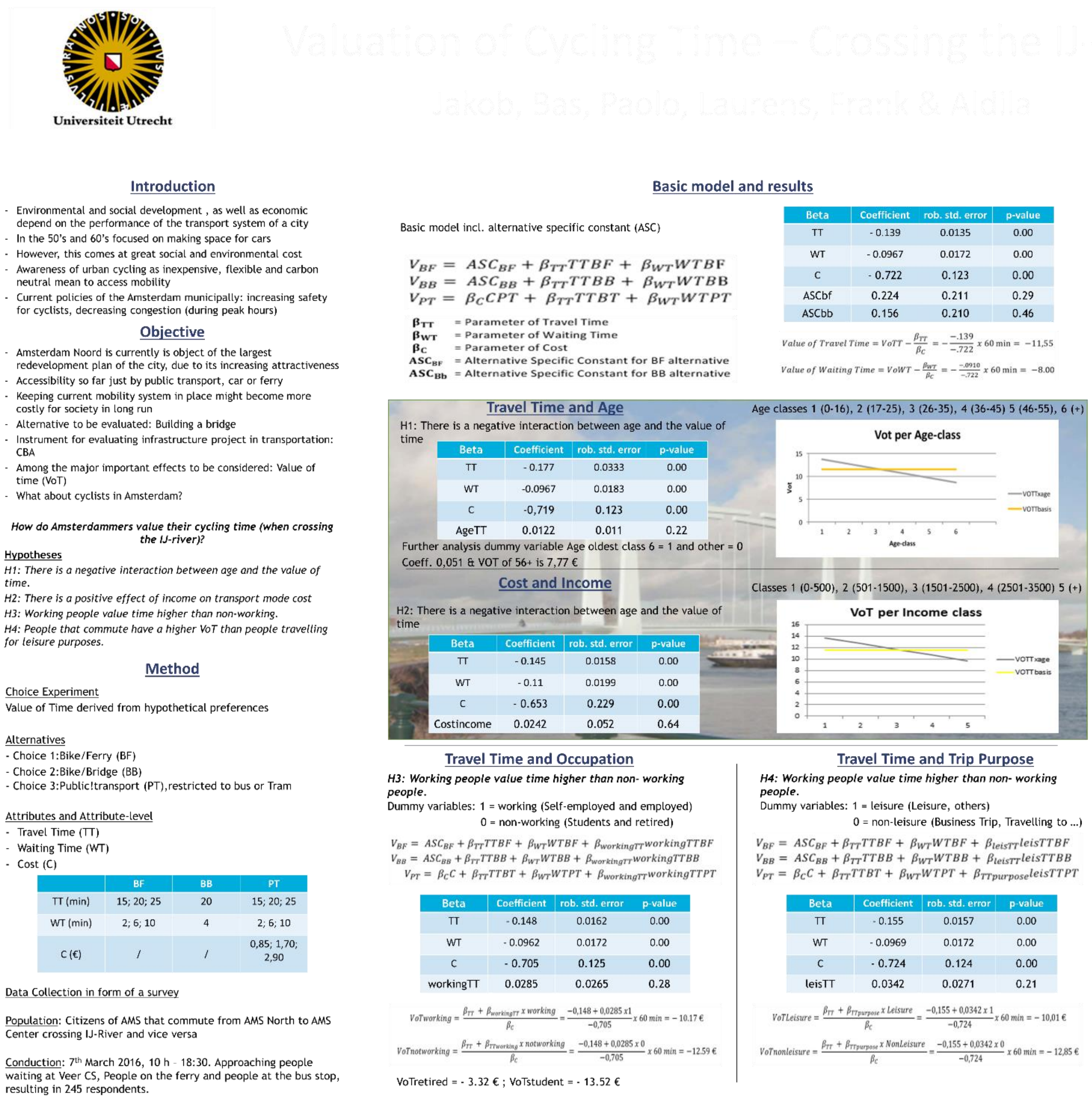
W4. Appraising cycling policies in ex-ante. Stadsregio Amsterdam & Planning for the Cycling City: Summer School. July 2016

Conferences

C1. Strategic Research and Innovation. JPI-Urban Europe. June 2016.

Appendix F – Value of Cycling Time study

Study seminar on the valuation of cycling time. For the full study report contact Paolo Ruffino (p.ruffino@uu.nl) or Paul Koster (p.r.koster@vu.nl).



Universiteit Utrecht

VU VRIJE UNIVERSITEIT AMSTERDAM

Valuation of Cycling Time – Crossing the IJ-river

Jakob, Bas, Paolo, Laurens, Frank & Aldila

Introduction

- Environmental and social development , as well as economic depend on the performance of the transport system of a city
- In the 50's and 60's focused on making space for cars
- However, this comes at great social and environmental cost
- Awareness of urban cycling as inexpensive, flexible and carbon neutral mean to access mobility
- Current policies of the Amsterdam municipally: increasing safety for cyclists, decreasing congestion (during peak hours)

Objective

- Amsterdam Noord is currently is object of the largest redevelopment plan of the city, due to its increasing attractiveness
- Accessibility so far just by public transport, car or ferry
- Keeping current mobility system in place might become more costly for society in long run
- Alternative to be evaluated: Building a bridge
- Instrument for evaluating infrastructure project in transportation: CBA
- Among the major important effects to be considered: Value of time (VoT)
- What about cyclists in Amsterdam?

How do Amsterdammers value their cycling time (when crossing the IJ-river)?

Hypotheses

H1: There is a negative interaction between age and the value of time.

H2: There is a positive effect of income on transport mode cost

H3: Working people value time higher than non-working.

H4: People that commute have a higher VoT than people travelling for leisure purposes.

Method

Choice Experiment

Value of Time derived from hypothetical preferences

Alternatives

- Choice 1:Bike/Ferry (BF)
- Choice 2:Bike/Bridge (BB)
- Choice 3:Public!transport (PT),restricted to bus or Tram

Attributes and Attribute-level

- Travel Time (TT)
- Waiting Time (WT)
- Cost (C)

	BF	BB	PT
TT (min)	15; 20; 25	20	15; 20; 25
WT (min)	2; 6; 10	4	2; 6; 10
C (€)	/	/	0,85; 1,70; 2,90

Data Collection in form of a survey

Population: Citizens of AMS that commute from AMS North to AMS Center crossing IJ-River and vice versa

Conduction: 7th March 2016, 10 h - 18:30. Approaching people waiting at Veer CS, People on the ferry and people at the bus stop, resulting in 245 respondents.

Basic model and results

Basic model incl. alternative specific constant (ASC)

$$V_{BF} = ASC_{BF} + \beta_{TT}TTBF + \beta_{WT}WTBF$$
$$V_{BB} = ASC_{BB} + \beta_{TT}TTBB + \beta_{WT}WTBB$$
$$V_{PT} = \beta_{C}CPT + \beta_{TT}TTBT + \beta_{WT}WTPT$$

β_{TT} = Parameter of Travel Time
β_{WT} = Parameter of Waiting Time
β_{C} = Parameter of Cost
ASC_{BF} = Alternative Specific Constant for BF alternative
ASC_{Bb} = Alternative Specific Constant for BB alternative

Beta	Coefficient	rob. std. error	p-value
TT	- 0.139	0.0135	0.00
WT	- 0.0967	0.0172	0.00
C	- 0.722	0.123	0.00
ASCbf	0.224	0.211	0.29
ASCbb	0.156	0.210	0.46

$$Value\ of\ Travel\ Time = VoTT - \frac{\beta_{TT}}{\beta_C} = -\frac{-.139}{-.722} \times 60\ min = -11{,}55$$

$$Value\ of\ Waiting\ Time = VoWT - \frac{\beta_{WT}}{\beta_C} = -\frac{-.0910}{-.722} \times 60\ min = -8.00$$

Travel Time and Age

H1: There is a negative interaction between age and the value of time

Beta	Coefficient	rob. std. error	p-value
TT	- 0.177	0.0333	0.00
WT	-0.0967	0.0183	0.00
C	-0,719	0.123	0.00
AgeTT	0.0122	0.011	0.22

Further analysis dummy variable Age oldest class 6 = 1 and other = 0

Coeff. 0,051 & VOT of 56+ is 7,77 €

Age classes 1 (0-16), 2 (17-25), 3 (26-35), 4 (36-45) 5 (46-55), 6 (+)

Cost and Income

H2: There is a negative interaction between age and the value of time

Beta	Coefficient	rob. std. error	p-value
TT	- 0.145	0.0158	0.00
WT	- 0.11	0.0199	0.00
C	- 0.653	0.229	0.00
Costincome	0.0242	0.052	0.64

Classes 1 (0-500), 2 (501-1500), 3 (1501-2500), 4 (2501-3500) 5 (+)

Travel Time and Occupation

H3: Working people value time higher than non- working people.

Dummy variables: 1 = working (Self-employed and employed)
0 = non-working (Students and retired)

$$V_{BF} = ASC_{BF} + \beta_{TT}TTBF + \beta_{WT}WTBF + \beta_{workingTT}workingTTBF$$
$$V_{BB} = ASC_{BB} + \beta_{TT}TTBB + \beta_{WT}WTBB + \beta_{workingTT}workingTTBB$$
$$V_{PT} = \beta_{C}C + \beta_{TT}TTBT + \beta_{WT}WTPT + \beta_{workingTT}workingTTPT$$

Beta	Coefficient	rob. std. error	p-value
TT	- 0.148	0.0162	0.00
WT	- 0.0962	0.0172	0.00
C	- 0.705	0.125	0.00
workingTT	0.0285	0.0265	0.28

$$VoTworking = \frac{\beta_{TT} + \beta_{workingTT}\ x\ working}{\beta_C} = \frac{-0{,}148 + 0{,}0285\ x1}{-0{,}705}\ x\ 60\ min = -10.17\ €$$

$$VoTnotworking = \frac{\beta_{TT} + \beta_{TTworking}\ x\ notworking}{\beta_C} = \frac{-0{,}148 + 0{,}0285\ x\ 0}{-0{,}705}\ x\ 60\ min = -12.59\ €$$

VoTretired = - 3.32 € ; VoTstudent = - 13.52 €

Travel Time and Trip Purpose

H4: Working people value time higher than non- working people.

Dummy variables: 1 = leisure (Leisure, others)
0 = non-leisure (Business Trip, Travelling to ...)

$$V_{BF} = ASC_{BF} + \beta_{TT}TTBF + \beta_{WT}WTBF + \beta_{leisTT}leisTTBF$$
$$V_{BB} = ASC_{BB} + \beta_{TT}TTBB + \beta_{WT}WTBB + \beta_{leisTT}leisTTBB$$
$$V_{PT} = \beta_{C}C + \beta_{TT}TTBT + \beta_{WT}WTPT + \beta_{TTpurpose}leisTTPT$$

Beta	Coefficient	rob. std. error	p-value
TT	- 0.155	0.0157	0.00
WT	- 0.0969	0.0172	0.00
C	- 0.724	0.124	0.00
leisTT	0.0342	0.0271	0.21

$$VoTLeisure = \frac{\beta_{TT} + \beta_{TTpurpose}\ x\ Leisure}{\beta_C} = \frac{-0{,}155 + 0{,}0342\ x\ 1}{-0{,}724}\ x\ 60\ min = -10{,}01\ €$$

$$VoTnonleisure = \frac{\beta_{TT} + \beta_{TTpurpose}\ x\ NonLeisure}{\beta_C} = \frac{-0{,}155 + 0{,}0342\ x\ 0}{-0{,}724}\ x\ 60\ min = -12{,}85\ €$$

Conclusion

How do Amsterdamers value their cycling time (when crossing the IJ-river)?

Separating the cycling time into travel time and waiting time, under consideration of alternative specific constants (ASC) the revealed values are €11.55 and €8 respectively. It is important to notice, that people prefer waiting over travelling longer.

Sociodemographic Interactions

Non of the sociodemographic aspects led to a significant influence on the VoT. This might be related to the very diverse distribution of the sample. Nevertheless, some of the results are revealing interesting patterns and have at least some explanatory power for giving an insight into the valuation of time.

Following the Hypotheses will be marked as Valid or Invalid, apart from the significance of the result.

H1: There is a negative interaction between age and the value of time

Valid: higher ages have a lower VoT. Municipality should take into account that peak hours are dominated by young people

H2: There is a positive effect of income on transport mode cost

Invalid: (small) negative effect of Income. VoT decreases with higher income. Biased by the interaction of age & TT and Students that might feel displeasure when biking.

H3: Working people value time higher than non-working people

Invalid: VoT of working people lower than of non-working. Biased by high VoT of students.

H4: People that commute have a higher VoT than people travelling for leisure purposes.

Valid: Trip-purpose leisure yields lower VoT. Peak hours dominated by commuters with higher VoT. Important implication for municipality policies.

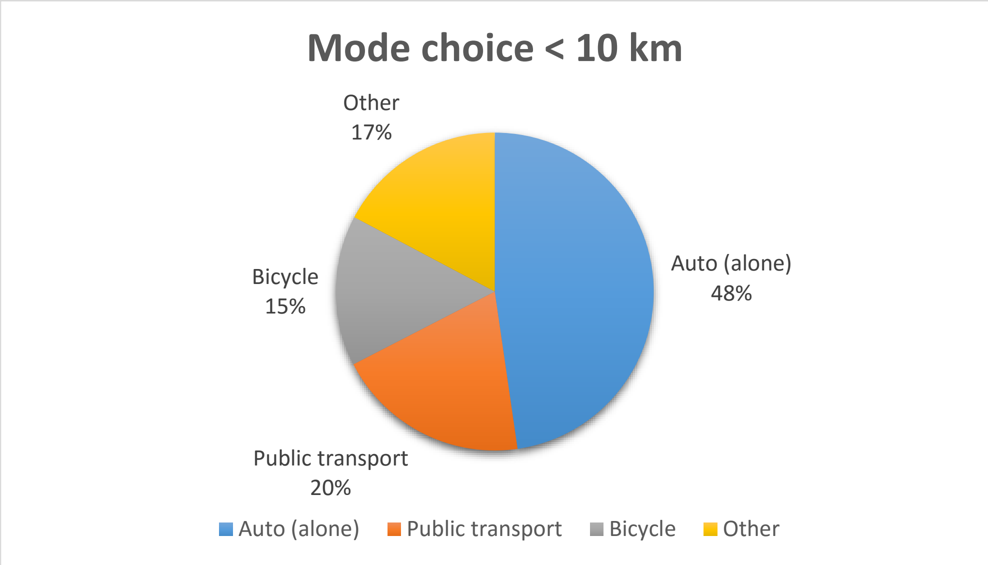
Discussion

If the existence of a bridge over the IJ-river is leading to decreased traveling times. It would mainly benefit younger people, either working or being student and especially in peak-hours when people do not travel on purpose of leisure activities. It might be advisable to do further investigation in this direction, as the number of observations is relatively small and the conclusion is based on the basic model and its results on € 11.55 is well inside the range of VoT's found by other researches in other European cities.

Appendix G – Bicycle traffic model

Figure 14 - Bicycle traffic model (2010)

Appendix H – Mode choice employees Schiphol



Schiphol employee mode choice < 10km (SOAB)

Transport mode (2013)	0 to 10 km	10 to 25 km	More than 25 km
Auto (solist)	1984 (52%)	12497 (55,4%)	22722 (63,5%)
Public transport (bus, train or mix)	821 (21,5%)	6407 (28,4%)	9086 (25,4%)
Bicycle (+e-bike)	636 (14,8%)	1072 (4,6%)	65 (0,2%)
Other (scooter, car pool, passenger)	447 (11,7%)	2618 (11,6%)	3900 (9,1&)
Total population	3819	22560	35772

Table – mode choice (SOAB, 2013)

Appendix I – Traffic Analysis

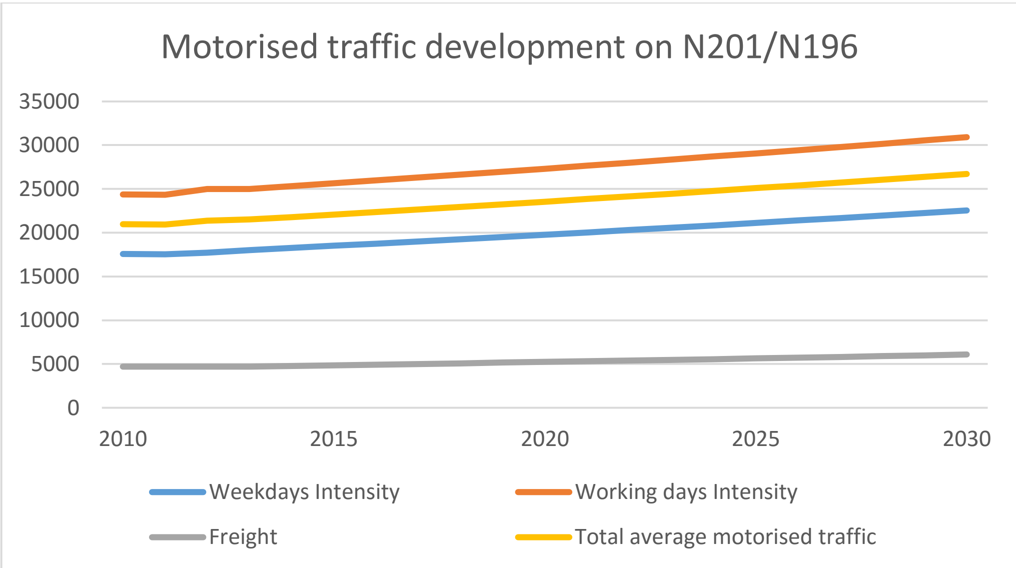
Traffic analysis

At the present time the Kruisweg has weekly average traffic intensity of about 18021 cars per day driving in the 2 directions and over 24997 during working days (Inteview SRA8, 2016). 81% of the traffic is composed by auto, scooters, buses. While a fairly big share of traffic is freight (about 19%, about 4724 per day).

Year	Traffic intensity weekday (average year in 2 directions)	Traffic intensity working day (average year in 2 directions)	Number of freight per day
2013	18021	24997	4724

Table 21 - Verkeersintensiteiten – N201 / N196 Kruisweg – Koolhovenlaan.

Assuming that the economy of the area will continue to expand in the coming decade, the traffic in the area is also likely to continue to grow. A scenario has been developed based on historic data of the N196 Fokkerweg-Aalsmeerderdijk (reference 2010-2013) and other provincial roads [40](CBS, 2015c) as no historic data is available for the Kruisweg. Based on the available data, a growth rate of traffic of 1,5% (conservative estimate) a year has been estimated[41]. Following this trend, it can be expected that by 2030 the average total motorized traffic will reach almost 32000 vehicles per day. This estimate has also been confirmed by the traffic model used by Venom (Traffic Model).



Graph – Trend car traffic on the Kruisweg

[40] Traffic intensity growth +10% between 2000 and 2010

[41] Trend estimated by using Venom Traffic Model (Stadsregio Amsterdam, 2016); Stella Modelling and other data from PNH, 2016. Logistic growth model based on the average growth rate of the past years and carrying capacity of the road.

Year	CO2/t	CH4/kg	NO2/kg	PM10/kg
2010	23856,495	3087,5	325,0	26
2030	30299,217	3921,3	412,8	31

Table – Quantity of particles emitted by traffic in the air by traffic on the Kruisweg each year

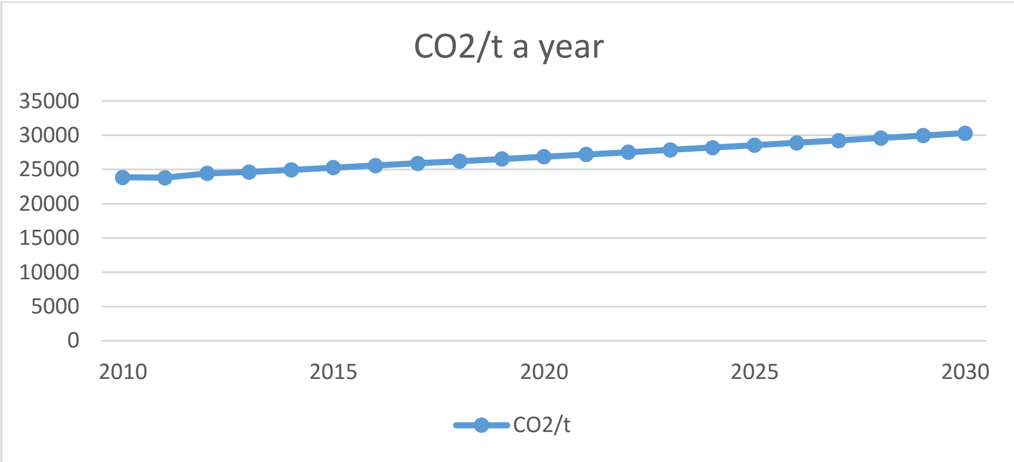


Table – Increasing CO2 emissions due to traffic (estimated[42])

In particular substances such as, CO2, CH4 and N2O are directly responsible for climate change and they impact human health. While, NOx, PO4 and NH3 cause Eutrophication, damaging the local ecosystem quality (de Bruyn et al., 2010).

[42] Based on average emissions per vehicle class (CBS, 2016), assuming 1,5 trips per day for 274 days. Technological advancement in engine quality is not accounted but the values are kept conservative.

Appendix J – Cycling Time

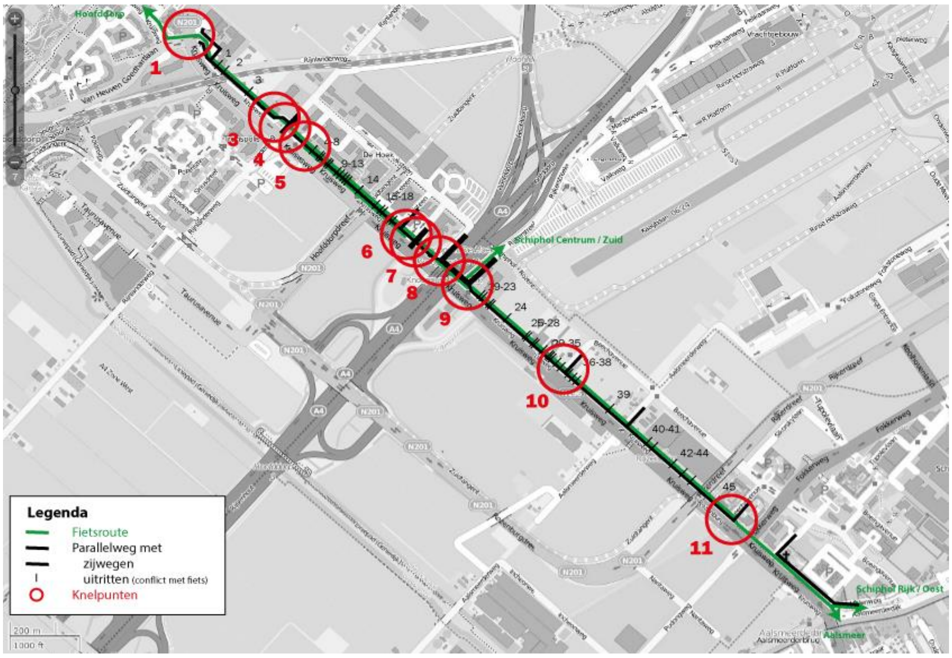


Table 22 - Main conflicts on the cycle path

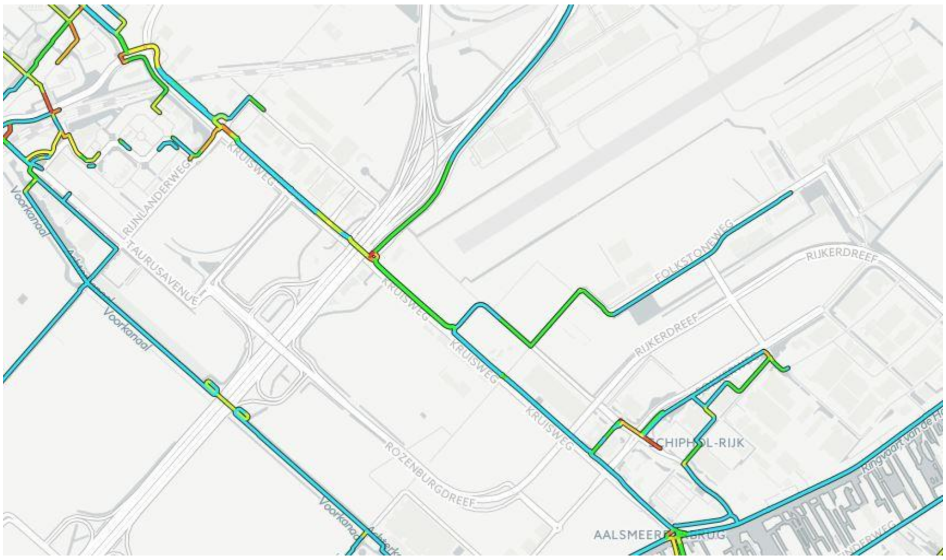


Table 23 - average travel speed heat map (BikePrint, 2015)

Stretch (Figure)	Speed	Based on (source)
Stretch 1 – 3	12 km/h	67 cyclists (bikeprint, 2015)
Stretch 3 – 5	10 km/h	53 cyclists (bikeprint, 2015)
Stretch 5 – 6	18 km/h	22 cyclists (bikeprint, 2015)
Stretch 6 – 8	16 km/h	56 cyclists (bikeprint, 2015)
Stretch 8 – 9	10 km/h	66 cyclists (bikeprint, 2015)
Stretch 9 – 10	16 km/h	52 cyclists (bikeprint, 2015)
Stretch 10 – 11	17 km/h	38 cyclists (bikeprint, 2015)

Total path	**14 km/h (average)**	**50 cyclists (bikeprint, 2015)**

Table 24 - Conservative averages (reduced by 2km) excluding speeds > 25/km (scooters) – capped.

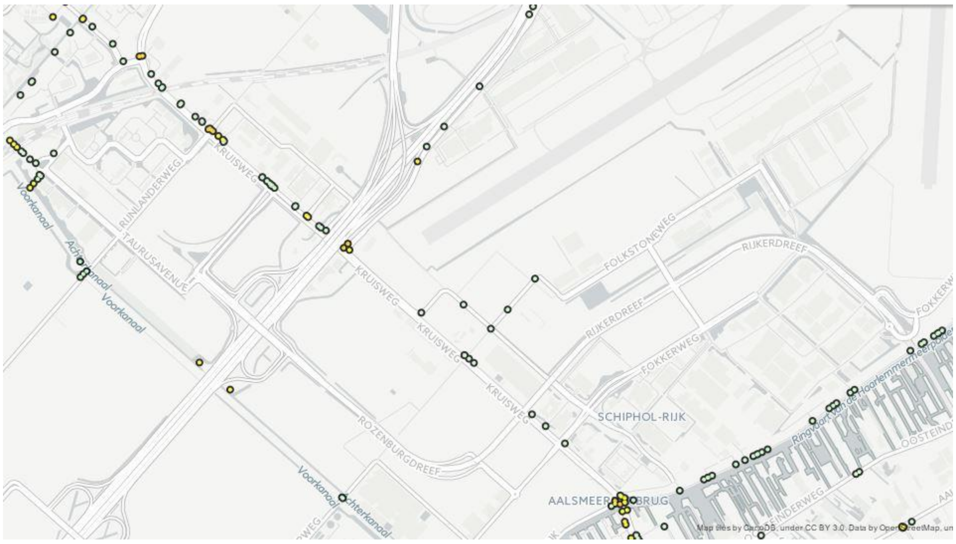


Figure: areas where delay is experienced

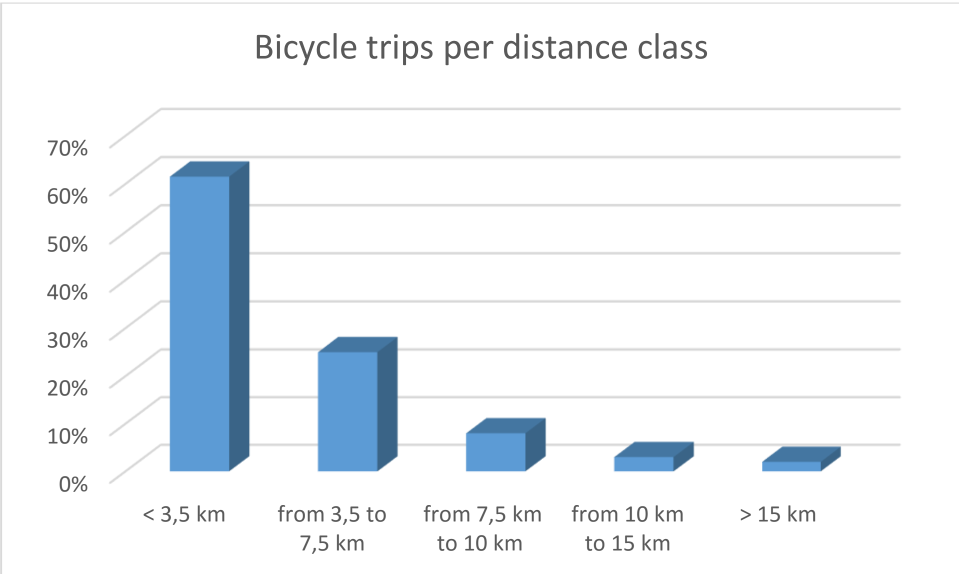
N° intersections	Total waiting time in min (sec)	Based on (source)
11	3 min (conservative)	50 cyclists (bikeprint, 2015)

Table 25 - Average waiting time to cross all the intersections

Appendix K – Data on bicycle use

Data	Value	Source
Time spent cycling per day	17 min (this also corresponds to time to Hoofddorp and Aalsmeer to Schiphol assuming no intersections and delays google)	CBS (2015)
Number of trips (day)	1,5 (return trips) – assumptions based on workers	CBS (2015)
Cycling trip	10 min	CBS (2015)
Average speed	16 km/h	CBS (2015)
Km cycled year	917 km/y	CBS (2015)
Days a year utilitarian	274	CBS (2015)
Purpose	1 /10 made for leisure	CBS (2015)
Days of year sport	50	CBS (2015)
Distance	60% of the trips usually take place within 3,5 km. About, 30% of the cyclists cover between 3,5 and 7,5 km per trip. While about 10% cycles between 7,5 and 15 km	CBS (2015)
Modal share Hoofddorp	15	Fietsberaad (2009)
Modal share Aalsmeer	20	Fietsberaad (2009)

Table 26 - bicycle use at the local level



[43]

Table 27 - bicycle trips per distance class in low-medium urbanised areas in the Province of Noord-Holland (CBS, 2015).

[43] Average values of low and medium urbanized areas, together with the average of the Province of Noord-Holland.

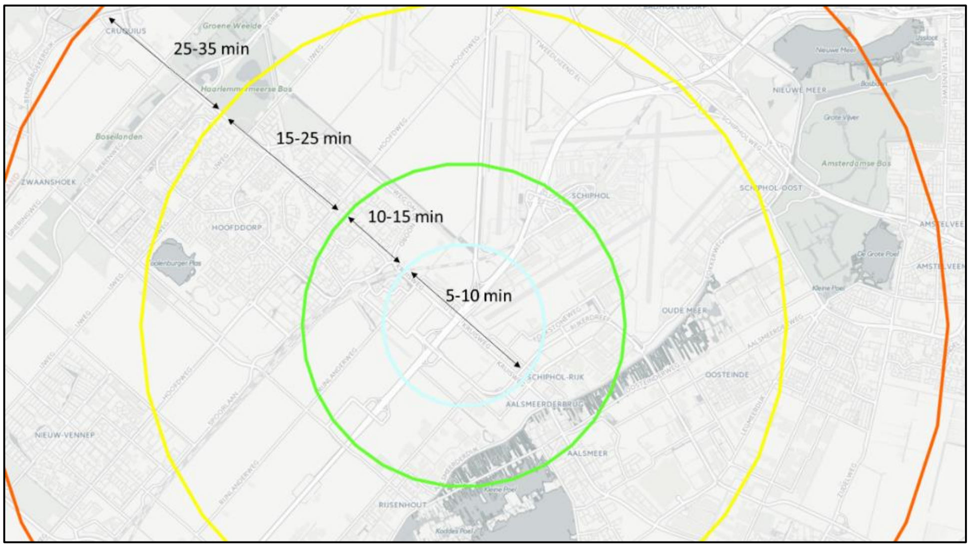


Table 28 - Isochrones showing the time needed to reach a certain area (theoretically), assuming an average speed of 16 km/h (add km).

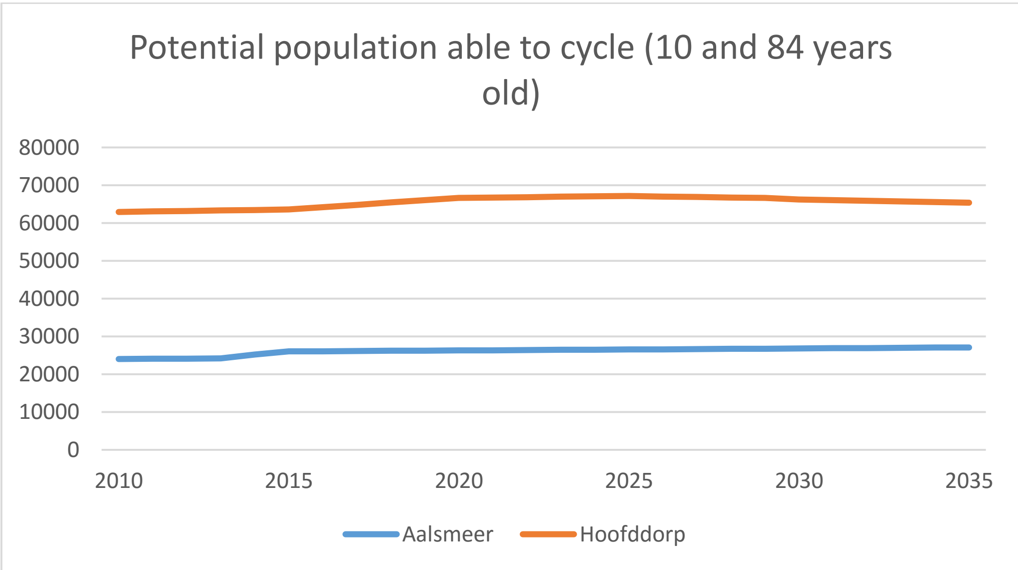


Table 29 - Trend of the population "able to cycle" (Gemeente Haarlemmermeer, 2015b; OIS, 2015).

Appendix L – Qualitative problem analysis