Valuing urban ecosystem services

A contingent valuation study on street trees in Oslo

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Master thesis in
Economics
at the Department of Economics

UNIVERSITY OF OSLO

October, 2015

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This master thesis is about part of the EU research project OpenNESS, on operationalization of natural capital and ecosystem services. The case study on Oslo was conducted by the Norwegian Institute for Nature Research, Vista Analyse AS and Oslo municipality. The stated preference study on street trees, one of several studies done in the Oslo case, was carried out by David Barton with help from Oscar Haavardsholm and is the focus of this master thesis.

2015

Valuing urban ecosystem services - A stated preference study on street trees in Oslo.

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Trykk: Reprosentralen, Universitetet i Oslo

Abstract

Ecosystem services is a broad term for the welfare humans derive from nature. For a number of reasons – such as missing markets, externalities, undefined property rights, and lack of information - the ecosystem services and the natural structures that underlie them are not adequately accounted for in the economy. This is a problem because it can lead to a poor use of resources.

This study is concerned with valuing street trees in Oslo. They provide a range of benefits to people living in the city, but their value is not fully accounted for in the economy. Population growth and densification of the city puts pressure on their existence in the city and on the municipality's budgets. It is important to document their value in order to ensure an urbanization that reflects people's preferences for street trees and the services they provide.

Valuing urban ecosystem services is challenging because there are so many different preferences and ecosystem services in a small geographical area. It is a high context density environment. Many of the services are both complementary and substitute goods to other services. Figuring out how to value different urban ecosystem services is not a straightforward process.

I have applied the contingent valuation method to estimate the value of Oslo's street trees. The data comes from an online web-survey on a representative sample carried out as part of the Oslo OpenNESS research project. The survey was designed to elicit the willingness to pay for a rise in the municipality's budget for street trees in order to maintain or increase today's level of street trees in respondents' street. I estimated that the mean WTP for each household for maintenance or increase in street tree density to be 333 NOK per year, over the course of the next 15 years. Aggregating over the share of household population of Oslo this becomes almost 60 million NOK per year. I only extrapolated to the same share of households as the share of respondents that reported a WTP, I have not assumed anything about the share that did not report WTP.

The policy relevance of this study is documenting the economic value generated by street trees in Oslo and defending their place in the city and on the municipality's budgets.

Preface

This master thesis is about a stated preference study on street trees in Oslo. It is part of the research project OpenNESS. I assisted David Barton in designing and conducting the survey, while I was allowed to write my thesis about the study. This thesis including the statistical analysis of the results from the survey is my own work.

I am very grateful to have been able to be a part of this exciting and important research project. I would like to thank David Barton, head of Oslo OpenNESS and my co-advisor, for taking me under his wing and including me in this interesting research field.

I would like to thank my advisor Kjell Arne Brekke, for great guidance and help in writing my thesis.

I would also like to thank my colleges at Vista Analyse, Henrik Lindhjem and Kristin Magnussen, two of the leading researchers in this field, for stimulation discussions on the topic.

Finally, a big thanks to my girlfriend, friends and family for fruitful conversations, proof readings and listening to me talk about ecosystem services these previous months.

Any errors or shortcomings are solely my own responsibility.

Oslo, October 2015

Oscar Haavardsholm

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Table of Abbreviations

ES	Ecosystem Services
NC	Natural Capital
ST	Street Trees
CBA	Cost Benefit Analysis
TEV	Total Economic Value
UV	Use Value
NUV	Non-Use Value
RP	Revealed Preferences
HP	Hedonic pricing
TC	Travel Cost
SP	Stated Preferences
CV	Contingent Valuation
CE	Choice Experiment
BT	Benefits Transfer
PC	Payment Card
WTP	Willingness to Pay
WTA	Willingness to Accept
CS	Consumer Surplus
CV*	Compensating Variation
EV	Equivalent Valuation
BF	Bid Function
UD	Utility Difference
MSB	Marginal Social Benefit
MPB	Marginal Private Benefit
MSC	Marginal Social Cost
NPV	Net Present Value
MA	UN(EP) Millennium Ecosystem Assessment
TEEB	The Economics of Ecosystems and Biodiversity
BGF	Blue Green Factor
OLS	Ordinary Least Squares
MLE	Maximum Likelihood Estimator

1 Summary

Ecosystem services is a broad term for the welfare humans derive from nature. For a number of reasons – such as missing markets, externalities, undefined property rights, lack of information, the ecosystem services and the natural structures that underlie them are not adequately accounted for in the economy. This is a problem because it can lead to a poor use of resources. Environmental degradation and destruction of natural structures that are of higher value to us than the benefits we get in return are examples of this. However, there are ways of valuing these services. By making the values clear to the decision-makers, we are in a better position to make good choices about tradeoffs between the environment and other concerns. With the speed and extent of humans effect on nature increasing – studying and valuing ecosystem services is increasingly important.

Today more than half the people in the world live in cities. At the same time as urban nature is becoming more valuable - because of more people benefitting from them and increased need for their services as the cities grow and condense – the pressures on the green structures grow. Competing alternative uses, worsening conditions and rising costs of provision means green structures have to be protected and conserved. Valuing urban ecosystem services is a good way of making these values explicit to the decision makers, and put them in a better position to make good choices about city planning. (Gómez-Baggethun & Barton, 2013)

City trees are one of the most important natural structures in cities. They provide a range of ecosystem services and are maybe the most visible of natural structures to people who live in cities. Oslo has many city trees, but with high population growth and densification of the city, city trees are under pressure. Both through alternative use of the land they occupy, higher cost and alternative use of the municipality's budget and more stress on the trees themselves. (Oslo Kommune, 2010)

In this master thesis I will analyze a stated preference study on street trees in Oslo. This study is part of the EU research project OpenNESS. My role in this study has been to assist David Barton in designing and conducting the contingent valuation survey. This thesis including the statistical analysis of the results from the survey is my own work. I will present the different valuation methods considered in this project to highlight the tradeoffs and considerations one has to make when valuing urban ecosystem services. The valuation method being used in the

end was contingent valuation. We decided to only focus on street trees, because it was a specific group of natural structures that was publicly owned and provided. This made the valuation scenario comprehensible and believable for the respondents.

I will present the theory underlying the study, and put it in a scientific context by presenting relevant studies in the field. I will analyze and comment on the results and discuss the economic implications of the study.

The main results of the study are:

- Street trees are important to human welfare, and most people in Oslo both value and want street trees in their neighborhood
- The majority of Oslo's inhabitants have a significant WTP for city trees
- Out of the respondents that accepted the valuation method (52,3%), the estimated mean WTP to keep the quantity of street trees in the future at its current or higher level is 333 NOK per household per year over the next 15 years.
- Aggregated over the appropriate share of the population of households in Oslo this accumulates to almost 60 million NOK per year over the next 15 years.

The policy relevance of this study is documenting the economic value generated by street trees in Oslo and defending their place in the city and on the municipality's budgets.

2 Introduction

In this section I will give some background and motivation for the study of this master thesis. Introducing ecosystem services and explaining why it is important to quantify and estimate the value they represent. The current situation in Oslo will be commented. The EU research project OpenNESS will be introduced and I will explain how it is related to the stated preference study of this master thesis. I will present the aim of the thesis including limits of the project. And finally, present the thesis structure.

2.1 Background and motivation

The natural environment is the foundation for human existence, and obviously very valuable to us. This is old knowledge, and most people feel it intuitively. However it is only recently that valuing the services we enjoy from the ecosystems has become an object of scientific study and a pressing political subject. The need for these studies has also become more pressing as the speed and scale of the effects of human behavior on nature have become more evident. Ecosystem services are basically all the goods and services provided by nature that humans benefit from. We will go into more detail about the term in chapter 3.

The neoclassical economic system has created massive externalities. There is a pervasive market failure to take nature sufficiently into account. Ecological scarcities, ecosystem degradation, biodiversity loss and climate change are the results. Valuing ecosystem services is a way of making these values explicit and puts us in a better position to make informed decisions. (R. Costanza et al., 1997)

It is important to acknowledge that the state of knowledge is incomplete. We do not know all the ways nature works and how it relates to our wellbeing and economic systems. But by trying, we are increasing our knowledge and improving our ways of valuing. And importantly, we get estimates that are very likely to be better than the often arbitrary and understated value that is given to nature implicitly through our choices in the current economic system. Economic valuation is always implicit or explicit; it cannot fail to happen at all. (Pearce, Atkinson, & Mourato, 2006).

The city of Oslo, OpenNESS and street trees

The city of Oslo is undergoing large changes. It is a rapidly growing city with a fixed city boarder. The high population growth and the" markagrensen"[1] mean higher densification, and a lot of city planning changes. This will put pressure on the existing green structures. It is important to value the green structures in order to justify their existence in the city and on the municipality's budget. Furthermore, valuation will put the city in a better position to get urbanization that reflects the inhabitants' preferences for green structures and ecosystem services.

The stated preference study in this master thesis is part of the Oslo case study of the EU research project OpenNESS. The aim of the research project is: *"... to translate the concepts of Natural Capital (NC) and Ecosystem Services (ES) into operational frameworks that provide tested, practical and tailored solutions for integrating ES into land, water and urban management and decision-making."* (OpenNESS, 2014)

Several other studies have been carried out in the Oslo case study - including literature review/meta-analysis, benefits transfer, hedonic pricing and time travel studies. (David N. Barton, 2015). My role in this study has been to assist David Barton in designing and conducting the contingent valuation survey.

Trees are the ecological foundation for many important ecosystem services. Oslo municipality currently uses a Danish valuation method VAT03, to calculate the liability or compensation value city trees. This is a technical valuation method based on costs connected to the provision of city trees as well as experts considerations of the trees benefits. (David N. Barton, 2015) We wanted to conduct a stated preference study in order to estimate a preference based valuation based on Oslo's inhabitants' willingness to pay for city trees.

Valuing urban ecosystem services is not a straightforward process. There are many considerations to be taken. The valuation method used in this study is contingent valuation. We decided to only focus on street trees, because it was a specific group of natural structures that was publicly owned and maintained. This made the valuation scenario comprehensible and believable for the respondents.

[1] Markagrensen is a boarder defined in a law from 2009, protecting the forest surrounding Oslo from built infrastructure, effectively hindering the city from expanding geographically.(LOV-2009-06-05-35,Klima- og miljødepartementet, 2009)

Figure 1 Street trees along Ring 2, Chr. Michelsens gate, photo by Mapaid AS.

The current situation in Oslo is quite good, with a substantial amount of street trees, exemplified in Figure 1. Oslo municipality values nature and environmental issues highly, with several policies and initiatives to protect and strengthen its "blue-green infrastructure".

Figure 2 Principle for planting trees along main streets of inner Oslo, suggestion from municipality plan.

Figure 2 illustrates a suggested principle for planting trees along the main streets of inner Oslo. This sort of policy is easier to execute when it can be justified by the economic values generated by street trees.

2.2 Research problem and limitations of thesis

2.2.1 Thesis objective

The objective of this master thesis is to estimate the value of the ecosystem services provided by the street trees in Oslo. This is done by conducting a contingent valuation study on a representative sample of the population of Oslo.

In addition to the main objective other interesting research questions reveal themselves. Are the inhabitants of Oslo content with the level of street trees, or do they want more or less? What is the reason for this - what are the benefits and disadvantages they experience from street trees? Are people willing to pay (WTP) for maintenance or increase in density of street trees? Is anyone willing to pay for a decrease? Does WTP depend on existing level of street trees, does it depend on desired level or the difference between these? Is there any substitution between street trees and other green structures? How do socioeconomic factors, individual preferences and attitudes explain WTP? Is it possible to study and value ecosystem services spatially explicitly in an urban context? And if so can we see how WTP and the other variables vary geographically? All of these questions where investigated – the results are presented chapters 8 - 9.

The study will be put in context by presenting the current state of knowledge, defining a knowledge gap that this thesis aims to fill, and discussing the economic implications of the study. There has been some research on the value of city trees, but none by contingent valuation in Oslo. Furthermore this study utilizes an interactive online survey format which makes the study spatially explicit and allows us to study geographical variation in the results. Different concerns in the design of the study made it necessary to diverge from the ideal theoretical set up. Specifically we did not explicitly define the exact amount of the good being valued. More about this in chapter 5. The combination of stated preference valuation made spatially explicit within an urban context is, as far as I have seen, a new approach in valuing urban ecosystem services.

2.2.2 Thesis structure

Chapter 1 is the summary of the thesis. *Chapter 2* is the introduction, which gives some background and motivation on the subject as well as a presentation of the thesis, defining its main research questions and setting limits to the scope of the thesis.

Chapter 3 Ecosystem services - introduces the subject matter, explains the history and gives the theoretical framework.

Chapter 4 Valuing ecosystem services - explains the theory on valuing ecosystem services, introducing economic value and different methods for valuing it - walking through the different methods, explaining the benefits and drawbacks of each method.

Chapter 5 Contingent valuation - goes into detail on the contingent valuation method, laying the theoretical foundation for the empirical part of the study. I will explain how to conduct a contingent valuation and relating to the study we have undertaken.

Chapter 6 Literature study - presents the most relevant literature and places this study in a broader research context. The chapter presents literature on ecosystem services and valuation methods in general and in an urban context and for trees in particular. I will identify a knowledge gap that this master thesis aims to fill.

Chapter 8 Theory and methodology (study design) - explains in detail what we have done in our study, drawing the theoretical and technical blueprint of the study.

Chapter 9 Data collection and summary statistics - presents the data collection method and presents the summary statistics.

Chapter 10 Econometric results - is where I analyze the data and gives estimates based on the scientific method. We extrapolate from the sample to the population and give a presentation of the findings.

Chapter 11 Discussion - is where we can put the results in a broader economic framework and discuss the study's implications. I will be explicit in the limitations of the study, but all the while draw the intended picture of the magnitude of ecosystem services that city trees produce in Oslo city every year, and the effects city planning before and now on these values.

Chapter 12 Conclusion – summary of entire study and conclusions.

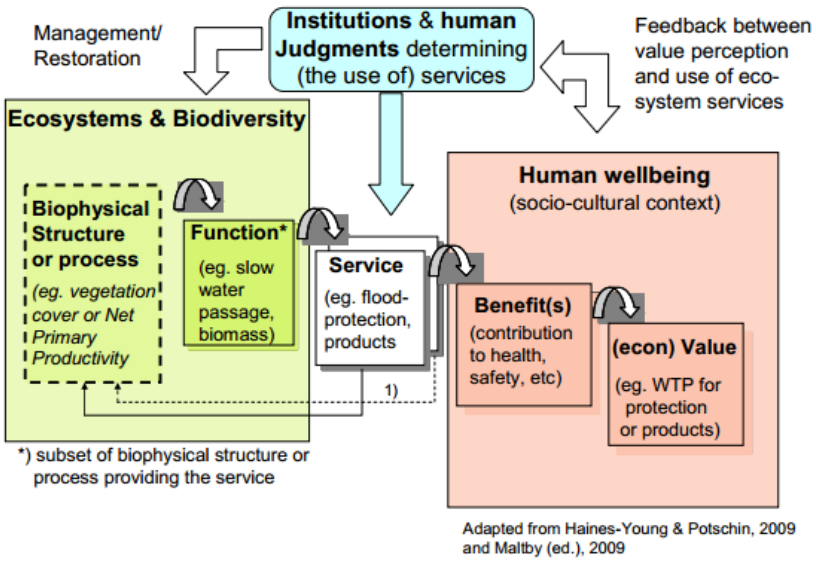
3 Ecosystem services

This chapter will introduce the theory behind ecosystem services. Providing some background and explaining why it is important to value. We will also look at the ecosystem services produced by city trees in particular.

3.1 What is ecosystem services

The term ecosystem service has many definitions. The UN Millennium Ecosystem Assessment (MA) defines it as "the benefits people obtain from ecosystems"(UNEP, 2005, p.55) Economics of Ecosystems and Biodiversity (TEEB) initiative defines it as "the ecosystems direct and indirect contribution to human welfare". (TEEB, 2010) In a paper criticizing its use, Fisher and Turner defined them as "… the aspects of ecosystems utilized (actively or passively) to produce human well-being" (Fisher & Turner, 2008, p.1168) All of the definitions relate to how nature is of value to humans. It is an anthropocentric concept.

Following these definitions I will not differentiate between goods and services, and in the following, use ecosystem services when talking about both goods and services, except otherwise stated.



1) One function is usually involved in the provision of several services and the use of services usually affects the underlying biophysical structures and processes in multiple ways. Ecosystem service assessments should take these feedback-loops into account.

Figure 3 The pathway from ecosystem structure and processes to human well-being. (TEEB, 2010)

Figure 3 illustrates TEEBs conceptual framework for ecosystem services. It shows how ecological structures and processes contribute to ecological functions that deliver services that are useful and of value to people. Trees for example are biophysical structures that produce many ecosystem services to people. One such ecosystem service is the cleaning of air. Trees' leaves can filter pollutants in the air, making the air cleaner and healthier for people to breath. This in turn is important to our wellbeing.

One biophysical structure or function can producing many services, and one service can be procured by many biophysical structures. Ecosystems are often very complex and interdependent with all the different components interacting and affecting each other. The theoretical framework is a way of conceptualizing these complex processes. (TEEB, 2010)

3.2 Categorizing ecosystem services

Categorizing ecosystem services is not a straightforward exercise. These are complex systems, and how we choose to categorize the different services may depend on the purpose. The Millennium Ecosystem Assessment has come up with a broad classification framework. According to MA we can divide ecosystem services in four categories; fundamental life processes, which is the basis for the three others; regulating-, producing- and recreational and knowledge services. As illustrated in Figure 4 with examples of each category. (UNEP, 2005)

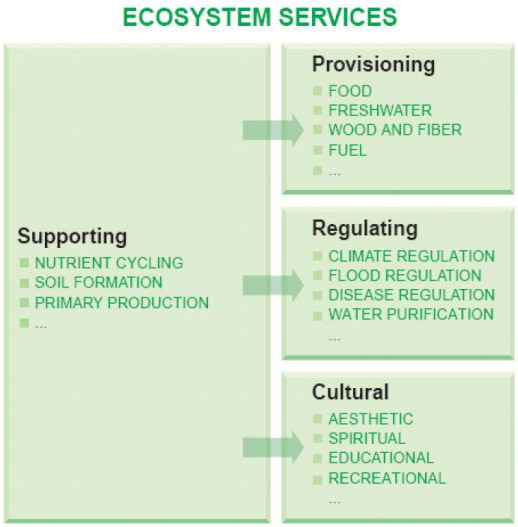


Figure 4 Different categories of ecosystem services. (UNEP, 2005)

The supporting ecosystem services are things like photosynthesis, nutrient cycling etc. This is the foundation for the other types of ecosystem services. If there was no nutrient cycling or

oxygen production, things could not grow and production of other types of ecosystem services would not be possible. Provision ecosystem services are things like food production, freshwater, wood and other types of material goods that grow in nature. Many of these, but not all, have some form of market where they can be traded. However, even here the valuation process is not complete, as there are many market failures such as lacking property rights, externalities, aspects of public goods etc.

Regulating ecosystem services can be climate regulation, like cooling in in warm climates. Or flood regulation, through water flow regulation and runoff mitigation. Cultural ecosystem services are things like beautiful views or natural structures that are of spiritual or educational importance. These values can be very large, but are often hard to quantify because their importance is decided inside humans and not by some external metric that is easy to measure, like the amount of water being purified or kilos of produce grown.

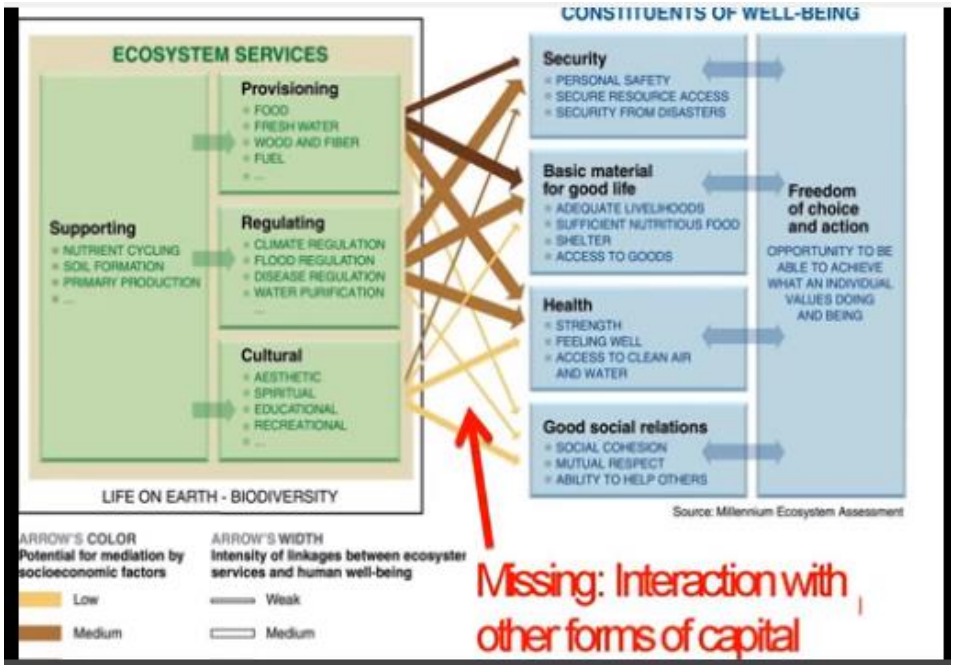


Figure 5 Different categories of ecosystem services and their interaction with constituents of human well-being. Original graph from UNEP 2005, augmented by Costanza in presentation. (Robert Costanza, 2013))

In Figure 5 we can see how the different ecosystem services affect different constituents of human well-being. The figure is originally from the MA 2005. The economist Robert Costanza has raised the criticism that the figure is missing the interaction of natural capital with other forms of capital such as built- and human capital.(Robert Costanza et al., 2014)

3.3 History of ecosystem services

The fact that nature has great value and provides us with many valuable services has been known since ancient times. But the science and sophistication on how well we study this has grown exponentially in later decades. The idea of land and other goods produced in nature as inputs in the economy has been around for a long time, but is has not been enough to integrate all the aspects of nature into the economy.

Ernst Schumacher introduced the term natural capital in his book "Small is beautiful" in 1973. "Natures services" by Gretchen Daily in (1997) and the seminal paper "The value of the world's ecosystem services and natural capital" by Robert Costanza et al. (1997) put ecosystem services on the agenda in the field of environmental economics.

The Millennium Ecosystem Assessment report in 2005 popularized the term ecosystem services. It emphasized the importance of ecosystem services and need take care of them. An initiative grew out of this, The Economics of Ecosystems and Biodiversity (TEEB). Since then research on ecosystem services has grown.

Probably the most famous study, the valuation of environmental destruction from the Exxon-Valdes oil spill in 2003 was subject to a lot of controversy and criticism. This propelled debates and further research on contingent valuation and the valuation of ecosystem services. The methods for doing valuation studies has become more advanced and have gained greater academic respect. This is a rapidly growing field.

The millennium ecosystem report is still an important report and often the starting point when discussing ecosystem services. The main findings of the report is that human actions are depleting Earth's natural capital, putting such strain on the environment that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted. At the same time, the assessment shows that with appropriate actions it is possible to reverse the degradation of many ecosystem services over the next 50 years, but the changes in policy and practice required are substantial and not currently underway. (UNEP, 2005)

3.4 Why is it important to value ecosystem services – markets and market failure

Ecosystem services are not adequately accounted for in the economy. They are often undervalued, directly or implicitly, sometimes not even accounted for at all. This leads to

poor use of resources. Environmental degradation, biodiversity loss and climate change are all examples of this. The values of most ecosystem services become exponentially high as they become scarcer and some of the changes are irreversible. This makes valuation of ecosystem services for environmental protection especially important. By making their value apparent, we are in a better position to make good decisions on how to should spend the planets resources.

The reason why ecosystem services are not adequately accounted for in the economy can be related to markets and market failure. According to economic theory perfectly competitive markets give an efficient allocation of scarce resources. This happens through the utility maximization of consumers and profit maximization of firms. The efficient allocation is defined to be Pareto optimal, i.e.no one can be made better off without anyone else being made worse off. This is the first welfare theorem. However there are a number of assumptions that need to be in place for this to be true:

A. Complete set of markets with well-defined property rights
B. Price taker behavior
C. Complete information
D. Zero transaction costs

In many cases these criteria's are not met for ecosystem services. There are missing markets and lack of clear property rights. Well-defined property rights are exclusive, transferable and secure. This implies that all resources must be either private or collective ownership, and this ownership must be enforces. Furthermore, all benefits and cost from the use of a resource must accrue to the owner exclusively. All property rights must be transferable from one owner to another in a voluntary exchange, and finally, property rights should be secure from involuntary seizure by other people or institutions. (Hanley, Shogren, & White, 1997)

Assigning property rights for some types of goods can however be difficult. We can classify goods according to weather they are rivalrous or non-rivalrous and weather use of them can be excludable or not, see Figure 6. This classification is not complete and goods can fall in a range between the categories, as is the case for many ecosystem services.

	Rivalrous (alternative use)	Non-rivalrous (joint use)
Excludable	Private goods (e.g. bread, shoes, automobiles etc.)	Toll/Club goods (e.g. theaters, night clubs, telephone service etc.)
Non-excludable	Common-pool resources/Common goods (e.g. fisheries, forests, groundwater basins, public park)	Public goods (e.g. national defense, climate regulation)

Figure 6 Types of goods, adapted from (Ostrom & Ostrom, 1999, p.78)

The problem with common goods is that the individual gain from use is larger than the individual cost, which may often be zero. This can cause overuse, and in some cases the destruction or degradation of a good. This was made evident in the influential paper Tragedy of the commons by Hardin. (Hardin, Lyons, & Edelson, 1973). Public goods are often under-provided because of incentives to free ride. Street trees can be classified as public goods. Once a tree is grown in the city, its ecosystem services are non-rivalrous (many people can enjoy them) and non-excludable (can't practically keep people from enjoying them).

The important mechanism at play in the market failures of ecosystem services are positive and negative externalities. Externalities are defined in economics as the costs or benefits that affects a party who did not choose to incur those costs or benefits. If we use street trees as an example, the trees provide many positive externalities (and some negative) to the people living in the city. They clean the air, manage water flow etc. To explain the concept of a public good let's presume that the positive externalities outweigh the negative.

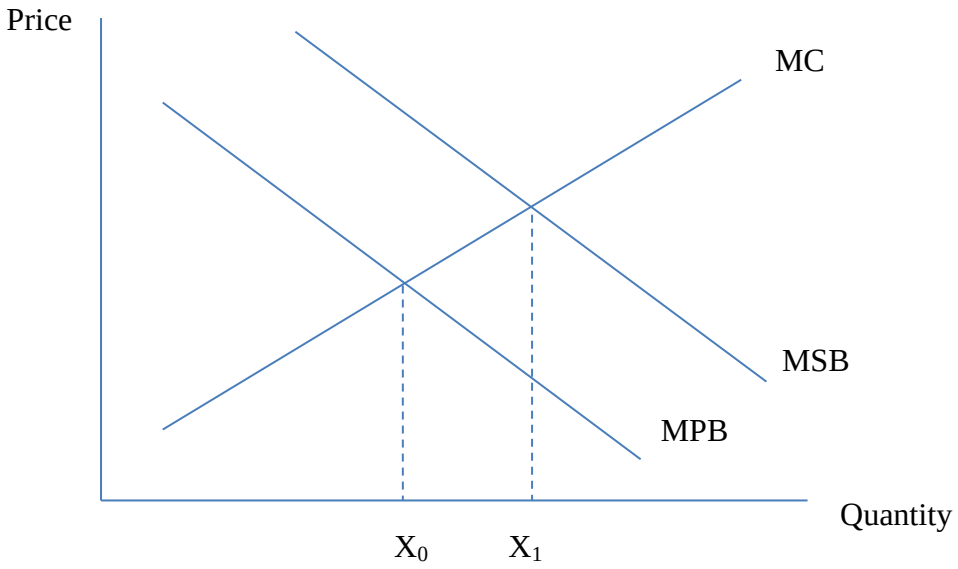


Figure 7 Market distortion in the case of a positive externality, adapted from (Kahn, 1998)

Let's say I planted trees on the edge of my property, this entailed costs and benefits to me. I would plant trees until the marginal private benefit (MPB) is equal to the marginal cost (MC), at level X_0 in Figure 7. But I did not internalize all the benefits other residents had from that tree. Then my private provision would not be efficient. The marginal social benefit (MSB) from an additional tree would outweigh the marginal cost. The socially optimal level of provision would be X_1, when marginal social benefit (MSB) is equal to marginal cost.

We can see how we would get a under provision of street trees if it where up to private people to plant and maintain them. This can justify a public provision of street trees. The marginal costs of providing street trees are known, but finding the marginal social benefit is not. How can the authorities know how much to provide? If there was a market for the services, the demand curve would reflect this. But because there is no market, because it is a public good and cannot practically exclude people from using it, we do not know the MSB. There are ways of finding it which will be discussed in the next chapter (chap. 4).

Missing markets, externalities, undefined property rights and lack of information are all reasons why ecosystem services often are not adequately accounted for in the economy. The mechanisms are overlapping and influence each other so several mechanisms may be at place at once. Valuing ecosystem services provides us with information that could lead to a better use of resources, but it is not sufficient. It only provides us with information. The government

still needs to enforce different policies to ensure better use of resources, i.e. provision of public goods, taxes or subsidies on externalities, enforce property rights etc. Valuing the ecosystem services is a step in the right direction when it comes to mending these market failures.

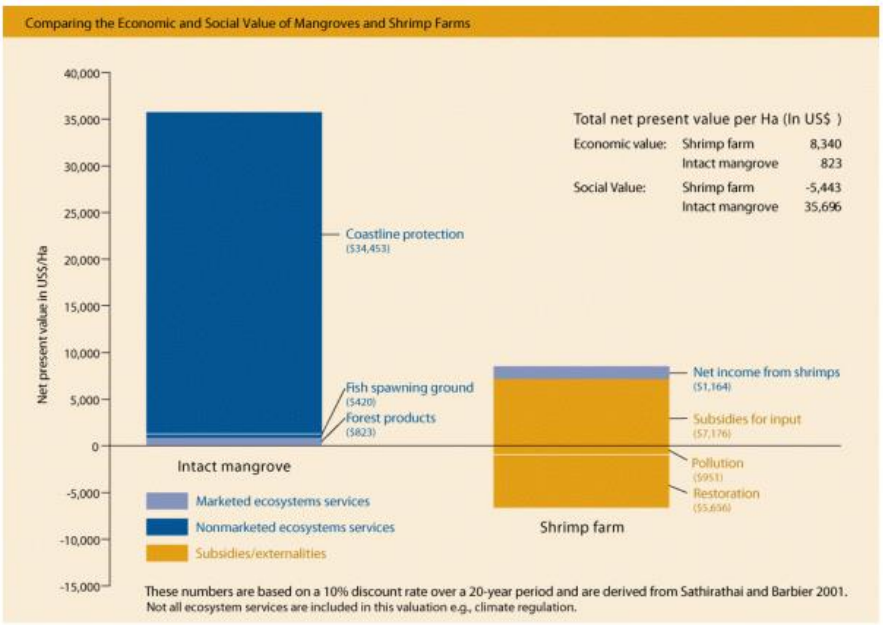


Figure 8 Comparing the economic and social value of mangroves and shrimp farms. (Ranganathan, 2008, p.5)

If there is no market for an ecosystem service, it is not explicitly accounted for in the economy. But it will still be implicitly valued through alternative uses. For example costal mangroves, types of trees that grow in water provide many important ecosystem services, such as coastline protection and nursery for many different species. However there is no market for these services. If someone decides to remove them to start a shrimp production site, the ecosystem services are implicitly being valued as less than the value of the shrimp production facilities. But it could very well be the case that the values of the mangroves are many times higher than the shrimp production facilities, such was the case in a study from Thailand by Sathirathai and Barbier (2001), presented in Figure 8. Because there is no market, there are no prices, and it is not clear to the government of Thailand, or the shrimp farmers what values they are giving up in order to sell shrimp. And importantly within the current economic system the incentives are for the people to cut the mangroves down in order to make money, when in fact the country as a whole are become poorer from doing so. (Sathirathai & Barbier, 2001)

Some people are skeptical to valuing nature in economic terms. Is it not enough to state that nature is valuable and that we should protect it? In a world with limited resources, there are necessarily tradeoffs. Valuating in economic terms helps us measure different tradeoffs up against each other, making it easier to use our resources efficiently. Prices act as a metric to compare different types of goods and services. Furthermore many decisions are made on the basis of price signals. Economic values communicate well to decision makers. In cost benefit analysis ecosystem services and natural capital with economic values can be included on the same level as other economic values.(Bateman et al., 2002) This will be discussed more in chapter 4.

It is not new that people may destroy/deplete the basis for their existence. Many civilizations have overused their resources, forcing them to move or go under as societies (Diamond, 2005). The difference today is that the scale and speed of our influence on nature is so large. We can do things that are irreversible. We may leave fewer options to our future generations and fewer resources - making life more difficult than it needs to be here on the planet.

3.5 Urban ecosystem services

Urban ecosystems services are ecosystem services generated within an urban area. With rising urbanization and more people living in cities than outside, urban ecosystem services are becoming increasingly important. At the same time as urban nature is becoming more valuable - because of more people benefitting from them and increased need for their services as the cities grow and condense – the pressures on the green structures grow. Competing alternative uses, worsening conditions and rising costs of provision means green structures have to be protected and conserved.

People in cities consume many times the area of the cities in terms of ecosystem services, depending on transporting goods and services into the city and waste out of it. The urban ecosystem services are increasingly important to the resilience of the city itself and the wellbeing of its inhabitants. (Gómez-Baggethun & Barton, 2013)

Many of local problems in cities are best met with local solutions. Here the urban ecosystem services become important. At the margin many of these services can be substituted by built infrastructure. But this may be at a high cost. The natural environment produces a lot of

services at a cost effective manner and have many positive externalities. The following quote from (Bolund & Hunhammar, 1999) expresses this point quite strongly:

"When humanity is considered a part of nature, cities themselves can be regarded as a global network of ecosystems. If compared with true, natural ecosystems, the man-made ones are however immature due to features like their rapid growth and inefficient use of resources such as energy and water (Haughton and Hunter, 1994). Odum (1971) even observes cities to be ''only parasites in the biosphere''.(Bolund & Hunhammar, 1999)

3.6 City trees' ecosystem services

Trees in urban areas provide a range of ecosystem services. Many studies have identified, demonstrated and tried to estimate these values. In the following we will present most relevant ecosystem services of city trees. It is important to notice the nature of ecosystem services, that many services can come from one biophysical structure and one ecosystem service can come from many biophysical structures. Even if trees do not do the heavy lifting of some ecosystem service, they are integral parts of the ecosystem, and contribute in helping the system function well and other ecosystem services be provided. The following presentation of services and disservices of street trees are based on the paper by (Gómez-Baggethun et al., 2013).

Table 1 Ecosystem services and disservices from city trees. (Gómez-Baggethun & Barton, 2013)

Services	Disservices
Supporting (habitat for species, maintaining biodiversity) Provision (food, wood) Regulating (climate regulation: temperature and water management/runoff mitigation, noise reduction, water and air purification, pollination, erosion control and protection from climate extremes, waste treatment, CO2 capture) Cultural (tourism, recreation, aesthetic benefits, cognitive development, place values and social cohesion, appreciation, spirituality)	View blockage Allergies Accidents Damages to infrastructure Habitat competition (birds, rodents, insects etc.)

3.6.1 Services

City trees produce **supporting** ecosystem services like being a **habitat for species.** Many species depend on trees in the city for their survival, like insects, animals, plants and mushrooms. City trees are important for **maintaining biodiversity**. Trees can be important ecosystems in themselves. Especially old trees can hos a range of different species. Furthermore they are integral parts of ecosystem they are a part of. Other species might be dependent on the presence of the trees for their survival.

Trees produce **provision** services like **food supply**. Generally speaking cities only produce a small share of the total amount of food they consume. There are however some food production in cities. This supplementary food source can be significant, and make a city more resilient in periods of crises. (McGranahan et al., 2005: 810). (Barthel et al., 2010; Barthel and Isendahl, 2013). (Altieri et al. 1999) Growing food may in fact be significant ecosystem service from trees in Oslo. Many gardens and some public trees are fruit or berry trees. To my knowledge there are no studies estimating the values of these trees, but taking into account the production volume and price at any given time gives a good estimate.

Most of the ecosystem services city trees produce are **regulating** services. **Climate regulation** such as **temperature regulation** are examples of this. **"***Urban trees moderate local temperatures by providing humidity and shade"*(Bolund & Hunhammar, 1999). The temperature regulation effect may be small in Oslo because a lot of the economic value generated from city trees comes from cooling cities in very warm seasons, by providing shade. This is not a big effect in Oslo as we do not see long periods of very high temperatures. **Water flow regulation and runoff mitigation** are some of the most important services trees provide in Oslo. They intercept of rainfall by tree canopies, slowing flooding effects. Furthermore, permeable ground around trees and their ability to soak up water reduces the chances and effects of flooding. (Bolund & Hunhammar, 1999) This will most likely become more important as clime change gives more extreme weather and heavy rainfall. Building drainage systems to tackle excess water, especially in the case of large rainfall/ melting of snow etc., is expensive. The natural infrastructure handles the problem in a very cost effective manner, as well as having many other positive effects.

There is a lot of sound in cities, and this may cause stress and harm on the inhabitants. Trees can alleviate **noise pollution** through absorption, deviation, reflection and refraction of sound

waves. (Aylor, 1972; Kragh, 1981; Ishii, 1994; Fang and Ling, 2003). In belt trees, for example, the sound waves are reflected and refracted, dispersing the sound energy through the branches and trees (Chaparro & Terradas, 2009). Air pollution in cities can reach unhealthy levels. (Sunyer et al., 2002). Trees **clean the air** by filtering out pollution particles through their leaves. (Nowak, 1994a; Escobedo et al., 2008) This can be especially important during certain seasons, like the winter season in Oslo, when there is little air circulation and the pollution sits like a lid over the city. Trees can facilitate the **spreading pollination and seed dispersion**, which is integral to the continued provision of ecosystem services. It is the way in which plants reproduce. Birds and insects can be important here, as well as the trees being important when hosting them.

City trees and other vegetation are very effective in **erosion control and protection from climate extremes.** The roots of trees keep soil together and control erosion, hindering landslides and can protect from climate extremes from storms etc. Trees contribute in **waste treatment.** Ecosystems filter out, retain and decompose nutrients and organic wastes for urban effluents through dilution, assimilation and chemical re-composition (TEEB, 2010). Trees **capture CO2** by storing excess carbon as biomass during photosynthesis. (Birdsey, 1992; Nowak, 1994b; Jo and McPherson, 1995; McPherson, 1998; McPherson and Simpson, 1998). The amount of CO2 stored is proportional to the biomass of the trees (Chaparro & Terradas, 2009).

City trees produce many **cultural** services. For certain trees, **tourism** to the trees can be thought of as an ecosystem service. Leisure, physical exercise, improved mental health through **recreation.** Studies show that trees can have **psychological** benefits through stress reduction, and improved health. (Kardan et al., 2015)

People find trees beautiful to watch, providing **aesthetic benefits.** City trees can be used for educational purposes and **cognitive development**. Trees can have **place values and** create **social cohesion** through a sense of place and emotional attachment. And people can feel a general **appreciation** of their existence. The natural structures facilitating or hosting **animals** that people value the existence and **sighting** of. People may have **spiritual** experiences or relationships to nature and trees in the city.

City trees also have **urban planning benefits**. They create direction, space, perspective, shelter, blockage, isolation, etc. Many of these are combinations of different services. Natural

structures and trees in particular play an important role in urban planning, with very specific uses and benefits. These are well known, but not accounted for economically, partly because value is so context specific.

3.6.2 Disservices

There are of course disservices associated with trees in the city. These also have to be accounted for when valuing ecosystem services. Trees can grow tall and take up a lot of space leading to **view blockage**. Views are something people value highly, and an unwanted blockage of that view by for example a tree can be thought of as a disservice. Some people are **allergic** to certain types of pollen from certain trees. **Accidents and damages to infrastructure** like trees or branches can fall and harm people or property (wires). Roots can grow and break concrete or pipes or other infrastructure. Trees can also lead to **habitat competition** from birds, rodents and insects that might be of trouble to people. Animals can spread disease, leave excrement's, rummaging in garbage etc. If we want a whole picture of the value of city trees we must weigh the services against the disservices. (Gómez-Baggethun & Barton, 2013)

4 Valuing Ecosystem Services

In this chapter I will briefly justify why I have chosen an economic valuation approach. Then explain the concept of economic value. Then look at the theory of estimating economic value and lastly present the different economic valuation methodologies.

Sound appraisal is at the heart of good policymaking, and robust valuation of impacts in monetary terms help decision makers to take proper account of them. … It will never be possible in practice to value all impacts, but we should aim to extend valuation to as many as we can. Valuation is implicit in most policy decisions, and it is preferable to make it explicit where possible to improve quality and transparency, whatever objections some may have. **(Bateman et al., 2002)**

The main reference for this chapter is the book **Economic Valuation with Stated Preference Techniques - A Manual, by Bateman et al. (Bateman et al., 2002)**

4.1 What do we mean by value

Value is defined as the relative worth, merit or importance of something. What we mean by value is not universally understood. There are many different types of values. When talking about natural capital we can measure biophysical, socio-cultural, health, justice and insurance values. Furthermore people have different sets of beliefs or moral values that lead them to place different values on things. How they measure the worth, merit or importance of something varies substantially across individuals, cultures and time. What is contained in these values and how we measure them vary substantially. But how do we compare them? Economic theory provides us with a framework to reconcile all these different types of values. This will be explained in the following. However, many people are highly skeptical towards using economic valuation on nature. I would like to address this skepticism at the outset.

4.1.1 Economists, markets, prices and valuation

When talking about valuation of ecosystem services, it might be useful to remind ourselves of a couple of distinctions. People get a lot of associations when they hear economics, values and prices - which in turn give them emotional reactions. These emotional reactions might inhibit a factual debate about the case at hand. Economics is not the same as markets. In

economics we care about things traded in markets, but also all the things that are not traded in markets. It is true that economists like markets, but we like markets when they are efficient. It is more precise to say that we like efficiency. Many things are not and should not be traded in markets. And markets do not always function properly, something economists are painfully aware of, contrary to many peoples' beliefs. Valuation is not the same as privatization or commodification. Valuing something does not necessarily mean we wish for it to be traded in markets. Expressing values in monetary terms is not the same as putting a price tag on it in the sense that we want to sell it in a market or exchange it for something else. Monetary terms can be used as a metric, just as feet or inches, to compare the relative worth, merit or importance of something. Furthermore, prices do not reflect the importance of a good to society. The famous diamonds and water paradox is a great example of this. Illustrating the apparent contradiction that water which is existential to a society has a lower price than diamonds, which are not as useful in terms of survival. Market prices are so that demand and supply is equal.

4.1.2 Anthropocentric vs intrinsic value

A lot of criticism is directed at the fact that economic valuation is an anthropocentric valuation approach. However this does not mean that we only care about ourselves. A lot of people care about other things than people, like plants and animals, so they do get accounted for in the economic value scheme. But even if we only do care about ourselves, many of these things will be value because of their use to us. And this is a contentious subject. The idea that things only have an instrumental value, that is, they are only valuable through their use to us. Many argue that things have intrinsic value, independently of us. This may well be the case, depending on what definition you have for value. The philosophical discussion surrounding this is beyond the scope of this thesis.

4.1.3 Limited resources, necessary tradeoffs

I will limit myself to say that I choose to take a pragmatic approach in this matter. Recognizing that the world is one of finite resources, and therefore necessarily there are tradeoffs. How we act on the planet should therefore be guided with the most amount of information in order to make the best decisions. The current way of valuing nature, or should I say lack of valuation of nature, has led to huge environmental degradation. I argue that the

question is not whether or not economic valuation is perfect, it is clearly not. But whether it is better to implement it than not. I would argue that we should explore the potential and use its insights in policy. It has already been proven that there is a lot of improvement to be done in our current valuation of nature.

4.1.4 Economic growth

Valuing ecosystem services make values apparent. If we destroy ecological structures and deteriorate ecosystem services that are of higher value than what we gain in return, in the pursuit of economic growth, we need a better account of economic values. The values being forgone should be part of the considerations we take into account when making decisions. This ties closely to the debate about the carrying capacity of the planet and zero economic growth arguments. It is not necessarily so that economic growth will lead to more environmental destruction. This has historically been the case and it is easy to make argument that the world cannot take more environmental damage, and therefore we must stop economic growth. I would argue that this is a consequence of poor terminology and/or taxonomy. When we do not have a complete accounting of the values of the world, including ecosystem services, economic growth may be used falsely. The type of economic growth that is unsustainable, that reduces the planets ability to produce value in the future, should not be called economic growth in the first place.

This does not mean that we have to have a complete account of all the worlds' values. It is possible to have an incomplete account and still decouple economic growth from environmental destruction to achieve sustainable economic growth. But valuing ecosystem services is an effective tool in this endeavor. By making the values clear an integrating it into our economic decision making, the outcomes will be more environmentally friendly and hopefully lead to a sustainable future. However it is important to emphasize that economic valuation is not perfect, and has to be viewed as a supplement to ecological, ethical and social scientific arguments.

4.1.5 Making value of ecosystem services apparent

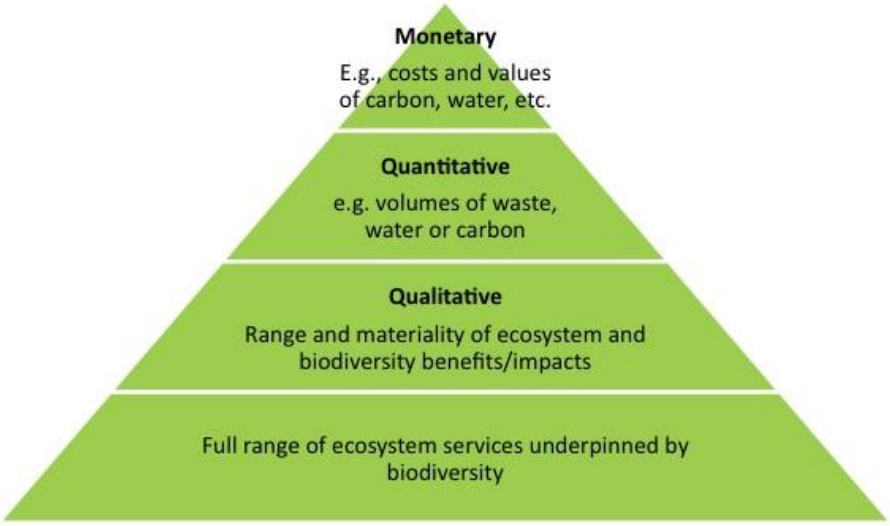


Figure 9: The value can be made apparent in different ways. Based on Brink (2008) and TEEB (2010).

The value of ecosystem services can be made apparent in different ways. We can make their value evident through qualitative methods, emphasizing ecosystem services respective importance in different areas and situations. One can go a step further in quantifying the services provided, like volumes of water cleaned or air filtered etc. Finally on could put a monetary value on these services through economic valuation. The different expressions of value can be ranked as illustrated in Figure 9. Because so many decisions are influenced by price signals, it may be good to have more economic valuation of ecosystem services. Furthermore economic values communicate well, and make sure that the ecosystems are well accounted for in economic analyses.

4.1.6 Required accuracy

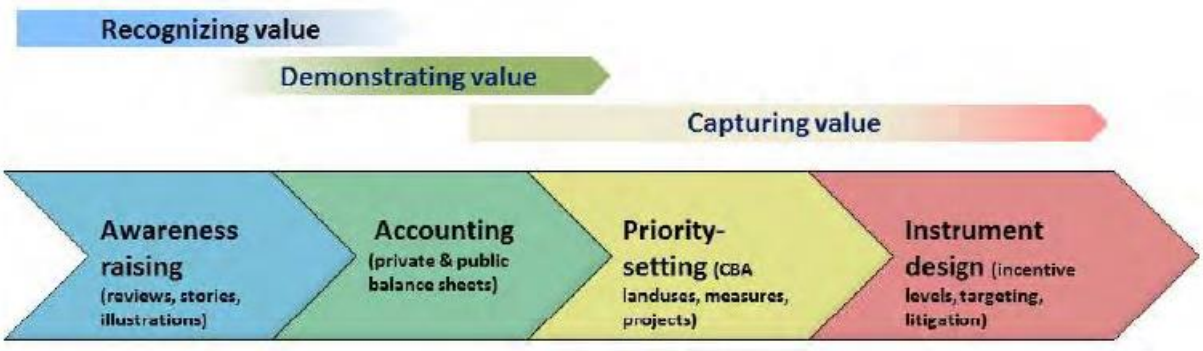


Figure 10: The required accuracy of the valuation depends on the area of use. (Barton, Lindhjem, Magnussen, & Holen, 2012)

The required level of accuracy of the valuation depends on the area of use. From Figure 10 we see that in order to recognize the value of ecosystem services, we don't need very accurate valuation. The accuracy need rises as we do accounting, do prioritizing and finally develop policies. This is also the recommendation of the Millennium Ecosystem Assessment report. We should recognize, demonstrate and value ecosystem services in order to have them better accounted for in the economy.(UNEP, 2005)

4.2 Explaining economic value

Economic value is one way to define and measure value. It is useful for the purpose of making choices that involve tradeoffs in allocating resources. According to neoclassical economic theory value is a reflection of individuals' preferences. Benefits and costs are defined according to how much an individual is willing to give up, or be compensated for, of something else he values in order to get it.

In this framework there is no absolute measure of value; there are only equivalences of value between one thing and another. This substitutability between goods means that any change in the quantity or quality can be directly offset by another type of good so that the consumer is indifferent between two situations. We can utilize this when valuing ecosystem services by calculating trade off ratios between goods that are not traded in markets.

In neoclassical economic theory it is assumed that all consumers are rational and sovereign. Meaning they know what they want and they are the best agents to make decisions about their own welfare. It is assumed that they are consistent and utility maximizing in their preferences for goods and services.

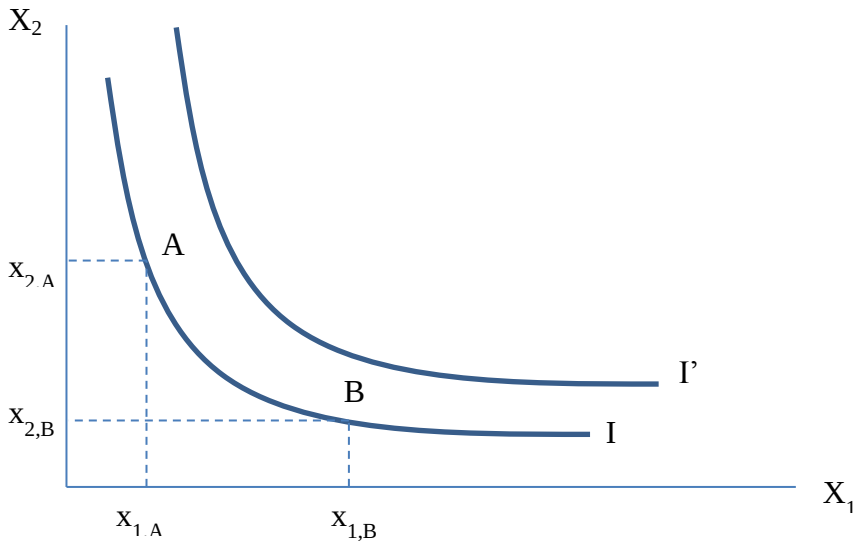


Figure 11 Indifference curves between two goods

Utility is often presented as indifference curves as shown in Figure 11. An agent with utility as expressed by the indifference curves in the figure is just as happy in situation A as with situation B. S/he is indifferent between consuming ($x_{2,A}$, $x_{1,A}$) and ($x_{2,B}$, $x_{1,B}$). But s/he would prefer any point on the line I' over any point on the line I.

Economic theory provides us with a framework for comparing all different things. We can classify things as cost or benefits according to their effect on our utility. Utility is a concept that entails all our preferences. Utility is a measure of preferences over some set of goods and services. So that we know if we are better or worse off by something depending on whether it gives us higher or lower utility. The utility concept places no limitation of people's preferences, beliefs or goals. The contents and form of a person's utility function is entirely dependent on the preferences of that person. Now, where peoples preferences come from is a separate debate and beyond the scope of this thesis. People's utility is revealed in their willingness to pay for something.

Important assumptions about people's utility are

- Reflexivity (each level of a good is as least as good as itself)
- Completeness (can always rank any two levels of good)
- Transitivity (if A>B and B>C then A>C)

- Continuity (no level is absolutely necessary, quantity or quality can always be traded off at the margin)

The maximization problem the consumers face is the how to maximize their utility given their resource constraints, that is the available resources to them such as income and wealth, and can be represented in the following way.

Max U(X) s.t. PX<=M

*Benefits and costs are **defined** in terms of individuals' preferences. An individual receives a benefit whenever he receives something in return for which he is willing to give up something else he values. To measure how large that benefit is, we measure how much he is willing to give up to get it. Conversely, an individual incurs a cost whenever she gives up something that she would willingly give up only if she was given something else that she valued as compensation. To measure how large that cost is, we measure how much would compensate her for incurring it.(Bateman et al., 2002)*

There is no absolute measure of value, there are only equivalences of value between one thing and another. Money can be used as a standard of measurement. It fulfills the desired qualities of a standard of measure. It is a good that everybody prefers more of rather than less, it is treated as a potential substitute for the array of benefits and costs we want to measure and it is finely divisible.

When we have a functioning market for a good we know the price of it. Consumers need only to decide if their willingness to pay (WTP) for it is higher than the price. If so he should buy it. The WTP is a measure of how much the good is worth to him/her. It expresses its value to him/her or how much s/he values it. There is the converse concept of willing to accept (WTA), which is how much would you be willing to get in order to give up a good you already have. How much would you sell it for? That is also a measure of the value of the good to a person.

WTP and WTA are useful concepts when we are dealing with goods and services where we do not have functioning markets. Economic theory and welfare economics provides us with a way of calculating the value for these goods and services. We can study changes in welfare/utility to find the marginal value. There are several different techniques for doing this, each one will be presented in the following.

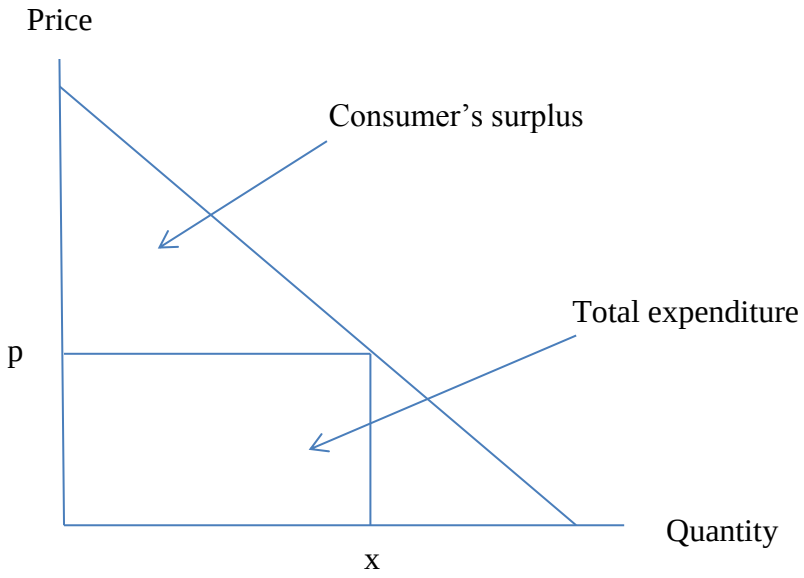


Figure 12 Demand curve, illustrating cunsumer's surplus and toatal expenditure on a private good

Figure 12 illustrates a typical demand curve for a private good, where the horizontal axis measures quantity and the vertical axis measures price. The demand curve reflects, for each quantity purchased, how much that individual is willing to pay for the last (or marginal) unit. If a good costs p, then he will buy x units. But his total WTP is larger than this expenditure on the good. For a smaller quantity of the good, he was willing to pay a higher price. The total WTP for a quantity x is the entire area underneath the demand curve up to the quantity in question. The total WTP is larger than the total expenditure. The difference between the WTP and total expenditure is the consumer's surplus and reflects the net benefit the individual receives form purchasing the quantity x of the good at the price p.

Total WTP = Market price + Consumer's surplus

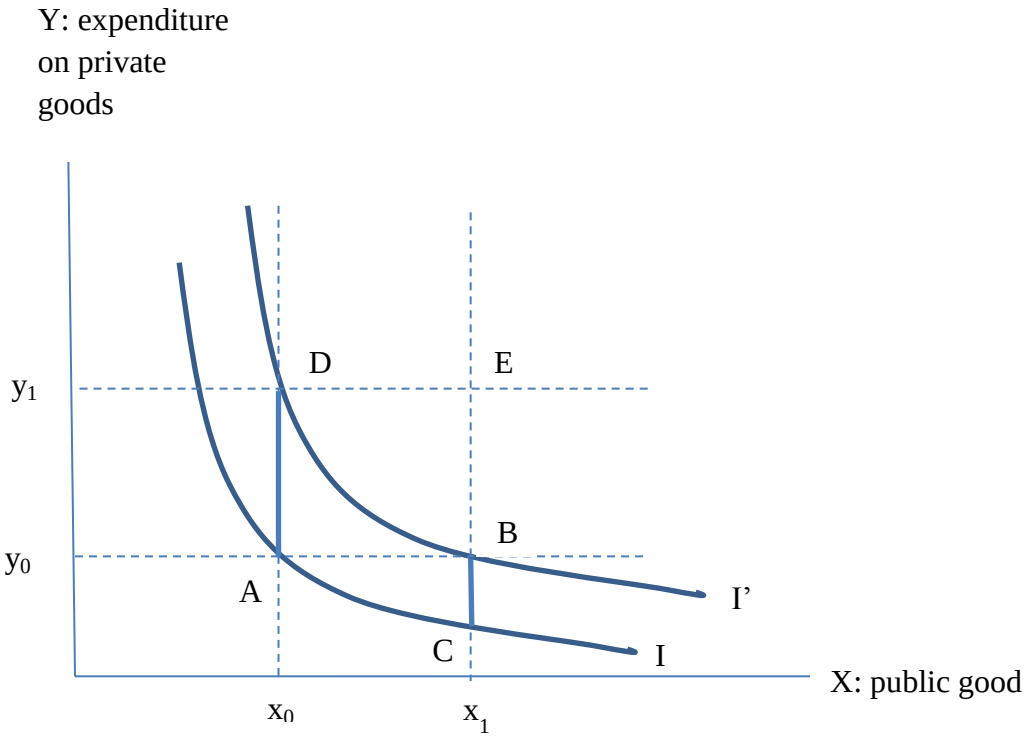


Figure 13 Indifference curves between expenditure on private goods and a public good. Illustrating WTP and WTA

$U(Q^0,Y^0) = U(Q^-,Y^+) = U(Q^+,Y^1) = U(Q^-,Y+WTA) = U(Q^+,Y-WTP)$

Figure 13 represents the preferences of an individual, where the horizontal axis measures quantity of a public good and the vertical axis measures expenditures on private goods. We can explain the concepts of WTP and WTA by using indifference curves. The indifference curve I' reflects combinations of private goods and a public good that the individual value equally. That is to say, he is indifferent between consuming (x_0, y_1) and (x_1,y_0). Each indifference curve can be thought of as corresponding to a level of welfare, with I' being higher than I.

There are several ways of measuring the value of a change in the quantity of a public good. First, consider an increase from x_0 to x_1. Suppose initially the individual is at the point A. The increase in public good would raise his wellbeing and bring him to point B. How much would he be willing to pay for the increase in public good? If we move along the I curve from A to C, the individual is at the same welfare level and has x_1 amount of public good, but less private goods. The distance BC illustrates the individual's WTP for the increase in a public good, because this is what he has to pay in order to get to the I' curve, or higher welfare level.

Considering the opposite case, the individual starts out in B and faces a decrease in the public good from x_1 to x_0. How much would he have to be compensated for going from x_1 to x_0 and still be at the same utility level. His WTA a decrease in public good from x_1 to x_0 is equal to DA. We can observe that the WTA is larger than the WTP: DA>BC. This is the always the case when indifference curves are convex to the origin and the public good is normal. WTP should be used when considering benefits, while WTA should be used when considering costs.

4.2.1 Total economic value

WTP or WTA are measures for individuals. To find the total economic value we have to aggregate - across individuals and over time. The motivation underlying the WTP/WTA affects the aggregation process. TEV is net sum of relevant WTP and WTA.

The total economic value of ecosystem services to humans can be divided in several subgroups, see Figure 14. Firstly we have the use value, from direct use either consumption or experience, or indirect use. Option value can also be regarded as a form of use value, since it relates to possibility of future use. We derive a value from the fact that we have the option of use in the future. Non-use value can be divided into existence-, bequest- and altruistic value. These relate to the value we have from knowing something exists, to having it exist for future generations and for the use of others.

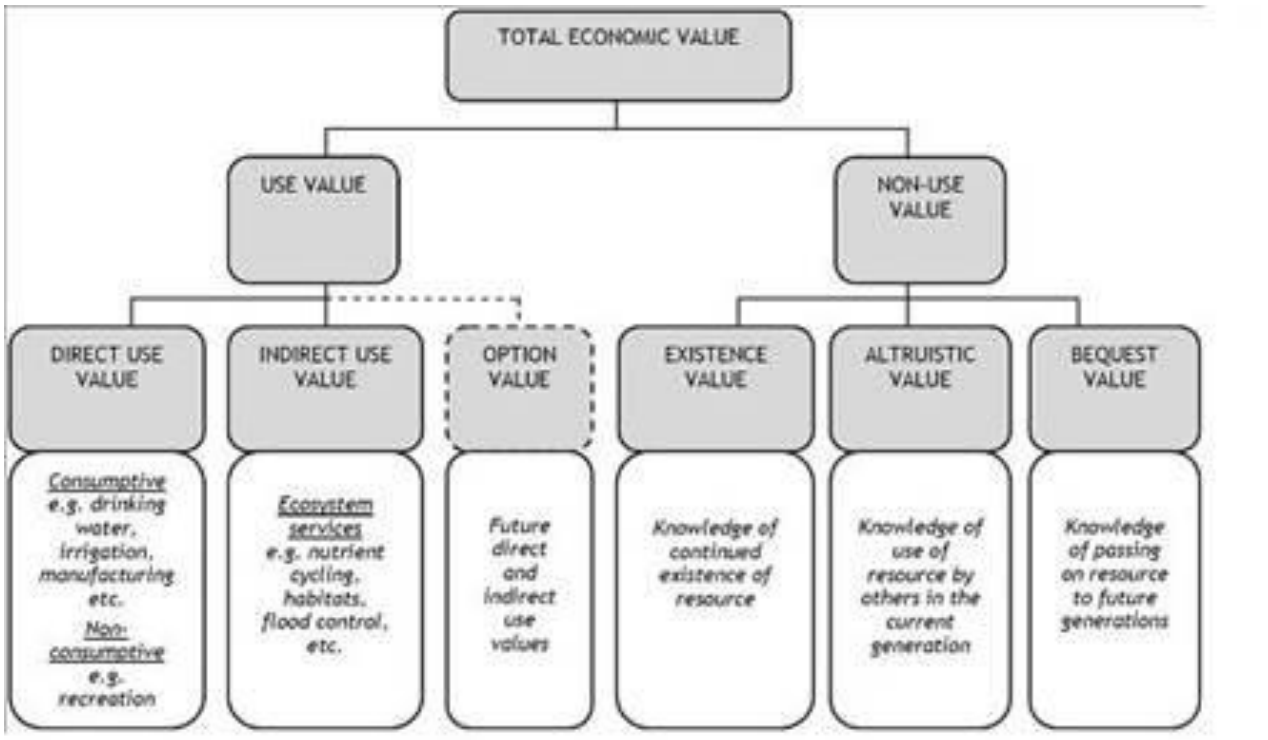


Figure 14: Logical framework to represent total economic value. Source: (Ltd, 2010) adapted from (TEEB, 2010)

4.3 Estimating economic value

When goods are traded in markets their value is apparent through their prices. When a good or service is not traded directly in a market, there are two ways of uncovering its value. Studying how it influences other/related markets (revealed preference techniques). Asking people what economic value they place on the good or service (stated preference techniques).

There are several ways of estimating economic value. We can divide the methods in five categories; markets, prevention and replacement costs, revealed preferences (travel time, hedonic pricing), stated preferences (contingent valuation, choice experiments) and benefits transfer. They all are valid methods, but differ in when they are used, what they mesure and in their benefits and shortcomings. In the following I will present the valuation methods and explain how they work. The contingent valuation method, wich is the method used in the valuation of street trees in this master thesis will be discussed in more detail in chapter 6.

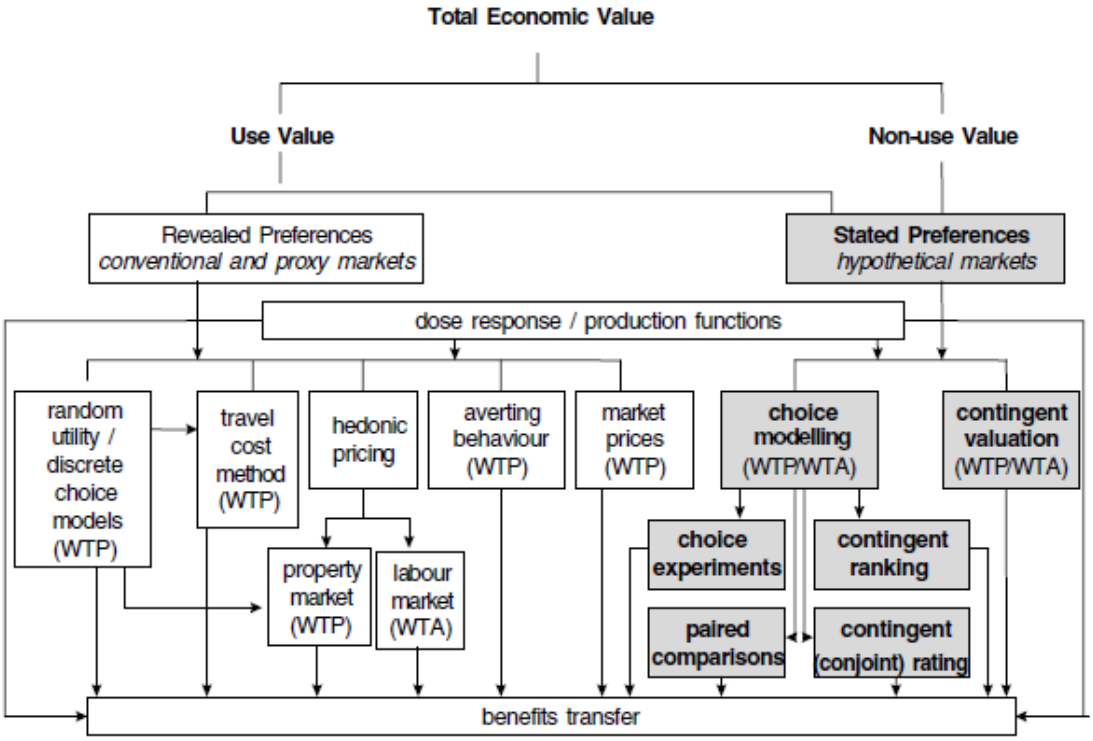


Figure 15 Total economic value and valuation techniques. (Bateman et al., 2002)

The different valuation methods differ in the type of markets they use (actual-, parallel- and hypothetical markets), their approach (market based, revealed- and stated preferences), and the type of value they measure (use value and non-use value). Figure 15 illustrates how they are related. Stated preferences method is highlighted. All the methods point to benefits transfer, which is the practice of using the results from one study and adjusting/correcting them in order to be used in another area/setting. This is necessary, because we will not have to value all ecosystem services in all situations at all times, but take the insights/knowledge discovered in one study and apply it in other situations.

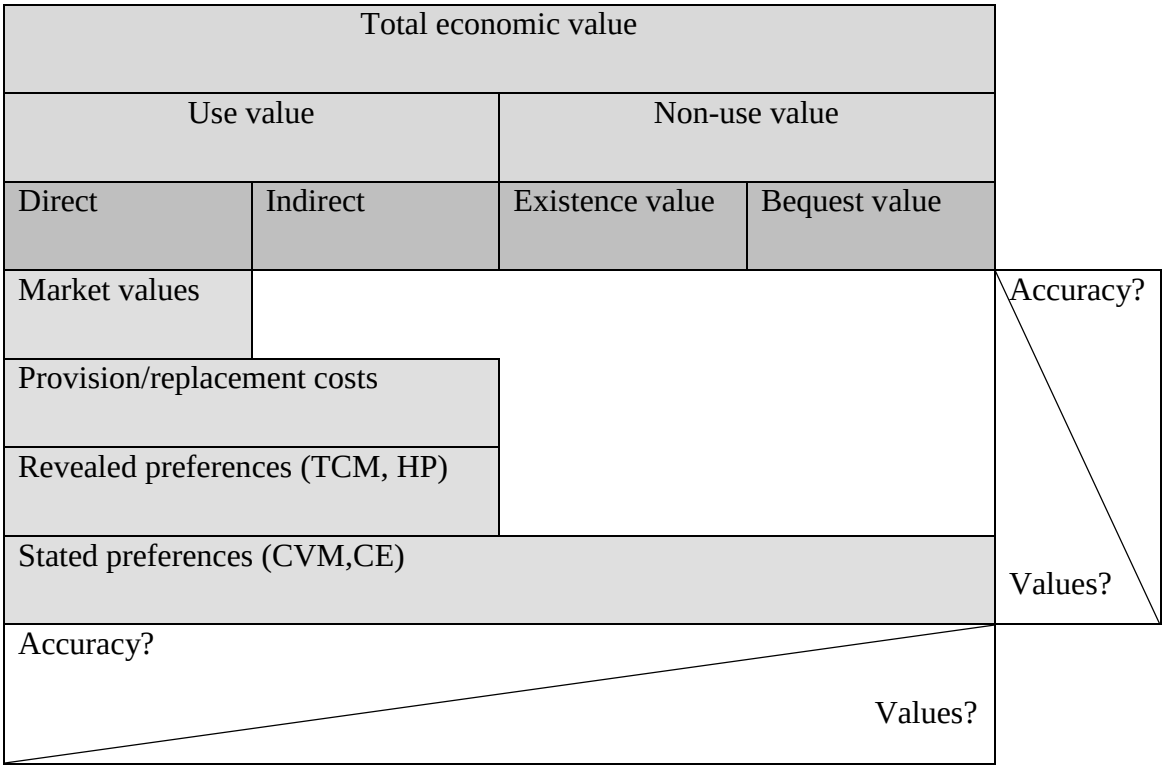


Figure 16 Total economic value and valuation techniques. Translated from (Magnussen, Lillehammer, Helland, & Gausen, 2010)

As illustrated in Figure 16 the different valuation methods differ in what they measure. Market values measure the direct use values of goods traded in markets. Provision or replacement costs and revealed preferences can also uncover indirect use value. The benefit in using stated preference valuation is that we are able to estimate also non-use values. However the type of method we use and the amount of values they are able to uncover is also related to its accuracy. There is a lot of debate over the validity and robustness of valuation methods.

4.3.1 Market based valuation – provision and replacement costs

The primary way we estimate economic value is based on prices that arise in markets. For goods that are traded in markets this is the obvious choice of valuation method. From the prices in a market we can estimate a demand curve. The area below the demand curve represents the agent's economic valuation of the good.

From the costs of provision we can stipulate a supply curve. The area above the cost of provision and below the demand curve is the total economic value from the good in this market. This is because we have to subtract to costs it took to provide the good. TEV can be divided into consumer surplus, CS, and producer surplus, PS or profits. See Figure 17.

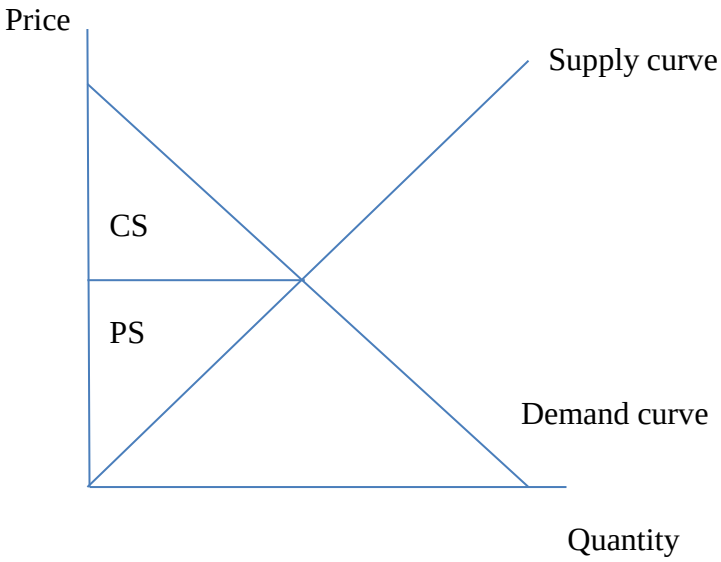


Figure 17 Consumer, producer surplus and total economic value

Provision/replacement costs

However there are a range of goods and services that are not traded in markets. This includes the majority of ecosystem services. For some ecosystem services it may still be possible to use markets to estimate value. This is the use of costs related to prevention or replacement costs from loss of an ecosystem service. (Valuate the costs and prices of policies and other actions that affect the provision or quality of an environmental good) For example if a nation decides to preserve a forest, make it illegal to cut down trees for timber etc., then the value of this forest is at least the cost of preservation. If the value was less than the cost, we would not do it, according to economic theory.

Or one could use replacement costs, if a city decided to cover its city with pavement, what is the cost of having to provide the water management service that the natural habitat used to do for free? They would have to build water mitigation systems etc. in order to handle the excess water. The cost of these systems that aim to replace the lost ecosystem service can be used as an estimate of the economic value of that ecosystem service.

This approach only takes into account the value from direct use. These methods do not provide true welfare measures as they are based on the costs, and do not reflect the true value of the benefits from the good in question.

4.3.2 Revealed preferences

Revealed preferences are methods where one uses parallel markets to estimate economic value. One could say people reveal their preferences for a good through choices in markets that are connect to the good in question. This approached is used when there is no direct market to estimate value from. This approach takes into account the value from direct use and indirect use.

Travel time valuation

Travel time valuation is when you estimate the price of the time it took to get to the ecosystem service or good, and use this as an estimate for the value of the good. For example lots of people travel to the Grand Canyon, spending time and resources getting there in order to see it. According to economic theory, the utility they get from seeing it is higher than the time cost from travelling there to do so, otherwise they would not have done it.

Hedonic pricing

Hedonic pricing is a method is where you use a parallel market, often the housing or labor market, to estimate the value of a good connected to that market. For example parks are nice, and on might think people value living next to parks. Then this valuation will appear in the property price of housing close to parks. This is done through an econometric exercise where you control for all other factors affecting housing prices, and the remanding effect is the effect of the park on the housing price, and therefore peoples valuation of the park.

4.3.3 Stated preferences

Stated preferences is an approach where you ask people how much they value a good. They state their preference. The main benefit from this approach is that it can estimate value of goods and services that are not traded in markets, and where it is not possible or difficult to do a revealed preference study. Furthermore, in addition to estimating use value, the method also measures non-use value, something all the methods above fail to do. It does so by creating hypothetical markets. This means we have a lot more control of the study, and can design it to our needs and purpose.

Contingent Valuation

Contingent valuation is a form of questionnaire where respondents are asked to say what they would be willing to pay, WTP, for a good given a certain situation. Or equivocally what they would be willing to accept, WTA, to forgo a good they are currently receiving or to undertake a disutility.

In the simplest case the contingent valuation method involves a single good, and the respondents are asked to state their maximum WTP or minimum WTA for a change in the good. If respondents answer truthfully (dependent on their ability and their biases), their answers will correspond to the utility change, i.e. the value of the change in the good to them. This is a good method for estimating value of environmental goods.

This method has received a lot of criticism because the results are based on what people say rather than what they do. This is a problem because it is an unfamiliar task, and people might not be able to elicit their true WTP/WTA. Furthermore people could have incentives to lie about their true WTP, this is been discussed in the literature, and surveys are designed in order to be incentive compatible, that is they are not incentivized to lie. There is the potential for biases, but there are also ways to reduce them. This method will be discussed further in chapter 5.

Choice Modeling

Choice modeling is a valuation method where respondents are given a series of choice sets. In each set, they have to choose between different scenarios. The scenarios are different in attributes relating to the good in question (quality, amount et.) and a price. They are forced to make tradeoffs, and through their choices they reveal their preferences. The choice experiments are designed in a way to get the most information from the respondents about their valuation of the good in question. The choices are analyzed in order to construct a WTP, and from this we can estimate an economic value.

Another benefit of the choice experiment is that the hypothetical effect that stated preference studies are criticized for is equal for all the estimates, so that no one estimate is biased in relation to another. That is why we get a good sense of the ranking of different attributes of the good from a CE.

4.3.4 Benefits transfer

There is a final category that is used very often called benefits transfer. This is a method where you transfer values estimated by the other studies from other places, correcting for differences, and apply them to your valuation objective. This is a cost effective method when one does not have the opportunity to conduct a study in the area of interest and when there are available studies that can be adjusted to make an estimate for the case at hand.

5 Contingent valuation methodology

In this chapter I will present the theory behind the contingent valuation study. I will also briefly explain why we chose this method and how our study deviates from the classical set up of a contingent valuation study.

5.1 Choice of methodology

It was not only the focus of this study to value ecosystem services but also to try to use a valuation method in an urban context to see if it worked. Valuing urban ecosystem services is challenging because of the "high density context" of the urban environment, with many overlapping and competing ecosystem services as well as other concerns in a small geographical area. Furthermore, we wanted to study urban ecosystem services spatially explicit. We used an online survey with interactive maps that linked answers to geographical locations.

The right type of valuation study depends on what you would like to value and for what purpose. Valuation studies in urban areas are more demanding because of higher requirements of special resolution, and multiple scales of analysis in sampling particular assets at specific locations within heterogeneous urban landscapes. There are many considerations one has to take into account. The scale, special resolution and reliability and accuracy requirement of the study can be illustrated in a 3D model, see Figure 18.

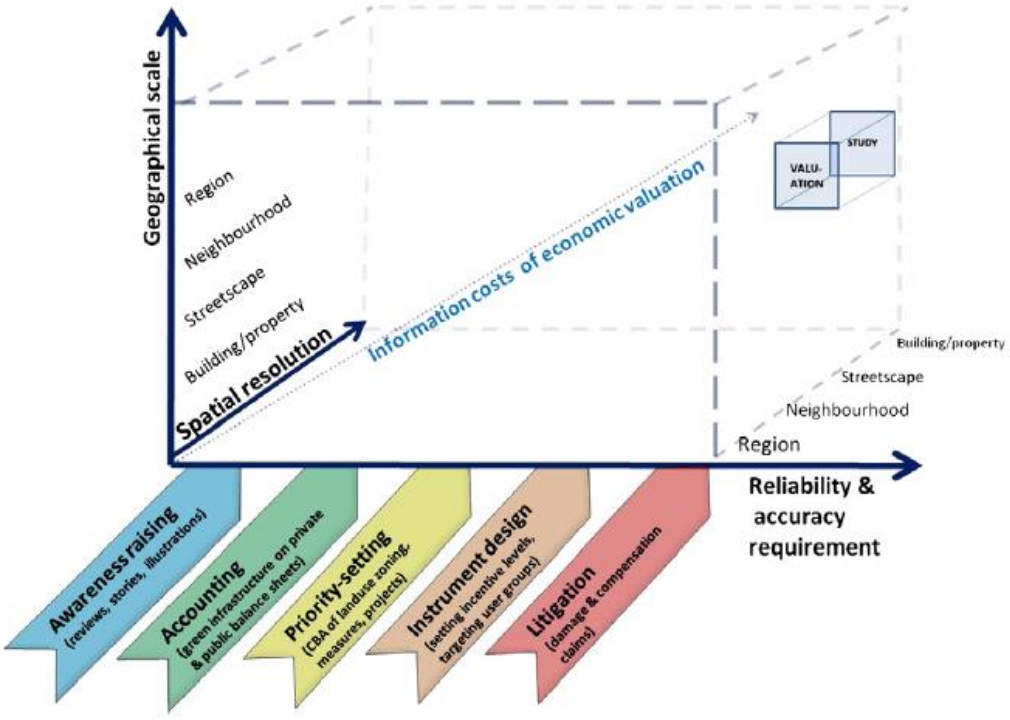


Figure 18 Economic valuation of ecosystem services in different urban planning contexts. Scale, resolution and accuracy and reliability. (Gomez-Baggethun and Barton 2013)

In the OpenNESS Oslo case study there had already been done a meta-study, a benefits transfer study and a hedonic pricing study. Time travel cost did not work well because it is hard to isolate the effect of ecosystem services on movement because of overlapping travel purposes. We considered choice experiment, a method that worked well in a hypothetical situation, but not so well when in a geographical explicit study where the situation varied for all the respondents.

One of the main tradeoffs we had to decide on, and which turned up again and again in all the different study ideas was between using a **hypothetical generic place versus a spatially explicit valuation study.** A hypothetical generic place is easier to design a study for, however, we do not get context specific estimates, and we are not able to study spatial variation. How does the valuation change in different parts of the city? This is an interesting and important part of the ecosystem services valuation field, and one we wished to explore in this study.

The contingent valuation method is way of valuing environmental goods directly. So we wanted to use this to measure people's valuation of street trees in their own street. Furthermore, street trees are publicly provided and financed through taxes. This makes it easy

to create a CV hypothetical scenario that is both understandable and believable by making it close to the real world situation.

5.2 Steps and components of a CV study

The main reference for this subchapter is the book Economic Valuation with Stated Preference Techniques - A Manual, by Bateman et al. (Bateman et al., 2002)

The contingent valuation method is deeply rooted in welfare economics, based on the neoclassical concept of economic value under the framework of individual utility maximization. The objective is to obtain a monetary (Hicksian) measure of welfare associated with discrete change in provision of an environmental good.(Hoyos & Mariel, 2010)

The method involves asking people directly how much they would be willing to pay for a certain amount or quality of a specific good or service, or willing to accept to forgo it. The valuation is contingent on a hypothetical scenario, which allows us to study goods and services that are not traded in markets. Asking many people this is practically done through the use of a survey. There are many ways to design and carry out surveys, including personal or telephone interviews, mail surveys or online web-surveys as we did in this study. When conducting a CV study one has to follow a number of steps and include certain components to create useful and valid results.

Hypothetical market

The way to obtain value estimates is by getting respondents to reveal their preferences in a hypothetical market. Constructing a hypothetical market that is both believable and comprehensible to the respondents is crucial to this endeavor. Construct a scenario which is close to real world situation is a good strategy to achieve this.

In the hypothetical market one needs a defined good, a defined change in the good to be value and a payment vehicle. The hypothetical market is constructed so that there is a direct link between the answer and a decision about an environmental change to be valued.

The hypothetical markets should include a reason for payment, making it clear for what and why the respondents are asked to express a willingness to pay. The way the express this is

through a bid vehicle. Furthermore the hypothetical market should include a provision rule. This is a mechanism for how the good is provided as function of stated value.

Defining target population and obtaining data

When valuing an ecosystem service one has to identify the target population. If one wants to capture the entire value of a good, the population can become quite large; it is all the people that enjoy it. As discussed in the previous chapter the values of something is not only that from direct use. People that never use the good may also value its existence or want it to exist for future generations; such is often the case for endangered species. However for practical purposes it is sometimes useful to limit a study to the most relevant population. It can be costly and difficult to ask every member of the population about their valuation of the good in question. Obtaining a representative sample from the population to conduct the study, and then use statistical methods to extrapolate from that sample is a cheaper and more practical approach.

There are different ways of obtaining a representative sample. For the purpose of this study and as a part of the OpenNESS Oslo project, we purchased a geographically representative sample of the inhabitants of Oslo, based on a randomized panel from the data-collection agency Norstat. The population was defined to the inhabitants of Oslo. They are not the only ones that enjoy the ecosystem services provided by street trees. There are of course other people that value them as well, tourists etc. But for practical purposes of the study and because the inhabitants of Oslo are the ones that pay for the street trees over the municipalities' budget, we wanted to estimate their WTP.

Estimate WTP

The contingent valuation is designed to get respondents to elicit their WTP for the good in question. The respondent's replies are then subject to econometric analysis to estimate mean WTP and study how different factors affect the estimated value.

Carry out validity checks

An important part of designing a CV study is carrying out validity checks. A CV is dependent on the quality of the replies the respondents give. And there are many reasons why the replies might be biased. One of the main critiques of CV method is the possible bias due to strategic

behavior. Although CV has proven to be less prone to strategic bias than first suspected. Other possible biases include:

1. Anchoring/starting point bias
2. Vehicle bias
3. Mental account/scope bias
4. Embedding
5. Major differences WTP-WTA.
6. Information bias

However, there are ways to minimize the potential for these, and ways to test for the existence of such biases.

Aggregate data

Finally the results are aggregated to get estimates that represent the population of interest. This is done by converting the estimated mean bids to population aggregates. It is also normal to utilize derived bids and bid functions for benefit transfer, so that the results from one study can be used in other locations and settings.

5.3 Main deviation from method/criticism

Contingent valuation is a direct valuation method that has been used extensively for valuing environmental goods. However, as the following quote emphasizes, the quality of the results from the study depends largely on the design and execution of the study.

"The principal challenge facing the designer of a CV study is to make the scenario sufficiently understandable, plausible and meaningful to respondents so that they can and will give valid and reliable values despite their lack of experience with one or more of the scenario dimensions" (Mitchell and Carson, 1989, p. 120)

In the process of designing a CV survey we made the decisions that lead us to not obtain a theoretically precise measure of the WTP for a certain amount of ecosystem services or natural structures (street trees). Rather the survey gives an indication of preferences for street tree density and documentation of existence of WTP – which in turn is useful for the municipality for policy.

When designing the study we had to make different choices. We construct a CV that did not specify status quo in absolute quantity. The problem was that the status quo change over time in street tree density is individual to each respondent. It is an unobserved variable and one of many reasons why the error term in the WTP is so big.

In the CV study we describe a future with population growth and rising pressure on street trees. And claimed that municipality needed more funds in order to maintain or increase the street tree density level. We did not specifying what the level street trees would be in each respondents street if they did not pay, only indicating that it would be lower than the current situation.

Alternative ways of describing status quo scenario	Advantages	Drawbacks
The one we used. Not specified what situation would be, only that street tree density would go down unless people payed a higher tax.	Easy to understand and believe. Did not require respondent specific information.	Amount of ecosystem service/natural structure/environmental good to be valued is not specified
Asked respondents to imagine that the trend in status quo in their street would be a certain x-percentage for the entire sample.	Gives a specified status quo alternative to calculate amount of good being valued.	Possibly hard to understand and believe for respondents. Will vary how suitable the scenario would be to each respondent.
Ask each respondent to suggest how many street trees there was x years ago and assume that this trend was correct and would	Gives a specific amount to be valued for each respondent based on their reporting on the change in their street.	Maybe hard for people to give account of this trend. Maybe hard to believe trend will continue because of specifics that led to change. Could be that street tree

continue.		levels have risen in previous period.
Measured change in street trees for each respondent's street and provided this respondent specific information.	Gives a specific amount to be valued for each respondent based on objective measure on the change in their street.	Very costly to obtain these estimates. Maybe hard to believe trend will continue because of specifics that led to change. Could be that street tree levels have risen in previous period.

The good to be valued in the contingent valuation survey was density of street trees in the respondents own street. The current situation was not the same for all respondents. The change in the good was not the same for all the respondents. First of all there was a division between the respondents that wanted to maintain the level of street trees and the ones that wanted to increase them. Furthermore the baseline scenario did not specify precisely what the amount of street trees would be in their street if they did not pay, only that there would be less. The following was the scenario WTP questions as described in the survey:

"There will be increasing pressure on public street trees due to population growth, building, traffic, parking, salting of roads and pollution. The need for maintenance and planting of new street trees will increase if one wants to maintain the current density of street trees.

(…) Are you willing to pay an increase in municipality taxes specifically for maintenance/increase of street trees in your street the next 15 years?

(…) Look at the amounts that are listed under. Click the amount that reflects the maximum amount your household would be willing to pay per year the next 15 years for maintenance/increase of street trees in your street." – Scenario and WTP question, translated from CV survey.

We did not define a scenario of what the level of street trees would be if they did not pay, we only described a scenario where there would be less. It was up to respondent to imagine what this would be. We chose this approach because we had no basis for saying what scenario

would be in the individual streets and we wanted to make it as believable as possible, allowing each respondent to answer according to their own belief. There is the problem of not knowing exact amount of street trees they are reporting WTP for. We could think of it as anything from all the trees to just the marginal level change.

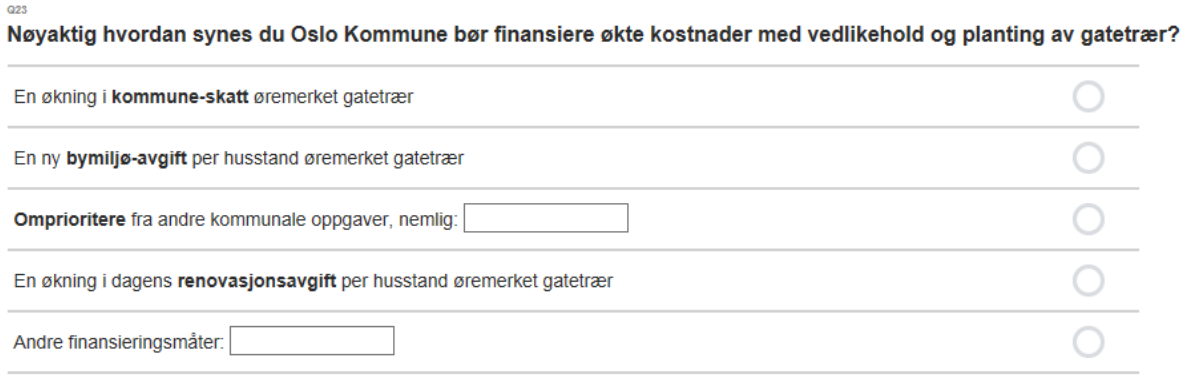


Figure 19 How should Oslo municipality finance the rising costs of street trees?

A payment vehicle was not defined in the CV question explicitly, but the respondents were asked how they thought Oslo municipality should finance the rising costs of street trees. It is interesting to see what respondents think is the best, although we were not able to study the effect of different payment vehicles on WTP.

5.4 History

Contingent valuation surveys where first used in the United States in the 1960's to estimate the value of wilderness areas to hunters and tourists. The use of CV method rose as a means of valuing damages to environmental resources. The most famous of these cases was the Exxon Valdez lawsuits. This case made CV famous but also subject to a lot of controversy. Critiques questioned the validity and reliability of the estimates the method produced.

In wake of use of CVM in Exxon *Valdez* oil spill, NOAA convened a blue-ribbon panel, chaired by two Nobel laureates, to assess the method. The conclusion of the panel was that: "CV studies can produce estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive use values" (58 *Federal Register* 460, January 15, 1993)

Since then the number of CV studies has risen. It is used in many countries and for many different purposes such as project appraisal and policy analysis.

In the a paper on the subject, (Hoyos & Mariel, 2010) divide the CV history in three periods:

1. 1943-1989. Origins up to Exxon Valdes case. Alternative to revealed preference methods such as TC

2. 1989-1992. Extensive debate following Exxon Valdez oil spill. Further research on theory and empirics on SP and non-market valuation techniques.

3. 1992- onwards. CV consolidated as method. Accepted academically and politically.

5.5 Advantages and drawbacks of CV

Table 2 Advantages, criticism and potential biases in contingent valuation method (Bateman et al., 2002)

Advantages CV	Criticism	Potential biases
WTP/WTA theoretical correct monetary measure of utility change CVM used for Non-use values Ex ante and ex post	Fail to take serious because non-binding Do not understand what being valued Strategically manipulate process by distorting true WTP Respondents give answers inconsistent w/ econ theory	Information bias Operational bias Design bias (starting point bias, vehicle bias) Hypothetical bias Strategic bias

There are many advantages to the CV method. The WTP/WTA are theoretically correct monetary measures of utility change. CV can be used to value non-use value of things. Because CV constructs hypothetical situations it is not limited by practical concerns. One example is that one can study past, present or future valuation scenarios.

One criticism of the method is that the CV can fail to be taken seriously since it is non-binding. Other criticisms are concerned with the cognitive task of answering hypothetical choices. Respondent may not understand what is being valued or be able to answer what they really would do in the situation in question. A third group of criticisms have to do with

possibility of respondent not giving their true WTP because they are acting strategically to manipulating the process. Others have pointed out cases where CV give answers that are inconsistent with economic theory.

These criticisms can lead to a range of potential biases in the estimated WTP. Information bias comes from the fact that respondents answer can be affected by the information that is provided to them. The design of the questionnaire can also affect the results, such as starting point bias or payment vehicle bias. The hypothetical bias is the bias that comes from the fact that it is a hypothetical situation. And finally there could be strategical bias from respondents lying in order to influence the estimate in one way or another.

There are some ways to investigate reliability and validity of CVM.

- Design to test for biases
- Analyze whether bid well behaved from an economic stand point. Estimate valuation function
- Replicate study
- Compare CVM results to other valuation methods

Following the Exxon Valdez case, a NOAA blue ribbon panel, including Solow and Arrow, revised all theoretical and empirical works on CV and compromised guidelines for conducting CV studies. Table 3 lists these guidelines and the measures taken in this study to follow them.

Table 3 General guidelines given by the NOAA panel and measures taken in the study.

Guideline	Measure taken in study
Probability sampling from the entire affected population	Sample from data-collection agency Norstat. Soft-quota on districts to get geographically representative. Reflects the population relatively well, except for immigrants which are underrepresented.
Minimize non-respondents	A number of strategies were undergone to minimize non-respondents.
Personal interview	The resources available and the technical features of the survey did not allow for personal interviews. But fit rather well with an online-survey.
Careful pretesting for interviewer effects	The survey was tested both in focus groups, pilot study and by researchers and the people at Norstat.

Clear reporting, of defined population, sampling method, non-response rate and composition, wording of questionnaire and communications	Defined population inhabitants of Oslo – important choice between aggregating for only reported WTP or all sample! Sampling method done by Norstat. Non-response rate almost 50%. Non-responses, different than rest of sample? Composition. Subsamples (true zero, post WTP, protests, inconsistent, arbitrary amount, donation- and tree density-motive. Wording of questionnaire. Wording of communications.
Careful pretesting of CV questionnaire	The survey was tested both in pilot study and by researchers and the people at Norstat.
Conservative design. By this they mean that one should generally prefer options that tend to underestimate, rather than overestimate WTP	We only aggregate to over share of population as share of sample that reported WTP. It is very likely that the rest of the population values street trees, but we do not assume this.
WTP format instead of WTA	WTP
Referendum format	Referendum in form that only important to study whether it is important to inhabitants, what amount they want and unveil a WTP. How many of them. If most people have WTP. And conservative estimate higher than cost of policy it is OK. Because municipality's self-cost principle.
Accurate description of program of policy	Policy is just an increase in the existing policy
Pretesting photographs to be used	No photo for CV. Pilot, researchers and Norstat.
Reminder of undamaged substitute commodities	Asked about substitutability of street trees before the CV
Adequate time lapse from possible concrete incident to be valued	N/A
Temporal averaging	Yes, per year over 15 period
"no-answer" option available	Several times. If respondent wanted less trees. Asked WTP. Report WTP amount, "0" and "vet ikke". If so, then why.
Yes/no follow ups to referendum question	Follow up to why no WTP (first and second most important reason). And yes WTP (what had in mind when reporting).

Cross-tabulations of other questions such as attitudes toward site, environment etc.	Yes! How long lived in Oslo, district, street. Outdoorsy. Activities. Attitude trees. Pos_trees. Neg_trees. Substitute/ownership_trees/q21_1-4. Living_arrangement. Q4_sum_view. Current, desired situation and change. Thought of when reporting_WTP. 1st and 2nd important reason why no WTP.
Checks for understanding	Pilot, focus groups, adjustment, no inconsistent answers.
Alternative expenditure possibilities provided	Reminds respondent that tax comes in addition to existing tax.
Present-value calculations made as clear as possible	What are we left with if we take the NPV of WTP over the next 15 years for Oslo's inhabitants?

6 Literature Study

In this chapter I will present a selection of relevant literature, and place this study in a broader research context. I will present literature on ecosystem services and valuation methods in general and in an urban context and for trees in particular. Finally, I will identify a knowledge gap that this master thesis aims to fill.

6.1 Literature on ecosystem services

In the article **The value of the world's ecosystem services and natural capital, by (R. Costanza et al., 1997),** many scientists made an estimate of the value of the world's ecosystem services and natural capital. Building on published studies and a few original calculations they came up with the estimate of a minimum value between US$ 16 – 54 trillion per year. Global GDP was US$ 18 trillion per year. There are large uncertainties in such an estimate which many critics pointed out, but the paper succeeded in its goal of bringing attention to the subject.

The ecosystem services agenda: bridging the worlds of natural science and economics, conservation and development and public and private policy by (Braat & de Groot, 2012), was the introductory paper to the The Ecosystem Services Journal that started in 2012. It presents a short history of the field. The paper discusses different developments, challenges and opportunities.

Terry Daniels and several others published a paper in 2012 arguing that cultural ecosystem services are not adequately defined or integrated in the ES framework. They claimed that there are many cultural ecosystem services, lending ideas from social and behavioral sciences, but that these are more subjective and difficult to measure than the more "hard" ecosystem services. However there are models for doing this. **(Daniel et al., 2012)**

The Norwegian literature review by Waaseth from 2003 studies the benefits of urban green structures on peoples' health and wellbeing. Ecosystem services seem to have a positive effect on inhabitant's physical and mental health as well as enhance motoric skills and social development in children. It also found that there is high pressure on urban green areas in Norway. The government is aware of the positive effects of green structures, but the author is uncertain if the current public regulations are able to secure adequate areas for urban

residents. State of knowledge is limited and fragmented and needs more empirical studies. **(Waaseth, 2006)**

6.2 Literature on valuing ecosystem services

The seminal paper **Valuing ecosystem services by Geoffrey Heal** included a discussion on value and prices as well as presenting the methods for valuing ecosystem services. It stressed the shortcomings of the methods and claimed that **v**aluation is neither necessary nor sufficient for conservation. Rather economics should help design institutions that provide incentives for the conservation of important natural systems and make humans impacts on biosphere sustainable. **(Heal, 2000)**

Other papers such as **The value of nature and the nature of value by (Daily et al., 2000)** pointed to the large potential valuation has, and making the point that valuation happens implicitly in the economy and that this is not sufficient. They stress the importance as well as formulate principles for valuation.

One of the most influential early papers on urban ecosystem services was written by Bolund and Hunhammar in 1999. They identify 7 ecosystems and 6 ecosystem services in urban areas and stress that ecosystem services in urban areas have large impact on quality of life in urban areas. They claim that urban ecosystem services can help tackle problems locally and efficiently. **(Bolund & Hunhammar, 1999)**

Economic and ecological concepts for valuing ecosystem services written by (Farber, Costanza, & Wilson, 2002) attempts to bridge the fields of ecology and economics to find concepts and methods of value for ecosystems. It presents the historical background and context with discussions on value in the two different fields. It covers the issues of ecological thresholds and uncertainty. There are conflicts between the different approaches, but both have contributions in trying to solve the many challenges when it comes to managing the natural resources.

Many others have called for a transdisciplinary approach to valuing ecosystem services as presented in the paper by Liu, Costanza, Farber and Troy in 2010. This synthesis of literature describes the history, use and future of valuing ecosystem services. The conclusions being

that it needs to become more transdisciplinary and more problem driven rather than tool driven. **(Liu, Costanza, Farber, & Troy, 2010)**

Most cities consume ecosystem services from areas many times the size of the actual city. This is often inefficient and unsustainable. In the paper Classifying and valuing ecosystem services for urban planning, by Gómez-Baggethun and David Barton, they argue that *"Conserving and restoring ecosystem services in urban areas can reduce the ecological footprints and the ecological debts of cities while enhancing resilience, health, and quality of life for their inhabitants."* **(Gómez-Baggethun & Barton, 2013).** They go on to present knowledge and methods for classifying and valuing ecosystem services for urban planning, including different valuation languages and dimensions as well as analytical challenges.

Gómez-Baggethun and others write about the importance of urban ecosystem services for its inhabitants and the global environment as urbanization is rising all over the world. Cities are important because most people live in them and because they have such a large impact on the environment.**(Gómez-Baggethun et al., 2013)**

6.3 Literature on valuing ecosystem services by contingent valuation

The paper **Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill by (Carson et al., 2003)**, reports on the study and results of the large scale CV of the famous Exxon Valdes Oil spill. The case gave rise to a lot of attention and criticism of CV, both of the conceptual underpinnings and the specifics of the technique of measurement. However a majority of CV WTP pass test of validity when compared to actual behavior. (Zhongmin, Guodong, Zhiqiang, Zhiyong, & Loomis, 2003)

The comprehensive paper by Hoyos and Mariel in 2010 synthesize the past, present and future of contingent valuation. The divide the history in three parts;

1. 1943-1989. origins up to Exxon Valdes case. Alternative to revealed preference methods such as TC

2. 1989-1992. Extensive debate following Exxon Valdez oil spill. Further research on theory and empirics on SP and non-market valuation techniques.

3. 1992-onwards. CV consolidated as method. Accepted academically and politically.

The technique has received lots of criticism concerning strategic behavior and non-rationality of responses. Even so it has been used extensively in economic valuation of natural resources. Following the Exxon Valdez case, a NOAA blue ribbon panel, including Solow and Arrow, revised all theoretical and empirical works on CV and compromised guidelines for conducting CV studies. There has been published more than 6000 CV papers in 50 years and CV is generally accepted, however any general valid statement about properties of CVM is impossible. **(Hoyos & Mariel, 2010)**

6.4 Literature on city trees

There is a range of literature on valuing trees in an urban environment. An attempt to value the street trees with the choice experiment method was carried out in Lodz, Poland. The experiment showed a large preference for street trees, and authors claimed the results from the study helped improve governance of urban ecosystem services in the city. **(Giergiczny & Kronenberg, 2014)**

Another approach to value street trees is by using hedonic pricing. A study from Portland, Oregon calculated values of trees based on house prices in the city.**(Donovan & Butry, 2010)**

Different studies have estimated value of trees and urban forests based on the services they provide using quantities of quantifiable services like air purification, water regulation etc. The paper by **(Jim & Chen, 2009)** uses several valuation methods and draws on other studies to measure different services provided by Urban forests in china.

Other studies like one done in Lisbon, Portugal uses a benefits transfer method. The study from Lisbon used the software iTree from the USA. This software calculate values based on information about trees in area as well other factors like threes effect on energy, air quality, CO2 reduction, water runoff and property value basted on previous studies.**(Soares et al., 2011)**. Another such study is **Ecological services of urban forests in Barcelona (Chaparro & Terradas, 2009).** It is a report which utilizes a computer program which evaluates the structure of urban forest, like species, density etc. and computes values based on functions for quantifiable services like carbos sequestering, pollution reduction etc. to estimate value of these services. The functions in these types of models get there estimates from other studies

and/or does original calculations. They can be seen as a type of benefits transfer, but they do not capture the value of all the ecosystem services. Furthermore they must be taken as approximations because they are based on general functions that are compromised to facilitate estimation, and not comprehensible studies.

Protest response and willingness to pay for culturally significant urban trees: Implications for Contingent Valuation Method (Lo & Jim, 2015) This study on city trees in Hong Kong applied the contingent valuation method. The authors stressed the issues of protest answers. Protest responses may be correlated with WTP in different ways, which in turn can bias the estimates.

It is interesting to see the fact that valuing ecosystem services works differently in different cultures. USA has a large amount of CV studies, while other studies in for example China have difficulty getting good results. Some raise the question if Chinese are less used to the market valuation mindset used in the type of studies. (Zhongmin, Guodong, Zhiqiang, Zhiyong, & Loomis, 2003). Other European studies like **The economic value of urban forest amenities: an application of the contingent valuation method (Liisa Tyrväinen & Väänänen, 1998)** find a willingness to pay for use, but point out that the method is not used as much in Europe as in the USA because of absence of legal obligation to require a monetary evaluation of environmental policies. There are a range of other contingent valuations studies on trees in urban areas, some of which are presented in Table 4 below.

I also reviewed some literature on trees in Oslo for local background. **Byens trær – Plan og bygningsetaten by (Clausen, 2014)** Presented a short history of trees in the city, as well as challenges and leagal protection of trees in Oslo. Other articles like **Grønn urbanisme (Stange, 2010)** contributed in giving some context.

There are many contingent valuation studies on environmental goods and some on street trees. They vary in the context and how they define the good, the change in the good as well as technical differences such as payment vehicle and statistical models used for analyzing the results. However, to the best of my knowledge there are no stated preference based valuation studies done on street trees in Oslo. Although there are several software valuation programs and models that estimate urban ecosystem services, I have not found any that study ecosystem services spatially explicit using a stated preference valuation method. Both of these factors

make the stated preference study on street trees in Oslo able to fill a gap in the literature and interesting from a scientific standpoint.

Table 4 Selection of studies on valuing ecosystem services in general and street trees inparticulart

Author(s)	Year	Country/region	Type of service/area valued	Method
R. Costanza et al.	1997	International	Global	BT
Braat & de Groot	2012	The Netherlands	Theoretical	n/a
Daniel et al	2012	USA	Cultural services	n/a
Waaseth	2006	Norway	Health effects	n/a
Heal	2000	USA	Theoretical	n/a
Daily et al.	2000	Sweden	Theoretical	n/a
Bolund & Hunhammar	1999	Sweden	Urban ecosystem services	n/a
Farber, Costanza, & Wilson	2002	USA	Theoretical	n/a
Liu, Costanza, Farber, & Troy	2010	USA	Synthesis	n/a
Gómez-Baggethun & Barton	2013	Norway	Urban ecosystem services	n/a
Gómez-Baggethun et al.	2013	International	Urban ecosystem services	n/a
Carson et al.	2003	USA	Oil spill	CV
Hoyos & Mariel	2010	Spain	Synthesis	n/a
Giergiczny & Kronenberg	2014	Poland	Street trees	CE
Soares et al.	2011	Portugal	Street trees	BT
Donovan & Butry	2010	USA	Trees in city	HP
Jim & Chen	2009	China	Urban forests	Model
Chaparro & Terradas	2009	Spain	Urban forests	Model
Lo & Jim	2015	China	Urban trees	CV
Liisa Tyrväinen & Väänänen	1998	Finland	Urban forests	CV
L Tyrväinen	2001	Finland	Urban forests	CV
Treiman & Gartner	2006	USA	Community forests	CV
Vesely	2007	New Zealand	Urban trees	CV
Sander, Polasky, & Haight	2010	USA	Urban trees	HP

7 Theory and Methodology (study design)

Chapter 8 Theory and methodology (study design) explains in detail what we have done in our study. The chapter goes through the design and research process, as well as drawing up the theoretical and technical blueprint of the study.

The main reference for this chapter is the book **Economic Valuation with Stated Preference Techniques - A Manual, by Bateman et al. (Bateman et al., 2002)**

The objective of the study is to try to value the ecosystem services being provided by the street trees in Oslo. A second focus of the study is to try to apply the ecosystem services theoretical framework and valuation methods to an urban context to see how it worked out and try to use new web survey methods to make the answers spatially explicit, and look for geographical variation in the results. We used an online web survey with interactive maps to make the answers spatially explicit. And we use the contingent valuation method to measure ecosystem services provided by publicly provided street trees. This allowed us to study respondent specific variation and construct the valuation scenario in an understandable and believable manner that did not differ too much from the real world situation. The target population was the inhabitants of Oslo, because they are the ones that have most of the benefit from the street trees (visitors to the city may also enjoy them) and they are the ones who finance the provision of street trees through a municipality tax.

We purchased a representative sample from the data-collection agency Norstat of one thousand respondents that reflected the geographical distribution in Oslo. We asked the respondents if they would be willing to pay an increase in a tax in order to maintain or increase the level of street trees density in their street. The elicitation format was a payment card and they could themselves choose the payment vehicle.

We had two focus groups and redesigned the questionnaire many times. We conducted a small pilot study/pre-test of the questionnaire and redesigned it before conducting the main survey.

For the purpose of writing this thesis I conducted an econometric analysis based on the responses from the survey and preformed validity and reliability tests before aggregating and reporting the results.

7.1 Population, sample and survey mode

The target population is people who receive benefits or costs from the non-market good in question. The target population for the CV study is the inhabitants of Oslo. There are other groups that value street trees in Oslo, such as tourists and other people who visit the city. However, for practical reasons we decided to limit the defined population to the inhabitants of Oslo. It would be more difficult and costly to get a sample that included visitors. Furthermore the households of Oslo are the ones that pay the taxes that finance the street trees, and they are the ones that pay would pay the tax in the hypothetical CV valuation scenario. We bought a representative sample from the data-collection agency Norstat. It randomly selected with a soft-quota on districts in order to ensure geographical representativeness, down to this level. We conducted a web-survey because of its cost-effectiveness and because it allowed for technical features linked to interactive digital maps. This was an area we were interested in exploring, in addition to making both the collection and analyzing of information faster and easier. With the respondents identifying home and trips on maps, we could link the rest of the information to geographically explicit positions. The sample size was 1000 respondents. This was enough to get statistically significant estimates, spatial variation and representativeness.

The sample size allowed us to study different things especially important was the link to the geographically detail. The precision of the sample in terms of figuring out exact WTP was not so important. But the geographical representativeness was important. The population of Oslo is pretty diverse. As far as variation in the characteristics of interest, we got a good variation when it came to amount of street trees, in place, desired level and geographical variation. The situation differs greatly from different parts of the city. Especially when it comes to possible substitutes to the environmental good in question; people living close to the forests, people living in residential areas with lots of private trees, people living close to parks and people living in more urban areas.

7.2 Designing and testing stated preference questionnaires

The questionnaire is the data-collection instrument. So having a good design is important so that questions elicit the desired information. We want to know how much the respondents are willing to pay to maintain or increase density of street trees. In other words how much are these trees worth to them. As mentioned, exactly how much trees they are putting a value on is not clear. We can study the difference in current and desired level, but not what it would be if they did not pay. But we have singled out exactly which trees, exactly what street in what part off Oslo, they are valuing.

We do not give them too much information, in order not to bias the results. But rather ask them relevant questions in order to prepare them mentally and get information on their preferences.

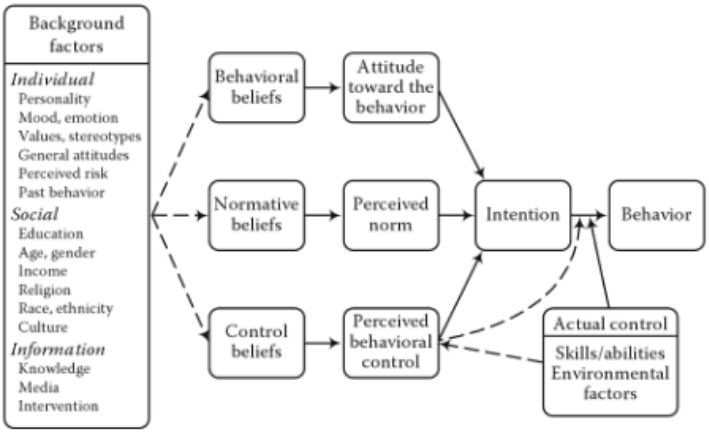


Figure 20 Schematic presentation of the reasoned action model (Fishbein & Ajzen, 2011)

However, WTP and WTA are behavioral intentions. There is the possibility that their reported WTP is not their true WTP. We can look at the theory of reasoned action to understand the process better. According to this theory one part of the thought process is based on their beliefs and evaluation about behavior, wherein laying the true WTP. Another part is the subjective norm, which contains opinions of others and motivations to comply. This may bias the provided answer away from its true value, if these are different in the CV setting than in the real world. Since the web-survey is anonymous and not interviewer is watching them give an answer, it is likely that this sort of bias is minimal. The lessons from the theory of reasoned

actions are; correspondence, proximity and familiarity. Attitudes for paying for goods, WTP, familiarity of behavior.

Table 5 Some elements of the tailored design method, (Dillman, 2000)

To establish trust	To increase rewards	To reduce social costs
• Provide token of appreciation in advance • Sponsorship by legitimate authority • Make task appear important • Invoke other exchange relationships	• Show positive regard • Say thank you • Ask for advice • Support group values • Give tangible rewards • Make questionnaire interesting • Give social validation • Communicate scarcity of response opportunities	• Avoid subordinating language • Avoid embarrassment • Avoid inconvenience • Make questionnaire short and easy • Minimize requests to obtain personal information • Emphasize similarity to other requests

The tailored design method developed by sociologist by Don Dillman gives us concrete advice on how to get higher response rate and better answers on surveys, see Table 5. Establishing trust, increasing rewards and reducing social costs are all things that were aimed at in our survey.

For CV surveys it is crucial that the hypothetical scenario is sufficiently understandable, plausible and meaningful. We based the scenario on the way in which street trees are financed today. This makes it understandable and familiar. However we also asked them what payment vehicle they thought was the best. And we did not explicitly say what the level of street trees would be if they did not pay.

Description of policy, constructed market and method of payment

The only attribute in addition to density of street trees, was height of street trees. We can measure desired change both in number of threes and total height. There are a range of substitutes. The closest are of course other trees, either private or public trees nearby; in gardens, parks or the forest. Other natural structures and green areas can act as substitutes.

However, the trees provide a range of services, so that there may be many other types of substitutions such as sound control, shading, drainage etc. The constructed market is not that different from the market in place. Although there is an incentive compatibility challenge in the fact that people may underreport their WTP because they do not want to be charged for this good. According to economic theory they should not have this perception, because the taxes they pay do in fact come from themselves. Several people I have spoken to seem reluctant to give a number because they do not see trees as something they should pay for. This conception should be explored in the data. The people that have high WTP may provide a higher WTP because they know that the cost will be spilled over the entire population of Oslo. The people who have low, no, or negative WTP have the incentive to overstate this. More information about the groups and how they compare to each other is in chapter 8.

Sections and objectives

We collected information on socioeconomic variables to study how they explained WTP. Furthermore this information could be used to create a benefits transfer equation so that the results from this study can be used in other areas by adjusting for the socioeconomic situation in that region. Information collected on respondents use of green areas in the city could be used to create respondent profiles and study if this affected WTP or if there was any substitutability. Information about respondents attitudes where interesting in relation to WTP but also their knowledge, preferences and opinions on ecosystem services, substitutes, public goods and as checks for validity and understanding of survey. Location information was collected to study spatial variation. Scope variables where interesting for the effect on initial, desired level of street trees, change and to check for validity and understanding.

We used interactive maps to get the information spatially explicit. We were afraid it would be difficult to use for some respondents, or that many would be unwilling to give up spatially explicit information. But this turned out not to be a problem, the technology is the same as many people use in their everyday life through, and we don't ask for more private information that they do not already give in other situations. We got information on where the respondent lived, the street tree density in their street and their desired level for street tree density there. We could link this information to their WTP for this change, and to the rest of the information collected. Furthermore data on respondents use of green areas where collected, on where, when, what, why, how long, how often, at what time etc. This was interesting in its own right for other purposes than the CV of street trees. However this information was useful in

creating profiles of respondents which could be compared to the CV of street trees. The web-survey was designed to be interactive, fun and easy to use. Many original features where used to get good quality data as well as make the user experience as good as possible. We had warm up questions and follow up questions. And the hypothetical CV situation was created to easy to understand as well as believe by making it as close to the way it is done today. We used a payment card because it is easy to use, there is hopefully no bias, and we could treat it as a continuous variable which facilitated the analyzing of results.

Focus groups and pilot study

We conducted two focus groups. One was a group of 5 students. They were asked to try out the different features of the survey, then asked some questions about the survey and spent some time discussing and giving their thoughts on how to improve the survey. The second focus group was a group of employees at NINA. Some had knowledge about trees and ecology others had experience with conducting surveys. Both focus groups were before we had landed on the final type of valuation method. They both pointed us in the direction that we should focus both the good we wanted to study and way in which we did so. This is part of the reason why we landed on the CV method.

We conducted a pilot study with volunteers from professional and social network. We got a lot of useful feedback and the survey was revised, shortened and the user-friendliness was improved considerably.

7.3 Analyzing stated preference data

After developing and testing the contingent valuation study, we conducted the main survey and obtained the stated preference data. The next step was analyzing it to obtain useful results.

In addition to the WTP respondents we collected data on household characteristics, attitudes, opinions and location characteristics. All the information would allow me to analyze the data in a meaningful way. Using this information I can construct a bid function to understand how respondents value street trees and what factors affect this valuation.

One of the main issues was dealing with non-responses - the respondents that did not report a WTP. We had several follow up questions to determine weather these where true zero

responses or protest answers. If I exclude the non-responses it may lead to systematic bias if non-responses are correlated to true WTP. Since I can't test for this, we assume true WTP of non-responders will be similar to that quoted by household with similar characteristics. Under this assumption as long as excluding non-respondents from data does not bias representativeness of sample, should not bias analysis of WTP data. If not representative, I would employ weighting procedures when analyzing data.

There are several groups of variables that could determine WTP. Household, program- and design characteristics. Household characteristics, like socio-economic characteristics, knowledge of the good being offered and attitudes towards the program being offered was collected and analyzed. More about this in the subsequent chapters. We did not include program- or design characteristics. These are variables that describe split-sample treatments designed to examine how the characteristics of the program being valued influence WTP or how questionnaire design influence WTP responses. We used the same program and same questionnaire design on all the respondents. We did however leave it open to the respondents to choose what payment vehicle and what they imagined the status quo would be if they did not pay for the program. We cannot study differences between the different answers because they were self-selected and we would not be able to account for what part of the difference in responses were attributed to program or questionnaire differences.

Missing data on household characteristics can be imputed, although it could be problematic if there was systematic difference between the ones who provided information and the ones who did not. We did not experience a lot of missing data so this did not turn out to be a problem in this survey.

7.3.1 Specification of the bid function

The following theoretical framework and equations are from chapter 5 is the book **Economic Valuation with Stated Preference Techniques - A Manual, by Bateman et al. (Bateman et al., 2002)**

The bid function explains variation in WTP based on characteristics of the good, prices of other goods, income and other socio-economic characteristics as well as other factors that may affect WTP. In the following we will go through how WTP can be defined in welfare economics, in order to justify using WTP as monetary measure of changes in respondent's

welfare. If the responses to CV questions are in a way that is consistent with welfare economic theory, they should elicit the household maximum WTP for the defined change in the good in question.

Let's call this non-market good Q. And define an indirect utility function, V(.). Income is expressed by Y, and price of goods by P. Other demographic and economic factors are represented by S. We can then write the households indirect utility function in the general form:

$$V(Y, P, S, Q)$$

We expect higher income Y and/or lower prices P would allow household to purchase more goods and therefore realize a higher utility. Also we assume that increasing the provision of the non-market good would lead to higher utility. Therfore:

$$V(Y, P, S, Q^0) < V(Y, P, S, Q^1)$$

In the CV survey respondents are asked to compare what they prefer of different levels of non-market good, Q^0 and Q^1. Since they get higher utility we would expect them to be willing to pay something for this. According to our assumptions giving up income reduces welfare, therefore the maximum WTP can be expressed as the monetary payment that ensures their utility is equal at both levels of provision of the non-market good. We define the quantity C such that:

$$V(Y, P, S, Q^0) = V(Y - C, P, S, Q^1)$$

C is the compensating variation measure of a change in the welfare: it is the household's maximum WTP to achieve the increase in provision of the non-market good. C can be expressed as a function of the other parameters in the model. C(.) is known as the bid function:

$$C = C(Q^0, Q^1, Y, P, S)$$

A households maximum WTP is bounded by their ability to pay, so:

$$C = C(Q^0, Q^1, Y, P, S) = WTP \leq Y$$

There are two approaches in specifying the bid function. One is the utility difference approach, which models the effect of different factors on the utility directly. The other is the bid function approach which models the effect of factors on WTP. These are equivalent theoretically, it has only to do with how to frame the effects, in terms of utility or WTP. There is a tradeoff between relative simple function against connection to neo-classical utility maximization theory.

The utility difference approach

We start out with the true indirect utility function:

$$V(Y, P, S, Q)$$

We then create a model of indirect utility function

$$v(y, p, s, q, \eta)$$

This allows us to write:

$$V(Y, P, S, Q) = v(y, p, s, q) + \eta$$

Where η can be thought of as the unobserved variation in tastes. We can express this model as a linear utility model:

$$v_q = \alpha_q + \beta_y + \eta_q \qquad q = 0 \; or \; 1$$

The utility function can be evaluated before and after the change in provision of the non-market good, q=0 and q=1.

- Prices of market goods and quantities of other non-market goods are assumed to be fixed throughout the analysis and are not included in the model of the indirect utility function.

- The parameter beta is the coefficient on (discretionary) income. It can be interpreted as marginal utility of income. Beta represents increase in utility form unit increase in income.

- Utility from provision of non-market good is captured by expression $\alpha_q + \eta_q$. The first part is observed, the second represents unobserved variation in tastes for the non-market good.

HH max WTP is given by C that solves:

$$\beta_y + \alpha_o + \eta_o = \beta(y - C) + \alpha_1 + \eta_1$$

$$C = \frac{(\alpha + \varepsilon)}{\beta}$$

$$where\ \alpha = \alpha_1 - \alpha_0\ \ and\ \varepsilon = \eta_1 - \eta_0$$

Specify alpha, the observed part of the utility change, as a function of the households characteristics (and where relevant program- and design characteristics).

$$\alpha = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \cdots + \alpha_k X_k$$

X's values taken by the k factors analyst believes may influence the welfare change experienced by the household. The k alphas measure the impact of each of the factors on the change in utility.

The bid function approach

The second approach has a bit easier set up. Instead deriving the bid function from an explicit specification of the underlying utility functions, we model the bid function directly:

$$C = C(Q^0, Q^1, Y, P, S)$$

$$c(q^0, q^1, y, p, s, e)$$

With e assumed to be the part of WTP that is determined by unobservable tastes of household for the non-market good.

We can express the model as a constant only bid function model:

$$C = a + e \qquad and\ 0 \leq C \leq y$$

Identical to the linear utility function model equation. Could include income effect

$$a = a_0 + by$$

The marginal impact of income on WTP is then expressed by b. Bid function models incorporate income effects in a very different manner to the utility difference models. Instead of rescaling a utility change to take into account of the utility purchasing power of money at different levels of income, income effects are incorporated in the bid function models as shifters of WTP. The function a can be parameterized to take into account other factors that important to determining WTP.

$$a = a_0 + by + a_1X_1 + a_2X_2 + \cdots + a_kX_k$$

The "a"s measure the impact of the variables directly on household's WTP.

7.3.2 Estimating mean and median WTP

The objective of the CV is to discover how much the population values a change in the good in question. But because we only have a sample from the population, I have to apply statistical analysis to estimate this value. If the sample is representative of the population the distribution of WTP responses in the sample should reflect the distribution of WTP responses in the population. If I find the average WTP of the sample, I can then aggregate the results from the sample to the population to find the value we are looking for. We can calculate both the mean and median to get a better understanding of the distribution.

The ***distribution*** of the WTP in a sample of respondents to a CV survey can be expressed in several ways. By a probability density function PDF: f(z,·), or a cumulative density function CDF: F(z,·) or by a survivor function: S(z,·) = 1 - F(z,·).

There are two ways of representing the central tendency of a distribution. The sample mean WTP is the average WTP expressed by the respondents. This can be represented mathematically by the following equations:

$$\bar{C} = \int_0^\infty z\, f(z;\cdot)dz$$

$$\bar{C} = \int_0^\infty 1 - F(z;\cdot)dz = \int_0^\infty S(z;\cdot)dz$$

The sample median WTP however, is the sample WTP that divides the sample exactly in half.

$$F(z;\cdot) = F(z;\cdot) = 0.5$$

$$\tilde{C} = F^{-1}(0.5) = S^{-1}(0.5)$$

These two values are the same if the distribution is symmetrical. But WTP distributions are often right skewed, making the mean higher than the median. The two different ways of summarizing the distribution of WTP can be interesting for different purposes. If one is using these measures to base decision on:

- An efficiency criteria, then the mean would be the most interesting statistic.
- Majority voting rule, then you would get a better idea of how the population is spread out by using the median.

We report both values to get the most information out of the sample. Other aspects of the distribution can be of interest such as the amount of households with zero benefit, if the benefits are highly concentrated and how benefits vary with different parameters such as geographical area.

7.3.3 Models for testing validity of WTP values

When analyzing the results from the CV study, we are looking for what variables that affect WTP in a significant manner. One way of testing the validity of these estimates is be comparing the estimated parameters of the models to see if they have signs that confirm to prior expectations based on theory or other literature. Furthermore we can conduct T-tests se weather or not there are statistically significant. The test is based on the t-statistic:

$$t = \frac{\hat{\alpha}_0}{s.e.(\hat{\alpha}_0)}$$

Which is compared compare with critical value for a two-tailed t-test with 95 per cent confidence. One is also interested in explanatory power of the whole model. A way of measuring this is by looking at the pseudo R^2 statistic.

$$R^2 = 1 - \frac{\ln L_{max}}{\ln L_0}$$

Were $L_{max}$is the value of log likelihood function from the estimated model with covariates and L_0 is value of the log of the likelihood function from the unparameterized model. The statsic ranges from 0 to 1, and the closer to 1 is, the better.

7.3.4 Models for BT

Finally we want to create a model for BT. Base on this we can estimate a transfer equation, which measures WTP as a function of households' characteristics that is easily identifiable in other contexts.

7.4 Validity and reliability

Validity refers to the degree in which the study measures the intended quantity. The results are valid when value stated by a survey respondent for a given good is equal to the actual value which the respondent would express for that good if given the opportunity in a real market. CV studies often make two implicit assumptions; respondents have preferences and use these to determine valuation responses and these preferences are consistent with economic theory.

One can draw a distinction between the validity of the CVM in general and validity of CV studies in particular. There is a lot of debate on the validity of CV as a method, but even if one does accept the method there are many pitfalls that CV studies need to avoid in order to create valid results. The validity of the results depends entirely on the design and execution of the study. The study must do its best to be believable, understandable and be incentive compatible. This means the respondent must accept the hypothetical scenario and have the interest to respond truthfully. There are several ways of testing the validity of the results, although none of them can confirm the validity of results fully, they can however increase the confidence in the results.

Content or face validity has to do with whether the right questions been asked in the right way and presented understandably. Is the good and change in good presented clearly? Is the method of providing and collecting payment plausible?

Construct validity has to do with construction the study according to economic theory. We can perform certain test on the data to see if they are in accordance with economic theory.

Finally convergent validity can be tested by comparing results to those from other studies or methods. The findings should converge if they reflect the same true value.

Reliability relates to the degree of replicability of a measurement. This can entail testing and retesting in order to obtain WTP same individual different points in time, although the act of surveying individuals may influence subsequent views. Another approach is to compare WTP distributions from two independent but statistically equivalent samples from same population, typically interview at different points in time. Or one can compare stability of the estimated bid function in repeated samples.

7.5 Aggregation

The final part of analyzing CV results is aggregating the data from the sample over the population. Doing this is a straightforward process of multiplying the estimated mean WTP with number of units in population, if all the following conditions are met:

- Population of interest has been chosen
- Unit of observation has been chosen
- Random sample drawn
- All units in sample answered
- All units in sample provided complete responses
- Statistics of interest has been chosen

However this is often not the case and one has to apply weighting procedures to try to account for shortcomings of the sample. In ours study the population of interest are the households of Oslo. The unit of interest was the household, with respondents answering on account of their household. We purchased a random sample from the data-collection agency Norstat, where the sample was drawn using a soft quota to capture the geographical distribution of households. Unfortunately, immigrants where underrepresented in the sample. Norstat continued to draw respondents until we had achieved to goal of 1000 respondents. However not all the respondents provided a WTP. More information on measures to deal with the challenges of underrepresentation of immigrants and share of respondents that did not give WTP is provided in chapter 9.

8 Data collection and summary statistics

Chapter 9 Data collection and summary statistics presents the data collection method and presents the summary statistics.

8.1 Sample of respondents

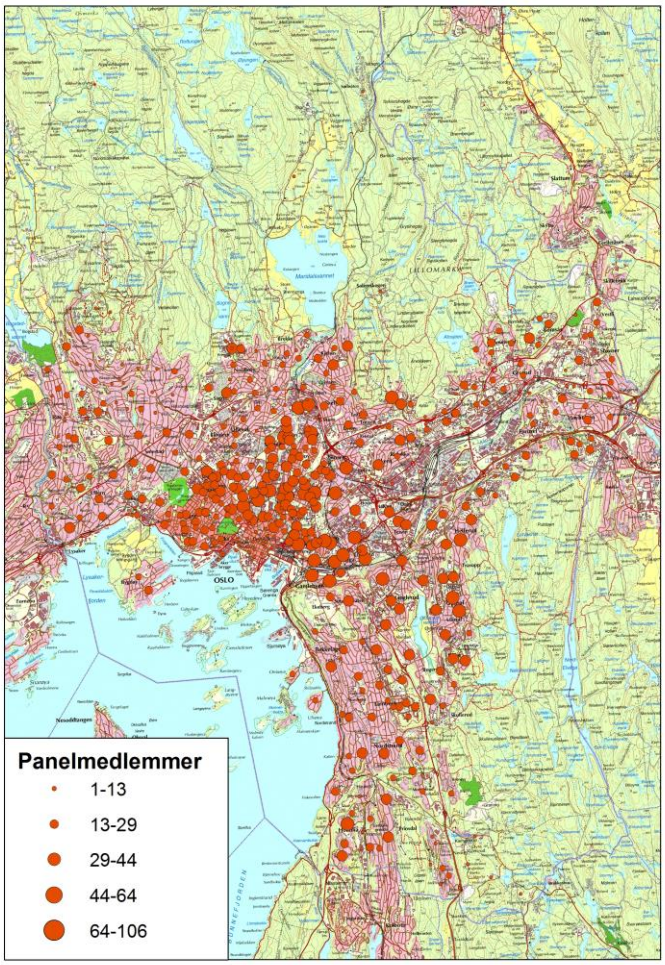


Figure 21Members of the panel. (Norstat, 2015)

The sample from the population of Oslo's inhabitants was selected through PANEL.no by the data collection-agency Norstat. See Figure 21 for illustration of geographical distribution of Norstat's panel members. We purchased this sample, requesting a random representative sample that reflects the geographical composition of the city. This was important since we were interested in studying spatial variation. A soft quota was used to ensure this, by drawing

randomly until fulfilling number respondents wished from each district based on the population distribution. I compared the data from our sample and data from SSB on Oslo inhabitants to check for representativeness.

There was a difference in the number of inhabitants in each zip code in Oslo and number of panel members in each zip code, making the probability of drawing a respondent from a certain zip code different from drawing a person from the population in randomized selection. Doing a randomized selection based on zip code would be too detailed for the panel. Therefore we did a randomized sample based on districts by setting a soft-quota on the districts. Meaning they stopped taking draws from a district when the quota from that district was filled.

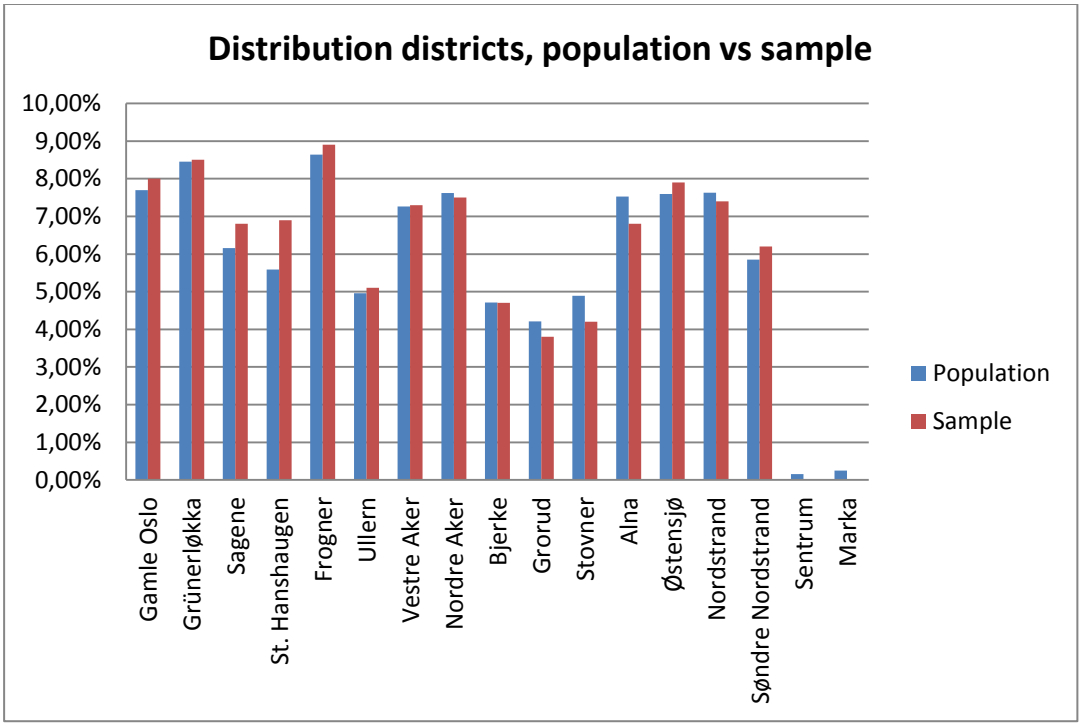


Figure 22 Distribution districts, population vs sample

The sample is representative for the population of Oslo. We did not have any respondents from Sentrum or Marka, but these districts are so small it does not matter. However they do represent the largest difference in terms of street trees so it would have been interesting to look at the replies from respondents in these districts.

The panel members answered the online web-survey, and we received the responses from Norstat and conducted our own analysis.

Socio-economic characteristics

For the full presentation of main summary statistics on socio-economic characteristics, see Appendix C. This includes number or percentage of respondents with each characteristics of interest, and an assessment of the representativeness of the sample compared to the population of interest; that is the household inhabitants of Oslo. The summary is presented in Table 6

Table 6 Respondent characteristics of sample compared to population

Respondent characteristics	Sample
Age	Good fit
Gender	Men slightly overrepresented
Education	Higher education distribution
Civil status	People with children underrepresented
Personal income	No good comparative statistic, but looks like a good fit
Place of birth	Immigrants underrepresented
District	Good fit
Living arrangement	Good fit

Overall the sample from Norstat reflects the population of Oslo fairly well. The only group that is significantly underrepresented is immigrants.

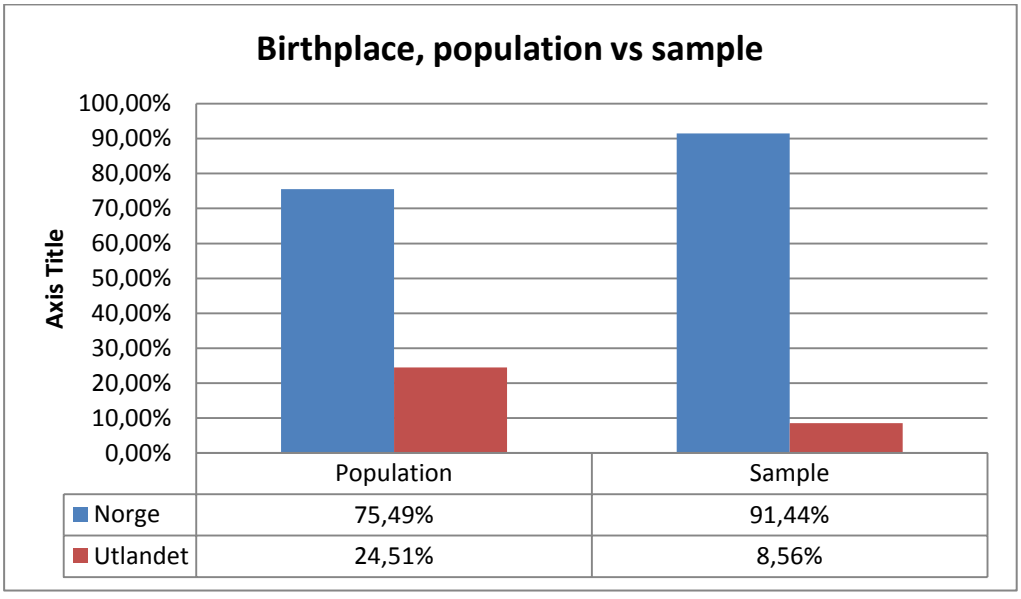


Figure 23 Birthplace, population vs sample

The population of Oslo is made up of 75% people born in Norway and 25% born abroad. In our sample only 9% was born abroad, making immigrants underrepresented in our sample.

Summary statistics: N, mean, sd
by categories of: born_utlandet

born_utlandet	WTP	age	gender	educat~n	civil_~s	income	outdoo~y
0	474	915	915	894	910	773	914
	340.1477	43.10492	1.48306	3.222595	6.341758	490944.4	41.95405
	539.558	16.61496	.4999862	.9598336	20.04167	244251.6	8.866916
1	49	85	85	85	85	64	85
	273.4694	40.58824	1.623529	3.494118	6.6	504687.5	40.81176
	334.8728	13.29097	.4873756	.9712967	20.44808	222845.7	9.667686
Total	523	1000	1000	979	995	837	999
	333.9006	42.891	1.495	3.24617	6.363819	491995.2	41.85686
	523.9133	16.36811	.5002252	.9633749	20.0664	242584.7	8.938362

born_utlandet	activi~s	attitu~s	bydel	sentru~y	q16	change
0	915	915	915	915	915	915
	5.790164	11.08415	7.650273	.3245902	2.549727	.7464481
	3.429457	2.182214	4.511605	.4684776	1.802165	1.731159
1	85	85	85	85	85	85
	6.376471	11.01176	7.835294	.3058824	2.941176	.8117647
	3.801555	1.76941	4.205572	.4635148	1.821518	1.531371
Total	1000	1000	1000	1000	1000	1000
	5.84	11.078	7.666	.323	2.583	.752
	3.464448	2.149543	4.484703	.4678567	1.806204	1.714478

Figure 24 Immigrants' characteristics compared to rest of sample

We compared values for the immigrants to those of the rest of the sample too see whether they differed. Immigrants had; lower WTP, slightly younger, more females, slightly higher educated, slightly higher income, little bit less outdoorsy, more activities, same attitude towards trees, lived a little bit less central, had a little more street trees but wanted more change in street tree density.

8.2 Summary statistics

In the following I will present some descriptive statistics of the survey including number or percentage of respondents indicating each possible response for some relevant questions. For summary statistics of all the relevant variables see Appendix C. In the subsequent section we will disaggregate groups according to identifiable groups of interest and investigate whether they differ significantly. And finally explore relationships between variables of interest.

8.2.1 Distribution of respondents across responses

There were a number of questions which were collected for the purpose of mapping the use of green structures in Oslo - a different study in the Oslo OpenNESS case study. These where not directly relevant to the CV study, but could be used to get some insight about the respondent types. Their explanatory power in relation to WTP was examined in the econometric analysis. To see the summary statistics of these questions see Appendix C. They

include questions about trips to different areas (forest, fjord and parks) in different seasons, activities done in green areas and interactive maps for drawing trips (what season, when in the week, how long + what activity and how often).

Other questions about household and location characteristics as well as attitudes were also collected. Such as view of natural structures from home, attitudes toward street trees, experienced benefits and costs from street trees where respondents live, reported current and desired street tree density in respondents' street, attitudes concerning street trees, and finally reported WTP.

The respondents were asked about their attitudes toward trees in the city. The vast majority was happy with amount or wanted more trees in Oslo, street trees in Oslo center and street trees in their district. Very few wanted less trees.

Respondents were asked about experienced benefits and disadvantages from street trees where they live. Most the respondents received benefits over 90%, whereas only 10% experienced disadvantages.

Figure 25 Form to report current and desired street tree situation in respondents' street

The respondent marked their house on the interactive digital map. They were shown a map excerpt of 100m in each direction of their house and asked to report the situation that most closely reflected the current density of street trees in their street. This was done to limit shortcomings in memory or biases, and give precise answers.

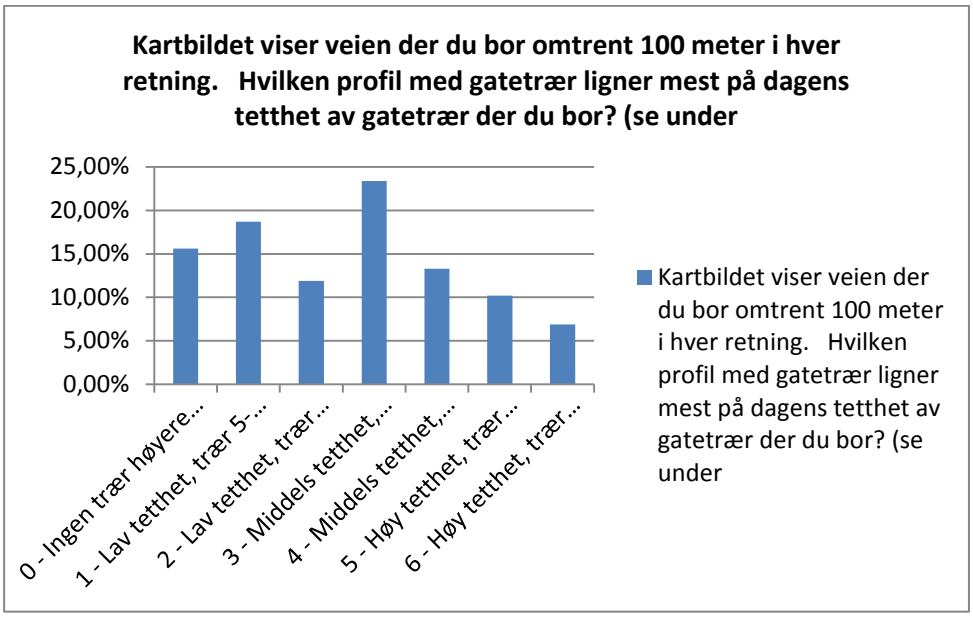


Figure 26 Distribution of current density of street trees in respondents' street

Figure 27 Distribution of desired density of street trees in respondents' street

With this information we could measure the difference in current and desired street tree density in the respondent's street.

change_trees	Freq.	Percent	Cum.
-10	6	0.60	0.60
-8	7	0.70	1.30
-5	32	3.20	4.50
-3	13	1.30	5.80
-2	7	0.70	6.50
0	561	56.10	62.60
2	31	3.10	65.70
3	120	12.00	77.70
5	158	15.80	93.50
8	43	4.30	97.80
10	22	2.20	100.00
Total	1,000	100.00	

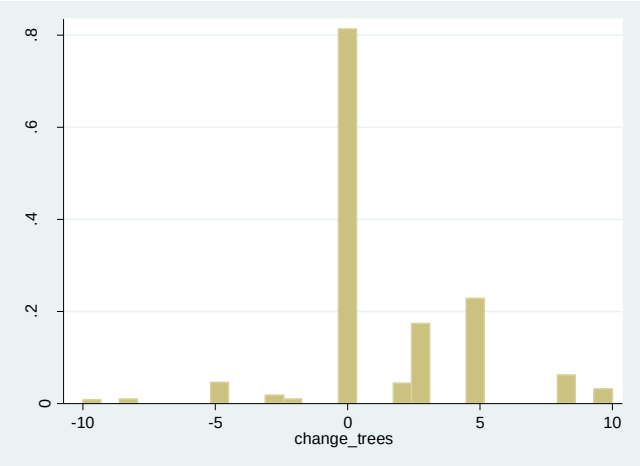


Figure 28 Distribution of desired change in level of street tree density in respondents own street, from survey.

More than 50% of the respondents wanted to maintain the current density of street trees, 40% wanted to increase it and only 6% wanted fewer street trees in their street. It is safe to say that people value and appreciate street trees where they live.

We asked the respondents some follow up questions about their attitudes concerning street trees. One of the things we were interested in was studying the substitution between public street trees and trees on private properties. The majority did not think street trees were not important because of other trees or natural structures acted substitutes. Another question was whether other trees acted as public goods that could be subsidized by the government. We found some indication of this.

Reported WTP for maintenance or increase in street trees

The environmental good in question was density of street trees in 100m of the street in front of respondents' house. The scenario was that with growing population there would be increasing pressures on the street trees of Oslo, and the costs of providing them for the municipality would go up. We asked whether they would be willing to pay to maintain or increase the level of street trees in their street, according to what they answered about their current and desired level of street tree density in their street. The respondents were themselves allowed to choose the payment vehicle. The payment would be annual and paid over the course of the next fifteen years.

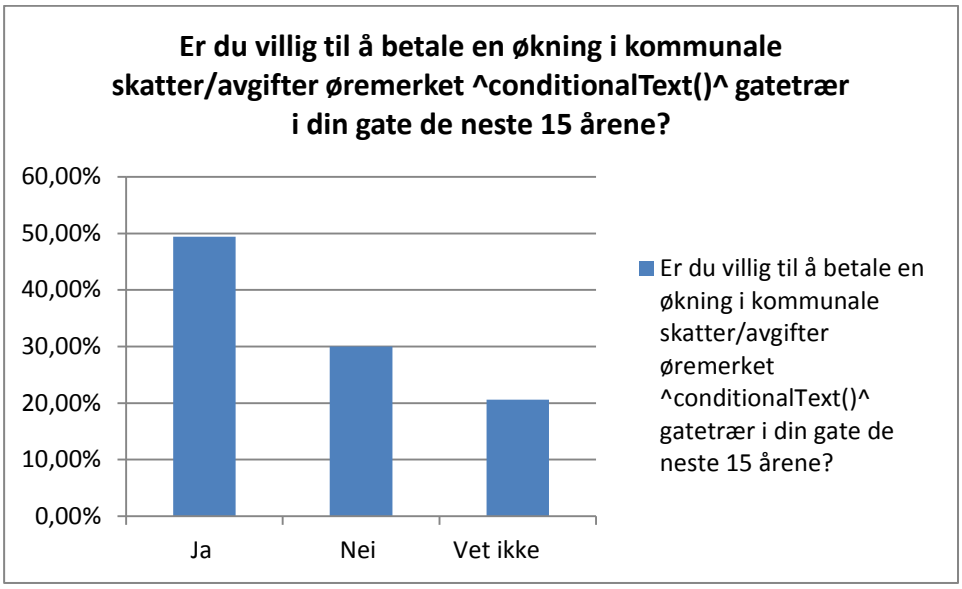


Figure 29 Number of respondents willing to pay for maintenance or increase in street trees

Half of the respondents were willing to pay for maintenance of increase in street trees. 30% reported they were not willing, and 20% did not know.

Table 7 Distribution of payment vehicle selected by respondents

BASE	423
En ny bymiljø-avgift per husstand øremerket gatetrær	25,50 %
En økning i dagens renovasjonsavgift per husstand øremerket gatetrær	25,80 %
En økning i kommune-skatt øremerket gatetrær	30,50 %
Omprioritere fra andre kommunale oppgaver, nemlig:	11,80 %
Andre finansieringsmåter:	6,40 %

One fourth of the respondents that said they were willing to pay chose a new city tax for every household specifically for street trees as the payment vehicle. One fourth chose an increase in an existing tax per household specifically for street trees. 30% chose an increase in the municipality tax specifically for street trees. 12% wanted the municipality to reprioritize from other expenditures. And 6% wanted another form of financing.

There is a point to make here about the fact that respondents were allowed to choose their own payment vehicle, arguably this means that the WTP reported where not done so in an identical manner. And we could not see the effect on WTP of different types of payment vehicle to see weather this part of the survey design had an effect on the reported WTP. We wanted people to understand and find the scenario plausible and decided to it in this way to

decrease the amount protest. And further more we wanted to see what type of payment vehicle the public wished to use in order to finance an environmental good such as this one.

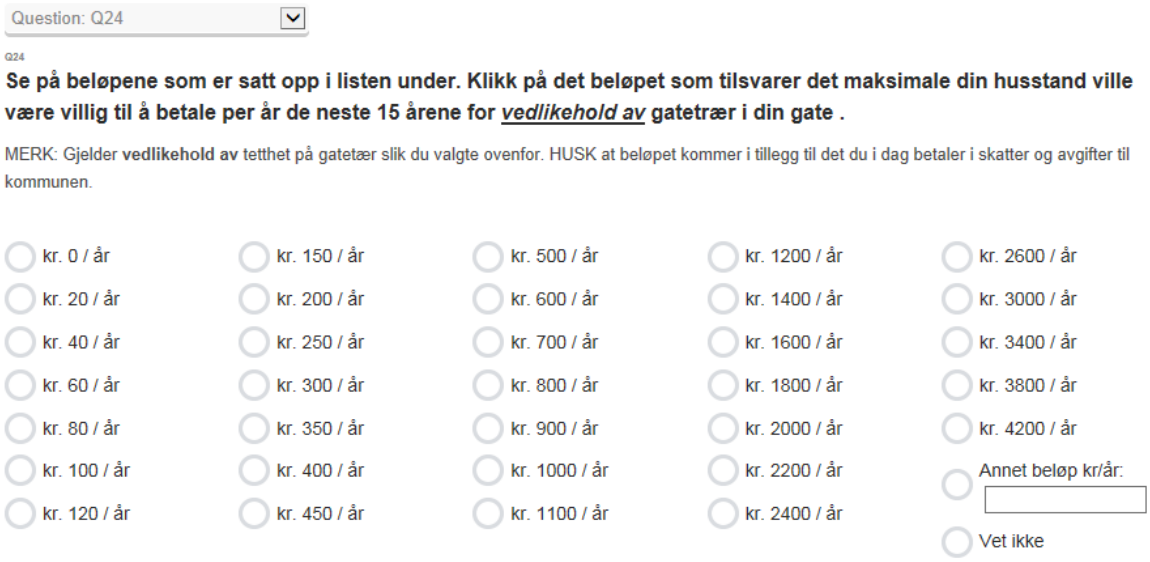


Figure 30 Picture of payment card used in survey

The respondents reported maximum WTP for the policy through a payment card, see Figure 30. The payment card had a large range and many levels in order to minimize anchoring bias.

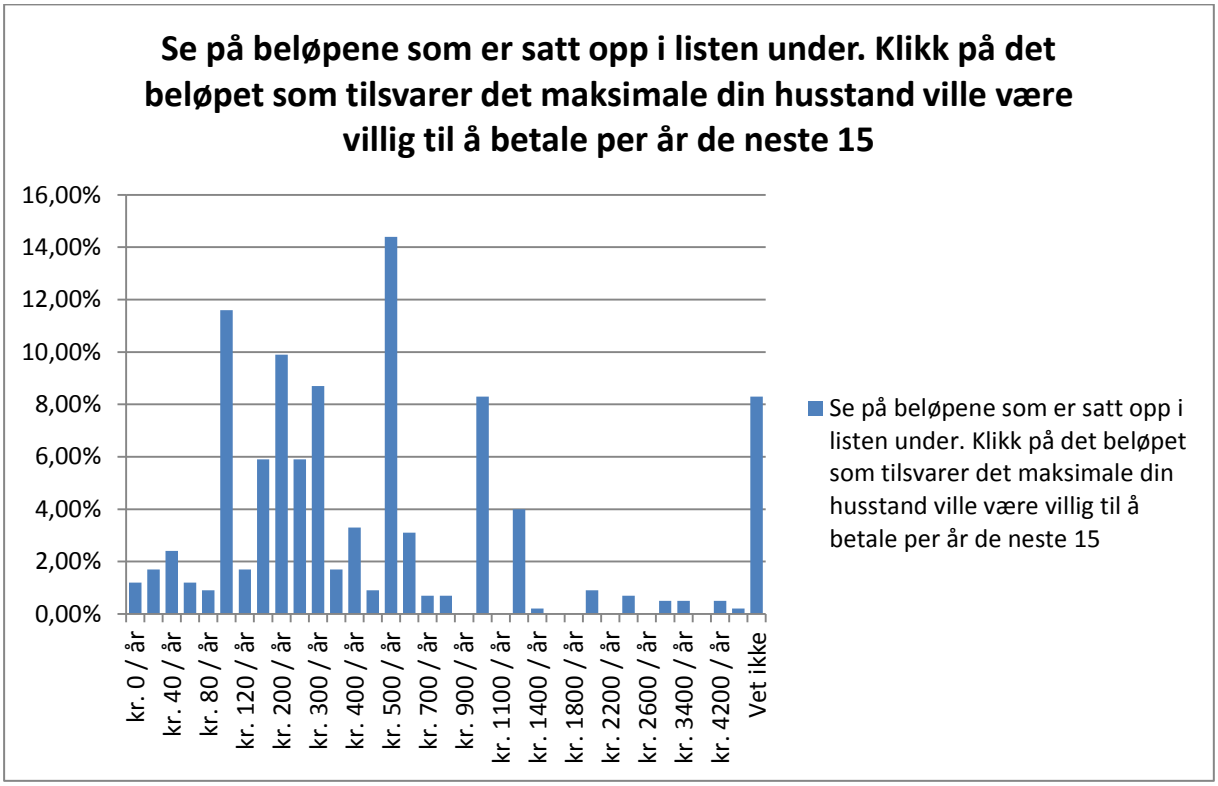


Figure 31 Distribution of reported WTP for maintenance or increase in street trees

In Figure 68 we see the distribution of reported WTP for maintenance or increase in street trees.

We asked some follow up questions to the respondents that had reported WTP to what they had had in mind when eliciting their WTP. This was used to investigate weather respondents had understood the CV exercise, and weather there was any scope effect.

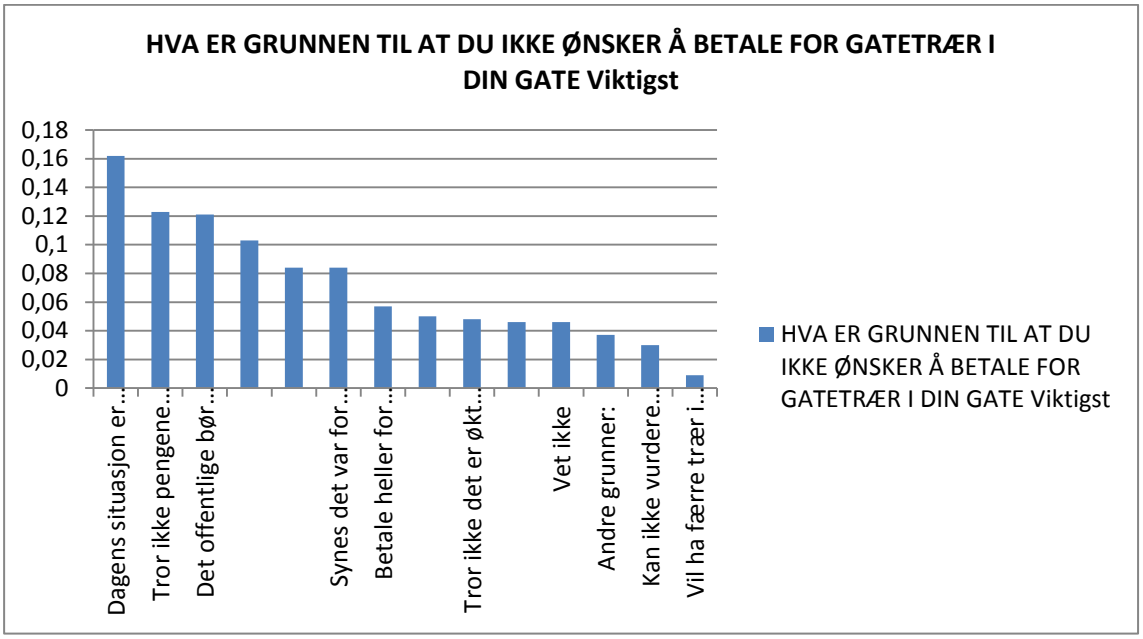


Figure 32 Reason for not wanting to report WTP

We asked follow up questions to the people that did not want to report a WTP and classified the answers as either true zero or protest responses. The subsequent distribution of reported WTP is presented in Figure 33. The distribution is clearly right skewed.

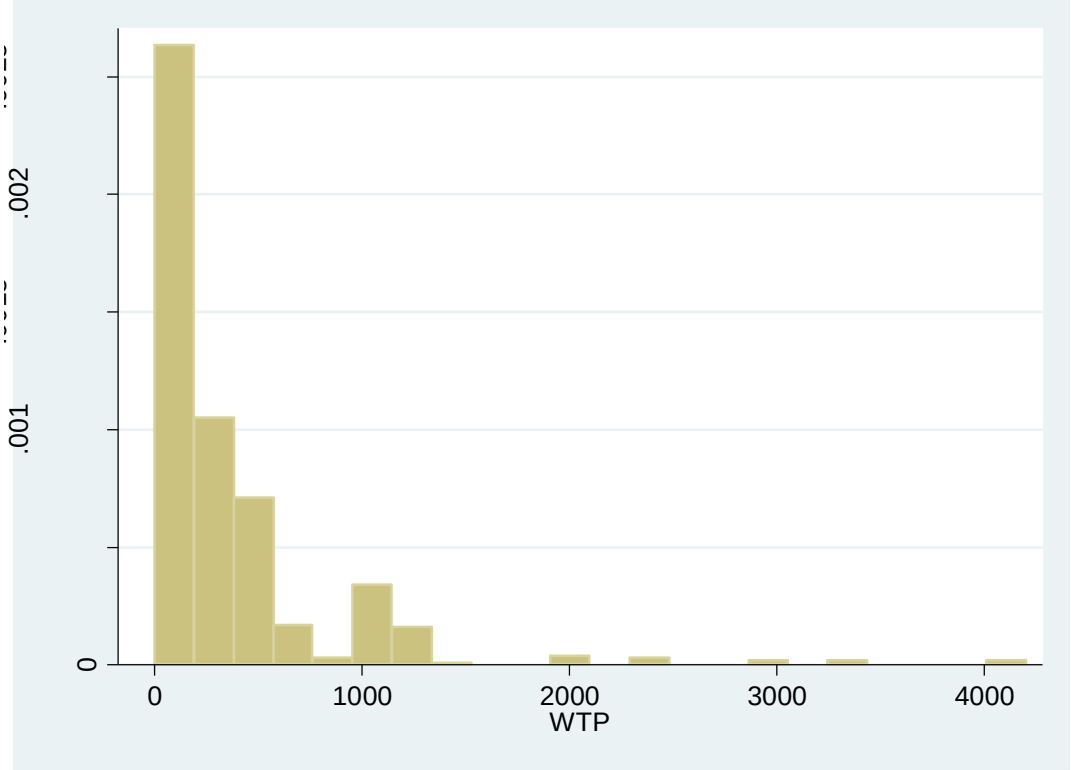


Figure 33 Distribution of reported WTP

We also wanted to know whether the people that wanted fewer street trees had a WTP to remove these trees. Very few did, and the few that did gave an unusually high number. Likely believing this was not a plausible cost to them, and possible being an incentive problem here, with them giving a high number to affect their wish.

8.2.2 Groups

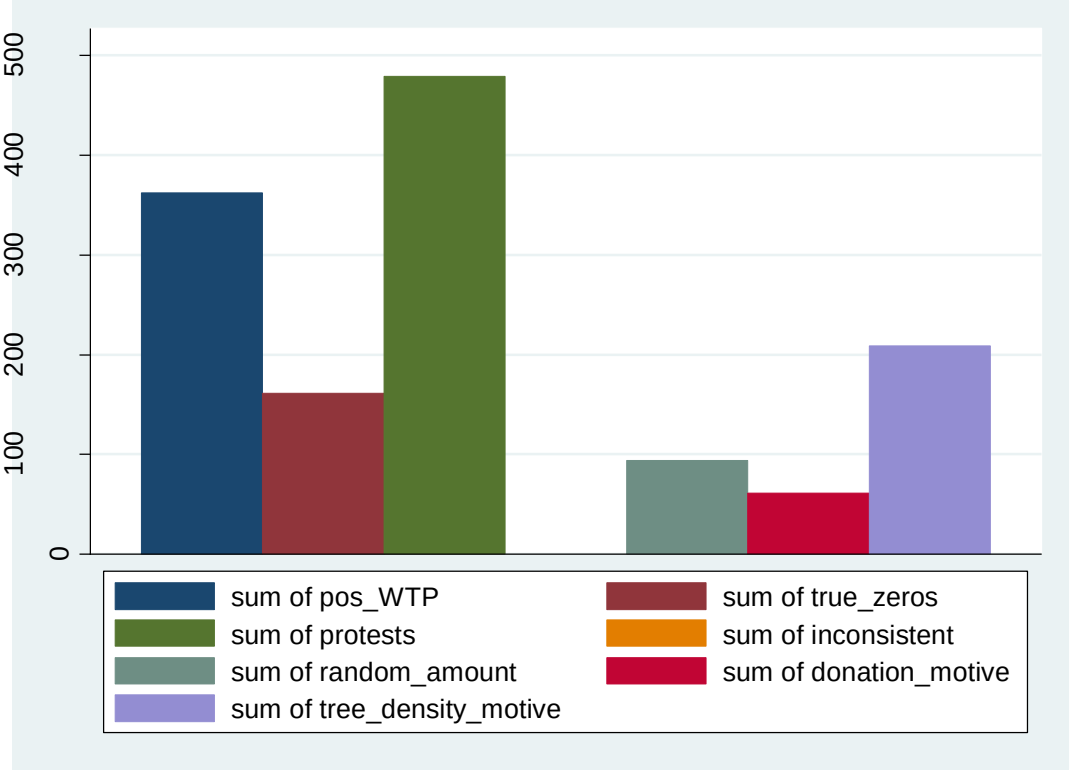


Figure 34 Number of respondents across different subsamples

Table 8 Number of respondents across different subsamples

Variable	Obs	Mean	Std. Dev.	Min	Max
pos_WTP	1000	.362	.4808193	0	1
true_zeros	1000	.161	.3677149	0	1
protests	1000	.477	.4997206	0	1
inconsistent	1000	0	0	0	0
random_amo~t	1000	.094	.2919747	0	1
donation_m~e	1000	.061	.2394501	0	1
tree_densi~e	1000	.209	.4067978	0	1

We can divide the respondents into different subsamples or groups according to the answers they gave to get a better idea of the distribution of answers in the survey. There was 1000 respondents in the survey, 523 gave reported a WTP. 363 of these respondents gave a positive WTP. 161 of them gave zero as their WTP. 477 of the respondents did not report a WTP. Nobody gave an inconsistent answer, meaning a positive WTP when they wanted a decrease in street trees. This is positive because it suggests that people understood the survey. Out of the people that gave WTP, 94 people gave arbitrary amount. These WTP answers where not counted since they did not reflect true WTP, but rather treated as no-answers. 61 people

reported that WTP was what they normally gave to good causes. This indicates a rather poor reasoning behind their WTP and suggests that it does not reflect their true WTP for street trees. Luckily this group was small. The group that reported that street tree density was the reason behind their reported WTP was 209. This is a rather small number since we wanted all the people reporting WTP to have this in mind when reporting WTP.

It is interesting to see how these groups vary in terms of the other variables and/or characteristics to see if they differ significantly.

WTP	age	gender	educat~n	civil_~s	income	outdoo~y	activi~s	attitu~s	bydel	sentru~y	q16	change
523	1000	1000	979	995	837	999	1000	1000	1000	1000	1000	1000
333.9006	42.891	1.495	3.24617	6.363819	491995.2	41.85686	5.84	11.078	7.666	.323	2.583	.752
523.9133	16.36811	.5002252	.9633749	20.0664	242584.7	8.938362	3.464448	2.149543	4.484703	.4678567	1.806204	1.714478
523	523	523	515	520	456	523	523	523	523	523	523	523
333.9006	42.1912	1.518164	3.357282	6.057692	479166.7	41.23709	6.202677	11.43977	7.206501	.3441683	2.541109	1.179732
523.9133	16.20208	.5001483	.9625883	19.526	231441.2	8.502941	3.551082	1.9539	4.336802	.4755511	1.705224	1.455012
362	362	362	356	359	320	362	362	362	362	362	362	362
482.4033	41.79282	1.497238	3.396067	5.579387	494062.5	40.12431	6.535912	11.81768	6.900552	.3867403	2.671271	1.28453
570.1441	15.7004	.5006844	.9179808	18.43754	231654.3	7.917757	3.560336	1.899094	4.379637	.4876774	1.700482	1.495787
161	161	161	159	161	136	161	161	161	161	161	161	161
0	43.08696	1.565217	3.27044	7.124224	444117.6	43.73913	5.453416	10.59006	7.89441	.2484472	2.248447	.9440994
0	17.29429	.4972752	1.053539	21.7818	227958.6	9.237506	3.424088	1.807872	4.170735	.4334607	1.684603	1.333456
0	477	477	464	475	381	476	477	477	477	477	477	477
.	43.65828	1.469602	3.122845	6.698947	507349.1	42.53782	5.442348	10.68134	8.169811	.2997904	2.628931	.2830189
.	16.53118	.499599	.9501595	20.65724	254741.5	9.355248	3.325375	2.28236	4.593393	.458647	1.911553	1.850955
73	94	94	93	92	82	94	94	94	94	94	94	94
284.1096	41.90426	1.585106	3.516129	4.945652	508536.6	39.54255	6.43617	11.20213	6.861702	.4042553	2.638298	1.265957
218.8787	15.85761	.4953455	.8798827	17.19786	228900.3	7.602581	3.4844	2.029777	4.180346	.4933787	1.696619	1.503941
56	61	61	60	60	53	61	61	61	61	61	61	61
424.6429	42.77049	1.508197	3.266667	8.2	467924.5	40.13115	6.147541	11.34426	6.885246	.3770492	2.737705	.9016393
377.7154	17.18177	.5040817	.8994663	24.2164	215525.8	7.965499	3.581601	2.414437	4.086964	.4886694	1.537331	1.350369
200	209	209	205	208	186	209	209	209	209	209	209	209
495.2	42.53589	1.497608	3.385366	6.802885	479032.3	40	6.607656	11.97608	6.727273	.4210526	2.712919	1.397129
537.5638	16.42846	.5011947	.892661	21.28243	232823.2	7.985564	3.580011	1.993837	4.381701	.4949134	1.73035	1.575104

Figure 35 The number of respondents, mean value and standard deviation for selected variables – of the groups; all, reported WTP, positive WTP, zero WTP, protests, random amount WTP, donation motive behind WTP and tree density motive behind WTP.

Respondents that reported WTP were a bit younger, more female, higher educated, poorer, less outdoorsy, more activities, wanted more trees, lived more central, less street trees in their street and wanted less change compared to rest of sample.

Respondents that reported positive WTP were a bit younger, more female, higher educated, less outdoorsy, more activities, wanted more trees, lived more central, more street trees in their street and wanted more change compared to rest of sample.

Respondents that reported zero WTP were a bit older, more female, more outdoorsy, less activities, wanted less trees, lived less central, less street trees in their street and wanted more change compared to rest of sample.

Respondents that did not report WTP were a bit older, less female, lower education, higher income, more outdoorsy, less activities, wanted less trees, lived less central, more street trees in their street and wanted less change compared to rest of sample.

Respondents that reported arbitrtary amount WTP had lower WTP, were a bit younger, more female, higher education, higher income, less outdoorsy, more activities, lived more central, more street trees in their street and wanted more change compared to rest of sample.

Respondents that reported donation_motive behind WTP had higher WTP, more female, lower income, less outdoorsy, more activities, more street trees in their street and wanted more change compared to rest of sample.

Respondents that reported tree density motive behind WTP had higher WTP, were a bit younger, higher education, lower income, less outdoorsy, more activities, wanted more trees, lived more central, more street trees in their street and wanted more change compared to rest of sample.

Another group of interest is the group of responded that reported a desired change of zero. That is they were happy with the tree density as it is today. The number of respondents in total and the respondents with change equal to zero was almost identical in distribution across subsamples. This indicates that there was nothing different about the group that wanted zero change, compared to the rest of the sample.

9 Econometric results

Chapter 10 Econometric results is where I analyze the data and estimate WTP for the sample. We also inspect geographical variation. And finally, aggregate from the sample to the population and give a presentation of the findings.

9.1 Analysis of WTP data

In the following section I present the type of data collected. I examine the treatment of refusals and protest bids, and check for any systematic bias in the characteristics of the sample if these bids are excluded. I present the weighting procedures to correct for lack of representativeness and the treatment of missing data. I present specification of the model and conduct model estimation and results. Finally estimation of mean and median WTP will be presented.

9.1.1 Type of data

We used a payment card that allowed respondents to report their WTP by choosing between 33 different values ranging from 0-4200 NOK/year or by specifying amount themselves. Only one person chose to specify amount themselves, and that amount was equal to one of the options in the payment card. The payment card was had a large range and was so detailed in order to minimize any anchoring bias. Furthermore the payment card was so extensive that we did not find it necessary to use interpret it as interval data, but rather treat it as a continuous range. The effect on the estimation from the two different approaches would likely not lead to any significant difference.

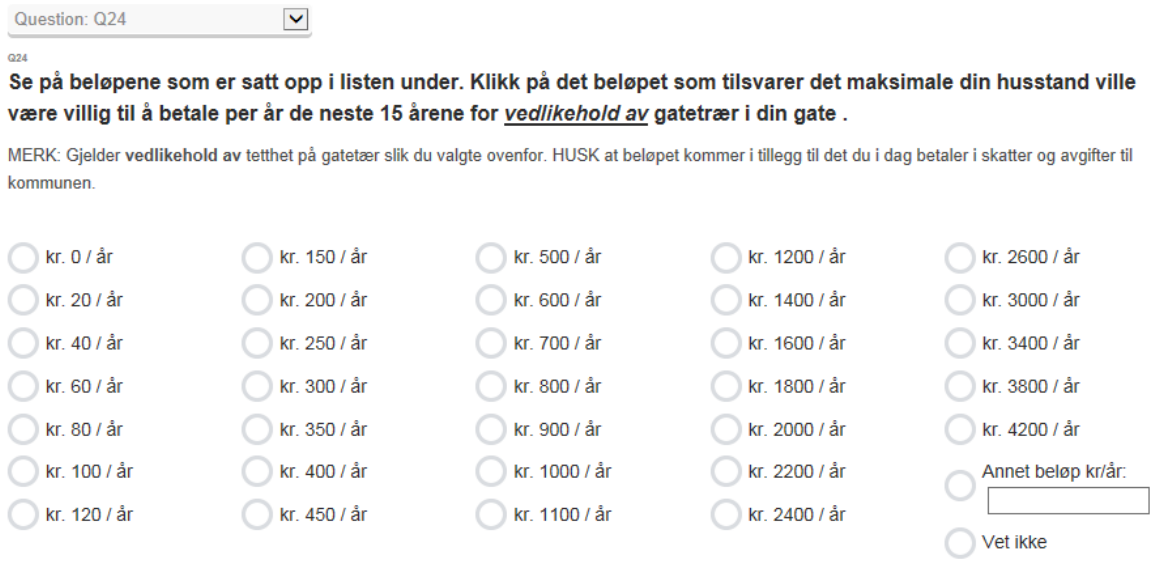


Figure 36 Payment card used in survey

9.1.2 Refusals and protest bids

We asked the respondents who did not want to report their WTP follow up questions on the reason why in order to classify them as either true zero answers or protest bids. See Table 9 for the classification. If the reason for why they did not report WTP was because they in fact had zero WTP, I would treat these answers as WTP=0 and they would go into the calculation of WTP. The protests would be left out.

Table 9 Reasons for not reporting WTP

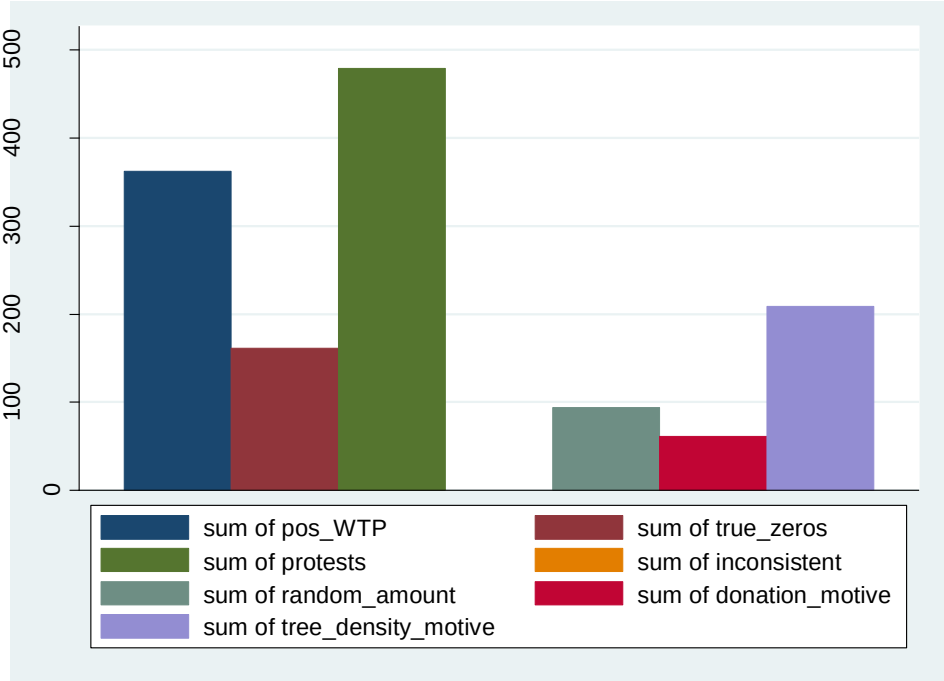
BASE	Protest svar
Tror ikke det er økt behov for vedlikehold i min gate	1
Tror ikke pengene blir øremerket gatetrær i min gate	1
Dagens situasjon er god nok i min gate	0
Vil ha færre trær i min gate	0
Ingen garanti for at min gate prioriteres	1
Betale heller for andre kommunale oppgaver	0
Bruker heller penger på andre ting	0
Det offentlige bør betale	1
Kommunale avgifter er allerede for høye	1
Har ikke råd til å betale noe mer	0
Kan ikke vurdere miljø i penger	1
Synes det var for vanskelig å svare	1
Vet ikke	1

Andre grunner:

In addition there was an opportunity to report "I don't know" in the payment card. And when asking people about what they had in mind when eliciting WTP, we found that some had reported there WTP arbitrarily, and decided that these would not be treated as true WTP.

The missing WTP values we are left with are:

1. People that reported WTP, but stated "I don't know"
2. People that did not report WTP and gave a protest reason (i.e. not a true zero WTP)
3. People that reported the WTP reported was arbitrary, and therefore not valid



Variable	Obs	Mean	Std. Dev.	Min	Max
pos_WTP	1000	.362	.4808193	0	1
true_zeros	1000	.161	.3677149	0	1
protests	1000	.477	.4997206	0	1
inconsistent	1000	0	0	0	0
random_amo~t	1000	.094	.2919747	0	1
donation_m~e	1000	.061	.2394501	0	1
tree_densi~e	1000	.209	.4067978	0	1

Figure 37 Number of respondents with positive WTP, zero WTP, protests, inconcsistent WTP, random-, donation- and tree densisity-motive behind WTP

After correcting for the refusals and protest bids we were left with the following numbers. 36% had positive WTP, 16% had true zero WTP, 48% protested. In addition to these subsamples there are three other groups identified. Inconsistent WTP, consisting of people that reported positive WTP but desired fewer street trees than the current situation. There were no respondents in this category, indicating that respondents had understood the CV set up. Respondents that reported that the motive behind their WTP was that it was similar to what they normally gave to good causes. Finally, the group that reported the motivation behind their WTP was wish for street trees in Oslo and or their street.

Summary statistics: N, mean, sd
by categories of: protests

protests	WTP	age	gender	educat~n	civil_~s	income	outdoo~y
0	523	523	523	515	520	456	523
	333.9006	42.1912	1.518164	3.357282	6.057692	479166.7	41.23709
	523.9133	16.20208	.5001483	.9625883	19.526	231441.2	8.502941
1	0	477	477	464	475	381	476
	.	43.65828	1.469602	3.122845	6.698947	507349.1	42.53782
	.	16.53118	.499599	.9501595	20.65724	254741.5	9.355248
Total	523	1000	1000	979	995	837	999
	333.9006	42.891	1.495	3.24617	6.363819	491995.2	41.85686
	523.9133	16.36811	.5002252	.9633749	20.0664	242584.7	8.938362

protests	activi~s	attitu~s	bydel	sentru~y	q16	change
0	523	523	523	523	523	523
	6.202677	11.43977	7.206501	.3441683	2.541109	1.179732
	3.551082	1.9539	4.336802	.4755511	1.705224	1.455012
1	477	477	477	477	477	477
	5.442348	10.68134	8.169811	.2997904	2.628931	.2830189
	3.325375	2.28236	4.593393	.458647	1.911553	1.850955
Total	1000	1000	1000	1000	1000	1000
	5.84	11.078	7.666	.323	2.583	.752
	3.464448	2.149543	4.484703	.4678567	1.806204	1.714478

Checking for any systematic bias in the characteristics of the protests compared to the rest of the sample. Protests are; slightly older, more male, little lower education, higher income, a little more outdoorsy, does fewer activities, want a little less trees than the rest of the sample, live less central, has a bit more street trees and wants a lot less change in street trees.

Weather this group is significantly different from the rest of the sample is important if we were to aggregate the results to the entire population. If non-response is correlated with true WTP, then excluding them would lead to a systematic bias in the results. Because we do not know true WTP, we cannot check for this. If we assume that non-responders have similar

WTP to those with similar characteristics. And if excluding non-responders does not bias the representativeness of sample, then excluding them will not bias WTP analysis.

I have chosen not to aggregate over the entire population. This approach does not say anything about the people that did not want to give WTP, so it is a conservative approach. When we will only aggregate over 52,3 percent aggregate of Oslo's household which is the percentage of the population that did elicit a WTP.

9.1.3 Weighting procedures/representativeness

Immigrants

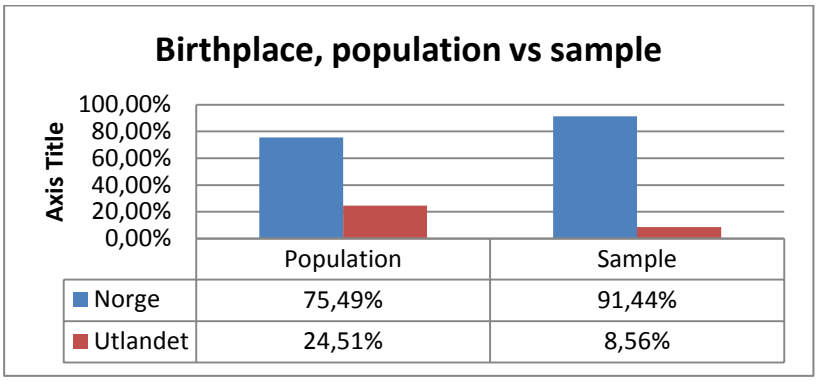


Figure 38 Birthplace of inhabitants of Oslo (SSB, 2015) compared to that in the sample

	Population	Sample	Mean WTP	Weighted mean WTP
Norge	75%	91% 340 WTP	340*0,91+273*0,09= 309+24=333	340*0,75+273*0,25= 255+68,25=323,25
Utlande	25%	9% 223 WTP		

Mean WTP 333 -> weighted WTP 323,25

When comparing the number of immigrants in the sample (9%) to that of the population (25%), it is clear that they are underrepresented in the survey. The Immigrants that where represented in the sample had a significantly lower mean WTP than the rest of the sample.

The mean WTP of the entire sample was 333 kroners a year per household over the next 15 years. Weighing the results to account for the under-representativeness ow immigrants I can obtain a new weighted mean WTP of 323,25. This is a 10,- difference in means estimated WTP, quite a significant difference in this context.

However since I have chosen not to aggregate over the entire population, it will not be necessary to correct for the under-representativeness of immigrants in the final calculations of thee results from the study.

9.1.4 Missing data

Variable	Obs	Mean	Std. Dev.	Min	Max
WTP	523	333.9006	523.9133	0	4200
age	1000	42.891	16.36811	18	90
gender	1000	1.495	.5002252	1	2
education	979	3.24617	.9633749	1	5
civil_status	995	6.363819	20.0664	1	98
income	837	491995.2	242584.7	100000	1500000
q32	1000	2.16	1.108887	1	5
q34_1	1000	4.393	.96617	1	5
q34_2	1000	3.723	1.298444	1	5
q34_3	1000	3.408	1.321848	1	5
outdoorsy	999	41.85686	8.938362	12	60
activities	1000	5.84	3.464448	0	21
attitude_t~s	1000	11.078	2.149543	3	15
neg_trees	117	2.675214	1.55269	0	7
pos_trees	812	5.406404	2.369631	1	12
q21_1	950	3.462105	1.244645	1	5
q21_2	950	3.426316	1.26155	1	5
q21_3	950	2.545263	1.147478	1	5
q21_4	950	2.501053	1.132664	1	5
zipcode	1000	667.414	316.1682	139	1295
bydel	1000	7.666	4.484703	1	15
q2	1000	3.773	6.141106	1	98
q4_sum_view	1000	3.15	1.749446	1	13
q16	1000	2.583	1.806204	0	6
q18	1000	3.335	1.747521	0	6
change	1000	.752	1.714478	-6	6
change_trees	1000	1.447	3.164681	-10	10
change_he~t2	1000	11.9775	29.69664	-110	110
change_he~t3	1000	8.88	26.53205	-100	100
q25_1	383	2.389034	1.054824	1	5
q25_2	383	1.895561	.885932	1	5
q25_3	383	3.156658	1.098071	1	5
q25_4	383	3.114883	1.220404	1	5
q25_5	383	3.451697	1.249981	1	5

The response rate on socioeconomic variables where quite good. Income was a bit low with 83,7 % of respondents giving an answer. We could try to predict missing data by creating regression equations explain variables as functions of other variables. And then use these regressions to predict the values of relevant variables for the missing values.

reg income age gender education

predict income_hat

sum income_hat

```
sum income_hat
```

Variable	Obs	Mean	Std. Dev.	Min	Max
income_hat	979	486259.5	126002.6	149028.2	836972.1

I tried doing this for income and got income values for 97,9 % of the respondents. It is unclear that this would in fact give us better explanatory power when studying WTP. I decided not to do continue with this approach.

9.1.5 Specification of the model

The bid function explains variation in WTP based on characteristics of the good, prices of other goods, income and other socio-economic characteristics as well as other factors that may affect WTP. There is a tradeoff between the two different approaches. The bid function is a relative simple function, but the utility difference model is more directly connected to neo-classical utility maximization theory. I have decided to go for the bid function approach. Where I calculate the effect of explanatory variables on WTP. Opposed to utility difference where they calculate the effect of explanatory variables on utility.

9.1.6 What variables to include in model

We investigated all the variables we had reason to expect had a significant effect on WTP. The variables are listed in Table 10 and grouped in four different groups – respondent characteristics, respondent attitudes, location characteristics and scope.

Table 10 Variables that may affect WTP

Group	Variable	Expected effect on WTP
Respondent characteristics	Age	+
	Gender	-
	Birthplace	-
	Education	+
	Civil status	+/-
	Personal income	+
	Number of people in household	+/-
	Age groups people in household	+/-
	How long lived in (Oslo, district, street)	+
	Outdoorsy	+/-
	Activities	+/-
Respondent attitudes	Attitude trees (Oslo, Oslo center and district)	+
	Benefits from street trees	+
	Disadvantages from street trees	-
	Street trees not important because of other public trees	-
	Street trees not important because of private trees that fulfill same functions	-
	These private trees should be treated as public street trees	+
	When private trees are regulated by public interest, owners should be compensated	+
Location characteristics	Zip code	+/-
	District	+/-
	Living arrangement	+/-
	View of natural structures from home	+/-
	Current street tree density	-
Scope	Desired street tree density	+
	Desired change in street tree density	+
	Are you willing to pay	+
	Amount WTP	+
	WTP motivated by street tree density in street	+
	WTP motivated by street tree density in city	+
	WTP motivated by comparing other taxes	-
	WTP motivated by what I usually donate to good causes	-
	WTP was arbitrarily chosen	-

WTP regressed against individual variables

Over 40 percent of the respondents that reported WTP report zero, meaning regressing WTP on explanatory variables by OLS could lead to biased and inconsistent estimates. Instead estimates have been obtained using the MLE model tobit ll(0). (Left censoring limit at 0)

I ran regressions (tobit ll(0)) to investigate the effect of the different variables on WTP. The variables with significant effect where:

Respondent characteristics: education, par_uten_barn, income, q33_4&_6 (Age groups people in household, 17-19 år & 35-49 år), periode_lived_in_oslo, outdoorsy, activities

Respondent attitudes: attitude_trær_i_oslo, attitude_gatetrær_i_oslo_sentrum, attitude_gatetrær_i_din_bydel, attitude_trees, pos_trees, q21_1/2/3 (Street trees not important because of other public trees, Street trees not important because of private trees that fulfill same functions, These private trees should be treated as public street trees)

Location characteristics: zipcode, bydel, grunerløkka, vestre_aker, bjerke, alna, sentrum_dummy, enebolig_leiet, leilighet_leiet

Scope: q18 (desired density), change/pos/trees/trees_pos/height2/height3, payment vechicle, q25_2/3/4/5 (WTP motivated by street tree density in city, WTP motivated by comparing other taxes, WTP motivated by what I usually donate to good causes, WTP was arbitrarily chosen)

9.1.7 Model estimation and results

Over 40 percent of the respondents that reported WTP report zero, meaning regressing WTP on explanatory variables by OLS could lead to biased and inconsistent estimates. Instead estimates have been obtained using the MLE model tobit ll(0). (Left censoring limit at 0)

Estimated models

Based on the variables that where significant in the one on one tobit regressions against WTP, we constructed a number of models. Each model had its variables correlation matrices checked, and one of the variables with a correlation higher that 0.3 in each correlation pair had to be dropped in order to avoid multicollinearity. For more details and explanation behind reason for which variables to be dropped see Appendix C. Table 11 presents results from

model with respondent characteristics, Table 12 presents results from model with respondent attitudes,

Table 13 presents results from model with location characteristics and Table 14 presents results from model with scope variables. Table 15 presents results from model with group variables except for scope in one model. Table 16 presents results from model with all variables in one model after dropping highly correlated variables.

Table 11 Model with respondent characteristics

VARIABLES	(1) Respondent characteristics	(2) Respondent characteristics
income	2.42e-05	
	(0.000152)	
nr_people_in_hh	-77.82**	
	(38.86)	
q33_4	-205.2	
	(147.3)	
q33_6	92.64	
	(74.50)	
period_lived_in_oslo	94.08**	
	(41.15)	
outdoorsy	-3.043	
	(4.466)	
activities	14.08	
	(9.818)	
Constant	32.16	557.2***
	(312.7)	(27.60)
Observations	307	307
rmse	.	.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the model with only respondent characteristics, the variables with a significant effect on WTP where number of people in household which had a negative effect and the period the respondent had lived in Oslo which had a positive effect.

Table 12 Model with respondent attitudes

VARIABLES	(1) Respondent attitudes	(2) Respondent attitudes
attitude_trees	102.8***	
	(15.31)	
pos_trees	60.51***	
	(12.40)	
q21_3	-18.34	
	(24.27)	
Constant	-1,241***	570.3***
	(200.4)	(23.05)
Observations	439	439
rmse	.	.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the model with only respondent attitudes, the variables with a significant effect on WTP where attitude toward trees and number of experienced benefits from street trees where respondent lived, both variables led to higher WTP.

Table 13 Model with location characteristics

VARIABLES	(1) Location characteristics	(2) Location characteristics
vestre_aker	-178.8	
	(125.2)	
bjerke	-220.6	
	(141.7)	
alna	-223.5*	
	(131.0)	
sentrum_dummy	153.5**	
	(70.28)	
enebolig_leiet	-939.7**	
	(417.7)	
leilighet_leiet	86.10	
	(83.08)	
Constant	165.4***	668.4***
	(47.57)	(26.03)
Observations	523	523
rmse	.	.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the model with only location characteristics, the variables with a significant effect on WTP was the dummy variable indicating weather the respondent lived in the center of Oslo, which led to higher WTP. If s/he lived in Alna, the WTP was lower. If respondent lived in a rented house, then the WTP would be quite a bit lower.

Table 14 Model with scope variables

VARIABLES	(1) Scope	(2) Scope
change	80.36***	
	(18.52)	
payment_vehicle	-31.52	
	(24.16)	
q25_2	-72.64**	
	(32.34)	
q25_3	64.29**	
	(28.78)	
q25_4	4.395	
	(26.16)	
q25_5	119.6***	
	(24.78)	
Constant	-57.63	518.2***
	(153.8)	(19.26)
Observations	362	362
rmse	.	.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the model with only scope variables, the amount of desired change had a significant effect on WTP which is what we would expect. This is also the case for what respondent had in mind when reporting WTP.

Table 15 Model from group variables except scope

VARIABLES	(1) combine-groups	(2) combine-groups
income	9.49e-05	
	(0.000145)	
nr_people_in_hh	-15.45	
	(37.12)	
q33_4	14.78	
	(144.2)	
q33_6	45.51	
	(69.36)	
period_lived_in_oslo	106.1***	
	(38.32)	
outdoorsy	-1.305	
	(4.005)	
attitude_trees	75.74***	
	(16.57)	
pos_trees	45.77***	
	(13.32)	
q21_3	-35.68	
	(25.99)	
vestre_aker	-23.87	
	(132.4)	
bjerke	-18.15	
	(147.3)	
alna	-270.7**	
	(127.0)	
sentrum_dummy	71.97	
	(70.83)	
enebolig_leiet	-3,102	
	(0)	
leilighet_leiet	85.06	
	(97.64)	
Constant	-1,222***	461.8***
	(345.5)	(23.73)
Observations	258	258
rmse	.	.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the model made up of the variable groups combined except for scope, the period lived in Oslo, their attitude towards trees, experienced benefits from street trees had a significant positive affect on WTP. While living in Alna led to a lower WTP.

Table 16 Model from all variables

VARIABLES	(1) All variables	(2) All variables
gender	22.48	
	(67.68)	
born_utlandet	-85.74	
	(111.6)	
income	0.000377**	
	(0.000157)	
barn_in_hh	-129.9	
	(83.12)	
period_lived_in_oslo	87.21**	
	(37.23)	
outdoorsy	-8.458**	
	(4.051)	
attitude_trees	123.3***	
	(16.71)	
q21_3	-40.60	
	(28.99)	
q21_4	-14.56	
	(30.35)	
sentrum_dummy	134.0*	
	(70.93)	
enebolig_leiet	-775.6**	
	(387.2)	
leilighet_leiet	255.8***	
	(94.20)	
q4_sum_view	44.08**	
	(19.21)	
q16	1.770	
	(19.39)	
Constant	-1,511***	634.9***
	(393.3)	(26.01)
Observations	456	456
rmse	.	.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the model made up of all the variables after removing variables that where too highly correlated, I found that income had a very small but significant positive effect on WTP. Period lived in Oslo also had a positive effect. The indicator outdoorsy which reflects the amount of trips respondent takes to the fjord, forests and parks of Oslo had a negative effect on WTP. This could indicate a substitution effect. Living in the center of Oslo had a positive effect. So did living in a rented apartment, but living in a rented house led to a lower WTP. This might have to do with the location specific conditions of rented apartments versus rented houses.

Model for benefits transfer

This is a model for benefits transfer; it only contains significant variables that can easily be found so that it can be used in other areas. Sentrum_dummy the largest significant variable. Income is significant in tobit regression, but effect is really small. Income is not significant in OLS regression.

Table 17 Results from benefits transfer model, using tobit and OLS

VARIABLES	(1) BT Tobit	(2) BT Tobit
income	0.000291*	
	(0.000149)	
sentrum_dummy	214.4***	
	(71.78)	
Constant	-11.81	700.3***
	(83.77)	(28.99)
Observations	456	456
rmse	.	.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(1) BT Reg
income	0.000173
	(0.000111)
sentrum_dummy	139.4***
	(53.57)
Constant	220.8***
	(60.73)
Observations	456
R-squared	0.021
rmse	544.9

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

9.1.8 Estimation of mean and median

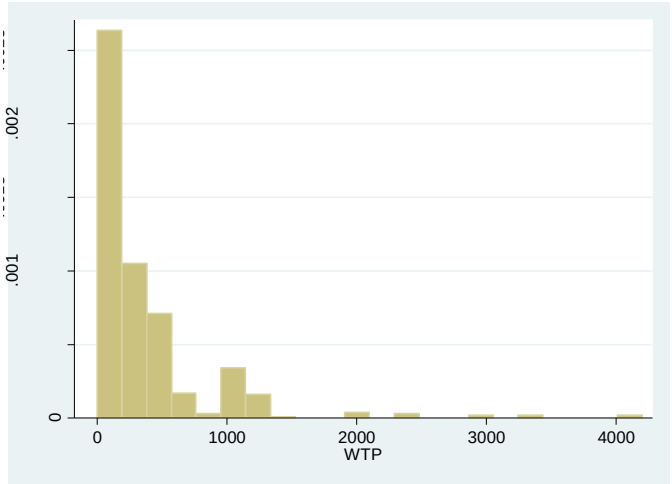


Figure 39 Distribution of reported WTP

Table 18 Results from estimated mean and median WTP

WTP

	Percentiles	Smallest		
1%	0	0		
5%	0	0		
10%	0	0	Obs	523
25%	0	0	Sum of Wgt.	523
50%	150		Mean	333.9006
		Largest	Std. Dev.	523.9133
75%	500	3400		
90%	1000	3400	Variance	274485.1
95%	1200	4200	Skewness	3.616021
99%	3000	4200	Kurtosis	21.13888

Based on the reported WTP from the sample of respondents in Oslo, the estimated sample mean WTP is 333 NOK per year for the next 15 years for maintenance or increase in street tree density. The estimated median WTP is 150 NOK.

9.2 Geographical variation

Because of the interactive maps used in the online survey we were able to connect to data to locations, and could investigate the data for geographical variation. I was lucky enough to have help from Megan Nowell at NINA in doing some analysis in ArcGIS. The following maps are her work.

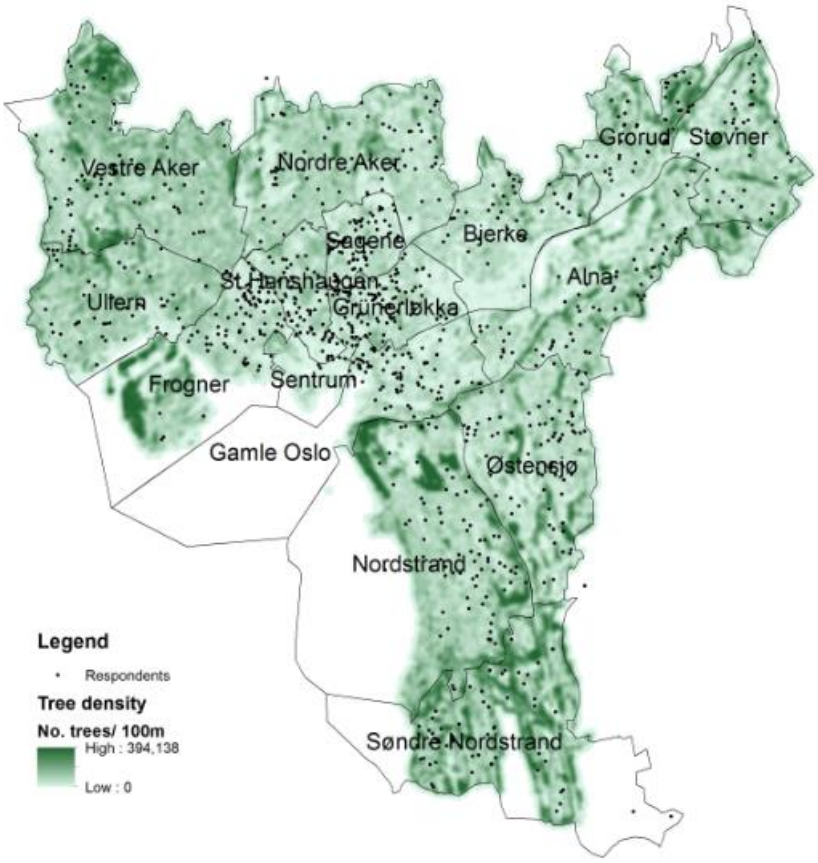


Figure 40 Respondent home location and tree density (Nowell, 2015)

Based on the respondents own reported current street tree density in their own street we can get an represent the street tree density variation in Oslo, represented by the map in Figure 40. This important to note that these are street trees and not all types of trees. There are many parks and forests that would be very visible on this type of map.

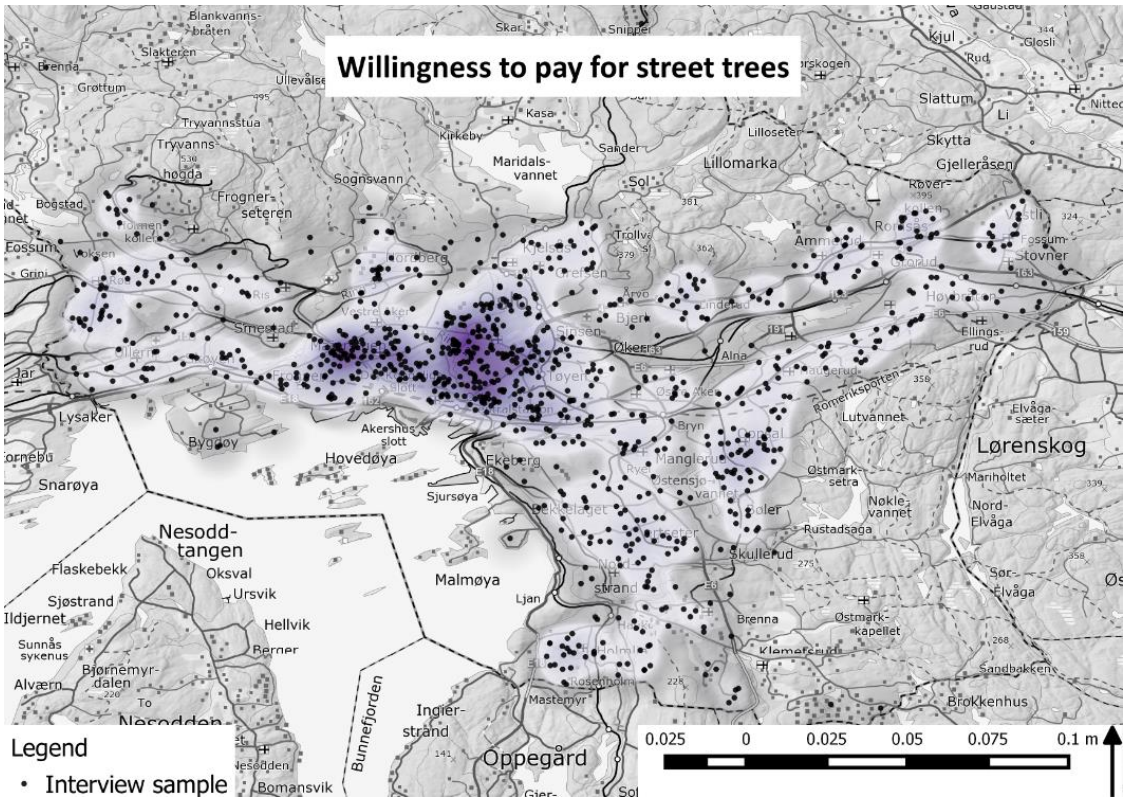


Figure 41 Heat map of WTP for street trees (Nowell, 2015)

Based on the reported WTP for street trees in their own street, we can see how the WTP varies geographically. Figure 41 shows a heat map of WTP, where darker color means higher WTP. We can clearly see that the people in the center of Oslo have a higher WTP for street tree density.

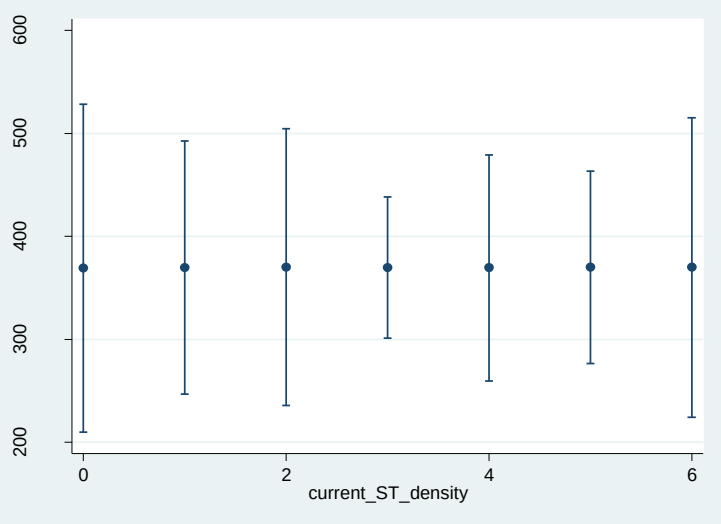
9.3 Validity testing

As discussed in section 7.4 validity and reliability, there are many potential pitfalls in a CV study, and several measures one can take to avoid them. After conducting a CV study one should investigate the validity of the results. We investigated scope, substitution affects, follow up questions and differences between different groups in the sample in order to strengthen the validity and look for potential weaknesses.

9.3.1 Scope

We can investigate the reported WTP for respondents with different initial level of street trees and desired level of street trees. This is a form of validity check to see if the valuation method gives answers in accordance with economic theory.

Current density street trees



q16	N	mean	se(mean)
0 - Ingen trær h	74	369.1892	81.24443
1 - Lav tetthet,	102	342.6471	62.73392
2 - Lav tetthet,	63	340.9524	68.61206
3 - Middels tett	133	289.6241	34.9894
4 - Middels tett	76	349.3421	56.08744
5 - Høy tetthet,	52	324.8077	47.66532
6 - Høy tetthet,	23	387.8261	74.25508
Total	523	333.9006	22.90913

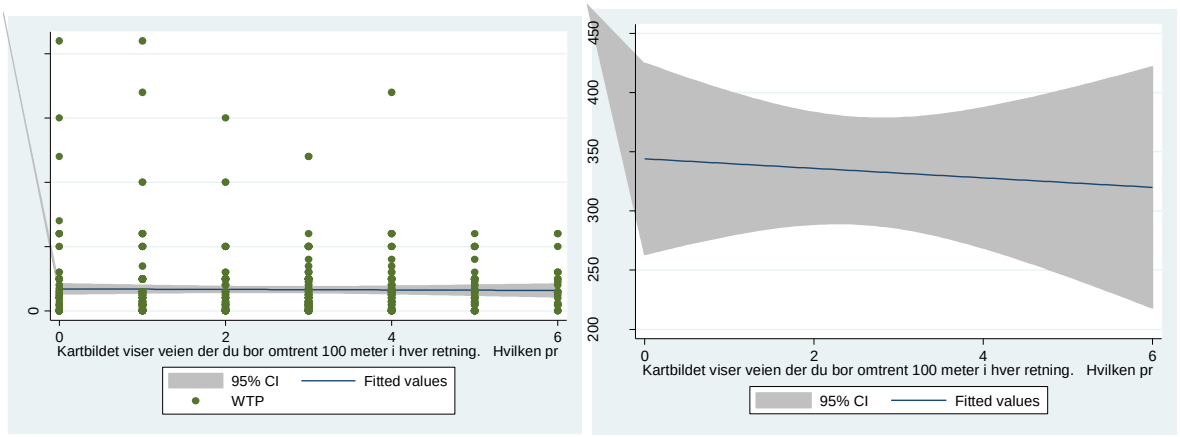
Figure 42 Estimated mean WTP and 95% confidence intervals for each current level of street tree density

We can see that there is not a large difference in the estimated mean WTP at each current level of street tree density.

Source	SS	df	MS
Model	24626.2244	1	24626.2244
Residual	143256617	521	274964.715
Total	143281243	522	274485.14

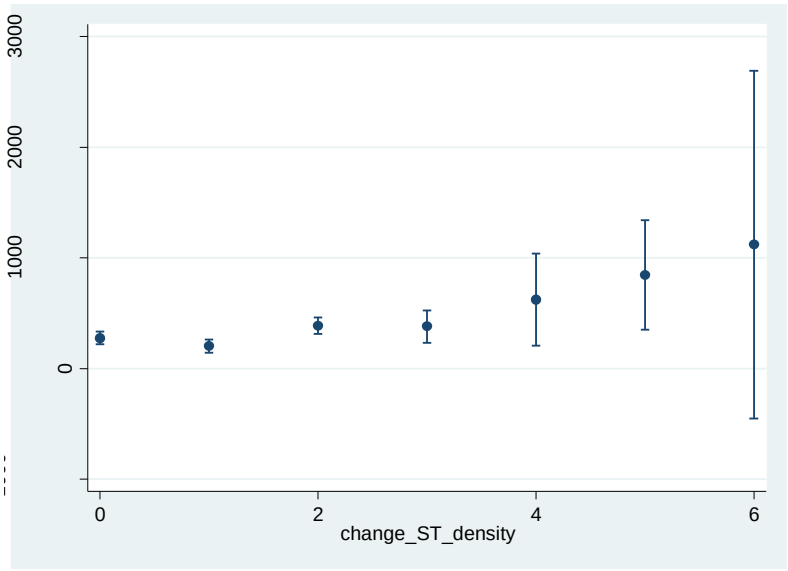
Number of obs	= 523
F(1, 521)	= 0.09
Prob > F	= 0.7649
R-squared	= 0.0002
Adj R-squared	= -0.0017
Root MSE	= 524.37

WTP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
q16	-4.027932	13.45928	-0.30	0.765	-30.46906	22.41319
_cons	344.136	41.17629	8.36	0.000	263.244	425.028



When we regress WTP on current level of street tree density, we see small negative relationship. But the effect of current level on WTP is not significant.

Desired change in density street trees



change_pos	N	mean	se(mean)
0	252	275.3571	28.73161
1	83	203.012	29.91993
2	99	386.7677	38.05486
3	50	378.4	74.35346
4	14	621.4286	212.7601
5	20	844	252.2513
6	5	1120	801.4986
Total	523	333.9006	22.90913

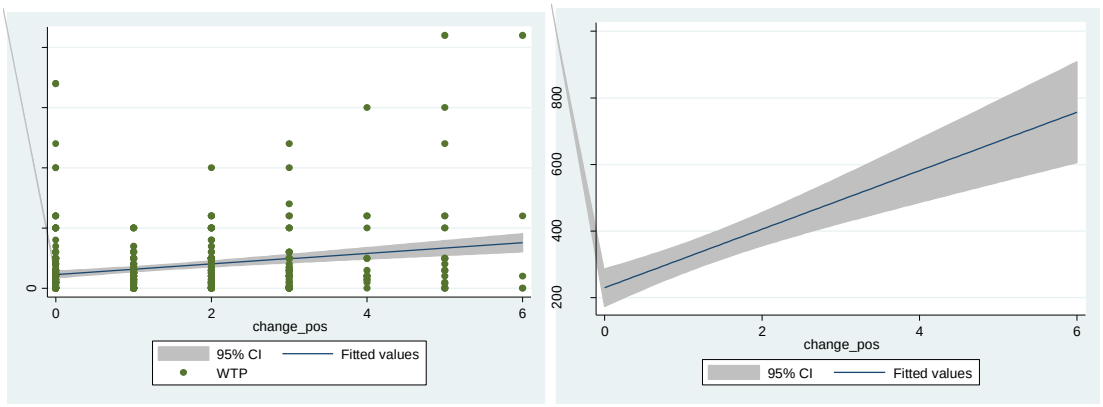
Figure 43 Estimated mean WTP and 95% confidence intervals for each level of desired change in street tree density

The estimated mean WTP is higher for larger magnitudes of positive change in street tree density. This fits well with economic theory that the WTP for an amount of a good increases with the amount of the good. The size of the confidence intervals of the estimates increase with the size of change. This is mainly because the amount of observations decrease with size of change.

Source	SS	df	MS
Model	8509443.42	1	8509443.42
Residual	134771799	521	258679.078
Total	143281243	522	274485.14

Number of obs	= 523
F(1, 521)	= 32.90
Prob > F	= 0.0000
R-squared	= 0.0594
Adj R-squared	= 0.0576
Root MSE	= 508.61

WTP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
change_pos	87.75033	15.29956	5.74	0.000	57.69393	117.8067
_cons	230.3787	28.64239	8.04	0.000	174.1099	286.6474



When regressing WTP on size of desired change we find a positive relationship. And the effect of change on WTP is significant.

9.3.2 Substitution ST and other trees

We checked for correlation between current situation and view of trees from house. View dummies included; trees on own property, trees on neighbors' property, trees in street, city park and forest. There was no significant correlation (>0.3 Pearson coeff) between current situation and any of the view dummies. Then tested regression of view on WTP, with the hypothesis that they are substitutes and would therefore have a negative effect on WTP. "Trees on own property" and "city park" have significant effect on WTP. But the effect is positive, meaning they are not substitute for street trees. Only "forest" dummy had negative effect on WTP, indicating substitution effect, but this was not a significant effect.

Other questions about people's attitudes gave an indication about substitution effect. Most respondents disagreed that street trees where not that important because there are so many other trees nearby.

Table 19 Respondents response to questions regarding street trees substitutability

```
. tab q21_1
```

Gatetrær er ikke så viktig der jeg bor siden det er mange andre trær på offentli	Freq.	Percent	Cum.
Helt enig	66	6.95	6.95
Litt enig	179	18.84	25.79
Verken enig eller uenig	195	20.53	46.32
Litt uenig	270	28.42	74.74
Helt uenig	240	25.26	100.00
Total	950	100.00	

```
. tab q21_2
```

Gatetrær inntil veibanen/fortauet er ikke så viktig siden det er mange andre træ	Freq.	Percent	Cum.
Helt enig	78	8.21	8.21
Litt enig	170	17.89	26.11
Verken enig eller uenig	206	21.68	47.79
Litt uenig	261	27.47	75.26
Helt uenig	235	24.74	100.00
Total	950	100.00	

We also carried out an extra check for consistency, if attitude about street trees in own district reflect desired change in street trees in street. We found a positive correlation which was good.

Table 20 Correlation between attitude about street trees in own district and desired change in street trees in street

```
. correlate q11_3 change
(obs=1000)

             |   q11_3   change
-------------+------------------
      q11_3  |   1.0000
      change |   0.4401   1.0000
```

9.3.3 What respondents had in mind when reporting WTP

Follow up questions about what people had in mind when reporting WTP was interesting in order to see what reasoning the respondents had used. We used a Likert scale and asked respondents if what they had in mind when reporting WTP vas influenced mostly by - desire for street trees in own street, desire for street trees in city in general, comparing to other municipality taxes they pay, what they usually give to "good" causes or was arbitrarily selected.

There were some respondents that reported WTP arbitrarily, meaning they were not based on true preferences. These answers where left out of the WTP econometric study. I had hoped more people had answered that their WTP was mostly influenced by their desire for street trees in their street because this was what we had asked them to express a WTP for. Only 231 agreed with this statement, which is a bit low.

I conducted an extra validity test to see weather respondents with positive WTP had higher correlation between WTP and size of change in ST. The group that thought about street trees in own street and/or street trees in entire city had a higher correlation between WTP and size of change in ST than the rest of the sample.

I also estimated the mean WTP for the different groups, and as expected the people that where was most influenced by desire for street trees in own street had higher mean estimated WTP than the other groups.

9.3.4 Subsamples/groups

We created different subsamples/groups of interest. First of all to see the distribution of different types of respondents, how many gave WTP, how many had zero WTP and how many did not give WTP (protests). Furthermore we wanted to see if there were any significant differences between the groups. We also created groups for people that gave inconsistent answers (positive WTP when desired lower street tree density), and different motives behind WTP; arbitrarily chosen, donation motive and tree density motive. Nobody gave inconsistent answer – that is reported positive WTP when they wanted fewer threes in their street. This is good for validity because it indicates that CV method was understood. However, the group that reported that street tree density was the reason behind their reported WTP was only 209 (out of 523 that reported WTP). This is a rather small number since we wanted all the reported WTP to have this in mind when reporting WTP.

9.4 Aggregation and implications

When it came to aggregating the results I ran into two main challenges. The fact that immigrants where not sufficiently represented in the sample and the fact that 47,7 percent of the respondents did not report a WTP.

Weighing procedures to account for the insufficient number of immigrants in the sample

We used data from Statistics Norway to find the number of immigrants in Oslo. (SSB, 2015) Adjusting for under-representativeness of immigrants, the estimated mean WTP is 323 instead of 333. But because of the aggregation approach chosen I did not use the corrected estimate.

Aggregate only over same percentage of population as percentage of sample that reported WTP

I have chosen not to aggregate over the entire population. This approach does not say anything about the people that did not want to give WTP, so it is a conservative approach. When we will only aggregate over 52,3 percent aggregate of Oslo's household which is the percentage of the population that did elicit a WTP.

When aggregating over the population we first start out with all the inhabitants of Oslo, 647.676 in 2015. In our sample we interviewed people in the age group 18-90 years, but since we were asking about household willingness to pay, we don't need to adjust the age, but rather get a number of household. In a household there may live children and/or elderly people outside the age range, and therefore represented in this way.

On average there are approximately 1,88 people in each household in Oslo. (SSB, 2015) This gives us 647.676/2=344.509 households. Out of these only 52,3 % was represented as WTP for street trees in our sample. That gives us 344.509*0,523=180.178 households with estimated mean WTP of 333 NOK. This gives us an annual WTP for maintenance or increase in street trees in Oslo over the next 15 years of 180.178*333=59.999.257.

We have estimated that there is an annual WTP over the next 15 years to pay almost 60 million NOK per year for maintenance or increase in street trees in Oslo.

10 Discussion

In the following chapter I will put the results in a broader economic framework and discuss the study's implications. I will be explicit in the limitations of the study, but all the while draw the intended picture of the magnitude of ecosystem services that city trees produce in Oslo city every year.

Choice of methodology and object of study

When I first started working on the research project it was very exciting. We had a theoretical framework that could help solve the problem of poor environmental resource management. However valuing the ecosystem services proved to be more difficult than I first expected, especially in an urban context. Many different valuation methods were used in the Oslo OpenNESS research project. For this particular study, we were going to utilize a stated preference valuation method. We were also interested in the possibilities that new technology gave us in making the study spatially explicit. We had to make many tradeoffs, when it came to scale, resolution and accuracy of the valuation, see Figure 44. In many ways the research project was just as much about how we measured ecosystem services as it was about measuring the particular ecosystem service. We spent a long time working on choosing a valuation format; this in turn explains why it took us so long to obtain the data.

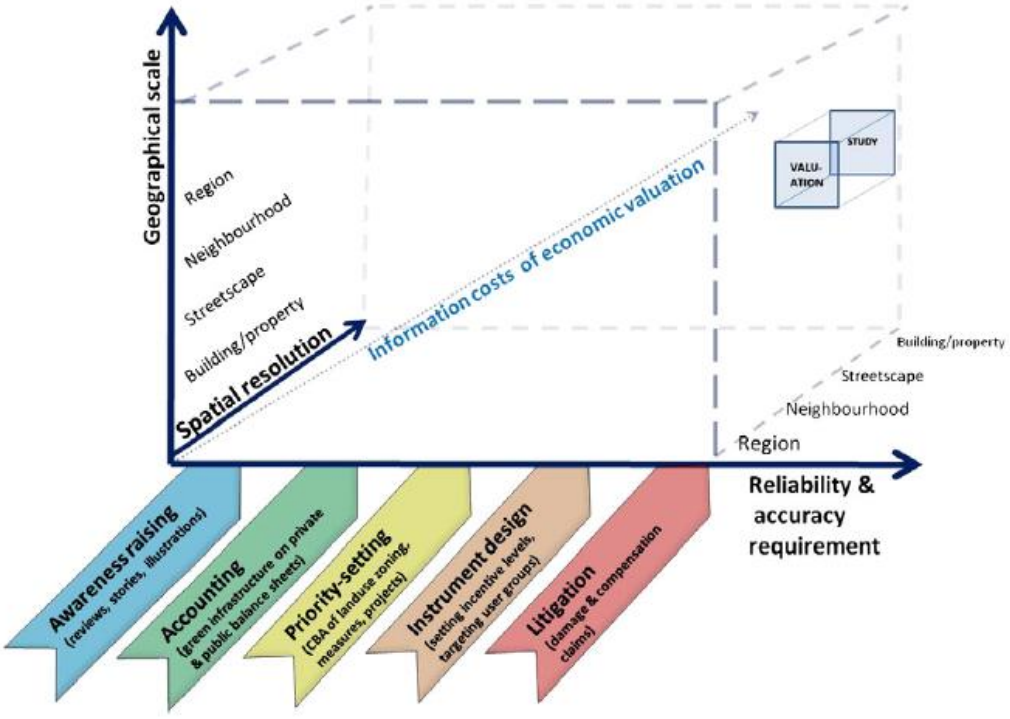


Figure 44 Economic valuation of ecosystem services in different urban planning contexts. Scale, resolution and accuracy and reliability. (Gomez-Baggethun and Barton 2013)

We were interested in trying to study variation in the city and explore the possibility of valuing ecosystem services at specific locations in an urban area. We understood that this would be difficult, and is the reason why we were not able to specify the exact amount of the good to be valued, because the scenario is different for each respondent. Furthermore the fact that each respondent only valued street trees at his/her location can explain why the WTP models did not have so many significant variables. The urban environment has a high spatial density of preferences and the stated preference method was not able to capture the diversity of preferences. We were not able to capture this when we were experimenting with choice experiments for green areas, and even when we zoomed in on street trees with contingent valuation it was still hard to find a unique model of preferences. This only goes to show that more research in this area is needed if we are going to be able to fully value ecosystem services in an urban environment in all the dimensions.

Preference based valuation compared to current valuation of street trees in Oslo

There is already a technical approach to valuation of city trees in Oslo. It is a Danish approach called the VAT03. It is based on the cost of replacement of different trees, and services they provide and the age of the tree and other factors. This is used mainly to decide damage reparations. Many of the tree valuation studies have this provision based valuation approach. But these approaches do not capture all the values created. According to economic welfare theory, the stated preference valuation study captures all the values. But this relies heavily on the assumption that people know all their preferences and how changes in goods and services affect their utility.

City trees produce many goods and services. These services are not always clear to people, they can be small in scale, or they could affect people indirectly through interactions with other natural structures and ecosystems or they might just be things that we are not conscious of. It is hard to imagine people being aware of all the benefits they have from trees in the city. When using stated preferences methods it is easy to ask oneself - do people know what they get and what they want? The stated preference approach can be seen as complementary approach other valuation methods, but none of the valuation methods are perfect on their own.

Valuation study

The study had one clear drawback in terms of valuing the ecosystem services of street trees in Oslo - there was not a clearly defined amount of street trees that was valued. Rather we documented that people value street trees in Oslo and that they are willing to pay to maintain or increase the level of street trees in their own street. This is more an indication of value and documentation of WTP, than a strict valuation of a defined amount of natural structures or the ecosystem services they provide.

The study followed practices to ensure a statistically representation of the population of Oslo. However it turned out that it was not a perfectly representative sample. Immigrants where clearly underrepresented. We explored weighting procedures to compensate for this and reported mean estimated WTP both with and without this correction.

Furthermore, not all the respondents reported a WTP. This is a signed that they did not accept, understand or where able to contribute to the method of valuation. When aggregating the results from the sample over the population we chose a conservative approach. We only aggregated over share of population that reported a WTP in the sample. This means that we do not say anything about the WTP or value of the street trees to the share of the population that did not report WTP. Only documenting and reporting on the share of the population that participated in this particular valuation study. It is possible that other methods or studies will be able to capture these values in the future.

Methodological interest

In addition to trying to valuate street trees in Oslo, the study had an ambition of trying to apply the stated preference valuing methodology on ecosystem services in an urban environment. It has been pointed out that trying to value ecosystem services in such a high density context is challenging and the traditional valuation methods can have difficulty in doing so. The study can therefore be seen as an attempt to deal with some of these challenges, but also a test for future studies to learn from.

Utilizing interactive online survey we were able to investigate geographical variation in the results. Interesting to see how results varied geographically. The study is relevant as a first attempt at applying new methods and trying to value ecosystem services in urban context through stated preferences and in spatially explicit manner. More research is need in this field in order to improve the methods and create better estimates.

Policy relevance

When it comes to the relevance of the study for policy it can be seen as a first step. The study may however still have direct policy implications. Referring to the accuracy requirements in Figure 10, we can see how many policy decisions do not need the finest accuracy. When it comes to street trees in Oslo, they are provided based on the self-cost principle. That is to say we don't need to know the exact value of the ecosystem services that street trees provide. We only need to know if the value exceeds the cost of providing it. In this valuation study we asked people if they were willing to pay for an increased spending on street trees. The fact that there is such willingness reflects the value these trees provide and defend their place in the city and on the municipality's budget. If one accepts the results from this study the municipality can defend expenses up to 60 million NOK per year in order to maintain or increase the street tree density. Utilizing the geographical variation in the results, we could also investigate where the demand for street trees is the highest.

Ideally we would like to have information on the cost of planting and maintaining street trees around Oslo to see where it is most profitable to spend more resources. This is beyond the scope of this paper. The paper can be used in the municipality's further work or as an invitation to further research on the matter.

11 Conclusion

Chapter 12 Conclusion we will try to summarize the entire study and present its conclusions. The study has given a presentation of the ecosystem services theory and background. It has applied this theory and the contingent valuation approach to investigate the values of street trees in Oslo. The results from this study can be used for policy decisions regarding Oslo's street trees. The experiences from the study can be used in further research on valuing urban ecosystem services.

Background and theory

Ecosystem services is a broad term for the welfare humans derive from nature. For a number of reasons – such as missing markets, externalities, undefined property rights, lack of information, the ecosystem services and the natural structures that underlie them are not adequately accounted for in the economy. This is a problem because it can lead to a poor use of resources. Environmental degradation and destruction of natural structures that are of higher value to us than the benefits we get in return are examples of this. However, there are ways of valuing these services. By making the values clear to the decision-makers, we are in a better position to make good choices about tradeoffs between the environment and other concerns. With the speed and extent of humans effect on nature increasing – studying and valuing ecosystem services is increasingly important.

Today more than half the people in the world live in cities. At the same time as urban nature is becoming more valuable - because of more people benefitting from them and increased need for their services as the cities grow and condense – the pressures on the green structures grow. Competing alternative uses, worsening conditions and rising costs of provision means green structures have to be protected and conserved. Valuing urban ecosystem services is a good way of making these values explicit to the decision makers, and put them in a better position to make good choices about city planning. (Gómez-Baggethun & Barton, 2013)

City trees are one of the most important natural structures in cities. They provide a range of ecosystem services and are maybe the most visible of natural structures to people who live in cities. Oslo has many city trees, but with high population growth and densification of the city, city trees are under pressure. Both through alternative use of the land they occupy, higher cost

and alternative use of the municipality's budget and more stress on the trees themselves. (Oslo Kommune, 2010)

The contingent valuation study on street trees in Oslo

This study is concerned with valuing street trees in Oslo. They provide a range of benefits to people living in the city, but their value is not fully accounted for in the economy. Population growth and densification of the city puts pressure on their existence in the city and on the municipality's budgets. It is important to document their value in order to ensure an urbanization that reflects people's preferences for street trees and the services they provide.

Valuing urban ecosystem services is challenging because there are so many different preferences and ecosystem services in a small geographical area. It is a high context density environment. Many of the services are both complementary and substitute goods to other services. Figuring out how to value different urban ecosystem services is not a straightforward process.

In this study I have applied the contingent valuation method to estimate the value of Oslo's street trees. I have assisted David Barton the leader of the Oslo OpenNESS research project in designing and conducting an online web-survey on a representative sample where we asked the respondents about their willingness to pay for a rise in the municipality's budget for street trees in order to maintain or increase today's level of street trees in respondents' street.

Main results and implications

I estimated that the mean WTP for each household for maintenance or increase in street tree density to be 333 NOK per year, over the course of the next 15 years. Aggregating over the relevant household population of Oslo this becomes almost 60 million NOK per year.

Based on the results from the study we found that most of Oslo's inhabitants want to maintain or increase level the level of street trees in their street and that there is a willingness to pay for these street trees. Furthermore the existence and willingness to pay for street trees varies geographically, with people living in the center of Oslo having a significantly higher WTP. We found that the ecosystem services theory is a useful framework. And that it is possible to value ecosystem services spatially explicit in an urban area, although more research in this area is needed.

The policy relevance of this study is documenting the economic value generated by street trees in Oslo and defending their place in the city and on the municipality's budgets. These types of studies can help create better policy for urban management.

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Table of appendices

Appendix A: Summary statistics

Sample of respondents

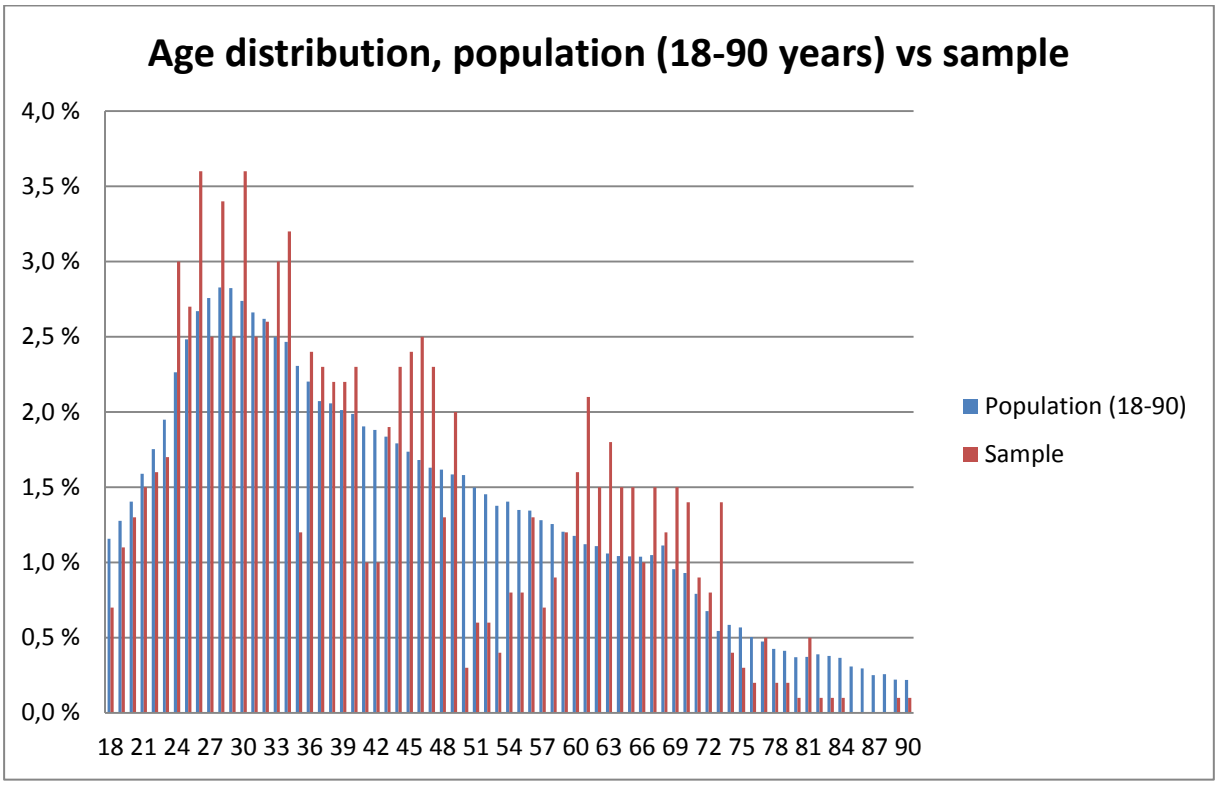


Figure 45 Age distribution, population vs sample

The age distribution in the sample reflects that of the population relatively well. An important point here is that we have only drawn a sample from the population over 18 years. We therefore have to compare it representativeness to that of the population between 18-90 years. When extrapolating the results from the sample to the general population we have to take this into account.

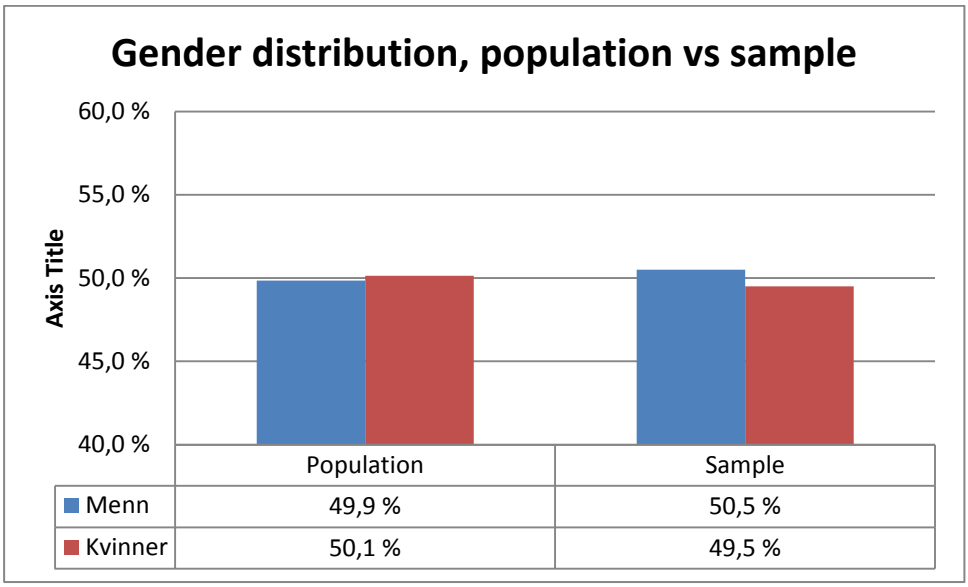


Figure 46 Gender distribution, population vs sample

The sample is slightly overrepresented by men by 0.6%.

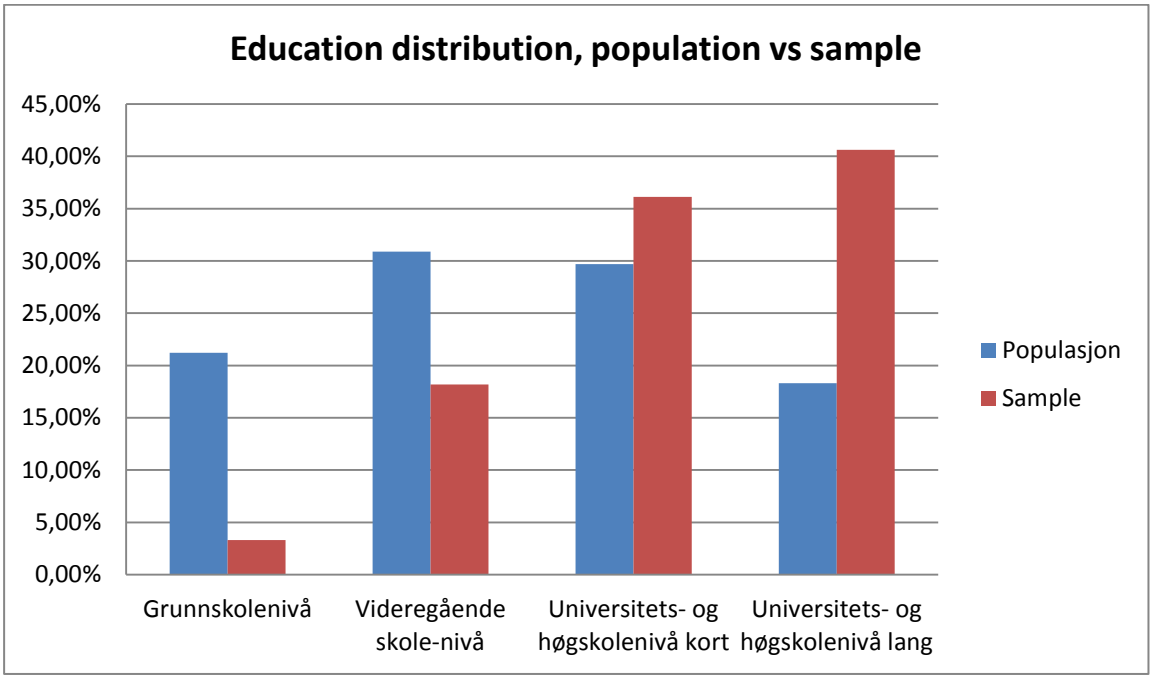


Figure 47 Education distribution, population vs sample

The sample is has a higher education distribution than the population. Does this effect the estimated WTP? Weigh the lower educated people's answers more heavily when extrapolating?

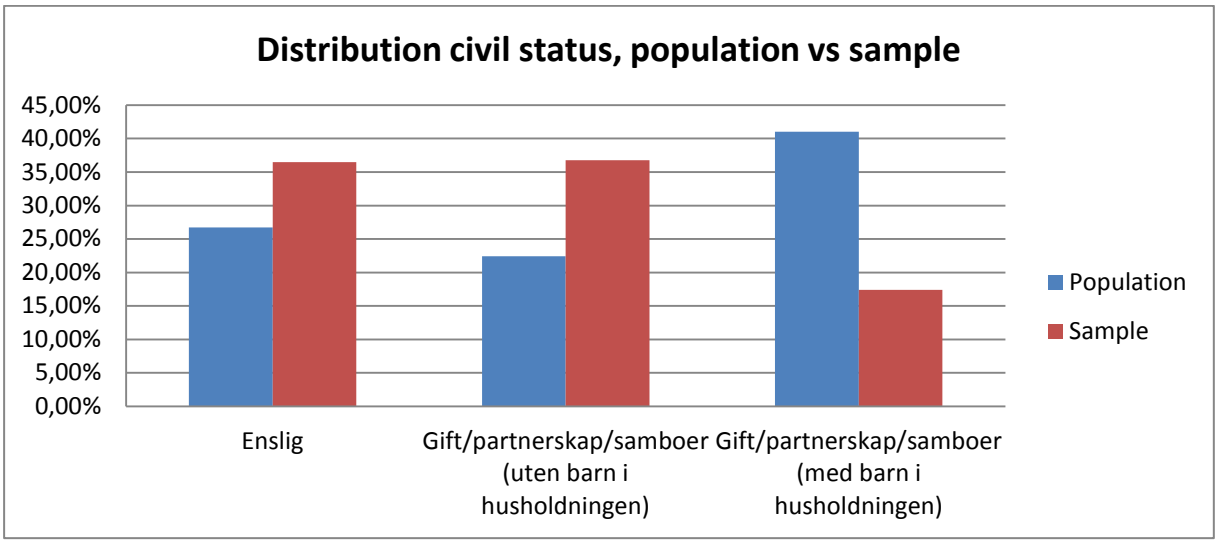


Figure 48 Distribution civil status, population vs sample

The categories from Statistics Norway and those in our survey did not match, making it hard to compare. However it does seem like people with children are underrepresented in our sample.

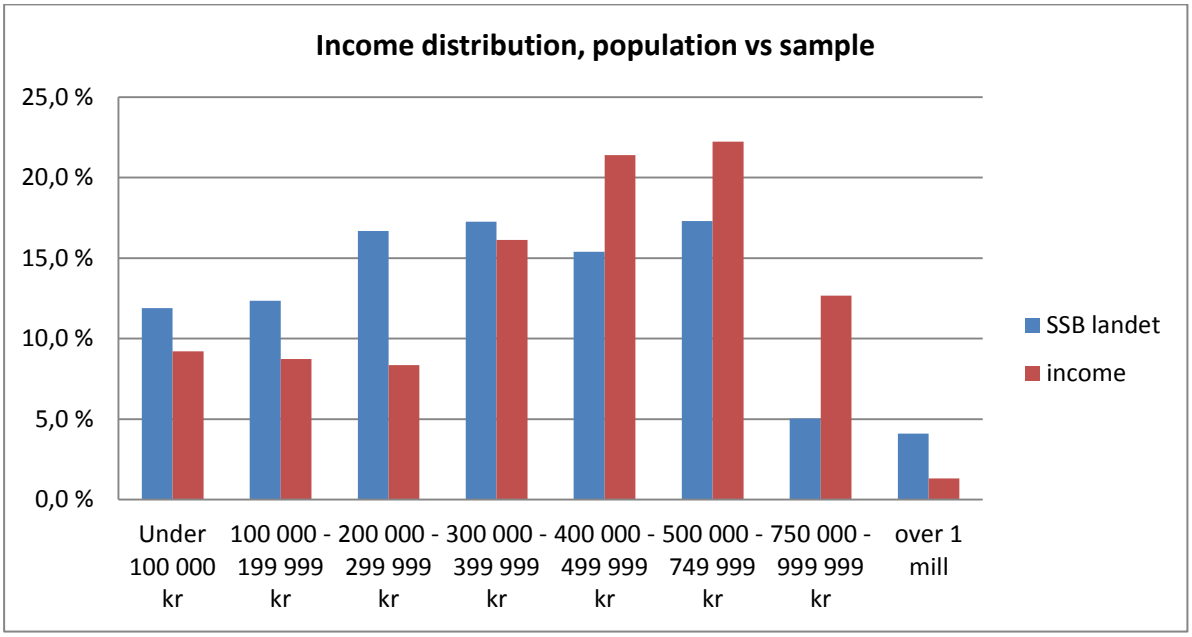


Figure 49 Income distribution, personal income country average against distribution of two different variables in survey, not counting and counting the people that did not want to report their income, respectively.

The only available data on personal income was for the country average, and the newest numbers was from 2013. Compared to the income distribution of the respondents, the sample seems to be a bit richer. But taking into account that the Oslo is richer than the country average and that income has risen since 2013, it might still be acceptably representable.

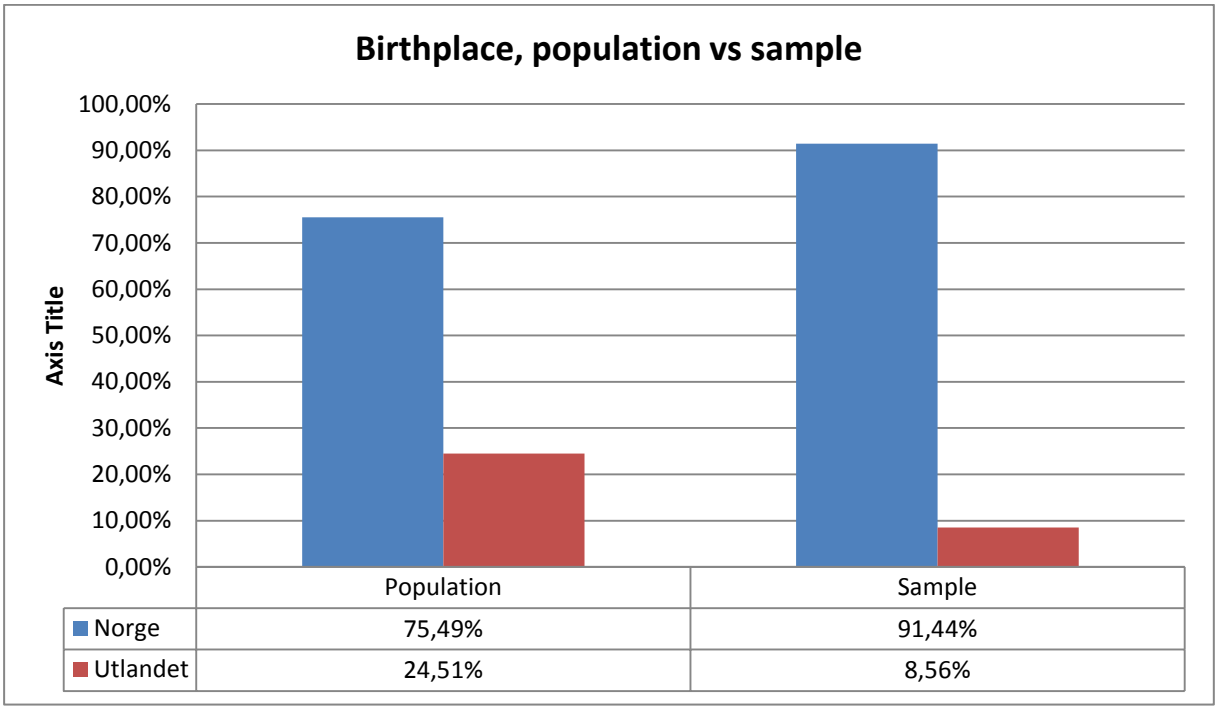


Figure 50 Birthplace, population vs sample

The population of Oslo is made up of 75% people born in Norway and 25% born abroad. In our sample only 9% was born abroad, making immigrants underrepresented in our sample.

Summary statistics: N, mean, sd
by categories of: born_utlandet

born_utlandet	WTP	age	gender	educat~n	civil_~s	income	outdoo~y
0	474	915	915	894	910	773	914
	340.1477	43.10492	1.48306	3.222595	6.341758	490944.4	41.95405
	539.558	16.61496	.4999862	.9598336	20.04167	244251.6	8.866916
1	49	85	85	85	85	64	85
	273.4694	40.58824	1.623529	3.494118	6.6	504687.5	40.81176
	334.8728	13.29097	.4873756	.9712967	20.44808	222845.7	9.667686
Total	523	1000	1000	979	995	837	999
	333.9006	42.891	1.495	3.24617	6.363819	491995.2	41.85686
	523.9133	16.36811	.5002252	.9633749	20.0664	242584.7	8.938362

born_utlandet	activi~s	attitu~s	bydel	sentru~y	q16	change
0	915	915	915	915	915	915
	5.790164	11.08415	7.650273	.3245902	2.549727	.7464481
	3.429457	2.182214	4.511605	.4684776	1.802165	1.731159
1	85	85	85	85	85	85
	6.376471	11.01176	7.835294	.3058824	2.941176	.8117647
	3.801555	1.76941	4.205572	.4635148	1.821518	1.531371
Total	1000	1000	1000	1000	1000	1000
	5.84	11.078	7.666	.323	2.583	.752
	3.464448	2.149543	4.484703	.4678567	1.806204	1.714478

Figure 51 Immigrants' characteristics compared to rest of sample

We compared values for the immigrants to those of the rest of the sample too see weather they differed significantly. Immigrants had; lower WTP, slightly younger, more females,

slightly higher educated, slightly higher income, little bit less outdoorsy, more activities, same attitude towards trees, lived a little bit less central, had a little more street trees but wanted more change in street tree density.

There was a difference in the number of inhabitants in each zip code in Oslo and number of panel members in each zip code, making the probability of drawing a respondent from a certain zip code different from drawing a person from the population in randomized selection. Doing a randomized selection based on zip code would be too detailed for the panel. Therefore we did a randomized sample based on districts by setting a soft-quota on the districts. Meaning they stopped taking draws from a district when the quota from that district was filled.

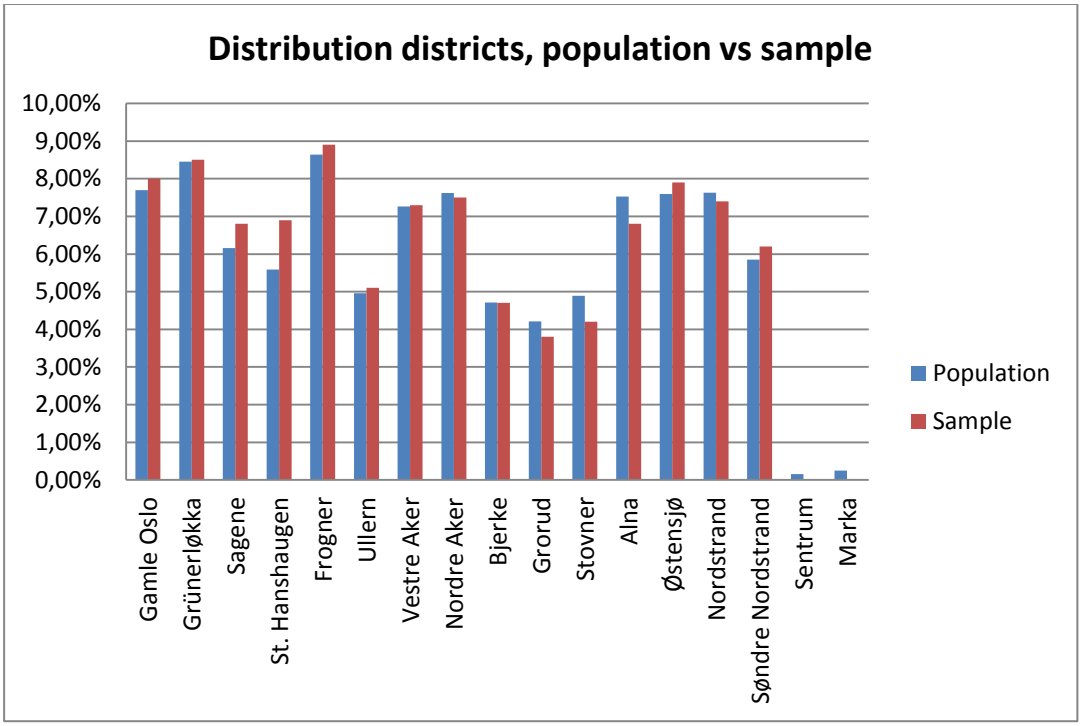


Figure 52 Distribution districts, population vs sample

The sample is representative for the population of Oslo. We did not have any respondents from Sentrum or Marka, but these districts are so small it does not matter. However they do represent the largest difference in terms of street trees so it would have been interesting to look at the replies from respondents in these districts.

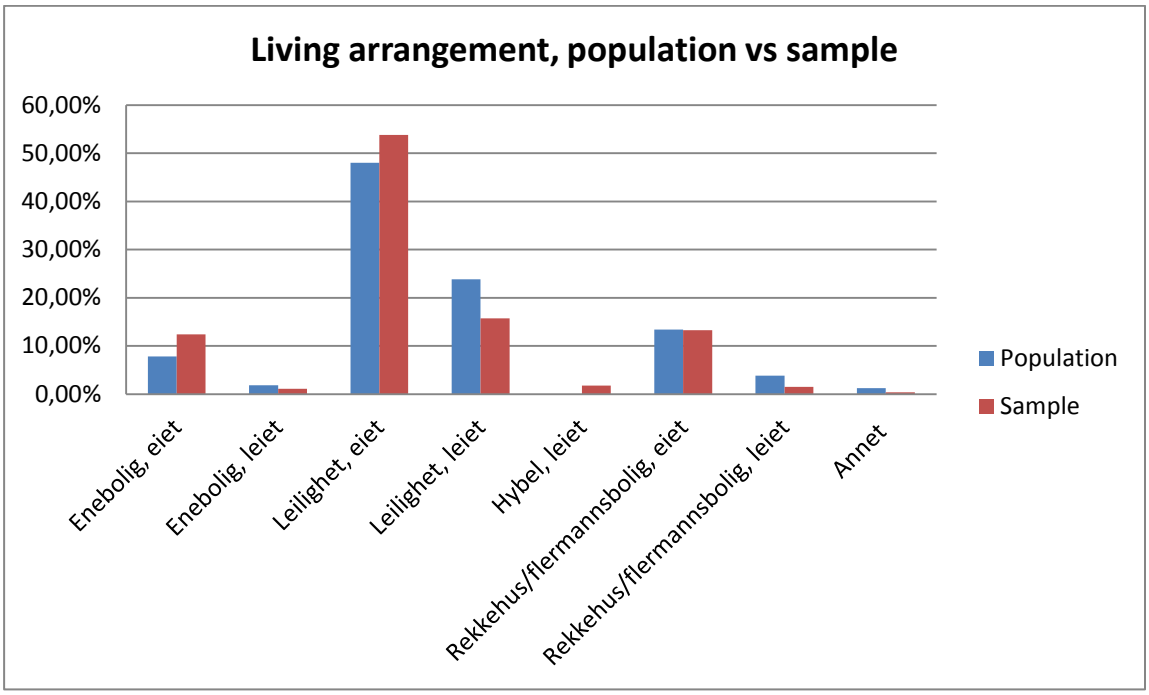


Figure 53 Living arrangement, population vs sample

The form of living arrangement in sample fits that of the population relatively well.

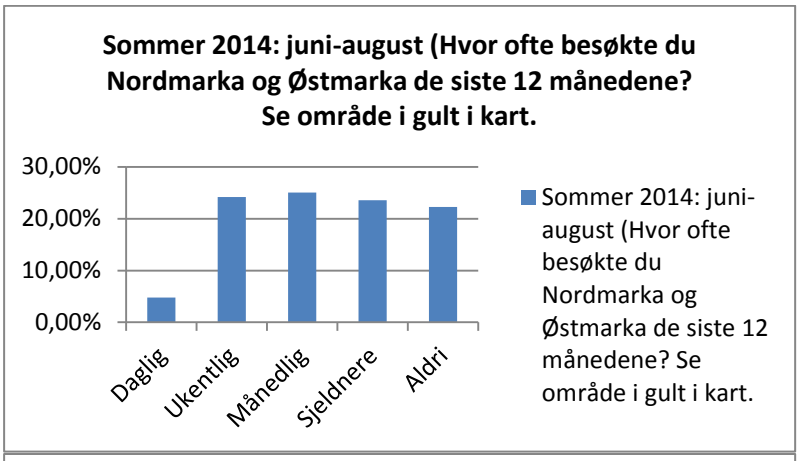
Overall the sample from Norstat reflects the population of Oslo fairly well. The only group that is significantly underrepresented is immigrants. We studied to see if the vary significantly compared to the rest of the sample in order to see if we had to do a correction. We deemed that xxx, and it will be weighted in the aggregation process accordingly to correct for this problem.

Summary statistics

Figure 54 View of natural structures from home

We can use this variable to check if there is a substitution effect between street trees and other natural structures by comparing the reported WTP for maintenance or increase in density of street trees in their street and what natural structures they can see from their home.

Nordmarka


Sommer 2014: juni-august (Hvor ofte besøkte du Nordmarka og Østmarka de siste 12 månedene? Se område i gult i kart.
30,00%
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Ukentlig
Månedlig
Sjeldnere
Aldri
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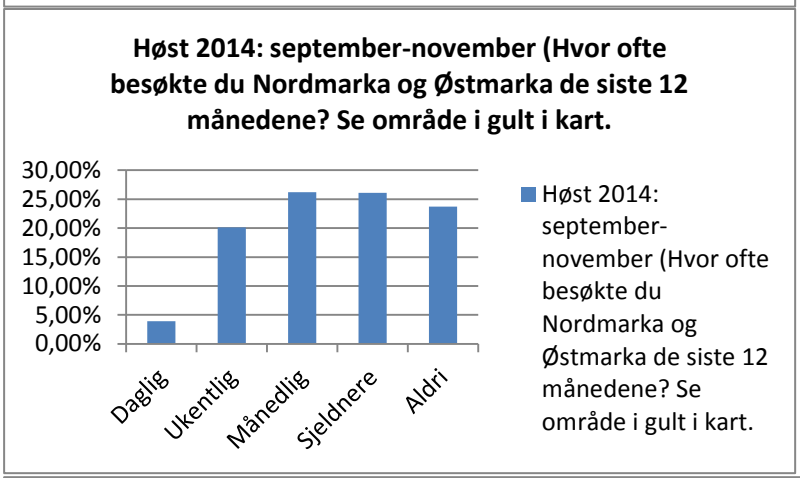
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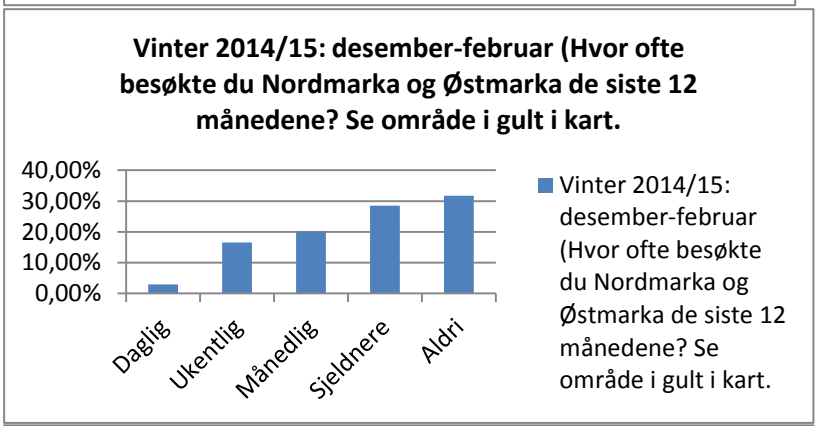
Vinter 2014/15: desember-februar (Hvor ofte besøkte du Nordmarka og Østmarka de siste 12 månedene? Se område i gult i kart.
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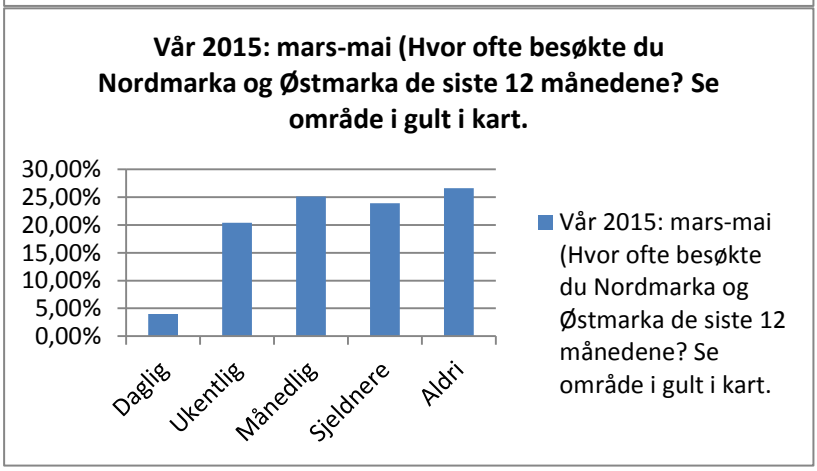
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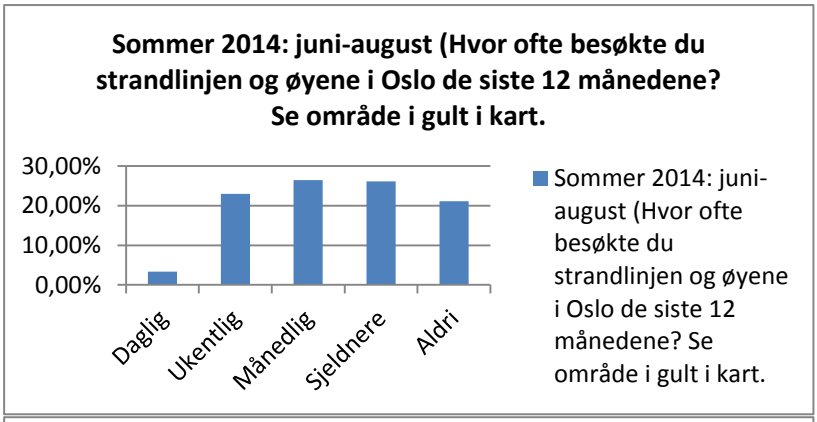
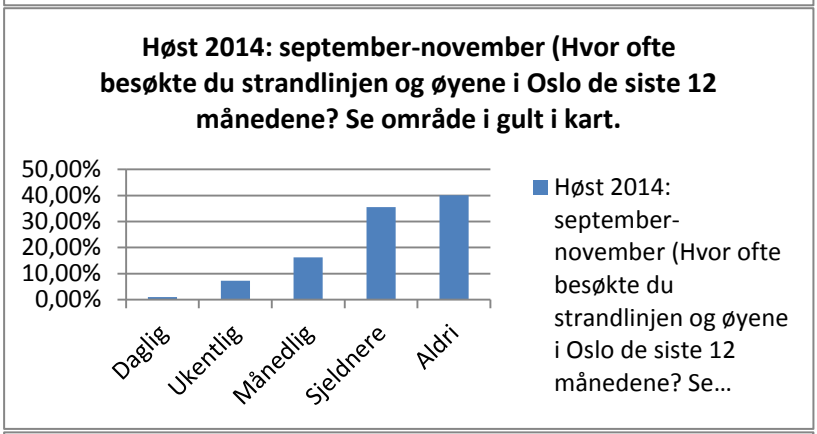
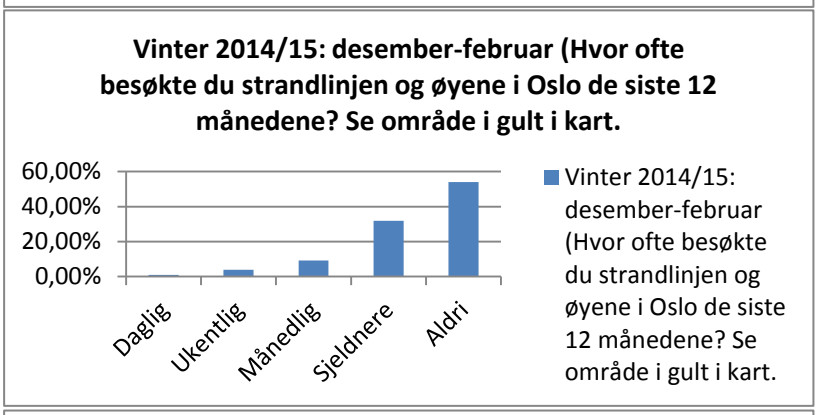
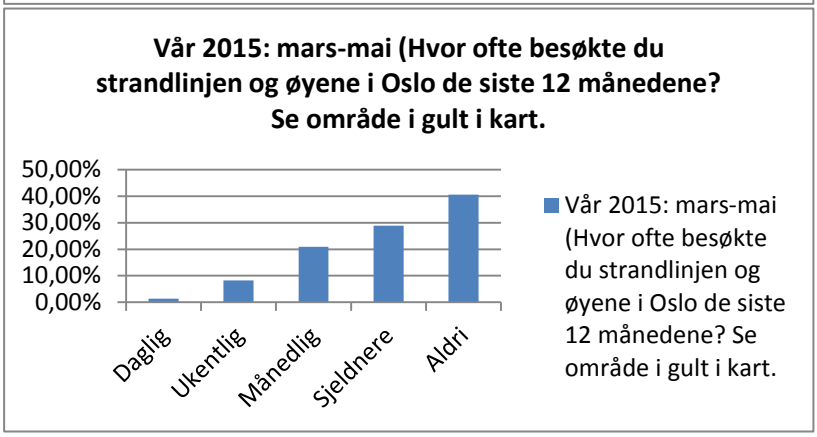
Fjorden

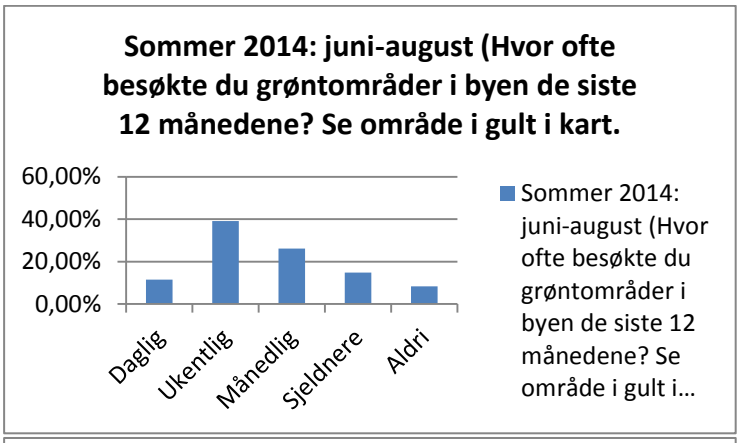








Parkene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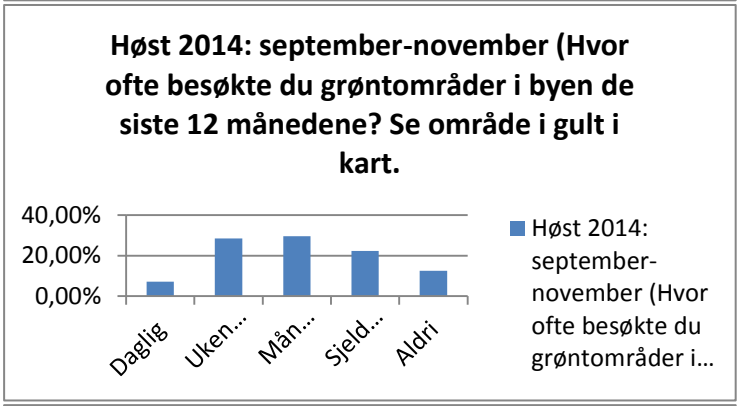
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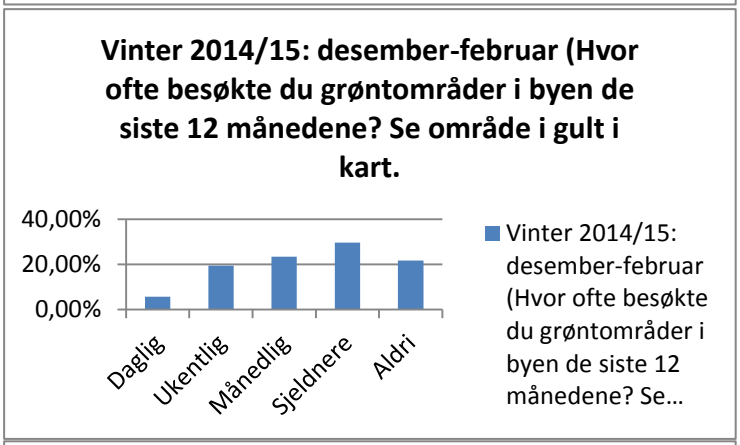
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Vår 2015: mars-mai (Hvor ofte besøkte du grøntområder i byen de siste 12 månedene? Se område i gult i kart.
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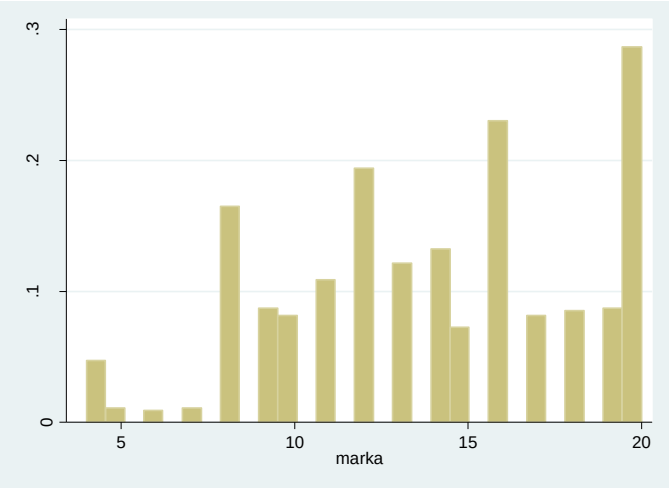
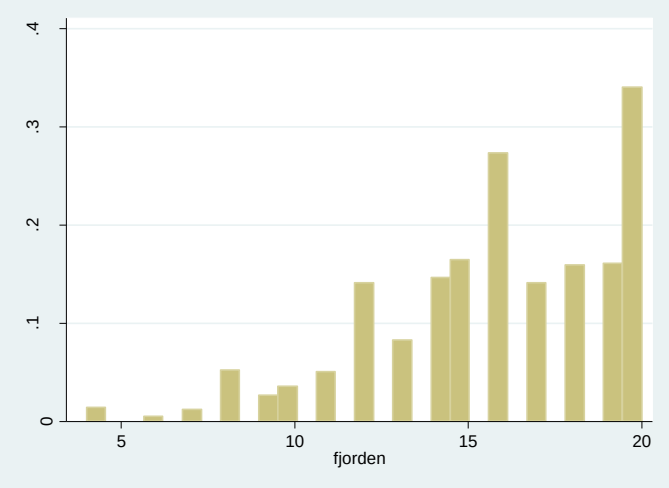
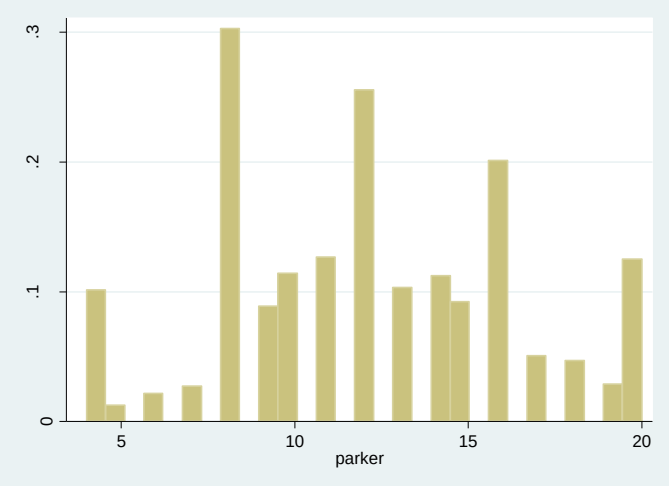
Vår 2015: mars-mai (Hvor ofte besøkte du grøntområder i byen de siste 12 månedene? Se område i gult i kart.

We created variables indicating respondents trips in each area (forest, fjord and parks) summarizing all seasons, for each season (summer, fall, winter, spring) summarizing all areas and a summary statistic “outdoorsy” as a indicator of how often the respondents takes trips in these areas in a year. The low numbers represent high frequency trips. (daglig=1, ukentlig=2, månedlig=3, sjeldnere=4 and aldri=5). We can use this variable to get a respondent profile, as an outdoorsy person, and to see weather this affects reported WTP for maintenance or increase in street tree density in their street. One could either imagine outdoorsy people being very fond of trees giving high WTP, or them getting enough trees on their trips and therefore having a lower WTP, a sort of substitution effect.



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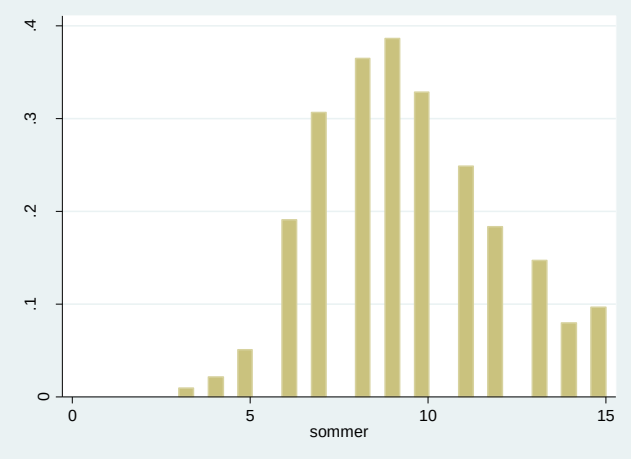
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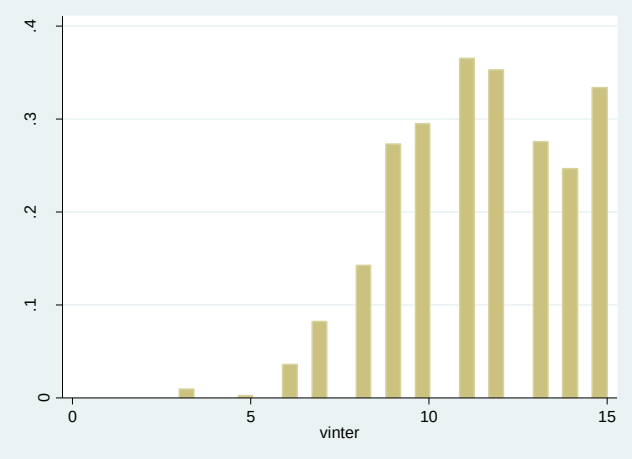
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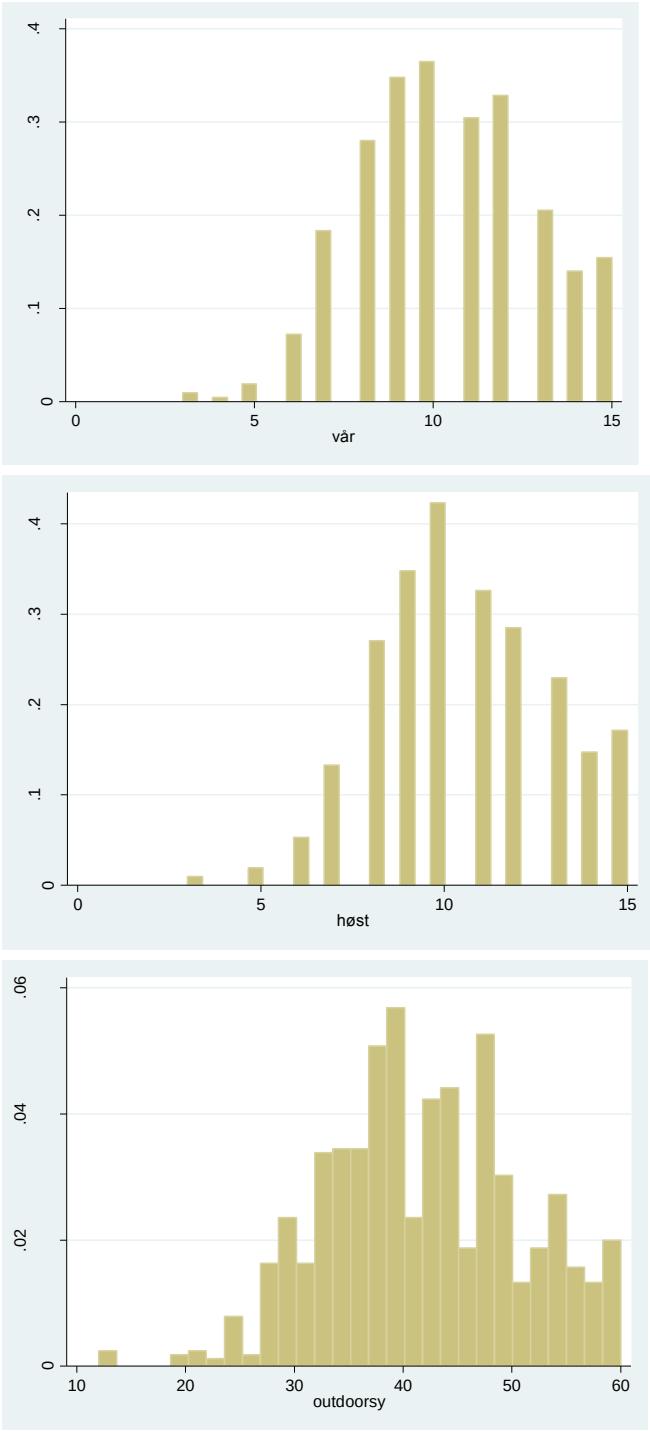
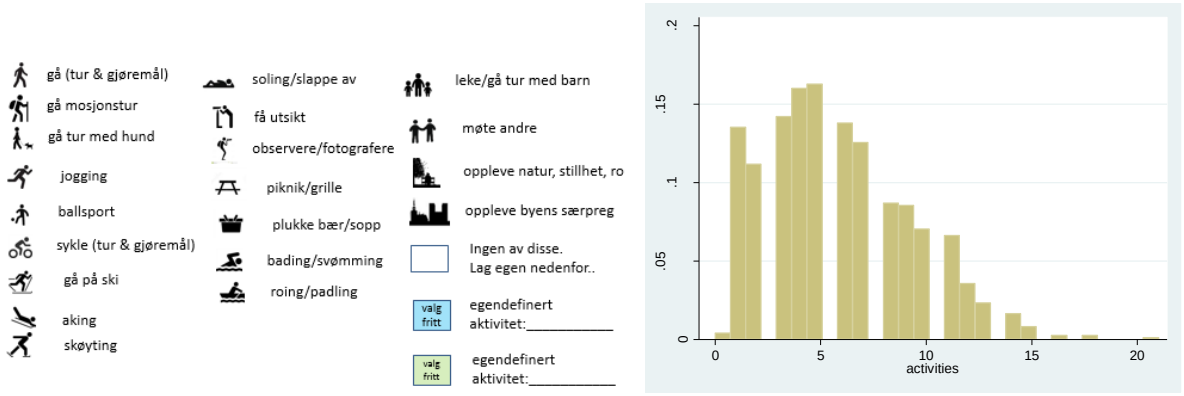


Figure 55: Distribution of frequency of trips to the forest, fjord and parks of Oslo



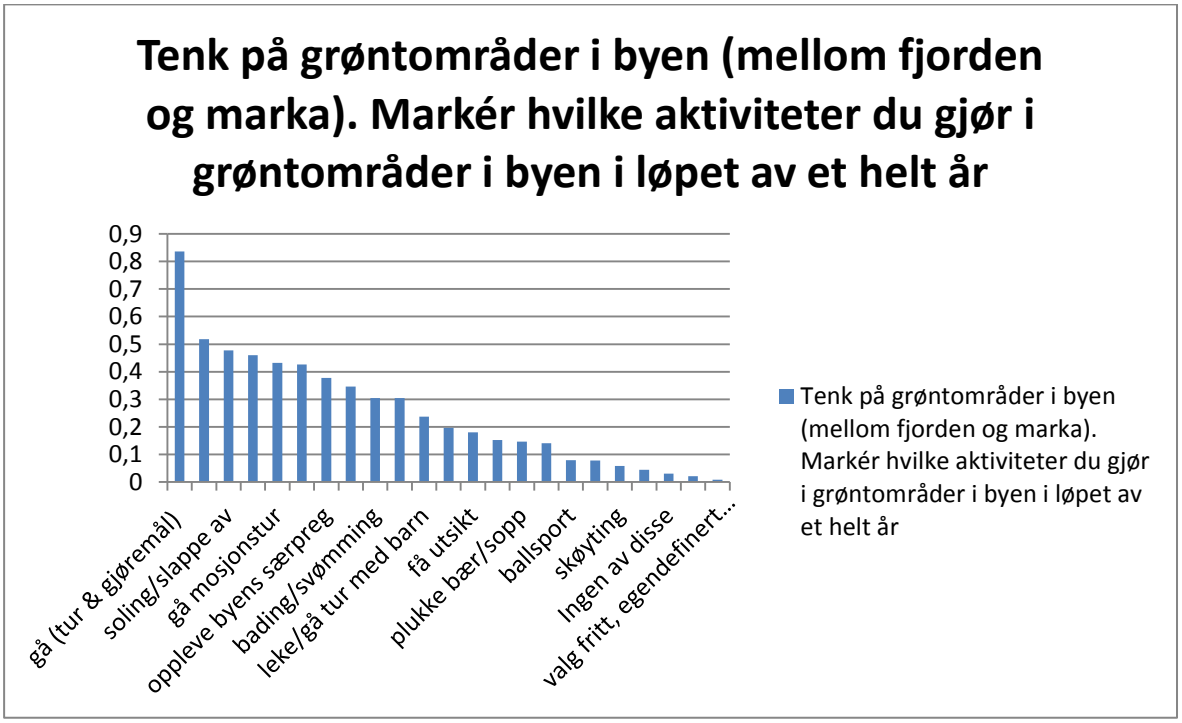


Figure 56 Activities respondents do in the green areas of Oslo in the course of a year

We also measured what activities people did on their trips to the different green areas. This created an activities profile on the respondent, weather he/she used the green areas for many different types of activities.

Figure 57 Interactive digital maps for drawing trips in green areas of Oslo

The respondents were asked to draw trips in green areas that they took the most often, as shown in Figure 57. People drew up to 5 different trips in interactive digital maps, where they also reported what time of year, what type of day (weekday, weekends or every now and then) and how much time the trip took (roundtrip).

Figure 58 Activities done on trips and how often

They also reported what activities where done on each trip and how often, see Figure 58.

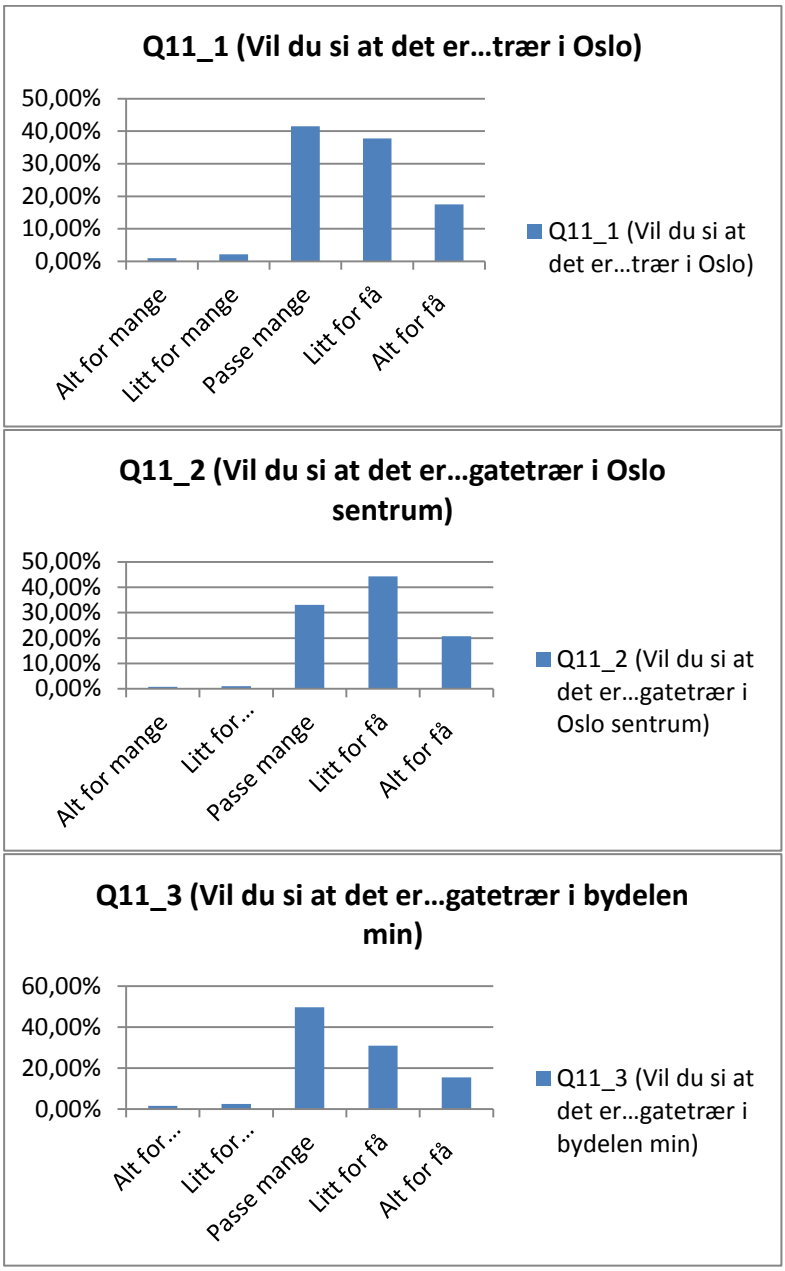


Figure 59 Attitudes toward trees in the city

The respondents were asked about their attitudes toward trees in the city. The vast majority was happy with amount or wanted more trees in Oslo, street trees in Oslo center and street trees in their district. Very few wanted less trees.

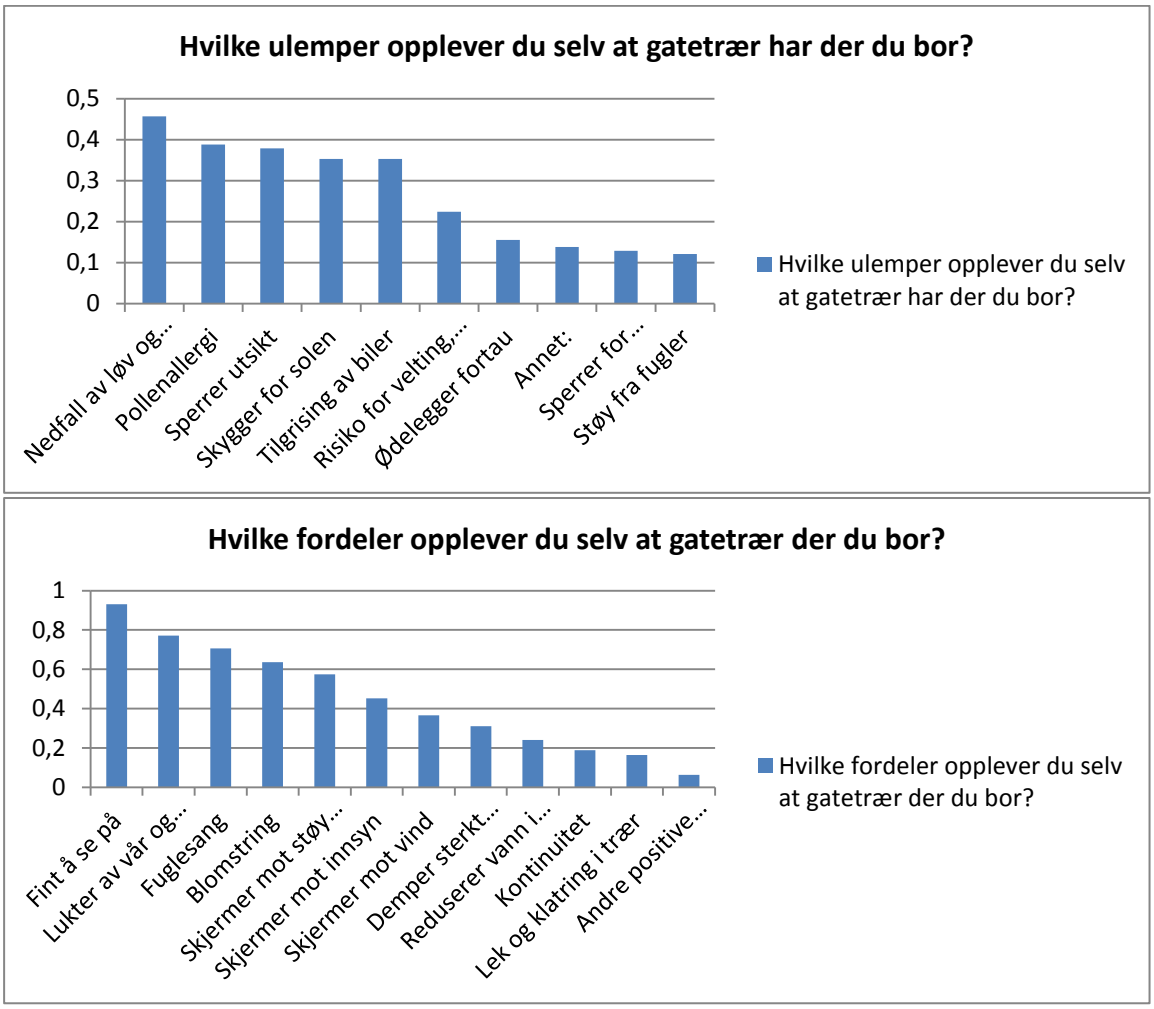


Figure 60 Positive and negative experiences from street trees where the respondent lives

Respondents were asked about experienced benefits and "costs"/disadvantages/loss/harm from street trees where they live. Most the respondents received benefits over 90%, whereas only 10% experienced disadvantages.

Figure 61 Form to report current and desired street tree situation in respondents' street

The respondent marked their house on the interactive digital map. They were shown a map excerpt of 100m in each direction of their house and asked to report the situation that most closely reflected the current density of street trees in their street. This was done to limit shortcomings in memory or biases, and give precise answers.

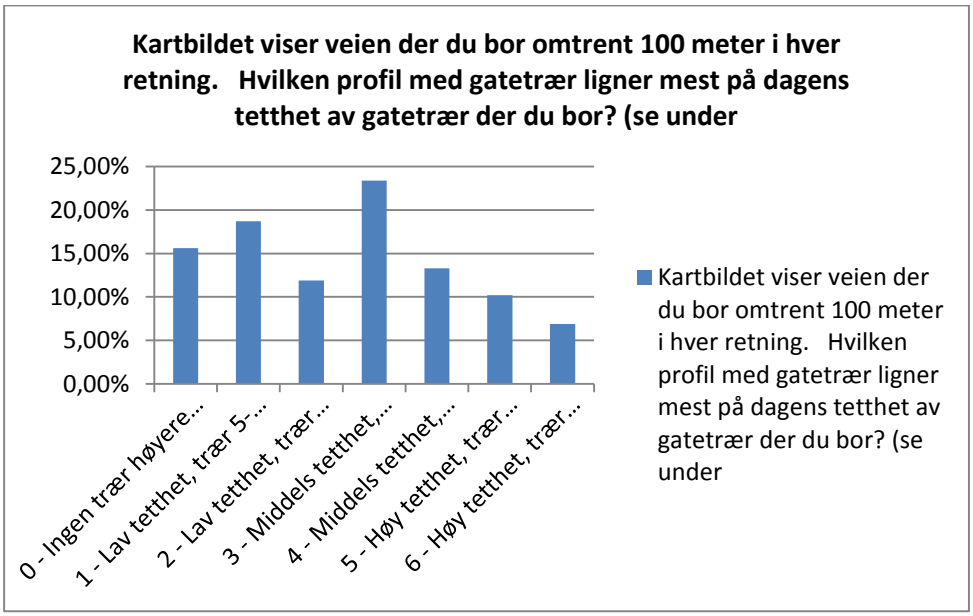


Figure 62 Distribution of current density of street trees in respondents' street

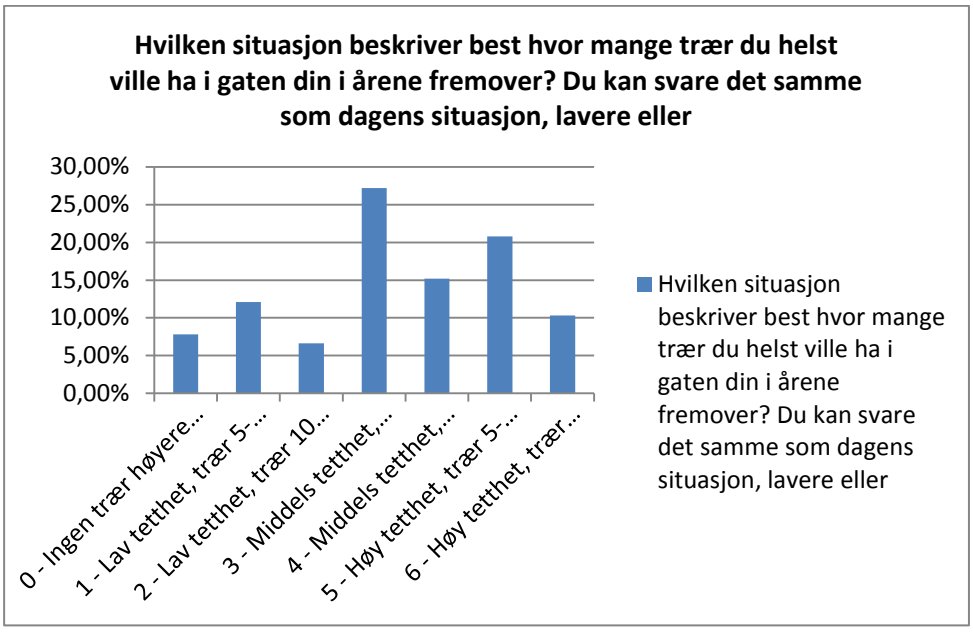
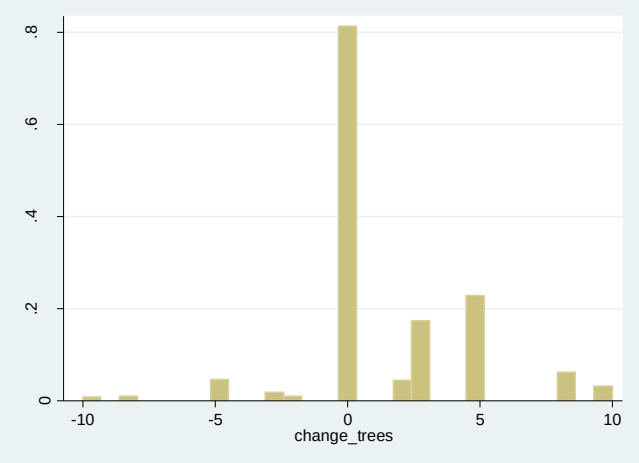


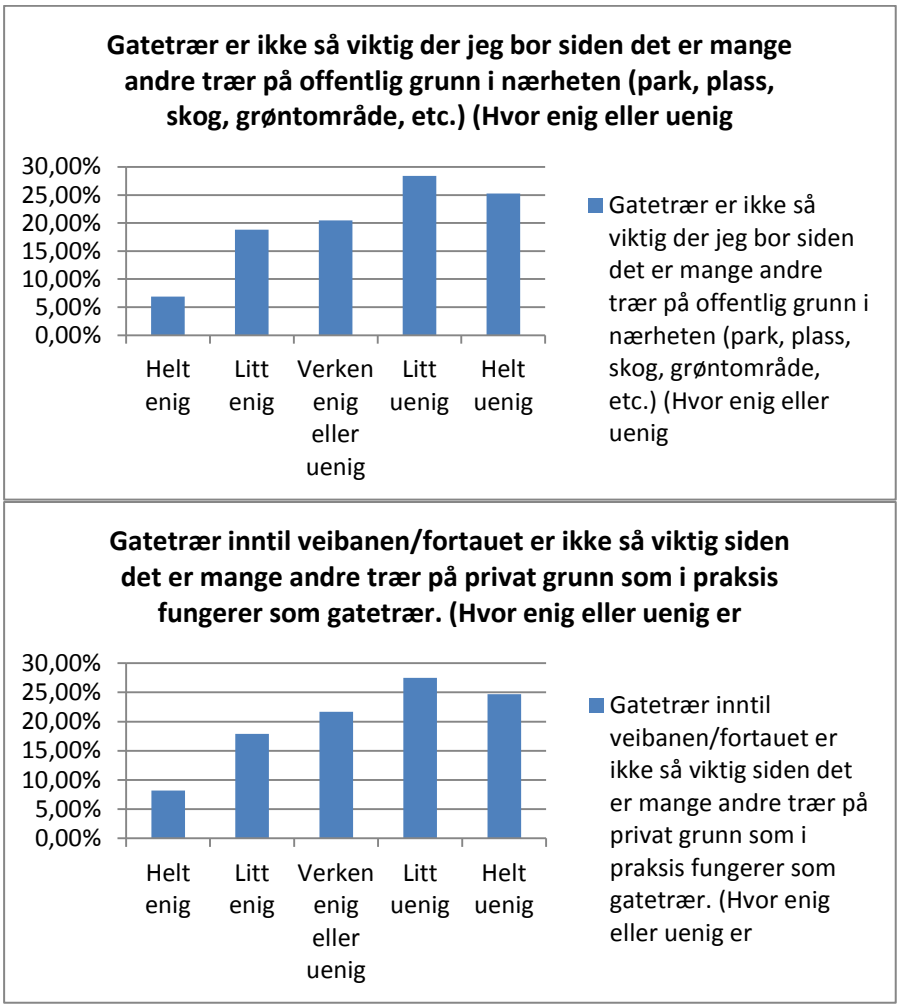
Figure 63 Distribution of desired density of street trees in respondents' street

With this information we could measure the difference in current and desired street tree density in the respondent's street.

change_trees	Freq.	Percent	Cum.
-10	6	0.60	0.60
-8	7	0.70	1.30
-5	32	3.20	4.50
-3	13	1.30	5.80
-2	7	0.70	6.50
0	561	56.10	62.60
2	31	3.10	65.70
3	120	12.00	77.70
5	158	15.80	93.50
8	43	4.30	97.80
10	22	2.20	100.00
Total	1,000	100.00	



More than 50% of the respondents wanted to maintain the current density of street trees, 40% wanted to increase it and only 6% wanted fewer street trees in their street. It is safe to say that people value and appreciate street trees where they live.


Gatetrær er ikke så viktig der jeg bor siden det er mange andre trær på offentlig grunn i nærheten (park, plass, skog, grøntområde, etc.) (Hvor enig eller uenig
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Gatetrær er ikke så viktig der jeg bor siden det er mange andre trær på offentlig grunn i nærheten (park, plass, skog, grøntområde, etc.) (Hvor enig eller uenig
Gatetrær inntil veibanen/fortauet er ikke så viktig siden det er mange andre trær på privat grunn som i praksis fungerer som gatetrær. (Hvor enig eller uenig er
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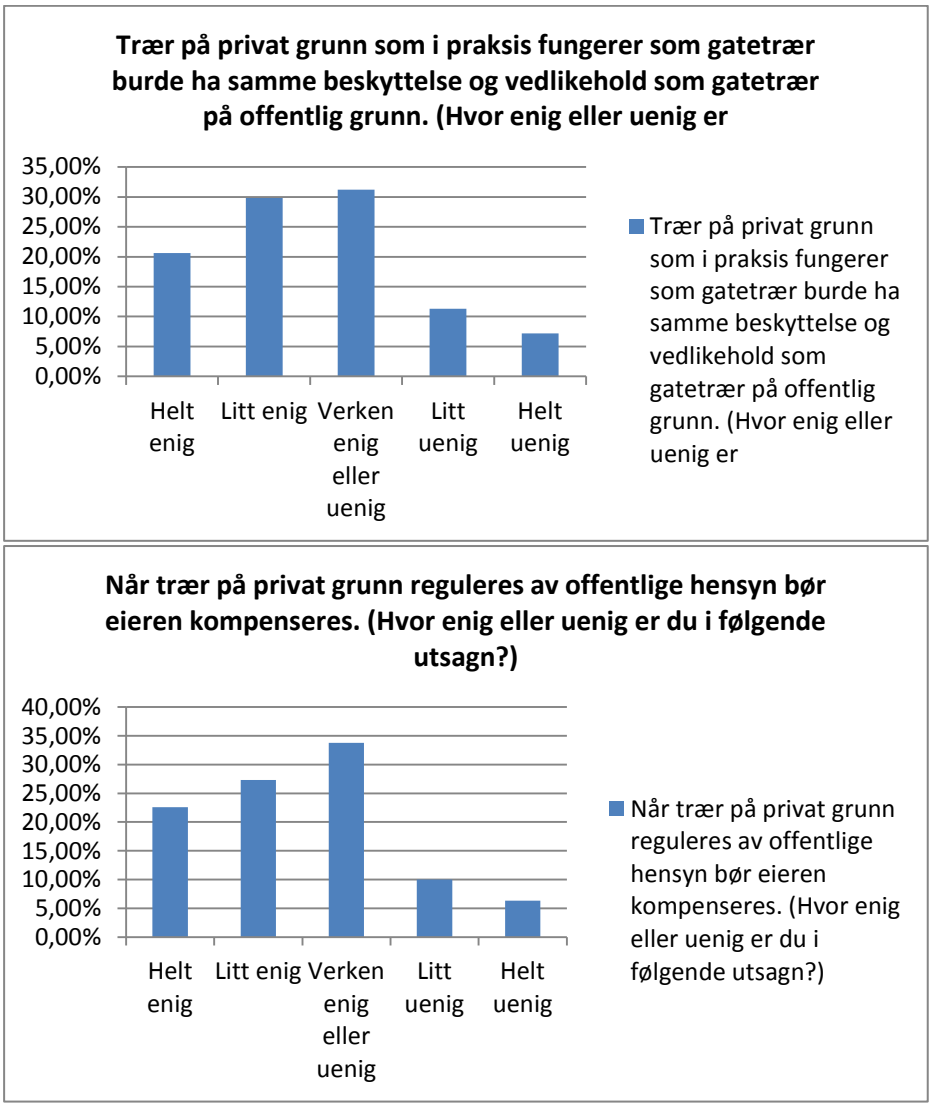

Figure 64 Attitudes concerning street trees

We asked the respondents some follow up questions about their attitudes concerning street trees. One of the things we were interested in was studying the substitution between public street trees and trees on private properties. The majority did not think street trees were not important because of other trees or natural structures acted substitutes. Another question was whether other trees acted as a public goods that could be subsidized by the government. We found some indication of this.

Reported WTP for maintenance or increase in street trees

The environmental good in question was density of street trees in 100m of the street in front of respondents' house. The scenario was that with growing population there would be increasing pressures on the street trees of Oslo, and the costs of providing them for the

municipality would go up. We asked whether they would be willing to pay to maintain or increase the level of street trees in their street. The respondents were themselves allowed to choose the payment vehicle. The payment would be annual and paid over the course of the next fifteen years.

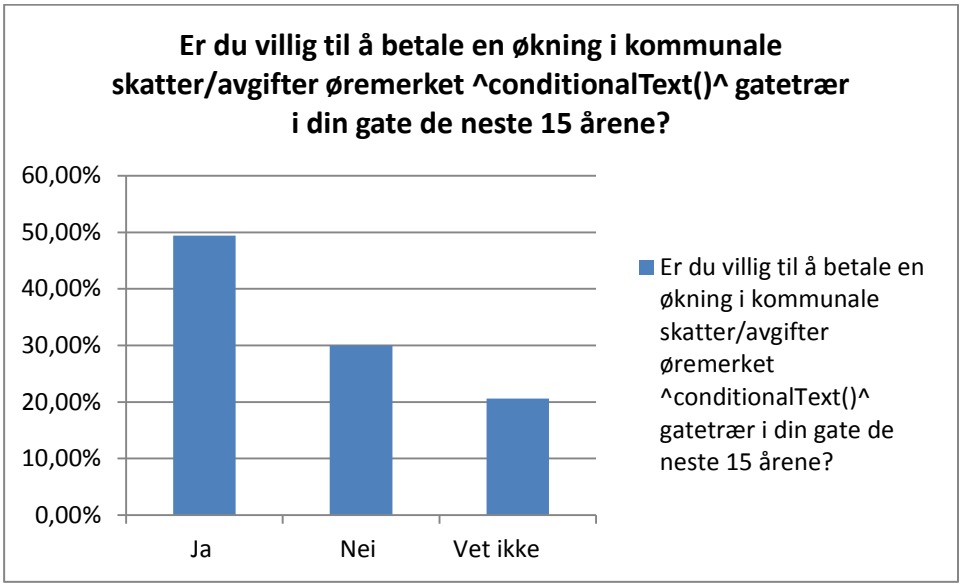

Figure 65 Number of respondents willing to pay for maintenance or increase in street trees

Half of the respondents were willing to pay for maintenance of increase in street trees. 30% reported they were not willing, and 20% did not know.

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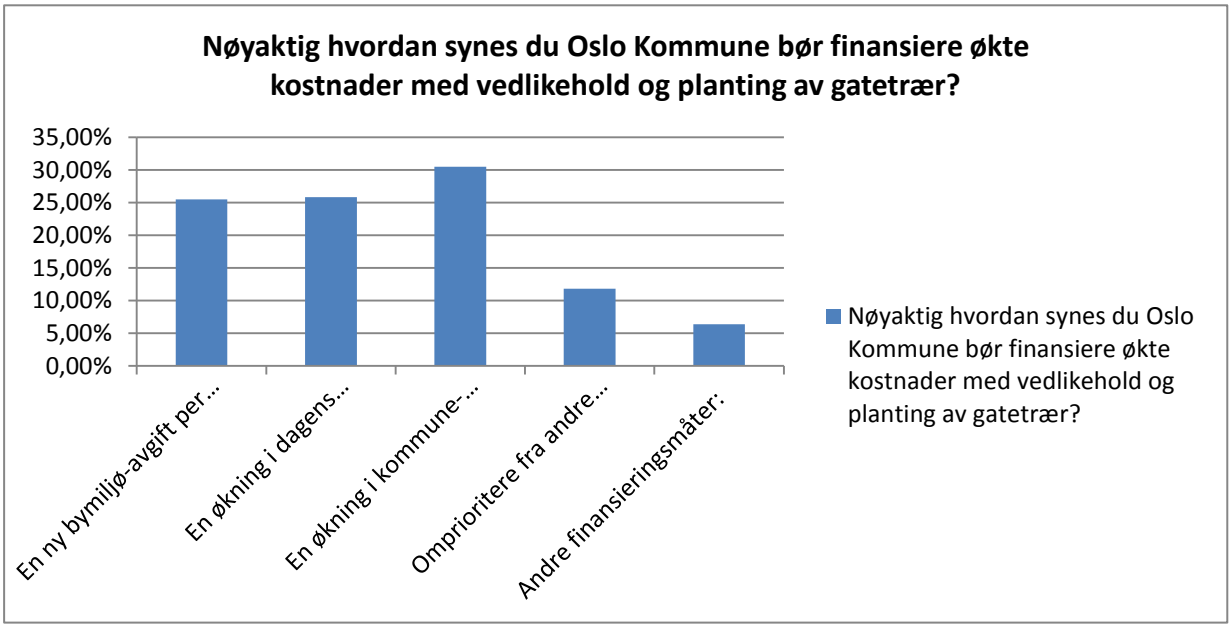


Figure 66 Distribution of payment vehicle selected by respondents

Table 21 Distribution of payment vehicle selected by respondents

BASE	423
En ny bymiljø-avgift per husstand øremerket gatetrær	25,50 %
En økning i dagens renovasjonsavgift per husstand øremerket gatetrær	25,80 %
En økning i kommune-skatt øremerket gatetrær	30,50 %
Omprioritere fra andre kommunale oppgaver, nemlig:	11,80 %
Andre finansieringsmåter:	6,40 %

There is a point to make here about the fact that respondents were allowed to choose their own payment vehicle, arguably this means that the WTP reported where not done so in an identical manner. And we could not see the effect on WTP of different types of payment vehicle to see weather this part of the survey design had an effect on the reported WTP. We wanted people to understand and find the scenario plausible and decided to it in this way to decrease the amount protest. And further more we wanted to see what type of payment vehicle the public wished to use in order to finance an environmental good such as this one.

One fourth of the respondents that said they were willing to pay chose a new city tax for every household specifically for street trees as the payment vehicle. One fourth chose an increase in an existing tax per household specifically for street trees. 30% chose an increase in the municipality tax specifically for street trees. 12% wanted the municipality to reprioritize from other expenditures. And 6% wanted another form of financing.

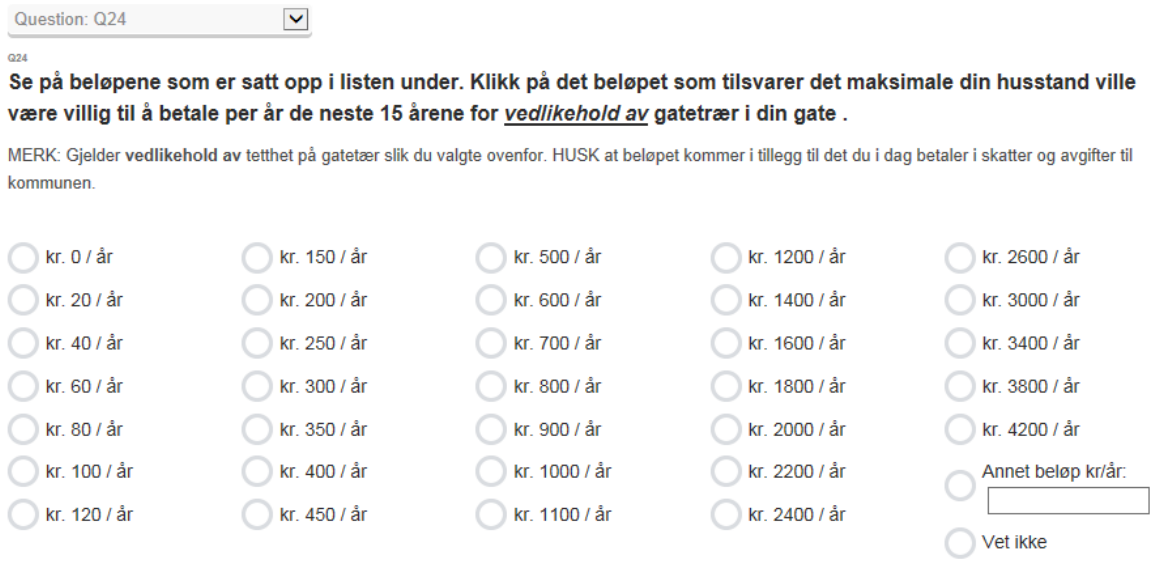


Figure 67 Picture of payment card used in survey

The respondents reported maximum WTP for the policy through a payment card, see Figure 67. The payment card had large range and many levels in order to minimize anchoring bias.

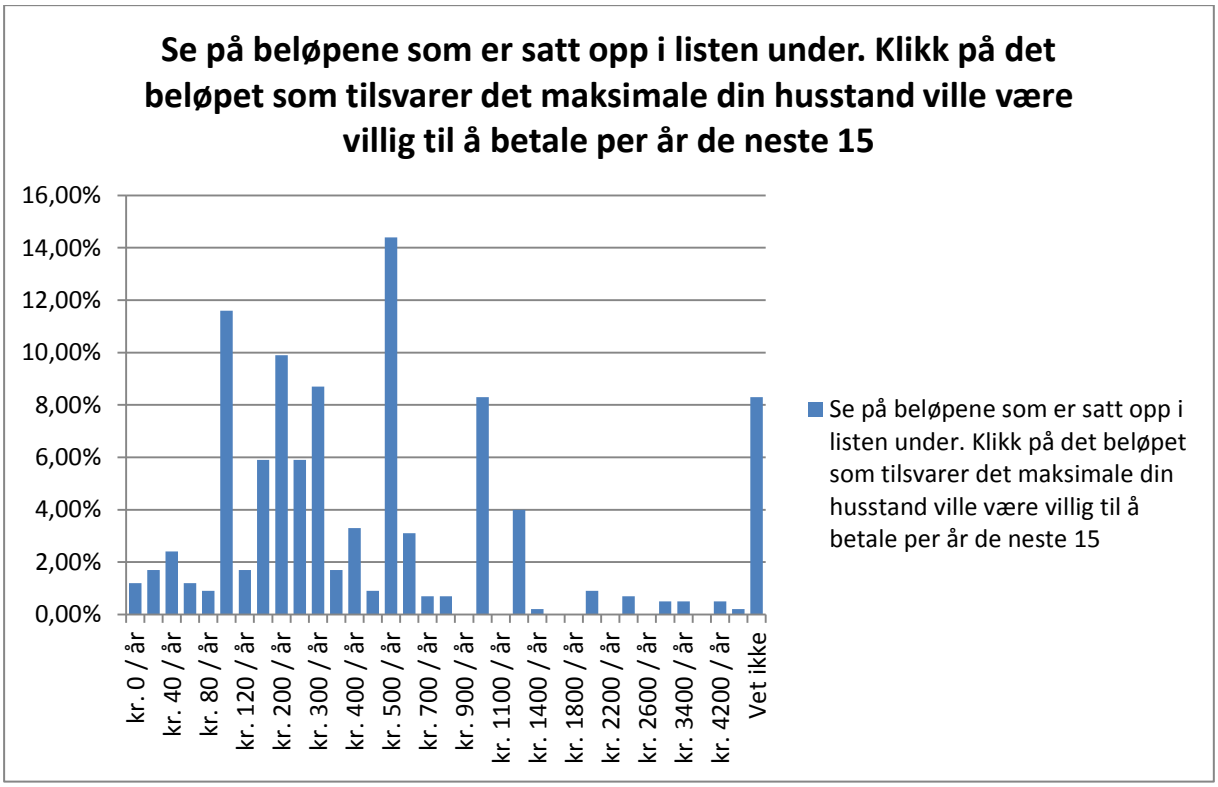
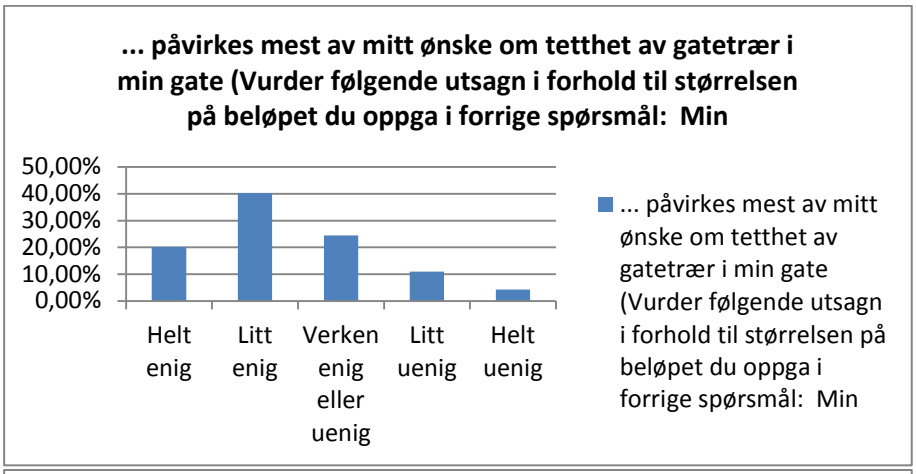
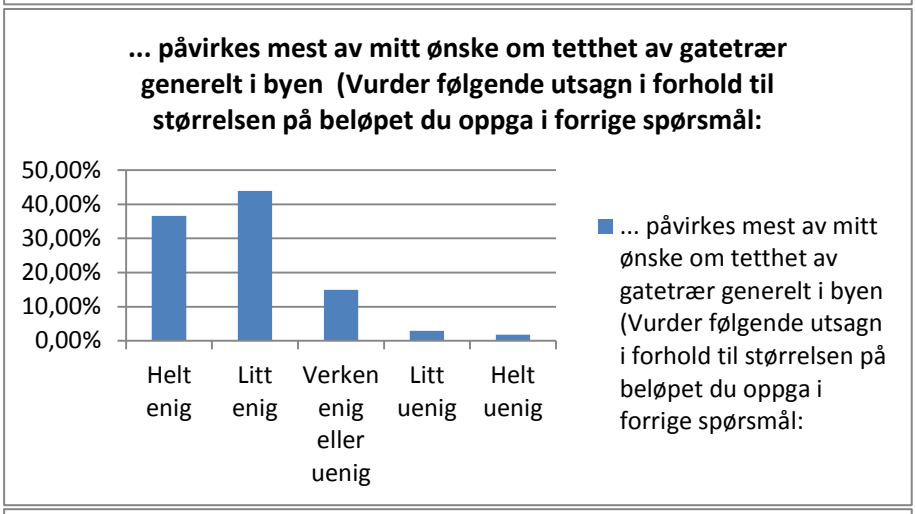
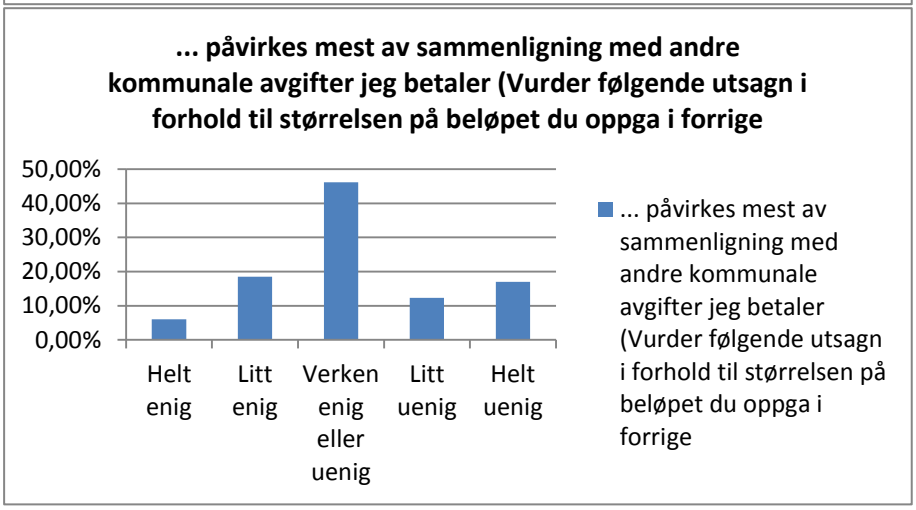


Figure 68 Distribution of reported WTP for maintenance or increase in street trees

In Figure 68 we see the distribution of reported WTP for maintenance or increase in street trees.


... påvirkes mest av mitt ønske om tetthet av gatetrær i min gate (Vurder følgende utsagn i forhold til størrelsen på beløpet du oppga i forrige spørsmål: Min
50,00%
40,00%
30,00%
20,00%
10,00%
0,00%
Helt enig
Litt enig
Verken enig eller uenig
Litt uenig
Helt uenig
... påvirkes mest av mitt ønske om tetthet av gatetrær i min gate (Vurder følgende utsagn i forhold til størrelsen på beløpet du oppga i forrige spørsmål: Min


... påvirkes mest av mitt ønske om tetthet av gatetrær generelt i byen (Vurder følgende utsagn i forhold til størrelsen på beløpet du oppga i forrige spørsmål:
50,00%
40,00%
30,00%
20,00%
10,00%
0,00%
Helt enig
Litt enig
Verken enig eller uenig
Litt uenig
Helt uenig
... påvirkes mest av mitt ønske om tetthet av gatetrær generelt i byen (Vurder følgende utsagn i forhold til størrelsen på beløpet du oppga i forrige spørsmål:


... påvirkes mest av sammenligning med andre kommunale avgifter jeg betaler (Vurder følgende utsagn i forhold til størrelsen på beløpet du oppga i forrige
50,00%
40,00%
30,00%
20,00%
10,00%
0,00%
Helt enig
Litt enig
Verken enig eller uenig
Litt uenig
Helt uenig
... påvirkes mest av sammenligning med andre kommunale avgifter jeg betaler (Vurder følgende utsagn i forhold til størrelsen på beløpet du oppga i forrige

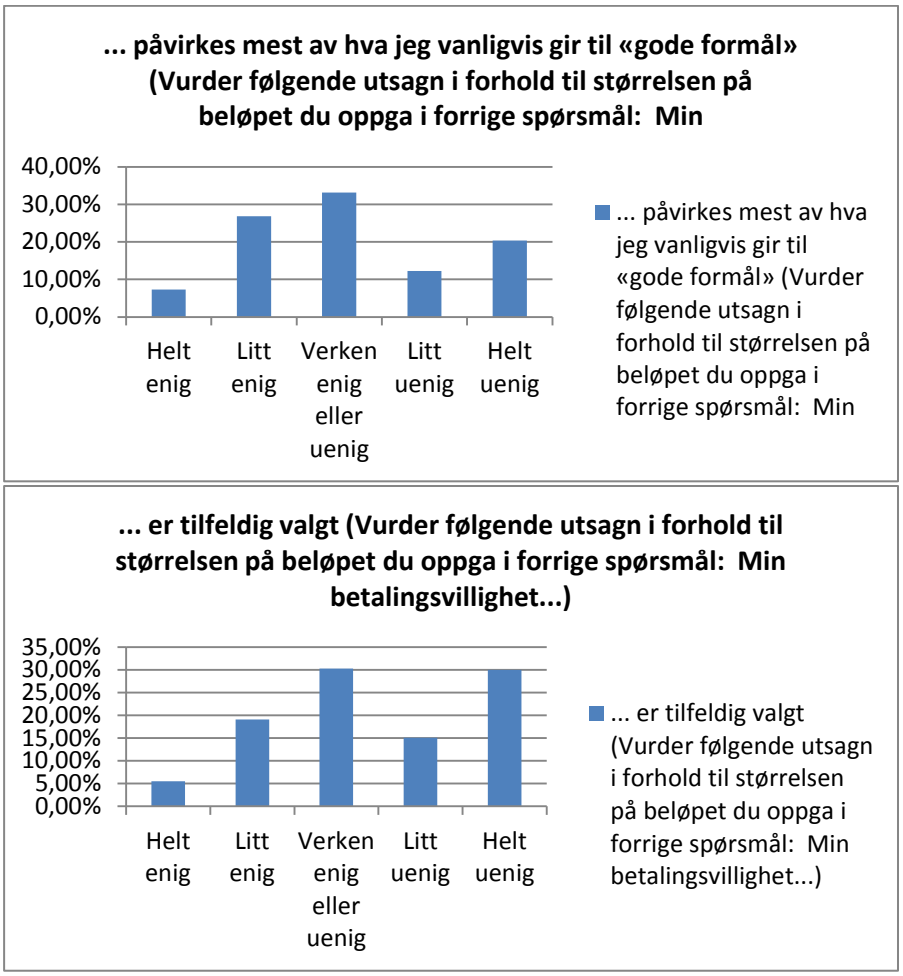


Figure 69 What respondents had in mind when reporting WTP

We asked some follow up questions to the respondents that had reported WTP to what they had had in mind when eliciting their WTP.

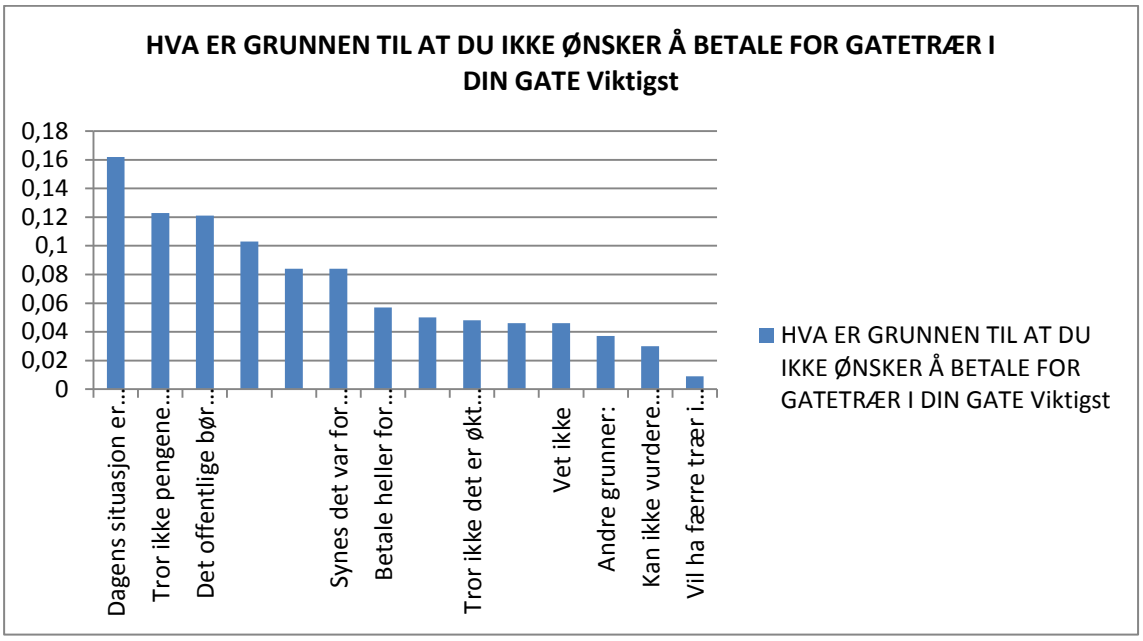
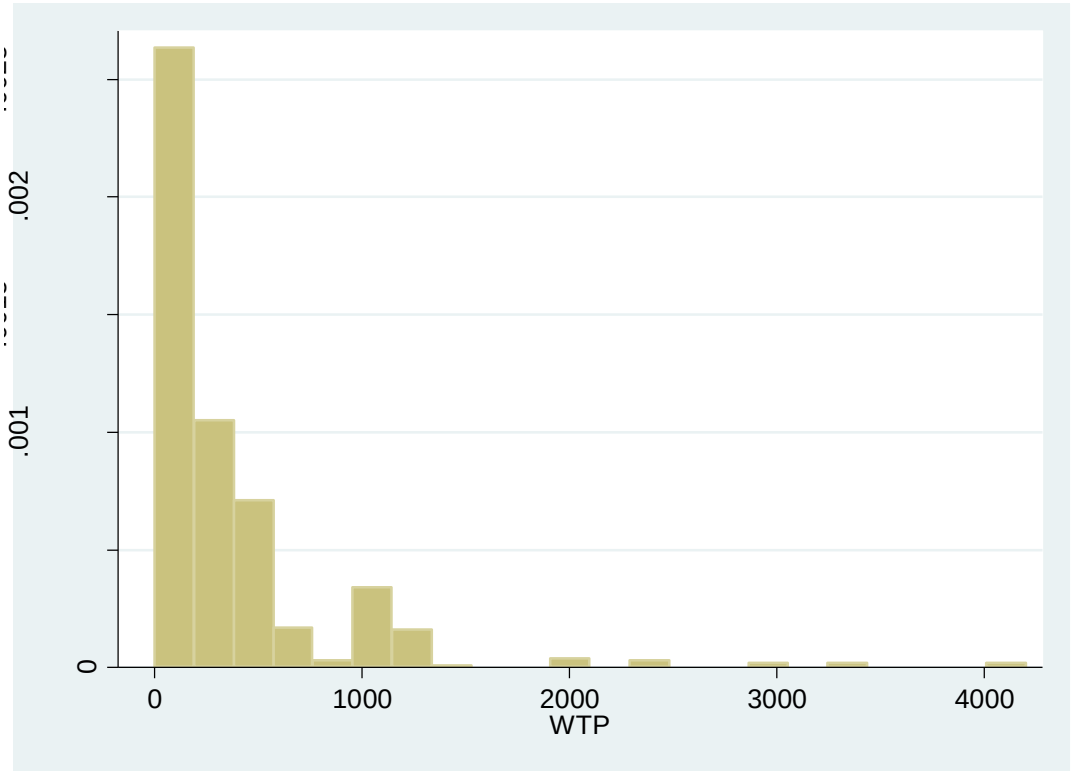


Figure 70 Reason for not wanting to report WTP

We asked follow up questions to the people that did not want to report a WTP and classified the answers as either true zero or protest responses. The distribution of reported WTP then looked like this.



The distribution is clearly right skewed.

We also wanted to know whether the people that wanted fewer street trees had a WTP to remove these trees. Very few did, and the few that did gave an unusually high number. Likely believing this was not a plausible cost to them, and possible being an incentive problem here. With them giving a high number to affect their wish.

Appendix B: Detailed econometric analysis of the results

Analysis of WTP data – See section 9.1

Converted the scale variable to NOK values, including classifying "other" reply as NOK value and "don't know" as non-reply. Left with a variable that is easy to work with. The follow up questions on reasons for not giving WTP where classified as either protest answer and was rightfully left out of the analysis, while true zero answers where classified as WTO equal to zero and included in the econometric analysis.

The follow up questions about what respondents had in mind when reporting WTP revealed that a few respondents gave an arbitrary amount. Decided to leave these out of econometric analysis because they were not genuine WTP answers.

Scope, embeddedness, validity

Change street trees. Created the change variable based on desired minus current street tree density level. Converted scale variable to different forms of values, including number of trees, height of trees 8mid range) and height of trees (lower bound). The change variable could be used to investigate scope effect.

Illustrating scope - See section 9.2.1**.** Are WTP estimates sensitive to the scope of the policy? We investigated whether the estimated WTP was different for different initial levels of street tree density and desired change in street tree density. We found a small negative relationship between current level and estimated mean WTP (not significant) and a positive relationship between desired level and estimated mean WTP (significant). This is a good sign and in accordance with economic theory - that peoples WTP decrease with amount they have and increase with amount they are valuing. This indicates that people understood the CV exercise

Substitution ST and other trees. Checked for correlation between current situation and view of trees from house. View dummies included; trees on own property, trees on neighbors' property, trees in street, city park and forest. There was no significant correlation (>0.3 Pearson coeff) wetween current situation and any of the view dummies. Then tested regression of view on WTP, with the hypothesis that they are substitutes and would therefore have a negative effect on WTP. "Trees on own property" and "city park" have significant effect on WTP. But the effect is positive, meaning they are not substitute for street trees. Only "forest" dummy had negative effect on WTP, indicating substitution effect, but this was not a significant effect.

Other questions about people's attitudes gave an indication about substitution effect. Most respondents disagreed that street trees where not that important because there are so many other trees nearby.

. tab q21_1

Gatetrær er ikke så viktig der jeg bor siden det er mange andre trær på offentli	Freq.	Percent	Cum.
Helt enig	66	6.95	6.95
Litt enig	179	18.84	25.79
Verken enig eller uenig	195	20.53	46.32
Litt uenig	270	28.42	74.74
Helt uenig	240	25.26	100.00
Total	950	100.00	

. tab q21_2

Gatetrær inntil veibanen/fortauet er ikke så viktig siden det er mange andre træ	Freq.	Percent	Cum.
Helt enig	78	8.21	8.21
Litt enig	170	17.89	26.11
Verken enig eller uenig	206	21.68	47.79
Litt uenig	261	27.47	75.26
Helt uenig	235	24.74	100.00
Total	950	100.00	

We also carried out an extra check for consistency, if attitude about street trees in own district reflect desired change in street trees in street. We found a positive correlation which was good.

```
. correlate q11_3 change
(obs=1000)
```

	q11_3	change
q11_3	1.0000	
change	0.4401	1.0000

We also wanted to see if the house type affected their attitude towards regulation of private trees that acted as street trees. Hypothesis being that there would be a difference between people that owned and rented. Unambiguous results.

q21_3 Trær på privat grunn som i praksis fungerer som gatetrær burde ha samme beskyttelse

q21_4 Når trær på privat grunn reguleres av offentlige hensyn bør eier kompenseres

Summary statistics: N, mean, sd
by categories of: q2 (Hvilke boligtype bor du i?)

q2	q21_3	q21_4
Enebolig, eiet	110	110
	2.6	2.309091
	1.16682	1.131253
Enebolig, leiet	11	11
	2.545455	2.272727
	1.21356	1.103713
Leilighet, eiet	514	514
	2.523346	2.55642
	1.11364	1.100119
Leilighet, leiet	153	153
	2.457516	2.45098
	1.186475	1.175077
Hybel, leiet	17	17
	2.588235	2.470588
	1.00367	.8744746
Rekkehus/flerman	128	128
	2.71875	2.578125
	1.229157	1.264969
Rekkehus/flerman	14	14
	2.357143	2
	1.215739	.7844645
Annet	3	3
	2	2.666667
	1	.5773503
Total	950	950
	2.545263	2.501053
	1.147478	1.132664

What respondents had in mind when reporting WTP.

Follow up questions about what people had in mind when reporting WTP was interesting in order to see what reasoning the respondents had used. We used a likert scale and asked respondents if what they had in mind when reporting WTP vas influenced mostly by - desire for street trees in own street, desire for street trees in city in general, comparing to other municipality taxes they pay, what they usually give to "good" causes or was arbitrarily selected.

There were some respondents that reported WTP arbitrarily, meaning they were not based on true preferences. These answers where left out of the WTP econometric study.

The more people that answered that their WTP was mostly influenced by their desire for street trees in their street because this was what we had asked them to express a WTP for. Only 231 agreed with this statement, which is a bit low.

```
. tab q25_1
```

... påvirkes mest av mitt ønske om tetthet av gatetrær i min gate (Vurder følgen	Freq.	Percent	Cum.
Helt enig	77	20.10	20.10
Litt enig	154	40.21	60.31
Verken enig eller uenig	94	24.54	84.86
Litt uenig	42	10.97	95.82
Helt uenig	16	4.18	100.00
Total	383	100.00	

We conducted an extra validity test to see weather respondents with positive WTP had higher correlation between WTP and size of change in ST. The group that thought about street trees in own street and/or street trees in entire city had a higher correlation between WTP and size of change in ST than the rest of the sample.

We also estimated the mean WTP for the different groups, and as expected the people that where was most influenced by desire for street trees in own street had higher mean estimated WTP than the other groups.

```
sum WTP
```

Variable	Obs	Mean	Std. Dev.	Min	Max
WTP	523	333.9006	523.9133	0	4200

```
sum WTP if q25_1_2_dummy==1
```

Variable	Obs	Mean	Std. Dev.	Min	Max
WTP	316	507.8481	591.2203	20	4200

```
sum WTP if q25_1_dummy==1
```

Variable	Obs	Mean	Std. Dev.	Min	Max
WTP	221	492.5339	576.6982	20	4200

Subsamples/groups – See section 8.2.2

Created different subsamples/groups of interest. First of all to see the distribution of different types of respondents, how many gave WTP, how many had zero WTP and how many did not give WTP (protests). Furthermore we wanted to see if there were any significant differences

between the groups. We also created groups for people that gave inconsistent answers (positive WTP when desired lower street tree density), and different motives behind WTP; arbitrarily chosen, donation motive and tree density motive.

Variable fix/explaining variables (renaming variables)

The following is an explanation on the variables being used in the econometric analysis. Some of the variables had to be adjusted while some new variables where created.

Age. Age given in years.

Gender. Gender represented by 1 if male and 2 if female

Birthplace. Dummy variables indicated if you were born in Oslo, other county or abroad. The same was done for respondents' mother and father to say something about cultural background.

Education. This variable indicates highest achieved education level. Divided in 5 groups; elementary school, high school, uni/college 1-3 years, uni/college 4+ years, uni/college 5+ years.

```
. tab no_educationlevel
```

Hva er din høyeste fullførte utdannelse?	Freq.	Percent	Cum.
Grunnskole	33	3.31	3.31
Videregående	181	18.15	21.46
Universitet-/høyskole 1-3 år (Bachelor	360	36.11	57.57
Universitet-/høyskole 4 år + (Master el	322	32.30	89.87
Universitet-/høyskole 5 år + (Doktorgra	83	8.32	98.19
Annet	18	1.81	100.00
Total	997	100.00	

Civil status. Civil status is represented by seven dummy variables for each civil status

```
. tab civil_status
```

Hva er din sivilstatus?	Freq.	Percent	Cum.
Enslig	363	36.48	36.48
Gift/partnerskap/samboer (uten barn i h	366	36.78	73.27
Gift/partnerskap/samboer (med barn i hu	173	17.39	90.65
Bor hos mine foreldre	38	3.82	94.47
Enke/enkemann	8	0.80	95.28
Vil ikke svare	10	1.01	96.28
Annet	37	3.72	100.00
Total	995	100.00	

Income. Different ranges from zero to over 1,5 million NOK per year. This was converted to variable with NOK value limits to make statistical analysis and interpretation easier.

```
. tab no_personal_income
```

Hva er din personlige inntekt (før skatt)?	Freq.	Percent	Cum.
0-100.000 NOK	77	7.77	7.77
100.001-200.000 NOK	73	7.37	15.14
200.001-300.000 NOK	70	7.06	22.20
300.001-400.000 NOK	135	13.62	35.82
400.001-500.000 NOK	179	18.06	53.88
500.001-600.000 NOK	117	11.81	65.69
600.001-700.000 NOK	69	6.96	72.65
700.001-800.000 NOK	38	3.83	76.49
800.001-900.000 NOK	62	6.26	82.74
900.001-1000.000 NOK	6	0.61	83.35
1.000.001-1.100.000 NOK	5	0.50	83.85
1.100.001-1.300.000 NOK	1	0.10	83.96
1.300.001-1.500.000 NOK	5	0.50	84.46
Vil ikke svare	125	12.61	97.07
Vet ikke	29	2.93	100.00
Total	991	100.00	

```
tab income
```

income	Freq.	Percent	Cum.
100000	77	9.20	9.20
200000	73	8.72	17.92
300000	70	8.36	26.28
400000	135	16.13	42.41
500000	179	21.39	63.80
600000	117	13.98	77.78
700000	69	8.24	86.02
800000	38	4.54	90.56
900000	62	7.41	97.97
1000000	6	0.72	98.69
1100000	5	0.60	99.28
1300000	1	0.12	99.40
1500000	5	0.60	100.00
Total	837	100.00	

Number of people in household.

Hvor mange personer bor de i din husstand (barn og voksne, inkludert deg selv)?	Freq.	Percent	Cum.
1 person	310	31.00	31.00
2 personer	414	41.40	72.40
3 personer	125	12.50	84.90
4 personer	108	10.80	95.70
5 personer eller flere	43	4.30	100.00
Total	1,000	100.00	

Children in household. Dummy variable indicating whether or not there are children in the household, based on age group of members in household.

Period lived in city, district and street. These variables indicated number of years respondent had lived in Oslo, current district and current street respectively.

Outdoorsy. Variable created based on questions regarding use of fjords, forest and parks in Oslo. It sums up amount of trips to each place in each season throughout last year. Gives us an impression about the respondent and how much he uses nature in city.

Activities. Variable created based on questions regarding use. What activities person does when using nature in Oslo. Sums number of activities respondent engages in. Gives us an impression about the respondent and how active the person is.

Attitude trees. Reports if the respondent wants more or less trees in Oslo, street trees in center of Oslo and street trees in own district.

Experienced positive negative effects of street trees. These variables report number of experienced benefits and costs from street trees where respondent lives.

Attitudes regarding street trees (q21_1-q21_4). These variables indicates the substitutability between public street trees and other natural structures and whether respondent feels private street trees that fiils same function as private street trees should be regulated in same way and if private owners should be compensated.

Location. Variables indicating zip-code and district. Created dummy variables for each district and one for living in Oslo center or outskirts of Oslo. Interesting to see if WTP varies with location. Used for hotspot analysis.

Living arrangement. Dummy variables indicating what sort of home and ownership status. Interesting to see if they value street trees differently. Also if ownership of property affects results.

View from house. View of natural structures from house. Interesting to investigate substitutability.

Current situation street trees in own street. Five different levels of street tree density.

Desired situation street trees in own street. Five different levels of street tree density.

Desired change. Desired level minus current level. Several different versions of this variable was created, including difference in level, number of trees, sum of tree height mid range and sum of tree height lower bound.

WTP. Reported household willingness to pay for maintained or increased level of street tree density, depending on reported desired change, in own street over the next 15 years.

What influenced/had in mind/motivation when giving WTP (q25_1-q25_5). Follow up questions about what people had in mind when reporting WTP was interesting in order to see what reasoning the respondents had used. We used a Likert scale and asked respondents if what they had in mind when reporting WTP vas influenced mostly by - desire for street trees in own street, desire for street trees in city in general, comparing to other municipality taxes they pay, what they usually give to "good" causes or was arbitrarily selected.

WTP to cut down trees. We asked the peopled that desired less street trees than the current situation if they would be willing to pay to decrease the level of street trees in their street. We only got a few answers, and most of them where unlikely high. This was not enough to pursue any formal statistical analysis.

Exploring effects on WTP.

Bydel. We investigated what districts had a significant effect on WTP. Found that living in Grunerløkka, Bjerke, Alna, had a significant effect on WTP. Created city center dummy based on districts in city center (Gamle Oslo, Grunerløkka, St. Hanshaugen, Frogner). Found that this had a significant positive effect on WTP. Probably because of less street trees, less substitutes and higher density populated areas.
Living arrangement. Found that renting "enebolig" or "leilighet" had significant postitve effect on WTP.
Barn in household. Found no significant effect of having children in household on WTP.
Education. Found that education had a positive effect on WTP.
Civil status. Found that couple with children had significant positive effect on WTP
Birthplace (self and parets). Birthplace of respondent or either of respondents parents had no significant effect on WTP.

Type of regression

```
. tobit WTP, ll(0)

Tobit regression                                  Number of obs   =        523
                                                  LR chi2(0)      =      -0.00
                                                  Prob > chi2     =          .
Log likelihood = -3005.6068                       Pseudo R2       =    -0.0000

------------------------------------------------------------------------------
         WTP |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _cons |   185.0376   32.24226     5.74   0.000     121.6973    248.3778
-------------+----------------------------------------------------------------
      /sigma |   683.8249   26.71274                      631.3475    736.3024
------------------------------------------------------------------------------

  Obs. summary:        161  left-censored observations at WTP<=0
                       362     uncensored observations
                         0 right-censored observations
```

```
reg WTP

      Source |       SS       df       MS              Number of obs =     523
-------------+------------------------------           F(  0,   522) =    0.00
       Model |           0     0           .           Prob > F      =       .
    Residual |   143281243   522   274485.14           R-squared     =  0.0000
-------------+------------------------------           Adj R-squared =  0.0000
       Total |   143281243   522   274485.14           Root MSE      =  523.91

------------------------------------------------------------------------------
         WTP |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _cons |   333.9006   22.90913    14.58   0.000     288.8952     378.906
------------------------------------------------------------------------------
```

```
. logit WTP

Iteration 0:   log likelihood =  -322.8798
Iteration 1:   log likelihood =  -322.8798

Logistic regression                               Number of obs   =        523
                                                  LR chi2(0)      =       0.00
                                                  Prob > chi2     =          .
Log likelihood =  -322.8798                       Pseudo R2       =     0.0000

------------------------------------------------------------------------------
         WTP |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _cons |   .8102398   .0947291     8.55   0.000     .6245741    .9959056
------------------------------------------------------------------------------
```

```
. probit WTP

Iteration 0:   log likelihood =  -322.8798
Iteration 1:   log likelihood =  -322.8798

Probit regression                                 Number of obs   =        523
                                                  LR chi2(0)      =      -0.00
                                                  Prob > chi2     =          .
Log likelihood =  -322.8798                       Pseudo R2       =    -0.0000

------------------------------------------------------------------------------
         WTP |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       _cons |    .501984   .0573883     8.75   0.000     .3895051    .6144629
------------------------------------------------------------------------------
```

Regress WTP (reg and tobit, ll(0))

Explored the effect of variables on WTP if following way:

- **One on one**
- **Groups (correlation matrix and reason for dropping)**
- **All (correlation matrix and reason for dropping)**
- **BT model**

After running one on one regressions of each variable against WTP, we found the significant variables. Divided into groups and checked for collinearity. The variables with a correlation higher than 0.3 where dropped in order to avoid collinearity. Below the correlation matrices in the section below, we specify what variable in the correlation pairs where dropped and reason why.

We ran regressions (tobit ll(0)) to investigate the effect of the different variables on WTP. The variables with significant effect where:

Respondent characteristics: education, par_uten_barn, income, q33_4&_6 (Age groups people in household, 17-19 år & 35-49 år), periode_lived_in_oslo, outdoorsy, activities

Respondent attitudes: attitude_trær_i_oslo, attitude_gatetrær_i_oslo_sentrum, attitude_gatetrær_i_din_bydel, attitude_trees, pos_trees, q21_1/2/3 (Street trees not important because of other public trees, Street trees not important because of private trees that fulfill same functions, These private trees should be treated as public street trees)

Location characteristics: zipcode, bydel, grunerløkka, vestre_aker, bjerke, alna, sentrum_dummy, enebolig_leiet, leilighet_leiet

Scope: q18 (desired density), change/pos/trees/trees_pos/height2/height3, payment vechicle, q25_2/3/4/5 (WTP motivated by street tree density in city, WTP motivated by comparing other taxes, WTP motivated by what I usually donate to good causes, WTP was arbitrarily chosen)

Correlation between variables inn each group

```
. *Respondent characteristics

.
. pwcorr WTP education par_uten_barn par_med_barn income nr_people_in_hh q33_4 q33_6 period_lived_in_oslo outdoorsy ac
```

	WTP	educat~n	par_ut~n	par_me~n	income	nr_peo~h	q33_4
WTP	1.0000						
education		1.0000					
par_uten_b~n		0.0536	1.0000				
par_med_barn		0.1133	-0.3475	1.0000			
income	0.0805	0.3582	0.0774	0.2243	1.0000		
nr_people_~h			-0.0741	0.6233	0.0782	1.0000	
q33_4		-0.1856	-0.2821	0.1219	-0.1175	0.2894	1.0000
q33_6			-0.2206	0.3095	0.2008	0.2978	0.1174
period_liv~o	0.0941			0.1095	0.2393	0.0842	0.1051
outdoorsy	-0.0800	-0.2082		-0.1061	-0.1664	-0.0787	
activities		0.0644			-0.0782	0.1187	

	q33_6	period~o	outdoo~y	activi~s
q33_6	1.0000			
period_liv~o	0.1462	1.0000		
outdoorsy	-0.0769	-0.0646	1.0000	
activities	0.1385	-0.1017	-0.3679	1.0000

Education was dropped because it was correlated with income, and income had a bigger effect on WTP. The variables “par_uten_barn” and “par_med_barn” where dropped because they were correlated with eachother and number of people in household.

```
. *Respondent attitudes

.
. pwcorr WTP attitude_trær_i_oslo attitude_gatetrær_i_oslo_sentrum attitude_gatetrær_i_din_bydel attitude_trees pos_trees q21_1 q21_2 q21_3, print(.1)
```

	WTP	attitu~o	attitu~m	attitu~l	attitu~s	pos_tr~s	q21_1
WTP	1.0000						
attitude_t~o	0.2923	1.0000					
attitude_g~m	0.2824	0.7584	1.0000				
attitude_g~l	0.2487	0.6359	0.5914	1.0000			
attitude_t~s	0.3157	0.9065	0.8862	0.8476	1.0000		
pos_trees	0.2403	0.2256	0.2623	0.1525	0.2425	1.0000	
q21_1	0.2200	0.3060	0.2956	0.2889	0.3366	0.1632	1.0000
q21_2	0.2117	0.3179	0.3069	0.3448	0.3669	0.1353	0.6428
q21_3	-0.0910	-0.1289	-0.1359	-0.1207	-0.1455	-0.1267	

	q21_2	q21_3
q21_2	1.0000	
q21_3		1.0000

The variables about attitude trees in Oslo, street trees in Oslo center and in district where all dropped and instead kept the variable attitude trees, which is a combination of these three variables. We did not get any more information from differentiating between these three attitudes at this point. The variables q21_1 and q21_2 about substitutability of street trees with other natural structures was dropped because they were correlated with each other.

```
. *Location characteristics

.
. pwcorr WTP zipcode bydel grunerløkka vestre_aker bjerke alna sentrum_dummy enebolig_leiet leilighet_leiet, print(.1)
```

	WTP	zipcode	bydel	gruner~a	vestre~r	bjerke	alna
WTP	1.0000						
zipcode		1.0000					
bydel	-0.1012	0.7414	1.0000				
grunerløkka	0.1498	-0.1214	-0.3853	1.0000			
vestre_aker				-0.0855	1.0000		
bjerke	-0.0770		0.0661	-0.0677	-0.0623	1.0000	
alna	-0.0893	0.1262	0.2612	-0.0823	-0.0758	-0.0600	1.0000
sentrum_du~y	0.1336	-0.5563	-0.7181	0.4413	-0.1938	-0.1534	-0.1866
enebolig_l~t							
leilig~leiet	0.0874	-0.2467	-0.1917	0.0656			-0.0947

	sentru~y	en~leiet	le~leiet
sentrum_du~y	1.0000		
enebolig_l~t		1.0000	
leilig~leiet	0.2251		1.0000

The variables “zipcode” and “bydel” are numbered in way that does not make them ideal for interpretation and they are negatively correlated with the “sentrum_dummy” variable. Therefore they are dropped from the model while the dummy variable is kept because it captures the effect of most clearly. Grunerløkka is also dropped because it is correlated with citer center dummy variable.

```
. *Scope

.
. pwcorr WTP q18 change change_pos change_trees change_trees_pos change_height2 change_height3 payment_vehicle q25_2 q25_
```

	WTP	q18	change	ch~e_pos	chang~es	ch~s_pos	chang~t2
WTP	1.0000						
q18	0.2247	1.0000					
change	0.2437	0.4557	1.0000				
change_pos	0.2437	0.3914	1.0000	1.0000			
change_trees	0.2499	0.4779	0.9414	0.9249	1.0000		
change_tr~os	0.2499	0.4239	0.9201	0.9249	1.0000	1.0000	
change_he~t2	0.2916	0.4920	0.9658	0.9583	0.9281	0.9030	1.0000
change_he~t3	0.2927	0.4615	0.9036	0.8800	0.8042	0.7392	0.9677
payment_ve~e	-0.0892						
q25_2	-0.1720						
q25_3	0.1864	0.1320	0.0923	0.0923	0.0971	0.0971	0.1214
q25_4	0.1355		0.1256	0.1256	0.1317	0.1317	0.1498
q25_5	0.2953		0.0973	0.0973	0.1035	0.1035	0.1053

	chang~t3	paymen~e	q25_2	q25_3	q25_4	q25_5
change_he~t3	1.0000					
payment_ve~e	0.0816	1.0000				
q25_2			1.0000			
q25_3	0.1266			1.0000		
q25_4	0.1476			0.4886	1.0000	
q25_5	0.0961		-0.1724	0.1486	0.1650	1.0000

The variable “q18” which represents desired level of street trees in street as well as all the different change variables except for one is dropped because of the high correlation between them.

Regression models with correlated variables dropped of each group

Respondent characteristics

```
. tobit WTP income nr_people_in_hh q33_4 q33_6 period_lived_in_oslo outdoorsy a
> ctivities, ll(0)

Tobit regression                                  Number of obs   =        307
                                                  LR chi2(7)      =      17.24
                                                  Prob > chi2     =     0.0159
Log likelihood =  -1802.986                       Pseudo R2       =     0.0048

------------------------------------------------------------------------------
         WTP |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      income |   .0000242   .0001516     0.16   0.874    -.0002742    .0003225
nr_people_~h |  -77.81703   38.86313    -2.00   0.046    -154.2959   -1.338147
       q33_4 |  -205.169    147.2707    -1.39   0.165    -494.9833    84.64539
       q33_6 |   92.64177   74.49932     1.24   0.215    -53.96566    239.2492
period_liv~o |   94.07867   41.15014     2.29   0.023     13.09919    175.0582
   outdoorsy |  -3.042841   4.466498    -0.68   0.496    -11.83248    5.746795
  activities |   14.08248   9.818189     1.43   0.153    -5.238765    33.40372
       _cons |   32.15598   312.7168     0.10   0.918    -583.2404    647.5524
-------------+----------------------------------------------------------------
       /sigma |   557.2286   27.60123                      502.9121    611.5451
------------------------------------------------------------------------------

  Obs. summary:         83  left-censored observations at WTP<=0
                       224     uncensored observations
                         0 right-censored observations
```

Respondent attitudes

```
. tobit WTP attitude_trees pos_trees q21_3, ll(0)

Tobit regression                                  Number of obs   =        439
                                                  LR chi2(3)      =      82.04
                                                  Prob > chi2     =     0.0000
Log likelihood = -2615.4379                       Pseudo R2       =     0.0154

------------------------------------------------------------------------------
         WTP |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
attitude_t~s |   102.7914   15.30542     6.72   0.000      72.7098     132.873
   pos_trees |   60.51055   12.39786     4.88   0.000     36.14354    84.87756
       q21_3 |  -18.33936   24.26637    -0.76   0.450    -66.03297    29.35425
       _cons |  -1240.799   200.3792    -6.19   0.000    -1634.628   -846.9695
-------------+----------------------------------------------------------------
       /sigma |   570.2759   23.04904                      524.9749     615.577
------------------------------------------------------------------------------

  Obs. summary:        113  left-censored observations at WTP<=0
                       326     uncensored observations
                         0 right-censored observations
```

Location characteristics

```
. tobit WTP vestre_aker bjerke alna sentrum_dummy enebolig_leiet leilighet_leie
> t, ll(0)

Tobit regression                                  Number of obs   =        523
                                                  LR chi2(6)      =      26.04
                                                  Prob > chi2     =     0.0002
Log likelihood = -2992.5846                       Pseudo R2       =     0.0043

------------------------------------------------------------------------------
         WTP |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 vestre_aker |  -178.7675   125.1579    -1.43   0.154    -424.648    67.11305
      bjerke |  -220.5783   141.7432    -1.56   0.120    -499.0418    57.8853
        alna |   -223.522    131.038    -1.71   0.089    -480.9544   33.91045
sentrum_du~y |   153.5211   70.27598     2.18   0.029     15.45948   291.5827
enebolig_l~t |  -939.7129   417.6648    -2.25   0.025    -1760.242   -119.184
leilig~leiet |   86.09813   83.08302     1.04   0.301    -77.12371     249.32
       _cons |   165.4096   47.56606     3.48   0.001     71.96311   258.8562
-------------+----------------------------------------------------------------
      /sigma |   668.4279   26.02973                      617.2909   719.565
------------------------------------------------------------------------------

  Obs. summary:        161  left-censored observations at WTP<=0
                       362     uncensored observations
                         0 right-censored observations
```

Scope

```
. tobit WTP  change  payment_vehicle q25_2 q25_3 q25_4, ll(0)

Tobit regression                                  Number of obs   =        362
                                                  LR chi2(5)      =      45.66
                                                  Prob > chi2     =     0.0000
Log likelihood = -2787.5376                       Pseudo R2       =     0.0081

------------------------------------------------------------------------------
         WTP |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      change |   88.42605   19.02378     4.65   0.000     51.01329   125.8388
payment_ve~e |  -30.04757   24.92309    -1.21   0.229    -79.06209   18.96696
       q25_2 |  -96.14257   32.98791    -2.91   0.004    -161.0176  -31.26751
       q25_3 |   68.61059   29.67756     2.31   0.021     10.24577   126.9754
       q25_4 |   18.50154   26.81959     0.69   0.491     -34.2427   71.24578
       _cons |   344.2763   133.3382     2.58   0.010      82.0493   606.5034
-------------+----------------------------------------------------------------
      /sigma |   534.5587   19.86624                      495.4891   573.6282
------------------------------------------------------------------------------

  Obs. summary:          0  left-censored observations
                       362     uncensored observations
                         0 right-censored observations
```

Combine these in one model (minus scope):

```
. tobit WTP income nr_people_in_hh q33_4 q33_6 period_lived_in_oslo outdoorsy attitude_t
> rees pos_trees q21_3 vestre_aker bjerke alna sentrum_dummy enebolig_leiet leilighet_le
> iet, ll(0)

Tobit regression                                Number of obs   =        258
                                                LR chi2(14)     =      66.77
                                                Prob > chi2     =     0.0000
Log likelihood = -1561.8665                     Pseudo R2       =     0.0209
```

WTP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
income	.0000949	.0001447	0.66	0.512	-.0001901	.0003799
nr_people_in_hh	-15.45319	37.12166	-0.42	0.678	-88.57299	57.66661
q33_4	14.78492	144.2072	0.10	0.918	-269.2649	298.8347
q33_6	45.5124	69.36136	0.66	0.512	-91.11104	182.1358
period_lived_in_oslo	106.0593	38.3162	2.77	0.006	30.58654	181.532
outdoorsy	-1.305174	4.004739	-0.33	0.745	-9.193445	6.583097
attitude_trees	75.73891	16.5669	4.57	0.000	43.10653	108.3713
pos_trees	45.77464	13.325	3.44	0.001	19.52794	72.02133
q21_3	-35.67903	25.99442	-1.37	0.171	-86.88113	15.52307
vestre_aker	-23.86825	132.3946	-0.18	0.857	-284.6505	236.914
bjerke	-18.15083	147.3224	-0.12	0.902	-308.3368	272.0351
alna	-270.6766	127.019	-2.13	0.034	-520.8703	-20.48296
sentrum_dummy	71.96663	70.83161	1.02	0.311	-67.55279	211.4861
enebolig_leiet	-3102.135	.	.	.	.	.
leilighet_leiet	85.06025	97.63981	0.87	0.385	-107.2642	277.3847
_cons	-1222.316	345.5079	-3.54	0.000	-1902.875	-541.7577
/sigma	461.769	23.7289			415.0294	508.5087

```
  Obs. summary:         57  left-censored observations at WTP<=0
                       201     uncensored observations
                         0 right-censored observations
```

Model with all variables

Variables could be in model:

```
. tobit WTP age gender born_utlandet born_mor_utlandet born_far_utlandet educati
> on enslig par_uten_barn par_med_barn income nr_people_in_hh barn_in_hh period_
> lived_in_oslo outdoorsy activities attitude_trees  q21_1 q21_2 q21_3 q21_4 sen
> trum_dummy enebolig_leiet leilighet_leiet q4_sum_view q16, ll(0)

Tobit regression                                  Number of obs   =        450
                                                  LR chi2(25)     =     136.34
                                                  Prob > chi2     =     0.0000
Log likelihood = -2556.6922                       Pseudo R2       =     0.0260
```

WTP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
age	-5.588179	2.585414	-2.16	0.031	-10.66997	-.5063887
gender	-30.57694	67.10676	-0.46	0.649	-162.4794	101.3255
born_utlandet	-31.15707	168.5748	-0.18	0.853	-362.5011	300.187
born_mor_ut~t	174.2895	130.2811	1.34	0.182	-81.78589	430.365
born_far_ut~t	-191.7135	149.8305	-1.28	0.201	-486.2145	102.7875
education	36.8476	36.7843	1.00	0.317	-35.4542	109.1494
enslig	5.415821	145.9237	0.04	0.970	-281.4061	292.2377
par_uten_barn	66.11803	142.2709	0.46	0.642	-213.5242	345.7602
par_med_barn	8.668234	170.2544	0.05	0.959	-325.9773	343.3138
income	.0003752	.0001689	2.22	0.027	.0000433	.0007072
nr_people_i~h	-17.74806	45.30981	-0.39	0.695	-106.8073	71.31115
barn_in_hh	-67.43011	129.6256	-0.52	0.603	-322.2172	187.3569
period_live~o	111.4552	39.99427	2.79	0.006	32.84399	190.0664
outdoorsy	-6.034802	4.354748	-1.39	0.167	-14.59433	2.524724
activities	-5.753546	10.52958	-0.55	0.585	-26.45008	14.94298
attitude_tr~s	91.92105	17.01496	5.40	0.000	58.4771	125.365
q21_1	139.5026	32.82216	4.25	0.000	74.98864	204.0166
q21_2	36.49512	34.05088	1.07	0.284	-30.43397	103.4242
q21_3	-53.58381	28.39488	-1.89	0.060	-109.3957	2.22807
q21_4	-19.29169	29.63529	-0.65	0.515	-77.54168	38.95829
sentrum_dummy	14.4709	72.5885	0.20	0.842	-128.2063	157.1481
enebolig_le~t	-738.069	380.9457	-1.94	0.053	-1486.841	10.70312
leilighet_l~t	244.3272	91.97772	2.66	0.008	63.53938	425.1151
q4_sum_view	47.53694	18.92342	2.51	0.012	10.3418	84.73207
q16	-28.31984	19.47574	-1.45	0.147	-66.6006	9.960919
_cons	-1620.532	437.1284	-3.71	0.000	-2479.734	-761.3292
/sigma	600.5763	24.6479			552.1294	649.0233

```
  Obs. summary:        134  left-censored observations at WTP<=0
                       316     uncensored observations
                         0 right-censored observations
```

After studying the correlation matrix, the following variables where dropped because they were highly correlated with other variables:

- Age
- born_mor_utlandet born_far_utlandet
- enslig
- par_med_barn
- nr_people_in_hh
- activities
- q21_1
- education
- par_uten_barn
- q21_2

```
. tobit WTP gender born_utlandet income barn_in_hh period_lived_in_oslo outdoorsy attitu
> de_trees q21_3 q21_4 sentrum_dummy enebolig_leiet leilighet_leiet q4_sum_view q16, ll(
> 0)

Tobit regression                                  Number of obs   =        456
                                                  LR chi2(14)     =     102.00
                                                  Prob > chi2     =     0.0000
Log likelihood = -2613.7518                       Pseudo R2       =     0.0191
```

WTP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
gender	22.48009	67.68012	0.33	0.740	-110.5347	155.4949
born_utlandet	-85.73701	111.5518	-0.77	0.443	-304.9748	133.5007
income	.0003771	.0001575	2.39	0.017	.0000676	.0006866
barn_in_hh	-129.9098	83.12415	-1.56	0.119	-293.2775	33.45789
period_lived_in_oslo	87.20958	37.23136	2.34	0.020	14.03709	160.3821
outdoorsy	-8.458114	4.050788	-2.09	0.037	-16.41931	-.4969149
attitude_trees	123.2544	16.71051	7.38	0.000	90.41244	156.0963
q21_3	-40.60027	28.9924	-1.40	0.162	-97.58035	16.3798
q21_4	-14.55865	30.34749	-0.48	0.632	-74.20196	45.08467
sentrum_dummy	134.0088	70.92958	1.89	0.060	-5.392334	273.4099
enebolig_leiet	-775.6448	387.2243	-2.00	0.046	-1536.674	-14.61517
leilighet_leiet	255.8216	94.20339	2.72	0.007	70.67941	440.9638
q4_sum_view	44.08186	19.21445	2.29	0.022	6.31883	81.8449
q16	1.77008	19.39122	0.09	0.927	-36.34037	39.88053
_cons	-1511.01	393.2742	-3.84	0.000	-2283.929	-738.0898
/sigma	634.9364	26.00508			583.8274	686.0454

```
  Obs. summary:        136  left-censored observations at WTP<=0
                       320     uncensored observations
                         0 right-censored observations
```

VARIABLES	(1) ndent characte	(2) ndent characte	(3) pondent attitu	(4) pondent attitu	(5) ion characteri	(6) ion characteri	(7) Scope	(8) Scope	(9) ombine-group	(10) ombine-group	(11) All variables	(12) All variables
income	2.42e-05								9.49e-05		0.000377**	
	(0.000152)								(0.000145)		(0.000157)	
nr_people_in_hh	-77.82**								-15.45			
	(38.86)								(37.12)			
q33_4	-205.2								14.78			
	(147.3)								(144.2)			
q33_6	92.64								45.51			
	(74.50)								(69.36)			
period_lived_in_oslo	94.08**								106.1***		87.21**	
	(41.15)								(38.32)		(37.23)	
outdoorsy	-3.043								-1.305		-8.458**	
	(4.466)								(4.005)		(4.051)	
activities	14.08											
	(9.818)											
attitude_trees			102.8***						75.74***		123.3***	
			(15.31)						(16.57)		(16.71)	
pos_trees			60.51***						45.77***			
			(12.40)						(13.32)			
q21_3			-18.34						-35.68		-40.60	
			(24.27)						(25.99)		(28.99)	
vestre_aker					-178.8				-23.87			
					(125.2)				(132.4)			
bjerke					-220.6				-18.15			
					(141.7)				(147.3)			
alna					-223.5*				-270.7**			
					(131.0)				(127.0)			
sentrum_dummy					153.5**				71.97		134.0*	
					(70.28)				(70.83)		(70.93)	
enebolig_leiet					-939.7**				-3,102		-775.6**	
					(417.7)				(0)		(387.2)	
leilighet_leiet					86.10				85.06		255.8***	
					(83.08)				(97.64)		(94.20)	
change							88.43***					
							(19.02)					
payment_vehicle							-30.05					
							(24.92)					
q25_2							-96.14***					
							(32.99)					
q25_3							68.61**					
							(29.68)					
q25_4							18.50					
							(26.82)					
gender											22.48	
											(67.68)	
born_utlandet											-85.74	
											(111.6)	
barn_in_hh											-129.9	
											(83.12)	
q21_4											-14.56	
											(30.35)	
q4_sum_view											44.08**	
											(19.21)	
q16											1.770	
											(19.39)	
Constant	32.16	557.2***	-1,241***	570.3***	165.4***	668.4***	344.3**	534.6***	-1,222***	461.8***	-1,511***	634.9***
	(312.7)	(27.60)	(200.4)	(23.05)	(47.57)	(26.03)	(133.3)	(19.87)	(345.5)	(23.73)	(393.3)	(26.01)
Observations	307	307	439	439	523	523	362	362	258	258	456	456
rmse	.	.	.	.	.	.	.	.	.	.	.	.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

```
. tobit WTP income sentrum_dummy, ll(0)

Tobit regression                                Number of obs     =        456
                                                LR chi2(2)        =      13.33
                                                Prob > chi2       =     0.0013
Log likelihood = -2658.0884                     Pseudo R2         =     0.0025

------------------------------------------------------------------------------
         WTP |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      income |    .000291   .0001493     1.95   0.052    -2.46e-06    .0005844
sentrum_dummy |   214.416    71.7789     2.99   0.003     73.35588    355.4761
       _cons |  -11.8146   83.76608    -0.14   0.888    -176.4319    152.8027
-------------+----------------------------------------------------------------
      /sigma |  700.2784   28.9882                      643.3107    757.2461
------------------------------------------------------------------------------

  Obs. summary:        136  left-censored observations at WTP<=0
                       320     uncensored observations
                         0 right-censored observations
```

```
. reg WTP income sentrum_dummy
```

Source	SS	df	MS
Model	2901128.99	2	1450564.49
Residual	134505807	453	296922.311
Total	137406936	455	301993.266

Number of obs	= 456
F(2, 453)	= 4.89
Prob > F	= 0.0080
R-squared	= 0.0211
Adj R-squared	= 0.0168
Root MSE	= 544.91

WTP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
income	.0001732	.0001106	1.57	0.118	-.0000441	.0003905
sentrum_dummy	139.4111	53.57249	2.60	0.010	34.12969	244.6926
_cons	220.7607	60.73307	3.63	0.000	101.4072	340.1142

```
. sum WTP
```

Variable	Obs	Mean	Std. Dev.	Min	Max
WTP	523	333.9006	523.9133	0	4200

```
. sum WTP if sentrum_dummy==0
```

Variable	Obs	Mean	Std. Dev.	Min	Max
WTP	343	283.2362	475.7792	0	4200

```
. sum WTP if sentrum_dummy==1
```

Variable	Obs	Mean	Std. Dev.	Min	Max
WTP	180	430.4444	594.6971	0	4200