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Preface

Recycling is an important issue in the modern world where indiscriminant consumerism strains already scarce resources, and waste from consumption pollutes the environment in which we live. This thesis examines the effect of information that is consistent or inconsistent with the recycling decision.

First, I would offer a great thanks to my advisor Eirik Romstad for being patient, understanding and demanding throughout this process, and for always taking the time to give good feedback, and answer any questions that I have had.

Second, I offer thanks to Ståle Navrud, Olvar Bergland and Frode Alfnes for valuable feedback during the process of creating the questionnaire.

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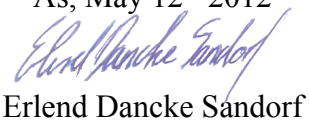
Fifth, I would like to thank the scout groups of Follo Krets of the Norwegian Scout Association and the local sports groups that have been kind enough to help distribute the questionnaire. A lot of this work would not have been possible without their help.

Last, I would like to thank family and friends for being supportive and reminding me that all work and no play is not a recipe for success.

Ås, May 12th 2012



Erlend Dancke Sandorf

Summary

The purpose of this thesis is to look at the effect of information in the voluntary private provision of public goods when this information is consistent or inconsistent with prior beliefs.

Public goods are per definition non-excludable and non-rival in consumption (Randall, 1983). An example of a pure public good is a clean environment. The provision of a public good or the sharing of a common-pool resource is often referred to as a social dilemma or a public goods game. A frequent assumption underlying economic models is that an economic agent is a self-serving utility maximizer who is only interested in his own payoff. Mainstream economic theory predicts that a pure public good will be undersupplied when relying on voluntary contributions alone (Bergstrom et al., 1986).

However, contrary to mainstream economic theory, people continue to make voluntary contributions to public goods in the form of charity, volunteering and recycling. This thesis focuses on the case of recycling.

Recycling reduces the environmental impact of private consumption, which is analogous to increasing environmental quality, and thus can be viewed as a private contribution to the public good a clean environment. We observe that people choose to recycle even though there is a substantial cost associated with this activity (Bruvoll et al., 2002). It has been suggested that social norms and social preferences play an important role in why people choose to contribute to a public good even though no financial incentives are present (Fischbacher and Gächter, 2008, Martin and Randal, 2008, Rege and Telle, 2004, Rege, 2004, Fehr and Fischbacher, 2003, Ostrom, 2000, Andreoni, 1990). However, little research has been done on how information affects the decision to contribute to a public good, here, recycle.

This thesis covers the following research questions:

1. How does new information affect the decision to recycle?
    a. What happens when this information is consistent with prior beliefs?
    b. What happens when this information is inconsistent with prior beliefs?
2. How does introducing a pricing instrument affect how effective new information is?

First, I use the utility maximization framework to develop a model to show how information affects the allocation of time between work, leisure and recycling. I assume the existence of a social norm that determines an individual's initial level of recycling. This is an example of a situation where the public good is provided privately and a situation governed by social norms. Second, I introduce a tax on residual waste or a subsidy on sorted waste. This represents a government provision of the public good. In addition to changing available income it has an important information aspect and it gives rise to crowding effects. Third, I have conducted a small survey to try to test some of the predictions of the model.

The analytical results provided by the model shows that when new positive and consistent information is made available, the group for which I can sign the effect of information consists of individuals in the medium income range. When new negative and consistent information is made available, the group consists of individuals with medium and high income. If the information is inconsistent, the model, as it is, predicts the effect of the new information if we know that the information will be incorporated and heeded by the individual.

Introducing pricing instruments change the composition of the group for which I can sign the effect. In the case of a subsidy the income range for which I can sign the effect of information becomes smaller, and in the case of a tax, it becomes larger. The thesis offers the explanation that this is because a tax is a stronger incentive instrument than a subsidy.

The results from the survey instrument give little support to some of the predictions made by the model. I believe the reason I am not able to trace more of the effect is because of a skewed and small sample and hence with little variation in reported behavior.

Sammendrag

Formålet med denne oppgaven er å se på effekten av informasjon på private bidrag til kollektive goder når denne informasjonen er konsistent eller inkonsistent med tidligere holdninger og handlinger

Et kollektivt gode er per definisjon ikke-rivaliserende og ikke-eksluderbart i forbruk (Randall, 1983). Et rent miljø er et eksempel på et slikt gode. Det private tilbudet av et kollektivt gode, eller bruken av en felles ressurs, er ofte omtalt som et sosialt dilemma. En vanlig antakelse I økonomiske modeller er at individer i en økonomi er egoistiske, nyttemaksimerene og kun bryr seg om sin egen uttelling. Økonomisk teori spår at et kollektivt gode vil bli tilbudt i for liten grad dersom en kun baserer seg på frivillige bidrag (Bergstrom et al., 1986).

I motsettning til hva økonomisk teori sier, så kan vi observere at folk bidrar frivillig til kollektive goder igjennom veldedighet, frvillig arbeid og resirkulering. Denne oppgaven fokuserer på resirkulering.

Resirkulering reduserer miljøpåvirkningen av privat forbruk, som er analogt med å øke miljøkvaliteten, og kan derfor sees på som et privat bidrag til det kollektive gode som et rent miljø er. En kan observere at folk velger å resirkulere på tross av at dette har en substansiell kostnad knyttet til seg (Bruvoll et al., 2002). Det har blitt foreslått at sosiale normer og sosiale preferanser spiller en viktig rolle i hvorfor folk velger å bidra til et kollektivt gode på tross av at det ikke finnes noen klare finansielle insentiver (Fischbacher and Gächter, 2008, Martin and Randal, 2008, Rege and Telle, 2004, Rege, 2004, Fehr and Fischbacher, 2003, Ostrom, 2000, Andreoni, 1990). På en annen side, lite forskning har vært gjort på effekten av informasjon på avgjørelsen om å bidra, og det leder meg til forskningsspørsmålene.

1. Hvordan påvirker informasjon avgjørelsen om å resirkulere?
    a. Hva skjer når denne informasjonen er konsistent med tidligere oppfatninger?
    b. Hva skjer når denne informasjonen er inkonsistent med tidligere oppfatninger?
2. Hvordan påvirker en skatt eller et subside hvor effektiv informasjon er?

Ved hjelp av nyttemaksimeringsrammeverket utvikler jeg en modell for å vise hvordan informasjon påvirker allokeringen av tid imellom jobb, fritid og resirkulering. Jeg antar at det

eksisterer et sett med sosiale normer som ligger til grunn for det eksisterende nivået av resirkulering. Dette er et eksempel på en situasjon hvor det kollektive godet er tilbudt privat og en situasjon hvor sosiale normer regjerer. Det neste steget er å introdusere en skatt på ikke-sortert avfall eller et subsidie på sortert avfall. Dette representerer en situasjon hvor en regulatør har gått inn for å tilby det kollektive godet. I tilegg til å endre disponibel inntekt har pris-instrumenter en viktig informasjonseffekt og det gir opphav til "crowding" effekter. Til slutt har jeg gjennomført en liten spørreundersøkelse for å teste noen av resultatene fra modellen.

De analytiske resultatene fra modellen viser at når ny positiv og konsistent informasjon blir gjort tilgjengelig består gruppen, som jeg kan si noe om effekten av informasjon for, av individer med middels inntekt. Når ny informasjon er negativ og konsistent består gruppen av individer med middels og høy inntekt. Hvis informasjonen er inkonsistent vil modellen, som den er, forutsi effekten av ny informasjon, hvis vi vet at informasjonen vil bli inkorporert og etterfulgt av individet.

Å introdusere pris-instrumenter endrer sammensetningen av gruppen som jeg kan analytisk avgjøre effekten for. I tilfellet med et subside blir inntektsgruppen som er påvirket av informasjon mindre, og i tilfellet med en skatt, større. Jeg tror at dette kan skyldes at en skatt er et sterkere insentivinstrument enn et subsidie.

Resultatene fra spørreundersøkelsen gir liten støtte til modellen, men dette skyldes i all hovedsak, skjevt og lite utvalg med liten variasjon i rapportert adferd blandt respondentene.

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Chapter - 1 Introduction

In a society with a focus on consumption, the recycling and reuse of old products is an important effort to reduce adverse environmental impacts. A recent article in Aftenposten[1] states the recycling program in Oslo is failing, and despite large information campaigns, increases in the fee on household waste and over-spending on the budget we are still far from the goal of 50 percent of household waste recycled by 2014 (Slettholm, 2012). To make information about recycling and sorting more readily available to the public, the Department of Waste Management in Oslo has created an application for smart phones that informs you when the next pick-up of household waste is and shows you the shortest and fastest way to get from where you are to the nearest recycling station (Haugnes, 2012).

The purpose of this thesis is to look at the effect of information on voluntary private contributions to public goods and what happens when this information is consistent or inconsistent with prior beliefs. A detailed introduction to public goods, the public goods game and results from public good experiments will be covered in chapter 2.

Recycling reduces the environmental impact of private consumption, which is analogous to increasing environmental quality, and thus can be viewed as a private contribution to the public good a clean environment. We observe that people choose to recycle even though there is a substantial cost associated with this activity. For example, in Norway, the time and effort that goes into recycling amounts to about half an hour per week and that about a 185 hours is spent on recycling per ton of household waste (Bruvoll et al., 2002). The same study found that households, on average, are willing to pay $20/year to have somebody else recycle for them. Although there is a difference between sorting and separating the waste, which is what households do, and recycling, which is the reuse of sorted waste, both terms are used interchangeably in this thesis and refer to the sorting activity that an individual undertakes.

It has been suggested that social norms and social preferences play an important role in why people choose to contribute to a public good even though no financial incentives are present (Fischbacher and Gächter, 2008, Martin and Randal, 2008, Rege and Telle, 2004, Rege, 2004, Fehr and Fischbacher, 2003, Ostrom, 2000, Andreoni, 1990). In the study by Bruvoll et al

[1] A large Norwegian newspaper

(2002) 86 percent of the respondents agreed to the statement: “I want to contribute to a better environment”, 42 percent: “I want to think of myself as a responsible person” and 65 percent: “I should do what I want others to do” (Bruvoll et al., 2002, p. 345). This suggests that there are social norms at work that make people recycle. The effect of social norms in the private provision of public goods will be discussed in greater detail in the next chapter.

Recycling, as discussed, is at this point in time a private contribution to the public good a clean environment. However, the government has the power and influence to intervene, and provide the public good through the use of pricing instruments, i.e. a tax or a subsidy, or a command and control approach. The effect of taxes and subsidies on private contributions in settings where social norms prevail have been well documented (Holmås et al., 2010, Nyborg et al., 2006, Rege, 2004, Rege and Telle, 2004, Gneezy and Rustichini, 2000, Frey, 1999). The effect of information, on the other hand, to the best of my knowledge, has received little interest, which is why I have chosen to look at the effect of information in the private provision of public goods. Information can be thought to have the ability to affect a decision, opinion, belief or action. This leads me to my research questions.

1. How does new information affect the decision to recycle?
    a. What happens when this information is consistent with prior beliefs?
    b. What happens when this information is inconsistent with prior beliefs?
2. How does introducing a pricing instrument affect how effective new information is?

These research questions allows me to closer examine the relationship between information and private contributions to public goods, using the example of recycling, in settings that are governed by social norms, and settings where a pricing instrument exists. I believe that this is interesting because it has implications for how a government might approach the issue of recycling.

To answer research question (1) I use the utility maximization framework and develop a model to show how information affects the allocation of time between work, leisure and recycling. I assume the existence of a social norm that determines an individual’s initial level of recycling. Then, I use the model to show how new information affects the time allocation. This is an example of a situation where the public good is provided privately and a situation governed by social norms.

To examine research question (2) I introduce a tax on residual waste, or a subsidy on sorted waste, into the model. This represents a government provision of the public good and allows me to examine what happens to the effect of information when pricing instruments are present. In addition to changing available income it has an important information aspect and it gives rise to crowding effects.

Third I have conducted a small survey to try to test some of the predictions of the model.

This thesis proposes a model to show how new information that is either consistent or inconsistent with a prior belief affects the level of contribution to a public good using the example of recycling. The model predicts that when new positive information is available it has the expected effect for individuals in the medium income range. When new negative information is made available it has the expected effect for medium- and high-income individuals. Introducing a tax makes the group, for which I can analytically sign the effect of information, larger, and the introduction of a subsidy makes the group smaller, in both cases of positive and negative information. The thesis offers the explanation that this is partly because a tax is a stronger incentive instrument than a subsidy. In the case of inconsistent information, the model as it is, predicts the effect if we know that the individual will act on the new information, in other words that the information is perceived as strong and valid. The results from the survey give little support to some of the results predicted by the model, however, if these results hold for a full-scale survey they are interesting. The analysis based on the survey has no external validity. To get better analytical results a full-scale survey is needed.

The rest of the thesis is outlined as follows. Chapter 2 is a thorough literature review that provides insights into public goods, social norms and the effect of information. Chapter 3 introduces the model, its assumptions, and provides a general discussion of the results predicted by it. Chapter 4 presents, analyzes and discusses the results from the questionnaire. Chapter 5 concludes the thesis and offers recommendations for future research.

Chapter - 2 Literature review related to the use of information

This chapter focuses on the effect of information that is consistent or inconsistent with prior beliefs on voluntary contributions to a public good. To examine this issue closer I have divided the chapter into three parts. First, I take a closer look at what a public good is, and how it can be provided. Second, I look at how social norms and pre-existing knowledge forms a basis for the current contributions i.e. the current level of recycling. This establishes the baseline for the decision to recycle. Third, I examine the effect of new information that is consistent or inconsistent with a prior belief or decision. This will form the theoretical foundation for the information parameter in the model. Further, I divide information into two sub-categories: social information and knowledge-information.

2.1 The supply of public goods

A public good is per definition non-excludable and non-rival in consumption (Randall, 1983). A good is non-excludable when nobody can be excluded from consuming the good and non-rival when my consumption does not limit your consumption of the same good. An example of a pure public good is a clean environment. Following from the definition of a public good, a private good is defined as excludable and rival in consumption. A good that is rival and non-excludable is known as a common-pool resource and a good that is non-rival and excludable is known as a club good. The latter two are not given weight in this thesis.

The provision of a public good or the sharing of a common-pool resource is frequently referred to as a social dilemma or a public goods game. A frequent assumption underlying economic models is that an individual is a self-serving utility maximizer that is only interested in his own payoff. Mainstream economic theory predicts that a pure public good will be undersupplied when relying on voluntary contributions alone (Bergstrom et al., 1986). The nature of a public good is such that nobody can be excluded from enjoying it, so why should anybody want to contribute, and incur a cost, when they can get the benefits cost-free? This prediction is known as the zero-contribution hypothesis, or the free rider hypothesis, and predicts an outcome in which nobody contributes. And this is the central issue in the public goods game.

A public good can be provided in two ways: (1) privately, relying on voluntary contributions or (2) through government provision. Although there exists situations that are combinations of

the two, for example where the government subsidizes production of the public good will be treated as government provision.

2.1.1 The private supply of public goods

Contrary to mainstream economic theory people contribute to public goods through volunteer work, contributions to charity and recycling to mention a few. The prediction of a Nash-equilibrium of zero contribution is often rejected (Fischbacher et al., 2001), and several experiments puts the average contributions, in one-shot linear public goods games, between 40-60 percent of the initial endowment (Ostrom, 2000). However, studies show that over time contributions decline to a point that is close to zero (Gintis et al., 2005, Lai et al., 2003, Fischbacher et al., 2001). The results from public goods experiments suggest that a public good can be provided privately, but there exist barriers to provision that need to be overcome. In the case of recycling, such barriers can be lack of knowledge about what materials are recyclable and lack of storage space for recycling bins (Schultz, 2002). Information can be used to reduce the barrier that is lack of knowledge.

2.1.2 The government supply of public goods

The private provision of public goods, and cooperation in public goods games, sometimes work and sometimes does not (Ostrom, 2000). These results have led to the realization that we may need governments to provide a public good because incentives are poorly aligned to facilitate private provision.

The government has several policy tools at its disposal and I will outline three ways in which a government can provide a public good.

1. The government can levy an environmental tax and use the tax revenues to provide the public good. In reality this can be an increase in the income tax, a lump sum tax per household or a tax on the amount of residual waste. The tax revenues can then be used on a central sorting and recycling station where the waste is sorted and recycled by a third party.
2. The government can subsidize the production of the public good. Like a tax a subsidy can take many forms. It can be a lump sum subsidy for households that recycle or a

subsidy on the amount of waste that is recycled. In effect this is a situation where the government pays individuals to recycle.

3. The government can use a command and control approach and make recycling a requirement by law.

Now that we know what a public good is and how it can be provided it is important to take closer look at what underlies the decision to voluntarily contribute to a public good. There are many reasons why people choose to contribute, and one of those reasons is social norms.

2.2 The importance of social norms

"In a world of strong external monitoring and sanctioning, cooperation is enforced without any need for internal norms to develop. In a world of no external rules or monitoring, norms can evolve to support cooperation. But in an in-between case, the mild degree of monitoring discourages the formation of social norms, while also making it attractive for some players to deceive and defect and take the relatively low risk of being caught" (Ostrom, 2000, pp. 147-148).

The demand for social norms arise when the action of one individual causes positive or negative effects for another (Fehr and Fischbacher, 2004). This suggests that social norms can be used to correct for an externality, the under-provision of a public good or the over-use of a common-pool resource. The theory of social norms has gained much traction over the last few decades. According to Elinor Ostrom (1998, 2000, 2005) and others, the importance of social norms and social preferences in the private provision of public goods, and the management of common-pool resources, cannot be underplayed. Public goods experiments suggest that social norms play an important role in why people choose to contribute to public goods (Rege, 2004, Ostrom, 2000, Frey, 1999). Thus supporting the creation and sustainability of social norms can be a low-cost method of providing a public good, but if norm adherence or enforcement becomes too costly then norms are likely to break down (Fehr and Fischbacher, 2004).

"Norms are particularly effective devices for social control, relative to law, when individual violations (though perhaps not aggregate violations) are too trivial, or the difficulty of proving guilt too great, to justify the expense of trials, police and prisons" (Posner and Rasmusen, 1999, p. 380).

"A social norm is a rule of behavior that is enforced by social sanctions" (Coleman, 1990 in Rege, 2004, p. 65). Norms can be on the form: "You shall not steal" or "polluting is bad". Laws are formalized norms and are often on the form: "Stealing is illegal" or "polluting is illegal". Social norms are a code of conduct and tell us how to act in a social context. Posner and Rasmussen (1999) focus on guilt and shame as social sanctions from violating a social norm. Guilt is an internal sanction that arises because you know that you have violated a social norm. Shame, on the other hand, is an external sanction that arises because others observe that you violate the social norm. For example, if you adhere to the social norm: "recycling is good for the environment", then you feel guilty if you throw everything in the waste bin, and you feel shame if your neighbor sees you doing it.

In the grand scheme of things, every decision you make affects somebody and every decision they make affects you. In other words decisions are made in a social context (Lin and Yang, 2006). This is especially clear in the provision of public goods. The decision to contribute is often guided by knowledge, information and social norms. No decision is made in total isolation from others. If this were the case, social norms would have little effect on the decision to contribute to a public good because there would be no social cost of violating the norm. "It is a game against your neighbors, not against nature or the authorities" (Lin and Yang, 2006, p.208).

Social preferences are a natural extension of social norms. In many ways social preferences are the expression of existing social norms, and it is through the social preferences that we can get a measure of the effect of social norms. An individual can have preferences for conditional cooperation (Fischbacher and Gächter, 2008, Martin and Randal, 2008), altruism (Andreoni, 1990, Fehr and Fischbacher, 2003), social approval (Rege, 2004, Rege and Telle, 2004) or reciprocity (Fehr and Fischbacher, 2003).

2.2.1 The crowding effects of pricing instruments

So far I have discussed how social norms make people voluntarily contribute to a public good. However, as we have seen, private contributions are not the only way to provide a public good. If the government chooses to provide the public good through a tax or a subsidy it is

important to take a closer look at the connection between social norms and pricing instruments. Introducing a pricing instrument gives rise to crowding effects.

Under identifiable conditions introducing a tax in a setting where social norms prevail may lead to a crowding out of social norms and environmental ethics and the net result is a lower provision of the public good (Holmås et al., 2010, Nyborg et al., 2006, Rege, 2004, Rege and Telle, 2004, Gneezy and Rustichini, 2000, Frey, 1999, Bergstrom et al., 1986), and that this effect persists even after policy reversal (Rege, 2004, Gneezy and Rustichini, 2000).

Andreoni (1993) tries to quantify the crowding out effect, as well as give a good overview of previous studies and lab experiments that have tried to do the same. Previous studies have put the crowding out effect between 5 and 28 percent. However the Andreoni (1993) study finds the crowding out effect to be as high as 71 percent on average. This suggests that the effect is not a complete crowding out, but an incomplete crowding out effect. The paper points out that:

"In contrast to the outside world the controlled setting of the laboratory deliberately eliminates other factors such as sympathy, political or social commitment, peer pressure, institutional considerations or moral satisfaction associated with particular causes that may influence contributions to public goods in general" (Andreoni, 1993, p. 1326) .

Suggesting that the crowding out effects found in laboratory experiments are smaller than what they would be in a real life setting.

A subsidy, on the other hand, has been shown to crowd in social norms, because it may be experienced as supporting existing norms (Rege, 2004, Frey, 1999).

It is important to keep in mind the crowding effects of pricing instruments when I discuss the effects of taxes and subsidies later.

2.3 The effects of information

The research reviewed here suggests how a public good can be provided and gives us an idea of why people choose to contribute to one, i.e. recycle. I now turn the attention to what

happens when new information is made available that is either consistent or inconsistent with a prior decision or belief.

We can think of information as having the ability to affect a decision, opinion, belief or action, and it has three important characteristics. Information can (1) be consistent or inconsistent with a prior decision, opinion, belief or action (Fischer et al., 2012, Fischer et al., 2011, Hart et al., 2009, Jonas et al., 2001, Freedman, 1965, Sears, 1965), (2) be positive or negative with respect to a prior decision, opinion, belief or action and (3) have varying degrees of strength, validity and reliability (Ditto et al., 1998, Ditto and Lopez, 1992). All of these information attributes will be discussed. I believe parts of the answer can be found in social psychology and the field of dissonance theory.

Social psychologists believe that an individual experiences cognitive dissonance after a decision is made, a standpoint is chosen, or a belief has been formed. It can be explained like this: When you have made a decision and you receive new information, cognitive dissonance arises because you have to face the possibility that you were wrong in the first place. Coming to terms with the fact that you have been wrong can be very painful for the individual and he therefore chooses the information that is consistent to reduce this unpleasant feeling. Cognitive dissonance is the distress experienced from the negative aspects of the chosen alternative and the positive aspects of the alternative not chosen. This unpleasant state of post decisional conflict is known as cognitive dissonance (Fischer et al., 2012, Hart et al., 2009).

Several studies show that people have a preference for consistent over inconsistent information (Fischer et al., 2012, Fischer et al., 2011, Hart et al., 2009, Jonas et al., 2001), that this effect is stronger when the decision is easily reversible (Hart et al., 2009), and when there is a limit on how much information is available (Fischer et al., 2005). The limit on information availability is closer to how information is gathered in the real world, because people have limited cognitive abilities to process all relevant information. This suggests that the confirmation bias, i.e. the preference for consistent information, is stronger in real life settings than in the laboratory experiments. All of the aforementioned studies explain this preference for consistent information as a way to reduce the cognitive dissonance that arises once a decision is made, not eliminate it (Fischer et al., 2012, Fischer et al., 2011, Hart et al., 2009, Jonas et al., 2001).

On the other hand, some earlier studies have found that people have a preference for inconsistent information (Freedman, 1965, Sears, 1965). Frey et al (2008) goes a long way in explaining these inconsistent results. When people are faced with only two pieces of information, one consistent and one inconsistent, they show a preference for inconsistent information, but as more information is made available they show a preference for consistent information. Frey et al (ibid.) offer the following explanation: "Information search basically follows the minimum-effort principle and, therefore, decision makers try to choose the selection criterion that best differentiates between all available pieces of information" (Frey et al., 2008, p. 241).

Interestingly, how an individual attains new information matters. Based on prospect theory (Kahneman and Tversky, 1979), Kastenmüller et al (2010) frames the information search process as gains or losses. The Kastenmüller et al (ibid.) paper argues that there are two ways of selecting information: A method of selection (MOS) and a method of elimination (MOE). The MOS is framed as gains, because you actively search for information and select the pieces that you want to examine more closely. The MOE is framed as losses, because you receive all the information and discard the information you do not want. The results from the Kastenmüller et al (ibid.) paper show that selective exposure to information was greater under the MOS than under the MOE, and the practical implication of this is that information should be presented as losses rather than gains to reduce the selective exposure bias. I believe that we can find examples of both types of information search processes in real life settings. Infomercials, commercials and fliers in your mailbox represent a MOE process, whereas information searches on the Internet represents a MOS process. This suggests that we need to know how an individual came by the information to attribute these results to the present study.

Most of the studies that have found preferences for a particular type of information have used a simultaneous information search process, where all information is given simultaneously, and an individual has to select the information he wants to examine (Fischer et al., 2012, Fischer et al., 2011, Hart et al., 2009, Freedman and Sears, 1965, Sears, 1965, Freedman, 1965). However, since people seldom have an overview of all available information, choices of what information to get is not simultaneous, but sequential (Jonas et al., 2001). Jonas et al (ibid.) indicate that people exhibit a stronger preference for supportive rather than non-

supportive information when the information search is sequential, suggesting that people in real life settings will have a stronger preference for consistent information.

Individuals have a tendency to accept positive and consistent information at face value. Negative or preference inconsistent information is more scrutinized and more sensitive to information quality. However, if inconsistent information is strong and valid, it is incorporated rather than dismissed (Ditto et al., 1998, Ditto and Lopez, 1992). There are also some apparently frivolous effects. For example, information presented by physically attractive individuals are more readily accepted as strong and valid, and less scrutinized than information given by less attractive individuals (Fischer et al., 2012). Suggesting that not only how, but who presents the information can have an effect.

A study by Brannon et al (2007) indicates that individuals with strong attitudes or beliefs have preferences for attitudinally consistent information, and will avoid information that will lead to a change in attitudes. Such people are less likely to change their attitudes simply because they are less likely to expose themselves to counter attitudinal information.

2.3.1 Knowledge- and social information related to recycling

I have divided information into two categories: Knowledge-information and social information. The reason for this is that social information contains information about the particular norms that exists in a society, as explained later, and when I introduce the information parameter into the model in chapter 3 it moves some of the utility that would otherwise come from recycling into the information parameter. This is explained in detail in chapter 3.

Knowledge-information is information about what materials are recyclable, how you go about recycling, where the recycling stations are located, how does the municipality treat recycled waste, how does the recycling program work and what are your benefits from recycling etc. Providing information of this kind increases knowledge, and as pointed out by Schultz (2002); lack of knowledge can be a barrier to recycling.

Social information relates in many ways to the social norms and prevalent behavior in a society, i.e., how much is recycled in your neighborhood, does your neighbor recycle, does

the municipality take recycling seriously, etc. Some studies show that an individual's contributions are positively correlated with the belief about others' contributions. Fischbacher and Gächter (2008) found that beliefs about other people's contributions decline if contributions decline, but not vice versa. Shang and Croson (2009) on the other hand found that "social information about others' high contributions positively influences one's own contributions" (Shang and Croson, 2009, p. 1434). Both the aforementioned studies used direct social information. Martin and Randal (2008) uses indirect social information, in that people can observe how much has been contributed, without being told so directly, and finds similar results to Shang and Croson (2009). These findings have been explained by the fact that people are imperfect conditional cooperators, and that they tend to conform to existing norms. An interesting input to the view of social information comes from Goldstein et al (2008). They find that the more closely the social information was related to the situation the recipient was in, the greater was the effect of the information. This indicates that information about the amount of waste that is recycled in a given neighborhood should have greater effect than information about how much is recycled in a municipality.

From the discussion in this chapter we have gotten a better take on how new information affects a decision, opinion, belief or action. The effect and direction of the information will enter as a weight in the utility function and is discussed in great detail in the next chapter, when I introduce the model and use comparative statics to examine the equilibrium shift that arises when new information is made available.

Chapter - 3 The model

This chapter introduces a model that shows what happens to an individual's recycling behavior when new information is made available. This information may be consistent or inconsistent with prior beliefs. The model that is developed here will answer both hypothesis (1) how does new information affect the decision to recycle, and hypothesis (2) how does introducing a pricing instrument affect how effective new information is.

For now we are in a public goods setting. Let us consider for a moment an economy with *n* individuals. These individuals, like myself, derive utility from private consumption, **C**, leisure, *L*, and the public good, *G*.

$$U_i(\mathbf{C}, L, G) \qquad (1)$$

An individual can spend a total amount of time *T* on the three types of activities. The time spent on work, T_W, determines the consumption level. The time spent on recycling, T_R, determines the private contribution to the public good and the rest of the time is spent on leisure activities, T_L. For simplicity everything that is not recycling or work is leisure. The time constraint is given by the following identity:

$$T \equiv T_W + T_L + T_R \qquad (2)$$

An individual can spend any amount of time, less than the total time *T,* on work at the wage rate, *w*, and total income, *M,* is given by the equation: $M = T_W w$. I assume that this individual spends his entire income on private consumption. **C** is a vector of consumer goods and **P** is vector of prices. Since private consumption equals income, then private consumption is given by:

$$\mathbf{PC} = T_W w . \qquad (3)$$

Leisure, *L*, is given by the total time spent on leisure activities, T_L, such that:

$$L = T_L \tag{4}$$

The total provision of the public good is given by the following production function:

$$G = \sum_{1}^{n-1} G_i + f(T_R) \tag{5},$$

where $\sum_{1}^{n-1} G_i$ is the contributions of everybody else, and $f(T_R)$ is the fraction of waste that you recycle, and can take on any value between 0 and 1. $f(T_R)$ is a monotonic function of the time spent on recycling. It is assumed that that $f'(T_R) > 0$ and that if $f\Delta T_R = 0 \rightarrow f(T_R) = 0$.

I assume that the only cost of leisure and recycling is the opportunity cost of time. Let me clarify. Suppose that your favorite leisure activity is running. The problem is that the leisure activity contains an element of private consumption, in that you have to buy running shoes. On the other hand, recycling requires that you buy trash bags, you use water to clean plastic containers and you have to drive to the recycling station. Again we have elements of private consumption. To avoid this problem of interaction between leisure, recycling and private consumption, everything that you buy, i.e. running shoes for running, or trash bags for recycling, is private consumption. The utility you derive from leisure is from the activity alone, and the utility you derive from the public good is the enjoyment of a clean environment. Although this simplification ignores some of the cross effects, it will simplify the model, and I believe little is lost by this simplification.

3.1 The maximization problem under private provision of the public good

Using equations (4) and (5), with some additional assumptions presented after the new formulation of the utility function, we get the following:

$$U_i(T_L, \theta f(T_R), \mathbf{C}) \tag{6}$$

From this formulation of the utility function an individual now derives utility from leisure directly through the time spent on leisure activities. I have simplified the utility derived from

the public good to be the utility derived from the part of the public good that you provide. This can be thought of as the utility derived from your additional level of recycling. This simplification moves the utility maximization problem from a public goods setting to a private goods setting, because now you only care about your own contributions. However, this is not entirely accurate. The utility derived from a public good like a clean environment, and the utility derived from the additional level of recycling that you provide is hard to measure. There might be other factors that influence the utility you get from recycling. For example, how you feel about yourself, how your neighbors see you, the pleasantness of the activity etc. These factors however are picked up in the information parameter θ in the form of information about what everybody else does, how they contribute, how they perceive you etc., and we have effectively moved these factors from the utility function into the information parameter.

θ is a monotonic function of information and it connects new available information and recycling. It can be thought of as a weight given to the utility you derive from recycling. Hence, it can either weaken or strengthen the utility derived from recycling. The beauty of monotonicity is that I avoid the assumption of homothetic preferences. If θ is increasing it is always increasing and if it is decreasing it is always decreasing. θ takes on a value greater than zero for positive information, because I assume that positive information will make you recycle more, and less than zero for negative information that will make you recycle less.

I assume diminishing marginal utility and that the first- and second- order derivatives of the utility function has the following signs[2]:

$$U_C > 0, U_L > 0, U_R > 0 \tag{7}$$

$$U_{CC} < 0, U_{LL} < 0, U_{RR} < 0 \tag{8}$$

I further assume that time spent on the different activities are substitutes, and that the cross-derivatives are greater than zero. This assumption should be unproblematic.

[2] To simplify the notation T_L has been suppressed to L and T_R has been suppressed to R in the subscript.

$$U_{CL} > 0, U_{LR} > 0, U_{CR} > 0 \tag{9}$$

Combining identity (2) with equation (3) I obtain the following budget constraint:

$$w(T - T_L - T_R) = \mathbf{PC} \tag{10}$$

The utility maximization problem for individual *i* then become:

$$\begin{aligned} &Max U_i(T_L, \theta f(T_R), \mathbf{C}) \\ &s.t. \\ &w(T - T_L - T_R) = \mathbf{PC} \end{aligned} \tag{11}$$

This problem is related to the case of voluntary contributions. There is no government intervention. The case of government intervention will be covered in subsequent sections of this chapter. From the maximization problem I construct the Lagrangian function and obtain the first order conditions.

$$L = U_i(T_L, \theta f(T_R), C) + \lambda(w(T - T_L - T_R) - \mathbf{PC}) \tag{12}$$

The first order conditions are:

$$\frac{\partial L}{\partial \lambda} = w(T - T_L - T_R) - \mathbf{PC} = 0 \tag{13.1}$$

$$\frac{\partial L}{\partial T_L} = \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L} - \lambda w = 0 \tag{13.2}$$

$$\frac{\partial L}{\partial T_R} = \theta \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_R} \frac{\partial f(T_R)}{\partial T_R} - \lambda w = 0 \tag{13.3}$$

$$\frac{\partial L}{\partial \mathbf{C}} = \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C}} - \lambda \mathbf{P} = 0 \tag{13.4}$$

$$\lambda = \frac{\partial U^*}{\partial w} \frac{1}{\left[T - T_L - T_R\right]} \tag{14}$$

λ is the shadow price of the income constraint (10) and it is interpreted as the marginal utility of the wage rate for working more[3].

To solve the first order conditions I employ the implicit function theorem. It states that evaluated at an optimal point $(\lambda^*, T_L^*, T_R^*, \mathbf{C}^*)$ the solution to the first order conditions is a function of the exogenous variables $(w, \mathbf{P}, \theta)$ such that:

$$F_y(T_L, T_R, \mathbf{C}, \lambda)H' = -F_x(w, \theta, \mathbf{P}), \tag{15}$$

where $F_y(T_L, T_R, \mathbf{C}, \lambda)$ is the bordered hessian matrix, H' is the matrix containing all the comparative statics, and $-F_x(w, \theta, \mathbf{P})$ is the matrix containing the derivatives of the first order conditions with respect to the exogenous variables. Using the implicit function theorem I obtain the comparative statics directly. A detailed mathematical approach and solutions are found in appendix 7.1.

Because the solution to the first order conditions is an equilibrium, the comparative static shows how a change in one exogenous variable shifts the solution to another equilibrium. It does not show the movement between to equilibriums or the reason for the shift.

3.1.1 How does time spent on recycling change when new information is made available

First let us take a closer look at the comparative static $\partial T_R^* / \partial \theta$. This comparative static is of key interest, and gets at the heart of this thesis. How does the time spent on recycling change when new information is made available?

[3] For a detailed approach on how λ is found please see Appendix 7.2

$$\frac{\partial T_R^*}{\partial \theta} = \frac{\overbrace{\frac{\partial U_i^{*2}(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta} K_{23}}^{Leisure} - \overbrace{\frac{\partial U_i^{*}(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)} \frac{\partial f(T_R)}{\partial T_R} K_{33}}^{Recycling} + \overbrace{\frac{\partial U_i^{*2}(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial \theta} K_{43}}^{Consumption}}{\det \bar{H}} \quad (16)$$

Before I can analyze the comparative static $\partial T_R^* / \partial \theta$ it is necessary to take a closer look at the cofactors K_{23}, K_{33} and K_{43}. The main results of the cofactor analysis will be sketched here, but for a more detailed view please see Appendix 7.1. The cofactor K_{23} is found by deleting the second row and the third column of the F_{Y32} matrix.

The analysis of the comparative static $\partial T_R^* / \partial \theta$ is two-fold. First I examine the case of positive information, i.e. where θ is greater than zero, and second I examine the case of negative information, i.e. where θ is less than zero.

3.1.1.1 What happens when the new information is positive?

In the case where θ is greater than or equal to zero, the determinant of the bordered Hessian matrix is negative. In other words the denominator is negative.

The sign on the first part of the numerator is determined by the cofactor K_{23} and the marginal utility of leisure when positive information about recycling is made available $\frac{\partial U_i^{*2}(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta}$. The cofactor K_{23} is negative when the wage rate is low or equal to zero and becomes positive as the wage rate increases. I assume that $\frac{\partial U_i^{*2}(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta}$ is negative when θ is positive. Think of it like this: If you receive positive information about recycling, then you are likely to substitute leisure time for more time spent on recycling, and thus the effect should be negative. This makes the first part of the numerator negative, and the denominator is negative, then it follows that the first part of the comparative static is positive except for those with the lowest level of income.

The sign on the second part of the numerator depends on the cofactor K_{33} and the marginal utility of recycling $\frac{\partial U_i^*(T_L,\theta f(T_R),\mathbf{C})}{\partial f(T_R)}\frac{\partial f(T_R)}{\partial T_R}$. The cofactor K_{33} is positive for all values of *w* greater than zero, and $\frac{\partial U_i^*(T_L,\theta f(T_R),\mathbf{C})}{\partial f(T_R)}\frac{\partial f(T_R)}{\partial T_R}$ is assumed to be positive because new positive information should make the marginal utility of recycling positive. From the comparative static we see that the numerator is negative and the denominator is negative and the second part of $\partial T_R^* \big/ \partial \theta$ is positive.

The sign on the third, and last, part of the numerator is given by the cofactor K_{43} and the marginal utility of consumption when positive information about recycling is made available $\frac{\partial U_i^{*2}(T_L,\theta f(T_R),\mathbf{C})}{\partial \mathbf{C}\partial\theta}$. The cofactor K_{43} is positive, but might become negative as *w* becomes very high and $\frac{\partial U_i^{*2}(T_L,\theta f(T_R),\mathbf{C})}{\partial \mathbf{C}\partial\theta}$ is assumed to be negative when θ is positive. The same logic applies here as before: If you receive positive information about recycling, then you are likely to substitute work time for more time recycling, and thus the effect should be negative. Since the last part of the numerator is negative and the denominator is negative, the last part of the comparative static is positive except for those with the highest level of income.

Thus the comparative static has the expected positive sign, except for very low- and very high-income groups.

Further we observe that the first term of the numerator that shows the change in leisure from new information that is negative for low-income groups because the cofactor multiplied in is negative for low-income groups. For high-income groups it is the last part of the numerator that shows the change in consumption from new information that is negative because the cofactor might be negative for very high wage rates. However, one should be careful when making this sort of interpretation from a comparative static. I only state it here, but the analysis will focus on the traditional approach to interpret a comparative static.

3.1.1.2 What happens when the new information is negative?

When new negative information is made available, i.e. in the case where θ is negative, the determinant of the Hessian matrix is positive. In other words the denominator is positive.

The first part of the numerator is now positive because the cofactor K_{23} is likely to stay positive for all wage rates, and I assume that $\frac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta}$ is positive. The logic is that when you receive negative information about recycling, then you are likely to value leisure time more, and the effect should be positive. Following, both the numerator and denominator are positive, and the first part of the comparative static is positive.

The second part of the numerator is positive because we assume that K_{33} is positive as shown in the cofactor analysis and I assume that $\frac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)} \frac{\partial f(T_R)}{\partial T_R}$ is negative. Think of it like this: If you receive new negative information, then the marginal utility of recycling should be negative.

The last part of the numerator is positive except for those with a very low wage rate. From the cofactor analysis we see K_{43} might be negative for low values of *w,* but becomes positive as the wage rate increases. The term $\frac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial \theta}$ is assumed to be positive, based on the same argument, as before, thus the last part of the comparative static is positive.

This shows that when new information is negative, the comparative static has the expected positive sign, except for very low-income groups. With negative information we see that the last part of the numerator that shows the change in consumption from new information is negative for low-income groups because the cofactor is negative for that group.

To conclude we see that when new positive information is made available the comparative static $\partial T_R^* / \partial \theta$, overall, has the expected positive sign for incomes in the middle range showing that information affects behavior as expected. Moreover, when new negative information is made available the comparative static has the expected sign for medium- and high-income individuals. Individuals with other incomes are also likely to have similar responses to

information but we cannot analytically sign this effect. Notice that in both of the aforementioned cases it was implied that the information was consistent with prior beliefs.

3.1.1.3 Consistent versus inconsistent information

Now that we have shown analytically what income group is likely to be affected by new information, we need to show what happens when new information is consistent or inconsistent with prior beliefs. This gives us four potential situations.

1. An individual believes that recycling is good for the environment, and receives information that supports this.
2. An individual believes that recycling is good for the environment, and receives information that challenges this.
3. An individual believes that recycling does not do anything for the environment, and receives information that supports this.
4. An individual believes that recycling does not do anything for the environment, and receives information that challenges this.

For this problem there exists two corner solutions, and these are likely to only exist if an individual has strong beliefs that recycling is good for the environment, i.e. he recycles everything, or strong beliefs that recycling does not do anything for the environment, i.e. recycles nothing. Let us examine both solutions more closely.

In the case where an individual recycles everything positive information does not have an effect on how much is recycled. However, the positive information supports the underlying norms and beliefs that formed the basis for the recycling decision in the first place, and thus can increase the utility you get from recycling, although the level of recycling stays the same. Inconsistent information, on the other hand, can have an effect on the level of recycling. If the inconsistent information is strong and valid enough, an individual might choose to recycle less and we observe a negative effect and a lower level of recycling and we move away from the corner solution.

The opposite can be said for the other corner solution where an individual recycles nothing. If new negative information is made available, i.e. consistent information, it does not have an

effect on the level of recycling, but it might increase an individual's utility because the new information strengthens the norms and values underlying the decision. If new inconsistent information is made available, and this information is strong and valid enough, we might see an increase in the level of recycling and we are moving away from the corner solution.

The interesting thing about the corner solutions is that it is the inconsistent information that can move us away from them, and from theory we know that people have a preference for consistent information, and that an individual will only heed inconsistent information if it is perceived as strong and valid enough. These corner solutions can be thought of as "extreme" behavior and thus the cognitive dissonance experienced from inconsistent information is likely to be higher, and people have an even greater preference for consistent information. This, however, needs to be tested. Furthermore, we can see from the comparative static $\partial T_R^* / \partial \theta$ that the initial level of recycling does not influence how you are affected by new information because all three components of the comparative static $\partial T_R^* / \partial \theta$ deals with the relative changes from new information being made available.

Instead of looking at all four situations separately I will put them into two groups: One in which the information is consistent, research question (1a), and one in which it is inconsistent, research question (1b), with the decision to recycle.

First I take a closer look at the two situations of consistent information.

1. In the case of new positive information, i.e. when θ is greater than zero, and the individual believes that recycling is good for the environment, we have the first case of consistent information. Under these circumstances we expect that $f(T_R)$ increases, i.e. the individual spend more time on recycling. $f(T_R)$ is found in the second term of the numerator of the comparative static $\partial T_R^* / \partial \theta$ and we see that information has the desired effect for individuals in the middle income range. If an individual already recycles everything, then this information merely supports the prior belief, but has no effect on the level of recycling. We know from the discussion of the effects of information that an individual has preferences for consistent information, and that this preference is likely to be stronger in real life settings compared to laboratory settings.

2. In the case of new negative information, i.e. when θ is less than zero, and the individual believes that recycling does not do anything for the environment; we have the second case of consistent information. Then we expect that $f(T_R)$ decreases, i.e. the individual spend less time on recycling. From the comparative static $\partial T_R^* / \partial \theta$ we see that information has the expected effect for medium- and high-income individuals. If an individual recycles nothing, then this information merely supports the existing belief and decision to recycle nothing, and we expect no effect on the level of recycling.

Second I take a closer look at the two cases of inconsistent information.

1. In the case where new information is positive, i.e. when θ is greater than zero, and the individual believes that recycling does not do anything for the environment; we have the first case of inconsistent information. To say something meaningful here, we need to think back to the discussion of what happens when new information is inconsistent. Remember that if the decision is easily reversible people have a stronger preference for consistent information. Inconsistent information could simply be discarded, valued as less reliable, biased or unimportant. So from theory this information will break the status quo if it is perceived as strong and reliable. If this is the case then $f(T_R)$ will increase, i.e. the individual spends more time on recycling. In the present case of recycling I would expect that there exists a strong preference for consistent information because the decision to recycle is easily reversible.

2. In the case of new negative information, i.e. when θ is less than zero, and the individual believes that recycling is good for the environment; we have the second case of inconsistent information. Theory suggests that the decision to contribute to a public good is based on norms. The tricky part here is that this information challenges both the norms and values that formed the basis for the decision to recycle and the decision itself. Think of the flow of information. People are introduced to a lot of information every day, not just one piece of information at a time. Therefore it is likely that inconsistent information will be discarded to reduce the cognitive dissonance, i.e. the post decisional conflict. The pain of accepting that what you have

been doing so far and spending so much time doing is wrong makes it hard to accept new inconsistent information. Therefore it is likely that this information, that challenges the recipient on two different levels, is discarded and we may observe no effect from new information.

The model shows that predicting the outcome of consistent information is fairly straightforward. On the other hand, in the case of inconsistent information the effect is fairly tricky to predict because in this case the effect relies on a third characteristic that is outside the model: the strength or reliability of the information. If we know that the individual will heed this new inconsistent information then the model, as it is, predicts the direction of the change in the amount of waste that is recycled.

3.1.2 How does time spent on recycling change when the wage rate changes?

What I have discussed so far is how the time spent on recycling changes when new information is made available. However, it is interesting to take a closer look at the income and substitution effects that arise when *w* changes. A change in the wage rate will directly affect the allocation of time between work, leisure and recycling. The comparative static $\partial T_R^* / \partial w$ is found in the third row of the first column in the H' matrix and shows how time spent on recycling changes when the wage rate changes.

$$\frac{\partial T_R^*}{\partial w} = \frac{\overbrace{\frac{\partial U^*}{\partial w}(K_{33} - K_{23})}^{Substitution-effect} - \overbrace{(T - T_L - T_R)^2 K_{13}}^{Income-effect}}{\det \bar{H}(T - T_L - T_R)} \qquad (17)$$

Investigating the change in time spent on recycling when the wage rate changes, everything else held constant, implies that θ is equal to zero. When θ is equal to zero the cofactors K_{13}, K_{23} and K_{33} are greater than zero and the determinant of the bordered Hessian matrix is less than zero. Further analysis shows that K_{33} is larger than K_{23} and $(K_{33} - K_{23})$ is positive.

Generally an increase in the wage rate gives rise to both an income effect and a substitution effect, and that these effects go in opposite directions.

The first term in the numerator on the right $\frac{\partial U^*}{\partial w}(K_{33} - K_{23})$ is positive and the denominator is negative, then it follows that the effect is downward. This effect is called the substitution effect. If the marginal utility of a wage increase, $\partial U^* / \partial w$, is small, then an individual will substitute time spent working for more time spent on recycling. On the other hand, it the marginal utility of a wage increase is large, the individual will substitute recycling time for longer work hours

The second term of numerator on the right $-\left(T - T_L - T_R\right)^2 K_{13}$ is negative and the denominator is negative, then it follows that the effect is upward. This is called the income effect. An increase in the wage rate allows an individual to work less and still have the same level of income. If the term in the numerator is large, meaning that the individual works long hours, the individual will work less and spend more time on recycling. This is not to be taken as an indication of satiation, but simply that for most individuals the marginal utility of money is positive but diminishing, and that the comparative static represents the shift from one equilibrium to another.

To conclude we see that a change in the wage rate has the expected effect on time spent on recycling. This result is logical when we think of the wage rate as the opportunity cost of time.

3.2 The maximization problem under government provision of the public good

Section 3.1 looked at how information affects the recycling decision, or the contribution to the public good, when this was provided privately without government intervention. However, if the government chooses to provide the public good or use pricing instruments as incentive mechanisms to increase provision, it is interesting to take a closer look at what happens to how information is perceived when a pricing instrument is introduced. From the discussion in chapter 2 we know that introducing pricing instruments affects the norms that underlie the initial decision to recycle, provide to the public good, and that pricing instruments can destroy the environmental norms. I argue that pricing instruments have two effects: the effect of the pricing instrument, including crowding effects, and an information effect.

The introduction of a pricing instrument will change the budget constraint to either:

$$w(T - T_L - T_R) + sf(T_R) = \mathbf{PC} \qquad \text{(subsidy on recycled materials } sf(T_R)) \qquad (18)$$

or

$$w(T - T_L - T_R) - t(1 - f(T_R)) = \mathbf{PC} \qquad \text{(tax on unsorted materials } t(1 - f(T_R)) \qquad (19)$$

Remember that the function $f(T_R)$ is a monotonic function of T_R such that it represents the fraction of total household waste that is recycled, and it can take on any value between 0 and 1. If it equals 1, then the individual recycles everything. If *s* is positive the government provides a subsidy on the fraction of waste that is recycled. In effect recycling is now an activity that increases money-income. If *t* is positive the government has levied a tax on the fraction of waste that is not recycled, and it represents a loss of money-income. Remember that $f'(T_R) > 0$ and that if $f\Delta T_R = 0 \rightarrow f(T_R) = 0$.

For a detailed mathematical approach, the new first-order conditions to the maximization problem and the new comparative statics please see Appendix A.2 and A.3. Here I limit my discussion to the changed comparative statics.

3.2.1 Government provision - the case of a subsidy

3.2.1.1 How does the time spent on recycling change when the subsidy rate changes?

First, I take a closer look at what happens when a subsidy on the amount of waste that is recycled is introduced. The incentive provided by the subsidy is that the more you recycle the more money you get, i.e. the government pays you to recycle. Remember from the discussion on crowding effects that a subsidy may have a crowding in effect because it is perceived to support already existing norms (Rege, 2004, Frey, 1999).

The comparative static $\partial T_R^* / \partial s$ shows how the time spent on recycling changes when the subsidy rate changes.

$$\frac{\partial T_R^*}{\partial s} = \frac{-f(T_R)(T - T_L - T_R)K_{13}^S - \frac{\partial U_i^*}{\partial w}\frac{\partial f(T_R)}{\partial T_R}K_{33}}{\det \bar{H}(T - T_L - T_R)} \tag{20}$$

It is expected that this comparative static is positive because an increase in the subsidy rate should lead to an increase in the amount of waste that is recycled. Remember from the cofactor analysis that K_{13}^S and K_{33} is positive for all positive values of *w* and that the determinant of the bordered Hessian matrix is negative when θ is equal to zero. Now it is easy to see that the effect of a subsidy is upward because both the numerator and denominator is negative.

Let us address the corner solutions. If an individual recycles nothing, then the first part of the numerator will be zero, i.e. $f(T_R)$ is equal to zero, and the effect of an increase in the subsidy rate is positive by the second part of the numerator i.e. an increase in the subsidy rate induces recycling.

In the case where an individual recycles everything i.e. $f(T_R)$ is equal to one, and then I expect that an increase in the subsidy has no effect on the time spent on recycling, but the valuation of labor and leisure change. When $f(T_R)$ equal one then $f\Delta T_R = 0$ and the second part of the numerator becomes zero and the subsidy effect becomes zero.

From $\partial T_R^* / \partial s$ we see that the expression is overall positive for all income groups and recycling levels, and that an increase in the subsidy rate has the expected effect.

3.2.1.2 How does the time spent on recycling change when new information is made available?

Now it is interesting to take a closer look at the effect of new information when recycling is subsidized. At first glance the comparative static $\partial T_R^* / \partial \theta$ looks exactly the same as in the case without the subsidy, but the subsidy changes the cofactors K_{23}^S and K_{43}^S. Please keep in mind the discussion of $\partial T_R^* / \partial \theta$ in the no-subsidy case, and I will focus the attention on the changes from the subsidy alone.

$$\frac{\partial T_R^*}{\partial \theta} = \frac{\overbrace{\frac{\partial U_i^{*2}(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta} K_{23}^S}^{Leisure} - \overbrace{\frac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)} \frac{\partial f(T_R)}{\partial T_R} K_{33}}^{Recycling} + \overbrace{\frac{\partial U_i^{*2}(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial \theta} K_{43}^S}^{Consumption}}{\det \bar{H}} \quad (21)$$

First I examine the case where θ is greater than zero. From the cofactor analysis we know that K_{23}^S can be negative for low income levels, but becomes positive as the wage rate increases, the same as in the no subsidy case. The subsidy makes it such that it becomes positive at a higher wage rate; in other words, the low-income group for which the cofactor is negative has now become larger.

The cofactor K_{43}^S becomes negative at a high wage rate, the same as in the no subsidy case, but because of the subsidy it becomes negative at a lower wage rate. In other words, the high-income group for which the cofactor is negative has become larger.

This suggests that the subsidy makes the group for which I can analytically sign the effect of positive information smaller.

Second, in the case of negative information, i.e. when θ is less than zero, the cofactor K_{23}^S may be negative for low wage rates and a positive subsidy, but becomes positive as the wage rate increases. Thus the cofactor is likely to be positive.

The cofactor K_{43}^S is likely to be negative for low wage rates and positive as the wage rate increases. However, it is likely to become positive at a higher wage rate because of the negative effect of the subsidy. In other words the low-income group, for which the cofactor is negative, has now become larger.

The above discussion suggest that the subsidy, in both the case of positive and negative, information makes the groups for which I can analytically sign the effect, smaller. The main effect of introducing a subsidy is that the low-income group has become larger. One explanation may be that people work less, i.e. labor income declines, because recycling is an activity that increases total income. This is logical when viewed in context of the information

effect of the subsidy itself. A subsidy conveys the message that recycling is a desired activity and it supports the social norms that recycling is good for the environment, and that the responsibility lies with the individual, thus more people may be inclined to discard negative information as unreliable or false.

3.2.1.3 How does the time spent on recycling change when the wage rate changes?

The next comparative static of interest is how does time spent on recycling change when the wage rate changes. We know that income directly affects the allocation of time between the different activities and a subsidy can be viewed as additional income from recycling. The change in time spent on recycling when the wage rate change is found in the comparative static $\partial T_R^* / \partial w$. Remember the discussion in the case with no subsidy and I will focus the attention on the changes from the subsidy only.

$$\frac{\partial T_R^*}{\partial w} = \frac{\overbrace{\frac{\partial U^*}{\partial w}(K_{33} - K_{23}^S)}^{Substitution-effect} - \overbrace{(T - T_L - T_R)^2 K_{13}^S}^{Income-effect}}{\det \bar{H}(T - T_L - T_R)} \tag{22}$$

Compared with the no-subsidy case we observe that the cofactors have changed when the subsidy was introduced. The cofactor K_{23}^S becomes positive at a higher wage rate and the cofactor K_{13}^S might be negative for *w* close to zero and positive *s*. The net effect is that the substitution effect is weighted more through the cofactors, and the income effect is weighted less. The implication is that an individual will need a higher wage hike to change his allocation of time when there is a subsidy.

3.2.2 Government provision - the case of a tax

3.2.2.1 How does the time spent on recycling change when the tax rate changes?

Second, I take a closer look at the other form of government intervention, what happens to the effect of information when a tax on residual waste is introduced. The economic incentive of the tax is to recycle to avoid tax payments. I expect the comparative static $\partial T_R^* / \partial t$ to be positive. The comparative static shows the effect of a change in the tax rate on time spent on

recycling. A closer inspection of the effect of the tax reveals that a tax can be viewed as a negative subsidy.

$$\frac{\partial T_R^*}{\partial t} = \frac{(f(T_R)-1)(T-T_L-T_R)K_{13}^T + \frac{\partial U_i^*}{\partial w}\frac{\partial f(T_R)}{\partial T_R}K_{33}}{\det \bar{H}(T-T_L-T_R)} \tag{23}$$

Remember that the cofactor K_{13}^T is positive for all positive values of *t* and *w*, and that K_{33} is positive for all positive wage rates, and that the determinant of the bordered Hessian matrix is negative, i.e. the denominator is negative.

First, let us examine the corner solutions where and individual either recycles everything, or nothing. If an individual recycles everything the term $(f(T_R)-1)$ becomes zero and the first part of the numerator drops out. The other thing that happens in the case where everything is recycled is that $f\Delta T_R = 0$ from a change in the tax rate, and the second part of the numerator is zero as well, and the expression is equal to zero, and we see that an increase in the tax rate for this individual has no effect.

If an individual recycles nothing then $(f(T_R)-1)$ becomes -1, and the first term in the numerator of $\partial T_R^* / \partial t$ is given a lot of weight. We see that for any fraction of waste recycled, except the case where everything is recycled, the first part of the comparative static is positive, and the effect is upward, because both the numerator and denominator is negative. The second part of the numerator is positive making the effect downward, thus the tax will have the expected effect if the marginal utility of a wage increase $\frac{\partial U_i^*}{\partial w}$ at the optimal point is low. If the marginal utility of a wage increase is high an individual will choose to work and pay the tax instead of recycling, and we see that the comparative static may have a negative sign.

3.2.2.2 How does the time spent on recycling change when new information is made available?

As in the case of a subsidy, it is interesting to see how time spent on recycling change when new information is made available and there is a tax on the amount of residual waste. The comparative static $\partial T_R^* / \partial \theta$ is affected by the tax rate through the cofactors K_{23}^T and K_{43}^T. Please keep in mind the discussion of the effect of information from before, and I will only focus on the changes that arise from the tax.

$$\frac{\partial T_R^*}{\partial \theta} = \frac{\overbrace{\frac{\partial U_i^{*2}(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta} K_{23}^T}^{Leisure} - \overbrace{\frac{\partial U_i^{*}(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)} \frac{\partial f(T_R)}{\partial T_R} K_{33}}^{Recycling} + \overbrace{\frac{\partial U_i^{*2}(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial \theta} K_{43}^T}^{Consumption}}{\det \bar{H}} \quad (24)$$

First, let us take a closer look at the case when new information is positive. When θ is greater than zero, the tax rate makes the cofactor K_{23}^T positive for a lower wage rate and the cofactor K_{43}^T positive for a higher wage rate. The result is that $\partial T_R^* / \partial \theta$ has the expected positive sign for a wider range of wage rates. In other words when a tax is used the group for which I can analytically sign the effect of information has become larger.

Second, let us take a closer look at the case of negative information. When θ is less than zero, the cofactor K_{23}^T is likely to always be positive. The introduction of a tax makes it more likely that the cofactor K_{43}^T is positive.

Thus, the tax makes the group, for which I can analytically sign the effect of both positive and negative information, larger in both the case of consistent and the case of inconsistent information.

3.2.2.3 How does the time spent on recycling change when the wage rate changes?

A tax directly affects disposable income. A tax on residual waste reduces income by the tax rate multiplied by the amount of residual waste, or said another way, the amount of recyclable waste that is not recycled. Let us now take a closer look at how time spent on recycling

changes when the wage rate changes, when the government uses a tax to induce recycling behavior. The result can be found in the comparative static $\partial T_R^* / \partial w$.

$$\frac{\partial T_R^*}{\partial w} = \frac{\overbrace{\frac{\partial U^*}{\partial w}(K_{33} - K_{23}^T)}^{Substitution-effect} - \overbrace{(T - T_L - T_R)^2 K_{13}^T}^{Income-effect}}{\det \bar{H}(T - T_L - T_R)} \tag{25}$$

From the comparative static $\partial T_R^* / \partial w$ we see that the substitution effect is still downward and the income effect is still upward, and that a wage increase will lead to more time being spent on recycling. The main effect of the tax is that the income effect is given more weight through the size of the cofactor K_{13}^T, meaning that an individual changes his allocation of time towards recycling for a smaller increase in the wage rate than in the no-tax case.

The term $(K_{33} - K_{23}^T)$ is still positive, but the introduction of a tax makes the cofactor smaller, and the term overall larger. The result is that the substitution effect is given more weight. However, it is difficult to analytically say how much these cofactors change and thus how the tax affects the size of the wage hike needed to change the allocation of time. But from theory it is likely that the wage hike needed is now smaller than in the no-tax case.

In the tax case the incentive is to recycle more to reduce the amount of taxes that you have to pay. However, if your wage rate increases you might choose to work more and just pay the taxes, if that leaves you strictly better off. Remember: "Fine enough or don't fine at all" (Lin and Yang, 2006, p. 208).

3.3 General discussion

I believe that some of the results predicted by the model require some extra attention. The nature of the utility maximization problem is such that income, determined by the wage rate, divides the groups for which I can analytically sign the effect of information. But I do not claim that income is the factor explaining why an individual recycles or how much. Income, or the wage rate, is a measure of the opportunity cost of time. It might be partial explanation in itself, or it might be an intermediary variable between education and the level of recycling.

I will now present some of my thoughts on this connection, but to be able to say anything more this needs to be tested empirically.

It is likely that the connection between education and income is such that low-income people have less education than high-income people. First, I take a closer look at the low-income group. There are several effects that may explain the results. An individual that earns a low wage may prefer to spend time working to put food on the table and thus spend less time on recycling and leisure. On the other hand this individual might choose to spend more time on leisure and recycling because the wage is already so low, that working more simply does not appeal to him, i.e. the opportunity cost of time is very low.

A high-income individual basically has the same choices as a low-income individual but the effects can be thought to be opposite. This individual earns a high wage and thus he can afford to take time off to spend on leisure and recycling. On the other hand, he has a very high opportunity cost of time, which in turn makes it very expensive not to work, and he might choose that instead.

Now I turn the attention to the education perspective. I believe that education increases knowledge and information processing skills.

First, let us take a closer look at individuals with low levels of education. These individuals might have a harder time judging, incorporating and acting on new information as a direct consequence of their low level of education. This is a negative effect that suggests that low-income people should be less responsive to new information. On the other hand, lowly educated people might be easier to persuade because they are less trained in critical thinking, which represents a positive effect of why information should work more strongly for this group of people.

Second, we take a closer look at highly educated individuals. Here we might have a positive effect in that they have better information processing skills, however, they are also more likely to question the information that they are provided because they are more trained in critical thinking. Thus, information presented to highly educated individuals might have to be more persuasive, argumentative and valid compared to information presented to individuals with a lower level of education.

Using both of the arguments above it is reasonable to believe that information has different effects for both income and education groups, although there might be a significant correlation between the two.

In the model I have divided time into three different "goods": Time spent on work, recycling and leisure. I argue that it is unlikely that that time spent on recycling comes out of working time, or that this effect is very small. I propose two reasons for this. The first being that recycling only takes about 6 minutes a day[4], and you would not leave work 6 minutes early because you have to get home and recycle. The second reason is that for most individuals in Norway working time is fixed at 37.5 hours a day, not counting over time, thus choosing to work less to make time for recycling may not be an option. On the other hand, it is unlikely that it comes directly out of leisure either. For example, one of your favorite leisure time activities is playing soccer. It is unlikely that you would leave soccer practice six minutes early because you have to get home and recycle. Thus recycling is an activity in itself that is neither work nor leisure.

Let us think back to the comparative static $\partial T_R^* / \partial \theta$ in equation (16). Based on these arguments it is likely that the first and last term of the numerator are small and that the main effect of information can be traced directly from the effect of information on the marginal utility of recycling and we can see that this effect is positive for positive information and negative for negative information for all income groups.

Another issue that might require some more explanation is why the groups affected by information is different in the six cases presented. In the three cases of positive and consistent information the effect of information can be analytically signed for middle-income individuals and that this group is smaller in the case of a subsidy, and larger in the case of a tax. In the three cases of negative and consistent information the effect can be signed for middle- and high-income individuals and that this group is smaller in the case of a subsidy and larger in the case of a tax. I offer the explanation that this is because a tax works more strongly than a subsidy. We can see this by examining the comparative statics $\partial \lambda^* / \partial s$ and

[4] Please see Table 7-2

$\partial\lambda^*/\partial t$. These two comparative statics show the change in the shadow price of time from changing the subsidy and tax, respectively. It is clear that the absolute value of a change in λ from a tax is greater than the absolute value of a change in λ from a subsidy, i.e., $\left|\partial\lambda^*/\partial t\right| > \left|\partial\lambda^*/\partial s\right|$.[5]

The model is limited in its applicability in that it only looks at the effects of information. Like many economic models it is a simplification of the real world and its worth has to be tested empirically. Other effects, like the crowding effects of pricing instruments or the strength and reliability of the information is outside the scope of the model.

[5] A detailed approach can be found in appendix 7.1.4

Chapter - 4 Results and analysis of the survey instrument

This chapter discusses the results from the questionnaire that was distributed to examine the norms, beliefs and knowledge about recycling among households.

Methodology: To reach a sufficiently large population, with the limited funds and time that is available for an M. Sc. thesis, the questionnaire was distributed using my advisor Eirik Romstad's contacts in local sports groups and my contacts in the Norwegian Scout Association. With this sampling method we were able to reach about 1500 households and with a response rate of a little over 10 percent I ended up with a sample of 160 households. Although the sample is non-random I believe this is an important demographic group of households with children.

The survey was distributed using the online survey tool Questback. To make sure the questionnaire worked as intended I conducted a pilot test of the survey on master students at the Norwegian University of Life Sciences. Then, before distributing the questionnaire, I checked that changing the screen resolution did not alter how the survey looked or functioned. This last step is important to reduce the barrier of responding for individuals with older computers.

The questionnaire can be found in Appendix 7.4. In the questionnaire respondents were asked to indicate their position on different statements relating to recycling activities, knowledge and information about recycling. Their position was indicated on a four-point Likert scale with a "don't know" option. There is an ongoing debate among researchers whether to use Likert scales with an odd or even number of choices, and how many choices to include. I chose to use an even scale to avoid a lot of neither/or answers, and "force" the respondent to take a standpoint rather than choosing indifference. Whether you get more positive or negative answers on an even-numbered scale is entirely context dependent (Garland, 1991). Without a control I am unable to say what is the case in the current study. Armstrong's (1987) results, on the other hand, show that changing the mid-point from neutral to undecided has little or negligible effect on the score suggesting that the difference between an odd or even scale is small.

Data: A first look at the data reveals that I have a skewed sample. The relevant descriptive and summary statistics can be found in table 7.1 and 7.2 in Appendix 7.3. From these statistics we see that the sample consists mostly of highly educated, high-income people that recycle. Comparing the sample with data from Statistics Norway shows that both the median income and the education level is substantially higher in my sample compared to the population as a whole, please see table 7.3 and 7.4 in Appendix 7.3.

However, the skewed sample is expected because of the sampling method employed. It is likely that individuals who volunteer, have their kids participate in sports and take the time to answer a survey like this are resourceful. Although, the sample is not representative I believe that I should be able to trace some of the results predicted by the model. The comparative statics from the model suggests that I should be able to observe the shifts, although to a smaller degree, for high-income individuals.

Analysis: In order to take a closer look at the data I have cross-tabulated the relevant variables and these can be found in Appendix 7.3 tables 7.5-7.20. This basic statistical analysis by itself is rather limited in results, but when viewed together with the relevant correlation coefficients it can hint at the direction of the shifts predicted by the model. A shift implies causation in that there is a cause and effect. In other words that a change in an exogenous variable, for example information, causes time spent on recycling to change. However, I only have access to correlation coefficients. To remind myself, a correlation does not say anything about the causal link between the variables, only the covariance, i.e., whether or not two variables move in the same direction and to what degree. The correlation coefficient then can give an indication of the direction of the shift we could observe from new information. This is not to be taken as solid evidence as I do not say anything about which of the two variables causes the change in the other. I can only assume, based on theory, the direction. For example I assume that new information affects time spent on sorting. It is unlikely that time spent on sorting affects whether or not you receive information.

Table 4-1The correlation coefficients between time spent on recycling, the recycling decision and variables related to knowledge-, social information and socio-economic factors

		Correlation coefficients			
Variable	**Short description*** **	**Time**	**Obs**	**Reycle**	**Obs**
Knowledge-information					
Infoimportant	I have received information about how important it is to recycle	0.1055	108		
Infowhat	I have recieved information about what and how to recycle.	0.0477	107		
Receiveinfowhat	I have received information about what and how to recycle. Dummy-variable	-0.0016	139	0.3193	151
Infojudgewhat	How would you judge the information that you received about what and how to recycle?	0.0996	100	-0.0527	102
Infowhenwhat	When did you last receive information about what and how to reycle?	-0.1559	88	-0.0547	90
Munirecycle	Does your municipality have a recyclingprogram?	0.071	144	0.3842	154
Judgerecycling	How would you judge the recycling program?	0.096	106	0.0257	109
Doyouknow	Do you know how the recycling program works?	0.1038	126	-0.0509	129
Knowsort	Do you know how the waste is sorted?	0.0706	126	-0.0136	129
Social information					
Muniserious	Do you feel that your municipality takes recycling seriously?	-0.0479	130	0.0299	138
Receiveinfofrac	I have received information about the fraction of waste that is recycled in my municipality.	0.2191	108	0.0798	119
Infojudgefrac	How would you judge the information that you received about the fraction of waste that is recycled.	0.9033	7		
Infowhenfrac	When did you last receive information about the fraction of waste?	-0.037	6		
Neighborthink	I recycle because I want my neighbors to think of me as a responsible person.	0.1627	146		
Neighbordo	I recycle because most of my neighbors recycle.	0.1247	139		
Neighborstarted	I recycle because my neighbors have started to recycle.	0.027	108		
Neighborrecycle	Do you think that your neighbors recycle?	0.1147	92		
Neighborresponsible	Do you think of your neighbors as responsible people?	-0.0445*	84	0.2362	91
Neighborhoodrecyc	Does your neighborhood have a local recycling program?	0.0311	136	0.1754	145
Demographic Variables					
Folloren	Dummy for whether you belong to a municipality in which Follo Ren operates	-0.0314	142	-0.1859	154
Sex	Sex	-0.1815	148	-0.2077	160
Age	Age	-0.007	148	-0.085	160
Housetype	What type of house do you live in?	-0.0928	148	-0.069	160
Kindergarden	How many kids in kindergarden	0.0348	146	-0.083	158
Inelementary	How many kids in elementary school	0.0856	146	0.0271	158
Inmiddleschool	How many kids in middle school	-0.0158	146	0.0031	158
Inhighschool	How many kids in highschool	-0.084	146	-0.0721	158
Education	What is your highest attained education	-0.0253**	145	-0.0195**	157
Hhincome	What is the total household income	0.0506	129	0.0361	141
Vote	Did you vote at the last election	0.0542	148	0.089	160
Environmentalorg	Is one or more members of the household member of an organization with an environmental agenda.	0.1621	148	-0.0359	160

* Coeff. 0.1016 if time <10 possibly due to extreme observations

** Without other education

***A more detailed description can be found in Table C.1

Based on the fact that 92.5 percent of my sample recycles, it is likely that there are social norms and values at play here that says recycling is good for the environment. This implies that new information is viewed as consistent with prior beliefs that recycling is good for the environment, which in turn can help explain why the variables move in the same direction, i.e., positive correlation between time spent on recycling and the information variables. Please note that a positive correlation implies consistent information regardless of whether the information is positive or negative.

First, I take a closer look at the variables related to knowledge information. From table 4.1 we see that all the variables related to knowledge information is positively correlated with time spent on recycling. This result is what I expect and what is predicted by the model. I assume that time spent on recycling does not affect whether or not you receive information, when you receive information or your knowledge of what and how to recycle, but that it is the other way

around. Thus, the correlations hint at the direction of the shift that would happen if the information or knowledge variables changed. One variable needs closer examination, and that is “infowhenwhat” (When did you last receive information about what and how to recycle?). Table 7.7 shows the cross tabulation between time spent on recycling per day and when you last received information about what and how to recycle. Now it is easy to see that if “infowhenwhat” increases, meaning that there is longer since you last received information, time spent on recycling is moving in the opposite direction, i.e., decreasing, suggesting an inverse relationship between the two variables.

Second, I take a closer look at the variables related to social information. From table 4.1 we see that what your neighbor does is positively correlated with the time you spend on recycling. However, here the direction of causation is difficult to assume based on theory. Do your neighbors recycle because you recycle, or do you recycle because your neighbors recycle? This makes it very hard to translate the effect into the direction of the shift, because this is most likely simultaneous and can be thought of as an iterating process that can be either positive or negative. Another reason why it can be difficult to interpret this as a hint of the direction of the shift is because the sample is a very homogenous group of households. The person that answered the survey represents the households and of those about 70 percent has at least one year of higher education, 80 percent has at least one child in kindergarten, 62.5 percent is between 40 and 50 years old and 67.5 percent are women.

The only variable that can give an indication of the direction of the shift from social information is whether or not you receive information about the fraction of waste that is recycled in your municipality. Based on the same argument as before, we see that the correlation coefficient is positive, that the two variables move in the same direction and that the shift that may arise from consistent information is as expected. The last two variables related to the fraction of waste that is recycled are more unreliable than the rest of the variables because of the few number of observations.

The municipalities in my sample belong to two different recycling programs. Follo Ren runs the recycling program in the municipalities Frogn, Nesodden, Oppegård, Ski and Ås, and Indre Østfold Renovasjon IKS runs the recycling program in Spydeberg and Hobøl.

Both Follo Ren (FR) and Indre Østfold Renovasjon (IØR) pick up residual waste, paper and cardboard from households. In addition IØR picks up plastic, food waste, glass and metal. Neither of the firms collect electronic waste or hazardous waste (FolloRen, 2012, IndreØstfoldRenovasjonIKS, 2012). Any sorted waste that is not picked up by either firm has to be dropped of at a recycling station. From table 4.1 we see that the correlation between time spent on recycling and whether or not Follo Ren runs the recycling program is close to zero, but that the correlation coefficient on the decision to recycle is negative indicating that if you live in a municipality in which Follo Ren operates you are less likely to recycle. One reason for this might be that the recycling program run by IØR is of a higher quality than the recycling program run by FR. In Tables 7.21 and 7.22[6] I have used a simple t-test to compare mean income and mean education between individuals belonging to either recycling program. The t-test suggests that there is no difference between mean household incomes in the two areas, but that households in the area run by FR has a significantly higher level of education. This result is consistent with what we see in Table 4.1 that education and recycling is negatively correlated.

Further analysis: The nature of the problem leads me to think that there is a selection mechanism at work here. We know that time spent on recycling is only observable after the decision to recycle is made. From my previous discussion of why people recycle, I believe that people who recycle are different from people that do not, in that they have different norms and values. Thus I might have a selection bias when I try to estimate the effect of information on time spent on recycling, which is of key interest here. However, I am unable to run a proper regression or a Heckman selection model because the dataset is too small, there is little variation on the selection variable and I have a serious problem with collinearity between some of the variables, which according to theory belongs in my model.

To conclude this chapter I am able to give an indication at some of the effects through the correlation coefficients and say something about whether or not the variables move together, which indicates the direction of the shifts in the model. These results are interesting in that they give some support to the model.

[6] In Appendix 7.3

Limitations: There are several limitations to this analysis. First, I was unable to do a proper regression because of too few observations and little variation in the data. Second, the data obtained from a survey like this leads to a self-reporting bias. People that recycle might say that they spend more time on recycling than they actually do, say that they recycle more than they do, or even that they recycle in the first place. The data problems, self-selection and self-reporting biases make me unable to draw further conclusions at this point.

Chapter - 5 Concluding Remarks

In conclusion this thesis proposes a model that shows how new information affect the decision to recycle, what happens when this information is consistent or inconsistent with the decision to recycle, and what happens when pricing instruments are introduced.

Research question (1) asks how does new information affect the decision to recycle? And is divided into two sub-questions: (1a) what happens when this information is consistent with prior beliefs? And (1b) what happens when this information is inconsistent with prior beliefs. Both of these are answered by the model and represent a situation of voluntary contributions to the public good that is a clean environment.

(1a) In the case of positive information the model shows that the group, for which I can analytically sign the effect, consists of individuals in the medium income range. In the case of negative information the group consists of medium- to high-income individuals. The results obtained from the survey shows that the information variables co-varies with the time spent on recycling, suggesting that the effect of information, as predicted by the model, is as expected. The thesis offers the following explanation for these results:

Income might be a partial explanation in itself where individuals with low levels of income has a very low opportunity cost of time and would rather spend time on leisure and recycling rather than spend time working, or they might have to work to put food on the table, and thus cannot afford to spend time on leisure and recycling. High-income individuals, on the other hand, has a very high opportunity cost of time and thus would rather spend time working, or it can be thought that they can afford to take time off from work and spend time on leisure and recycling.

Another possibility is that income is an intermediary variable between recycling and education. It may be that individuals with a low level of education has lower information processing skills and thus have a harder time judging the information that he receives or he is more susceptible to new information because he is less educated in critical thinking and thus are more likely to take information at face value. Highly educated individuals on the other hand may have better information processing skills, but they are more trained in critical

thinking and information presented to this group may have to be more persuasive and argumentative.

(1b) When information is inconsistent the model, as it is, predicts the change in time spent on recycling if we know that new information is incorporated and acted upon.

Research question (2) asks how does introducing a pricing instrument affect how effective new information is? This represents a situation where the government intervenes and provides the public good.

The model shows that introducing pricing instruments change the composition of the group for which I can analytically sign the effect of new information. In the case of a subsidy the income range for which I can sign the effect of information becomes smaller, and in the case of a tax, it becomes larger. The thesis offers the explanation that this is because a tax is a stronger incentive instrument than a subsidy.

Limitations: The model is limited in its applicability in that it only looks at the effects of information on the decision to recycle. The crowding effects of the pricing instruments and the strength and reliability of the information is outside the scope of the model. The results from the survey instrument is limited because of poor data quality, selection problems and self-reporting and should only be viewed as an indication of the effect of information.

Further research: It would be interesting to see if the new equilibrium created by a change in available information is a stable equilibrium, or if using information is just a short-term solution, if any. Another possibility is to extend the model and see how information can affect the use of a common pool resource. Further, the predictions made by the model needs to be tested empirically, for example through a full-scale survey. This survey needs to have a sufficiently large and random sample such that it is representative of the population. I was unable to do such a survey here because of the limited time and funds available.

Chapter - 6 Literature

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Chapter - 7 Appendices

7.1 Solving the first order conditions and obtaining the comparative statics.

This appendix shows in detail the solutions to the maximization problem. Since I do not know the functional form, or the functional relationship between the different variables, I apply the implicit function theorem to solve the first order conditions and obtain the comparative statics.

The implicit function theorem states that evaluated at an optimal point $(\lambda^*, T_L^*, T_R^*, \mathbf{C}^*)$ the solution to the first order conditions is a function of the exogenous variables $(w, \mathbf{P}, \theta)$ such that:

$$F_y(T_L, T_R, \mathbf{C}, \lambda)H' = -F_x(w, \theta, \mathbf{P}) \tag{7.1}$$

Where $F_y(T_L, T_R, \mathbf{C}, \lambda)$ is the bordered hessian matrix, H' is the matrix containing all the comparative statics and $-F_x(w, \theta, \mathbf{P})$ is the matrix containing the derivatives of the first order conditions with respect to the exogenous variables. Using the implicit function theorem I obtain the comparative statics directly.

7.1.1 The case of private contribution – no tax and no subsidy

The maximization problem:

$$\begin{aligned} &Max U_i(T_L, \theta f(T_R), \mathbf{C}) \\ &s.t. \\ &w(T - T_L - T_R) = \mathbf{PC} \end{aligned} \tag{7.2}$$

I construct the Lagrangian and obtain the first order conditions:

$$L = U_i(T_L, \theta f(T_R), \mathbf{C}) + \lambda(w(T - T_L - T_R) - \mathbf{PC}) \tag{7.3.1}$$

FOC:

$$\frac{\partial L}{\partial \lambda} = w(T - T_L - T_R) - \mathbf{PC} = 0 \tag{7.3.2}$$

$$\frac{\partial L}{\partial T_L} = \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L} - \lambda w = 0 \tag{7.3.3}$$

$$\frac{\partial L}{\partial T_R} = \theta \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_R} \frac{\partial f(T_R)}{\partial T_R} - \lambda w = 0 \tag{7.3.4}$$

$$\frac{\partial L}{\partial C} = \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C}} - \lambda \mathbf{P} = 0 \tag{7.3.5}$$

When I apply the implicit function theorem I obtain the following matrices.

$$\begin{bmatrix} 0 & -w & -w & -\mathbf{P} \\ -w & U_{LL} & \theta U_{LR} & U_{LC} \\ -w & \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix} \begin{bmatrix} \partial\lambda^*/\partial w & \partial\lambda^*/\partial\theta & \partial\lambda^*/\partial\mathbf{P} & \partial\lambda^*/\partial s \\ \partial T_L^*/\partial w & \partial T_L^*/\partial\theta & \partial T_L^*/\partial\mathbf{P} & \partial T_L^*/\partial s \\ \partial T_R^*/\partial w & \partial T_R^*/\partial\theta & \partial T_R^*/\partial\mathbf{P} & \partial T_R^*/\partial s \\ \partial\mathbf{C}^*/\partial w & \partial\mathbf{C}^*/\partial\theta & \partial\mathbf{C}^*/\partial\mathbf{P} & \partial\mathbf{C}^*/\partial s \end{bmatrix} = - \begin{bmatrix} T - T_L - T_R & 0 & -\mathbf{C} \\ -\lambda & \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta} & 0 \\ -\lambda & \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_R} \frac{\partial f(T_R)}{\partial T_R} & 0 \\ 0 & \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial \theta} & -\lambda \end{bmatrix}$$

Now I need to evaluate the bordered hessian determinant before I can use Cramer's rule to solve for the comparative statics.

7.1.1.1 Evaluating the bordered Hessian determinant

$$\bar{H} = \begin{bmatrix} 0 & -w & -w & -\mathbf{P} \\ -w & U_{LL} & \theta U_{LR} & U_{LC} \\ -w & \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix} \tag{7.4}$$

$$\det \bar{H} = -(-w)K_{21} + (-w)K_{31} - (-\mathbf{P})K_{41} \tag{7.5}$$

$$\det \bar{H} = wK_{21} - wK_{31} + \mathbf{P}K_{41} \tag{7.6}$$

Where K_{21} is the cofactor obtained by deleting the second row and first column of $\det \bar{H}$. To sign the determinant properly it is important to first sign the cofactors.

7.1.1.1.1 The cofactor K_{21}

$$K_{21} = \begin{bmatrix} -w & -w & -\mathbf{P} \\ \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \\ U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix} = +(-w)\left[\theta U_{RR} U_{CC} - \theta U_{RC}^2\right] - (-w)\left[\theta U_{RL} U_{CC} - \theta U_{RC} U_{CL}\right] + (-\mathbf{P})\left[\theta U_{RL} \theta U_{CR} - U_{CL} \theta U_{RR}\right]$$

First, let us take a closer look at the case of positive information, i.e., where θ is greater than zero. We see that the first term of the cofactor, K_{21}, is negative because the inside of the bracket $\left[\theta U_{RR}U_{CC} - \theta U_{RC}^2\right]$ is positive. This is positive under the article of faith that own-effects are greater than cross-effects. The second term of the cofactor $-(-w)\left[\theta U_{RL}U_{CC} - \theta U_{RC}U_{CL}\right]$ is negative because the inside of the bracket is negative. The third and last term $+(-\mathbf{P})\left[\theta U_{RL}\theta U_{CR} - U_{CL}\theta U_{RR}\right]$ is negative because inside of the bracket is positive. This makes the cofactor overall negative when θ is greater than zero.

Second, let us take a closer look at the case where new negative information is made available, i.e., where θ is less than zero. The first two terms of the cofactor is positive because now the inside of the bracket of the first term is negative and the inside of the bracket of the second term is positive. The last term is ambiguous. The inside of the bracket of the last term is likely to be negative because own-effects are assumed to be greater than cross-effects, thus the last term is positive as well. In the case where the inside of the brackets of last term is positive, and the last term negative, the cofactor becomes positive as *w* increases. The cofactor is positive when θ is less than zero.

Third, let us look at the case where no new information is available, i.e., when θ is equal to zero. In this situation the cofactor is equal to zero.

To conclude the cofactor is negative when θ is greater than zero, positive θ when is less than zero and zero when θ is zero.

7.1.1.1.2 The cofactor K_{31}

$$K_{31} = \begin{bmatrix} -w & -w & -\mathbf{P} \\ U_{LL} & \theta U_{LR} & U_{LC} \\ U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix} = +(-w)\left[\theta U_{LR}U_{CC} - \theta U_{CR}U_{LC}\right] - (-w)\left[U_{LL}U_{CC} - U_{CL}^2\right] + (-\mathbf{P})\left[U_{LL}\theta U_{CR} - U_{CL}\theta U_{LR}\right]$$

First let us examine the case of new positive information, i.e., where θ is greater than zero. The first term of the cofactor K_{31} is positive because the inside of the bracket $+(-w)\left[\theta U_{LR}U_{CC} - \theta U_{CR}U_{LC}\right]$ is negative. The second term $-(-w)\left[U_{LL}U_{CC} - U_{CL}^2\right]$ is positive for

both positive and negative values of θ. The last term $(-\mathbf{P})\left[U_{LL}\theta U_{CR} - U_{CL}\theta U_{LR}\right]$ of K_{31} is positive. The cofactor is overall positive when θ is greater than zero.

Second let us take a closer look at the case where new information is negative, i.e., where θ is less than zero. The first and last term becomes negative, because the inside of the brackets of the first and last term are both positive. The second term is negative. The cofactor is likely to be negative because the effects of the first and last term will dominate the second term for all values of *w*.

Third, in the case where no new information is available, i.e., when θ is zero, the cofactor is positive.

7.1.1.1.3 The cofactor K_{41}

$$K_{41} = \begin{bmatrix} -w & -w & -\mathbf{P} \\ U_{LL} & \theta U_{LR} & U_{LC} \\ \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \end{bmatrix} = +(-w)\left[\theta U_{LR}\theta U_{RC} - \theta U_{RR}U_{LC}\right] - (-w)\left[U_{LL}\theta U_{RC} - \theta U_{RL}U_{LC}\right] + (-\mathbf{P})\left[U_{LL}\theta U_{RR} - \theta U_{RL}^2\right]$$

First let us examine the case when new information is positive, i.e., where θ is greater than zero. The first term $+(-w)\left[\theta U_{LR}\theta U_{RC} - \theta U_{RR}U_{LC}\right]$ of the cofactor K_{41} is negative because the inside of the bracket is positive. The second term $-(-w)\left[U_{LL}\theta U_{RC} - \theta U_{RL}U_{LC}\right]$ is negative because the inside of the bracket is negative. The last term $+(-\mathbf{P})\left[U_{LL}\theta U_{RR} - \theta U_{RL}^2\right]$ is also negative because the inside of the bracket is positive. The cofactor is overall negative.

Second, let us examine the case where new information is negative, i.e., where θ is less than zero. The first term is ambiguous. It is likely that the inside of the bracket of the first term is negative under the assumption that own-effects are larger than cross-effects, and the first term is positive. The second term is positive because the inside of the bracket is positive, and the last term is positive because the inside of the bracket is likely to be negative. Even in the case where the first term is negative, the cofactor is positive when *w* equals zero and will stay positive for any *w* because the last two terms will dominate the first.

Third, in the case where no new information is made available, i.e., where θ is zero, the cofactor becomes zero.

7.1.1.1.4 The signs of the bordered Hessian Matrix

In conclusion the determinant of the bordered Hessian matrix is negative when θ is greater than or equal zero, and positive when θ is less than zero.

7.1.1.2 Obtaining the comparative statics

7.1.1.2.1 How does the time spent on recycling change when new information is made available?

Using the implicit function theorem it is relatively easy to obtain $\partial T_R^* / \partial \theta$. I replace the third column of F_y with the second column of F_x and solve the following matrix by Cramer's rule. The matrix is called F_{Y32} to show that the second column of F_x has replaced the third column of F_y. The cofactor K_{23} is found by deleting the second row and third column of the F_{Y32} matrix. The nominator of $\partial T_R^* / \partial \theta$ is the determinant of the F_{Y32} matrix and the denominator is the bordered hessian matrix.

$$F_{Y32} = \begin{bmatrix} 0 & -w & 0 & -\mathbf{P} \\ -w & U_{LL} & -\dfrac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta} & U_{LC} \\ -w & \theta U_{RL} & -\dfrac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)} \dfrac{\partial f(T_R)}{\partial T_R} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & -\dfrac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial \theta} & U_{CC} \end{bmatrix}$$

$$\frac{\partial T_R^*}{\partial \theta} = \frac{-(-\dfrac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta})K_{23} + (-\dfrac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)} \dfrac{\partial f(T_R)}{\partial T_R})K_{33} - (-\dfrac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial \theta})K_{43}}{\det \bar{H}} \tag{7.4}$$

I rewrite the expression slightly and obtain:

$$\frac{\partial T_R^*}{\partial \theta} = \frac{\frac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta} K_{23} - \frac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)} \frac{\partial f(T_R)}{\partial T_R}) K_{33} + \frac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial \theta}) K_{43}}{\det \bar{H}} \quad (7.5)$$

7.1.1.2.2 How does the time spent on recycling change when the wage rate changes?

I obtain the comparative static $\partial T_R^* / \partial w$ directly by replacing the first column of the F_x matrix by the third column of the F_y matrix and solve using Cramer's rule.

$$F_{Y31} = \begin{bmatrix} 0 & -w & -(T - T_L - T_R) & -\mathbf{P} \\ -w & U_{LL} & \lambda & U_{LC} \\ -w & \theta U_{RL} & \lambda & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & 0 & U_{CC} \end{bmatrix}$$

$$\partial T_R^* / \partial w = \frac{-(T - T_L - T_R) K_{13} - \lambda K_{23} + \lambda K_{33}}{\det \bar{H}} \quad (7.6)$$

I re-write the expression slightly and obtain:

$$\partial T_R^* / \partial w = \frac{\lambda (K_{33} - K_{23}) - (T - T_L - T_R) K_{13}}{\det \bar{H}} \quad (7.7)$$

To gain a better insight from the comparative static I substitute in the expression for λ. A detailed approach on how λ is found, can be seen in appendix B.

$$\partial T_R^* / \partial w = \frac{\frac{\partial U^*}{\partial w}(K_{33} - K_{23}) - (T - T_L - T_R)^2 K_{13}}{\det \bar{H}(T - T_L - T_R)} \quad (7.8)$$

7.1.1.2.3 Evaluating the cofactors

To be able to say something meaningful about the comparative static I need to sign the cofactors. A cofactor is the signed minor of a matrix. To evaluate the cofactors I use the Laplace expansion of evaluating *n*th-order determinants (Chiang and Wainwright, 2005). The sign charts of the minors begin over with each new determinant.

7.1.1.2.3.1 The cofactor K_{13}

$$K_{13}=\begin{bmatrix} -w & U_{LL} & U_{LC} \\ -w & \theta U_{RL} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & U_{CC} \end{bmatrix}=-w\left[\theta U_{RL}U_{CC}-U_{CL}\theta U_{RC}\right]-(-w)\left[U_{LL}U_{CC}-U_{CL}^{2}\right]+(-\mathbf{P})\left[U_{LL}\theta U_{RC}-\theta U_{RL}U_{LC}\right]$$

First, I examine the case when new information is positive, i.e., where θ is greater than zero. The first term $-w\left[\theta U_{RL}U_{CC}-U_{CL}\theta U_{RC}\right]$ of K_{13} is clearly positive because the inside of the bracket is negative. The second term $-(-w)\left[U_{LL}U_{CC}-U_{CL}^{2}\right]$ is positive because the inside of the bracket is positive. The last term $+(-\mathbf{P})\left[U_{LL}\theta U_{RC}-\theta U_{RL}U_{LC}\right]$ is positive because the inside of the bracket is negative. This means that the cofactor is positive for all positive values of *w* and *w* equal to zero.

Second, I examine the case when new information is negative, i.e., where θ is less than zero. The first term of the cofactor is negative because the inside of the bracket is positive. The second term is still positive, and the last term is negative because the inside of the bracket is positive. When *w* equals zero the cofactor is negative and stays negative as *w* increases because the first and last term will dominate the second. Thus the cofactor K_{13} is negative when θ is less than zero.

Third, I examine the case when no new information is made available, i.e., where θ is zero. Now the cofactor is positive.

7.1.1.2.3.2 The cofactor K_{23}

$$K_{23}=\begin{bmatrix} 0 & -w & -\mathbf{P} \\ -w & \theta U_{RL} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & U_{CC} \end{bmatrix}=-(-w)\left[(-w)U_{CC}-(-\mathbf{P})U_{CL}\right]+(-\mathbf{P})\left[(-w)\theta U_{RC}-(-\mathbf{P})\theta U_{RL}\right]$$

First, I examine the case when new information is positive, i.e., where θ is greater than zero. The first term $-(-w)\left[(-w)U_{CC}-(-p)U_{CL}\right]$ of the cofactor K_{23} is positive because the inside of the bracket is positive. The second term $+(-\mathbf{P})\left[(-w)\theta U_{RC}-(-\mathbf{P})\theta U_{RL}\right]$ is ambiguous. The

second term is negative when *w* equals zero and for low wage rates, but as the wage rate increases the inside of the bracket becomes negative and the second term becomes positive. This makes the cofactor negative for *w* equal to zero and small values of *w* and it becomes positive as *w* increases.

Second, I examine the case when new information is negative, i.e., where θ is less than zero. The first term is still positive and the last term is still ambiguous. The last term becomes negative as *w* increases because the inside of the bracket becomes positive. When *w* is equal to zero the cofactor is positive, as *w* increase the first term is positive for all positive values of *w* and the second term is positive for low values of *w.* As the wage rate increases the first term becomes large and it is likely that it will dominate the negative second term and the cofactor stays positive.

Third, I examine the case where no new information is available, i.e. where θ is equal to zero. Now the cofactor is positive.

7.1.1.2.3.3 The cofactor K_{33}

$$K_{33} = \begin{bmatrix} 0 & -w & -\mathbf{P} \\ -w & U_{LL} & U_{LC} \\ -\mathbf{P} & U_{CL} & U_{CC} \end{bmatrix} = -(-w)\left[(-w)U_{CC} - (-\mathbf{P})U_{CL}\right] + (-\mathbf{P})\left[(-w)U_{LC} - (-\mathbf{P})U_{LL}\right]$$

The cofactor K_{33} does not depend on the sign on θ and therefore it is the same regardless of the type of new information. The first term $-(-w)\left[(-w)U_{CC} - (-\mathbf{P})U_{CL}\right]$ of K_{33} is positive because the inside of the bracket is positive. The last term $+(-\mathbf{P})\left[(-w)U_{LC} - (-\mathbf{P})U_{LL}\right]$ is positive because the expression inside the bracket is negative. The result is that K_{33} is positive for all positive values of *w* and *w* equal to zero.

7.1.1.2.3.4 The cofactor K_{43}

$$K_{43} = \begin{bmatrix} 0 & -w & -\mathbf{P} \\ -w & U_{LL} & U_{LC} \\ -w & \theta U_{RL} & \theta U_{RC} \end{bmatrix} = -(-w)\left[(-w)\theta U_{RC} - (-\mathbf{P})\theta U_{RL}\right] - w\left[(-w)U_{LC} - (-\mathbf{P})U_{LL}\right]$$

First, I examine the case where new information is positive, i.e. where θ is greater than zero. The cofactor K_{43} is ambiguous in its sign. The first term of the cofactor $-(-w)\left[(-w)\theta U_{RC} - (-\mathbf{P})\theta U_{RL}\right]$ is positive for low values of *w* but becomes negative as *w* increases. The second term of the cofactor $-w\left[(-w)U_{LC} - (-\mathbf{P})U_{LL}\right]$ is positive for all positive values of *w* since the inside of the bracket is always negative. When *w* equals zero the cofactor is equal to zero, and as *w* increases the first term becomes negative and the second term is positive. It is likely that the cofactor is positive, but it might become negative if the wage rate is very high.

Second, I examine the case when new information is negative, i.e. where θ is less than zero. The first term is negative for low wage rates and becomes positive as the wage rate increases. There is no change in the second term. Thus the cofactor might be negative for low values of *w* but becomes positive as the wage rate increases. When *w* equals zero the cofactor is zero.

Third, I examine the case when no new information is available, i.e. where θ equals zero. Now the cofactor is positive.

7.1.2 The case of government provision – a subsidy

Equation (A.2.1) is the Lagrangian function for the maximization problem when a subsidy is introduced. When solving this problem I will not discuss the methodology and approaches as detailed as in the previous section, however I will spend more time on the three cofactors that change when a subsidy is introduced and its implications.

$$Max U_i(T_L, \theta f(T_R), \mathbf{C})$$
$$s.t.$$
$$w(T - T_L - T_R) + sf(T_R) = \mathbf{PC} \qquad (7.9)$$

$$L = U_i(T_L, \theta f(T_R), \mathbf{C}) + \lambda(w(T - T_L - T_R) + sf(T_R)) - \mathbf{PC}) \qquad (7.10)$$

The FOC:

$$\frac{\partial L}{\partial \lambda} = w(T - T_L - T_R) + sf(T_R) - \mathbf{PC} = 0 \tag{7.11.1}$$

$$\frac{\partial L}{\partial T_L} = \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L} - \lambda w = 0 \tag{7.11.2}$$

$$\frac{\partial L}{\partial T_R} = \theta \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)} \frac{\partial f(T_R)}{\partial T_R} + \lambda(-w + s\frac{\partial f(T_R)}{\partial T_R}) = 0 \tag{7.11.3}$$

$$\frac{\partial L}{\partial \mathbf{C}} = \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C}} - \lambda \mathbf{P} = 0 \tag{7.11.4}$$

$$\begin{bmatrix} 0 & -w & -w + s\frac{\partial f(T_R)}{\partial T_R} & -\mathbf{P} \\ -w & U_{LL} & \theta U_{LR} & U_{LC} \\ -w + s\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix} \begin{bmatrix} \partial\lambda^*/\partial w & \partial\lambda^*/\partial\theta & \partial\lambda^*/\partial\mathbf{P} & \partial\lambda^*/\partial s \\ \partial T_L^*/\partial w & \partial T_L^*/\partial\theta & \partial T_L^*/\partial\mathbf{P} & \partial T_L^*/\partial s \\ \partial T_R^*/\partial w & \partial T_R^*/\partial\theta & \partial T_R^*/\partial\mathbf{P} & \partial T_R^*/\partial s \\ \partial\mathbf{C}^*/\partial w & \partial\mathbf{C}^*/\partial\theta & \partial\mathbf{C}^*/\partial\mathbf{P} & \partial\mathbf{C}^*/\partial s \end{bmatrix} = -\begin{bmatrix} T - T_L - T_R & 0 & -\mathbf{C} & f(T_R) \\ -\lambda & \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta} & 0 & 0 \\ -\lambda & \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)} \frac{\partial f(T_R)}{\partial T_R} & 0 & \lambda \partial f(T_R)/\partial T_R \\ 0 & \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial \theta} & -\lambda & 0 \end{bmatrix}$$

7.1.2.1 Evaluating the bordered Hessian matrix when a subsidy is introduced

I will only focus on the changes from the subsidy when evaluating the determinant.

$$\bar{H} = \begin{bmatrix} 0 & -w & -w + s\frac{\partial f(T_R)}{\partial T_R} & -\mathbf{P} \\ -w & U_{LL} & \theta U_{LR} & U_{LC} \\ -w + s\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix}$$

$$\det \bar{H} = -(-w)K_{21}^S + (-w + s\frac{\partial f(T_R)}{\partial T_R})K_{31}^S - (-\mathbf{P})K_{41}^S \tag{7.12}$$

$$\det \bar{H} = wK_{21}^S - wK_{31}^S + s\frac{\partial f(T_R)}{\partial T_R}K_{31}^S + \mathbf{P}K_{41}^S \tag{7.13}$$

To sign the determinant properly it is important to first sign the cofactors.

7.1.2.1.1 The cofactor K_{21}^S

$$K_{21}^{S}=\begin{bmatrix} -w & -w+s\dfrac{\partial f(T_R)}{\partial T_R} & -\mathbf{P} \\ \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \\ U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix}=+(-w)\left[\theta U_{RR}U_{CC}-\theta U_{RC}^{2}\right]-(-w)\left[\theta U_{RL}U_{CC}-\theta U_{RC}U_{CL}\right]-(+s\frac{\partial f(T_R)}{\partial T_R})\left[\theta U_{RL}U_{CC}-\theta U_{RC}U_{CL}\right]+(-\mathbf{P})\left[\theta U_{RL}\theta U_{CR}-U_{CL}\theta U_{RR}\right]$$

From the cofactor it is obvious that the only change from the no-subsidy case is the term $-(+s\frac{\partial f(T_R)}{\partial T_R})\left[\theta U_{RL}U_{CC}-\theta U_{RC}U_{CL}\right]$. In the case of new positive information, i.e. when θ is positive, this term is positive. In the case of new negative information, i.e. when θ is negative, this term is negative. In the case where no new information is available, i.e. when θ is equal to zero, the term is equal to zero. It is easy to see that the introduction of the subsidy reduces the value of the cofactor by the subsidy term.

7.1.2.1.2 The cofactor K_{31}^{S}

$$K_{31}^{S}=\begin{bmatrix} -w & -w+s\dfrac{\partial f(T_R)}{\partial T_R} & -\mathbf{P} \\ U_{LL} & \theta U_{LR} & U_{LC} \\ U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix}=+(-w)\left[\theta U_{LR}U_{CC}-\theta U_{CR}U_{LC}\right]-(-w)\left[U_{LL}U_{CC}-U_{CL}^{2}\right]-(+s\frac{\partial f(T_R)}{\partial T_R})\left[U_{LL}U_{CC}-U_{CL}^{2}\right]+(-\mathbf{P})\left[U_{LL}\theta U_{CR}-U_{CL}\theta U_{LR}\right]$$

From the cofactor it is easy to see that the only change from the no subsidy case is the term $-(+s\frac{\partial f(T_R)}{\partial T_R})\left[U_{LL}U_{CC}-U_{CL}^{2}\right]$. In the case of positive new information, i.e. when θ is greater than zero, the cofactor is positive, and smaller by the subsidy term. In the case of new negative information, i.e. when θ is less than zero, the cofactor is negative and larger by the subsidy term. When θ is zero the cofactor is positive if $w > s\dfrac{\partial f(T_R)}{\partial T_R}$.

7.1.2.1.3 The cofactor K_{41}^{S}

$$K_{41}^{S}=\begin{bmatrix} -w & -w+s\dfrac{\partial f(T_R)}{\partial T_R} & -\mathbf{P} \\ U_{LL} & \theta U_{LR} & U_{LC} \\ \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \end{bmatrix}=+(-w)\left[\theta U_{LR}\theta U_{RC}-\theta U_{RR}U_{LC}\right]-(-w)\left[U_{LL}\theta U_{RC}-\theta U_{RL}U_{LC}\right]-(+s\frac{\partial f(T_R)}{\partial T_R})\left[U_{LL}\theta U_{RC}-\theta U_{RL}U_{LC}\right]+(-\mathbf{P})\left[U_{LL}\theta U_{RR}-\theta U_{RL}^{2}\right]$$

From the cofactor it easy to see that the only thing that is different from the no-subsidy case is the term $-(+s\frac{\partial f(T_R)}{\partial T_R})\left[U_{LL}\theta U_{RC} - \theta U_{RL}U_{LC}\right]$. In the case of positive new information, i.e. when θ is greater than zero, the term is positive, and reduces the value of the cofactor by the subsidy term. In the case of new negative information, i.e. where θ is less than zero, the term is negative, and reduces the value of the cofactor by the subsidy term. In the case where θ is zero the cofactor K_{41} becomes zero.

In conclusion $\det \bar{H}$ is negative when θ is greater than or equal zero, and positive when θ is less than zero for $w > s\frac{\partial f(T_R)}{\partial T_R}$.

7.1.2.2 Obtaining the comparative statics

7.1.2.2.1 How does time spent on recycling change when the subsidy rate changes?

I use the same approach as before to obtain the comparative statics. I will not describe this in detail, as the reader already knows how this is done. The first comparative static of interest here is how does the time spent on recycling change when the subsidy rate changes: $\partial T_R^* / \partial s$. I replace the third column of F_y with the fourth column from F_x and obtain the following matrix.

$$F_{Y34}^S = \begin{bmatrix} 0 & -w & -f(T_R) & -\mathbf{P} \\ -w & U_{LL} & 0 & U_{LC} \\ -w + s\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & -\lambda\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & 0 & U_{CC} \end{bmatrix}$$

Solving this by Cramer's rule yields the following comparative static.

$$\frac{\partial T_R^*}{\partial s} = \frac{-f(T_R)K_{13}^S - \lambda\frac{\partial f(T_R)}{\partial T_R}K_{33}}{\det \bar{H}} \qquad (7.14)$$

We know that λ is positive. Substituting in for λ we get:

$$\frac{\partial T_R^*}{\partial s} = \frac{-f(T_R)(T - T_L - T_R)K_{13}^S - \frac{\partial U_i^*}{\partial w}\frac{\partial f(T_R)}{\partial T_R}K_{33}}{\det \bar{H}(T - T_L - T_R)} \tag{7.15}$$

7.1.2.2.2 How does time spent on recycling change when new information is made available?

Using the same approach it is relatively easy to obtain $\partial T_R^* / \partial \theta$. Replacing the third column in F_y with the second column from F_x and solve the following matrix by Cramer's rule.

$$F_{Y32}^S = \begin{bmatrix} 0 & -w & 0 & -\mathbf{P} \\ -w & U_{LL} & -\frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta} & U_{LC} \\ -w + s\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & -\frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)}\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & -\frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial \theta} & U_{CC} \end{bmatrix}$$

$$\frac{\partial T_R^*}{\partial \theta} = \frac{\frac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial \theta}K_{23}^S - \frac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)}\frac{\partial f(T_R)}{\partial T_R}K_{33} + \frac{\partial U_i^*(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial \theta}K_{43}^S}{\det \bar{H}} \tag{7.16}$$

7.1.2.2.3 How does the time spent on recycling change when the wage rate changes?

$$F_{Y31}^S = \begin{bmatrix} 0 & -w & -(T - T_L - T_R) & -\mathbf{P} \\ -w & U_{LL} & \lambda & U_{LC} \\ -w + s\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \lambda & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & 0 & U_{CC} \end{bmatrix}$$

$$\partial T_R^* / \partial w = \frac{\lambda(K_{33} - K_{23}^S) - (T - T_L - T_R)K_{13}^S}{\det \bar{H}} \tag{7.17}$$

Substituting in for λ. For a detailed approach please see appendix B:

$$\partial T_R^* / \partial w = \frac{\frac{\partial U^*}{\partial w}(K_{33} - K_{23}^S) - (T - T_L - T_R)^2 K_{13}^S}{\det \bar{H}\left(T - T_L - T_R\right)} \tag{7.18}$$

7.1.2.2.4 Evaluating the cofactors

Before I continue I need to sign the cofactors.

7.1.2.2.4.1 The cofactor K_{13}^S

$$K_{13}^S = \begin{bmatrix} -w & U_{LL} & U_{LC} \\ -w + s\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & U_{CC} \end{bmatrix} = -w\left[\theta U_{RL}U_{CC} - U_{CL}\theta U_{RC}\right] - (-w + s\frac{\partial f(T_R)}{\partial T_R})\left[U_{LL}U_{CC} - U_{CL}^2\right] + (-\mathbf{P})\left[U_{LL}\theta U_{RC} - \theta U_{RL}U_{LC}\right]$$

Notice that the only difference between K_{13}^S and K_{13} is the subsidy term. The subsidy effect is shown in the second term of the cofactor $-(-w + s\frac{\partial f(T_R)}{\partial T_R})\left[U_{LL}U_{CC} - U_{CL}^2\right]$. In the case of new positive information, i.e. when θ is greater than zero, the cofactor is positive, however, by introducing a subsidy the cofactor is smaller by the subsidy term. In the case of new negative information, i.e. when θ is less than zero, the cofactor is larger by the subsidy term, in other words increases the likelihood that it is negative.

7.1.2.2.4.2 The cofactor K_{23}^S

$$K_{23}^S = \begin{bmatrix} 0 & -w & -\mathbf{P} \\ -w + s\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & U_{CC} \end{bmatrix} = -(-w + s\frac{\partial f(T_R)}{\partial T_R})\left[(-w)U_{CC} - (-\mathbf{P})U_{CL}\right] + (-\mathbf{P})\left[(-w)\theta U_{RC} - (-\mathbf{P})\theta U_{RL}\right]$$

Notice that the only change in the cofactor is the subsidy rate and this is shown in the first term $-(-w + s\frac{\partial f(T_R)}{\partial T_R})\left[(-w)U_{CC} - (-\mathbf{P})U_{CL}\right]$ of K_{23}^S. In the case of new positive information, i.e. when θ is greater than zero, the cofactor becomes positive at a higher wage rate because of the negative effect of the subsidy.

In the case of new negative information, i.e. when θ is less than zero, the cofactor is negative for low wage rates and a positive subsidy because the subsidy effect is negative. However, the cofactor becomes positive as the wage rate increases. In other words a higher wage rate is needed for the cofactor to become positive, i.e. negative for low income groups.

7.1.2.2.4.3 The cofactor K_{43}^{S}

$$K_{43}^{S}=\begin{bmatrix} 0 & -w & -\mathbf{P} \\ -w & U_{LL} & U_{LC} \\ -w+s\dfrac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \theta U_{RC} \end{bmatrix}=-(-w)\left[(-w)\theta U_{RC}-(-\mathbf{P})\theta U_{RL}\right]+(-w+s\frac{\partial f(T_R)}{\partial T_R})\left[(-w)U_{LC}-(-\mathbf{P})U_{LL}\right]$$

Notice that the only difference between this cofactor and the cofactor in the no-subsidy case is the subsidy term, and this effect is found in the second term

$$+(-w+s\frac{\partial f(T_R)}{\partial T_R})\left[(-w)U_{LC}-(-\mathbf{P})U_{LL}\right].$$

In the case of new positive information, i.e. when θ is greater than zero, the cofactor is likely to be positive. The introduction of a subsidy makes the cofactor smaller by the subsidy term. Introducing a subsidy makes the cofactor negative at a lower wage rate because of the negative effect of the subsidy.

In the case of new negative information, i.e. when θ is less than zero, the first term becomes positive as the wage rate increases. The negative effect of the subsidy term makes it likely that the cofactor is negative for a higher wage rate. In other words a higher wage rate is needed for the cofactor to become positive, which makes the low-income group larger.

7.1.3 The case of government provision – a tax

Equation (A.3.1) is the Lagrangian function for the maximization problem when a tax is introduced. When solving this problem I will not discuss the methodology and approaches as detailed as in the first section, however, I will spend time on the three cofactors that change when the tax is introduced.

$$Max U_i(T_L, \theta f(T_R), \mathbf{C})$$
$$s.t.$$
$$w(T - T_L - T_R) - t(1 - f(T_R)) = \mathbf{PC} \tag{7.19}$$

$$L = U_i(T_L, \theta f(T_R), \mathbf{C}) + \lambda(w(T - T_L - T_R) - t(1 - f(T_R)) - \mathbf{PC}) \tag{7.20}$$

The FOC:

$$\frac{\partial L}{\partial \lambda} = w(T - T_L - T_R) - t(1 - f(T_R)) - \mathbf{PC} = 0 \tag{7.21.1}$$

$$\frac{\partial L}{\partial T_L} = \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L} - \lambda w = 0 \tag{7.21.2}$$

$$\frac{\partial L}{\partial T_R} = \theta \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)} \frac{\partial f(T_R)}{\partial T_R} + \lambda(-w - t\frac{\partial f(T_R)}{\partial T_R}) = 0 \tag{7.21.3}$$

$$\frac{\partial L}{\partial \mathbf{C}} = \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C}} - \lambda \mathbf{P} = 0 \tag{7.21.4}$$

$$\begin{bmatrix} 0 & -w & -w - t\frac{\partial f(T_R)}{\partial T_R} & -\mathbf{P} \\ -w & U_{LL} & \theta U_{LR} & U_{LC} \\ -w - t\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix} \begin{bmatrix} \partial\lambda^*/\partial w & \partial\lambda^*/\partial\theta & \partial\lambda^*/\partial\mathbf{P} & \partial\lambda^*/\partial s \\ \partial T_L^*/\partial w & \partial T_L^*/\partial\theta & \partial T_L^*/\partial\mathbf{P} & \partial T_L^*/\partial s \\ \partial T_R^*/\partial w & \partial T_R^*/\partial\theta & \partial T_R^*/\partial\mathbf{P} & \partial T_R^*/\partial s \\ \partial\mathbf{C}^*/\partial w & \partial\mathbf{C}^*/\partial\theta & \partial\mathbf{C}^*/\partial\mathbf{P} & \partial\mathbf{C}^*/\partial s \end{bmatrix} = -\begin{bmatrix} T - T_L - T_R & 0 & -\mathbf{C} & 1 - f(T_R) \\ -\lambda & \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial T_L \partial\theta} & 0 & 0 \\ -\lambda & \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial f(T_R)} \frac{\partial f(T_R)}{\partial T_R} & 0 & -\lambda \partial f(T_R)/\partial T_R \\ 0 & \frac{\partial U_i(T_L, \theta f(T_R), \mathbf{C})}{\partial \mathbf{C} \partial\theta} & -\lambda & 0 \end{bmatrix}$$

I will not discuss the determinant of the Bordered Hessian Matrix in detail here. As is obvious the effect is the opposite of that in the subsidy case since a tax can be viewed as a negative subsidy. Thus the determinant of the bordered hessian matrix is negative when θ is greater than or equal to zero and positive when θ is less than zero.

7.1.3.1 Obtaining the comparative statics

7.1.3.1.1 How does the time spent on recycling change when the tax rate changes?

The third comparative static of interest here is how does the time spent on recycling change when the tax rate changes: $\partial T_R^*/\partial t$. Using the same approach as before, I replace the third column of F_y with the fourth column from F_x and obtain the following matrix.

$$F_{Y34}^{T}=\begin{bmatrix} 0 & -w & f(T_R)-1 & -\mathbf{P} \\ -w & U_{LL} & 0 & U_{LC} \\ -w-t\dfrac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \lambda\dfrac{\partial f(T_R)}{\partial T_R} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & 0 & U_{CC} \end{bmatrix}$$

Solving this by Cramer's rule and substituting in the expression for λ yields the following comparative static.

$$\frac{\partial T_R^*}{\partial t}=\frac{(f(T_R)-1)(T-T_L-T_R)K_{13}^{T}+\dfrac{\partial U_i^*}{\partial w}\dfrac{\partial f(T_R)}{\partial T_R}K_{33}}{\det \bar{H}(T-T_L-T_R)} \tag{7.22}$$

7.1.3.1.2 How does the time spent on recycling change when new information is made available?

Using the same approach it is relatively easy to obtain $\partial T_R^{*}/\partial\theta$. Replacing the third column in F_y with the second column from F_x and solve the following matrix by Cramer's rule.

$$F_{Y32}^{T}=\begin{bmatrix} 0 & -w & 0 & -\mathbf{P} \\ -w & U_{LL} & -\dfrac{\partial U_i(T_L,\theta f(T_R),\mathbf{C})}{\partial T_L\partial\theta} & U_{LC} \\ -w-t\dfrac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & -\dfrac{\partial U_i(T_L,\theta f(T_R),\mathbf{C})}{\partial f(T_R)}\dfrac{\partial f(T_R)}{\partial T_R} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & -\dfrac{\partial U_i(T_L,\theta f(T_R),\mathbf{C})}{\partial \mathbf{C}\partial\theta} & U_{CC} \end{bmatrix}$$

$$\frac{\partial T_R^*}{\partial\theta}=\frac{\dfrac{\partial U_i^*(T_L,\theta f(T_R),\mathbf{C})}{\partial T_L\partial\theta}K_{23}^{T}-\dfrac{\partial U_i^*(T_L,\theta f(T_R),\mathbf{C})}{\partial f(T_R)}\dfrac{\partial f(T_R)}{\partial T_R}K_{33}+\dfrac{\partial U_i^*(T_L,\theta f(T_R),\mathbf{C})}{\partial\mathbf{C}\partial\theta}K_{43}^{T}}{\det\bar{H}} \tag{7.23}$$

7.1.3.1.3 How does the time spent on recycling change when the wage rate changes?

$$F_{Y31}^{T}=\begin{bmatrix} 0 & -w & -(T-T_L-T_R) & -\mathbf{P} \\ -w & U_{LL} & \lambda & U_{LC} \\ -w-t\dfrac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \lambda & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & 0 & U_{CC} \end{bmatrix}$$

$$\partial T_R^* \Big/ \partial w = \frac{\lambda(K_{33} - K_{23}^T) - (T - T_L - T_R)K_{13}^T}{\det \bar{H}} \tag{7.24}$$

Substituting in for λ I obtain:

$$\partial T_R^* \Big/ \partial w = \frac{\frac{\partial U^*}{\partial w}(K_{33} - K_{23}^T) - (T - T_L - T_R)^2 K_{13}^T}{\det \bar{H}\left(T - T_L - T_R\right)} \tag{7.25}$$

7.1.3.1.4 Evaluating the cofactors

Before I continue I need to sign the cofactors.

7.1.3.1.4.1 The cofactor K_{13}^T

$$K_{13}^T = \begin{bmatrix} -w & U_{LL} & U_{LC} \\ -w - t\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & U_{CC} \end{bmatrix} = -w\left[\theta U_{RL}U_{CC} - U_{CL}\theta U_{RC}\right] - (-w - t\frac{\partial f(T_R)}{\partial T_R})\left[U_{LL}U_{CC} - U_{CL}^2\right] + (-\mathbf{P})\left[U_{LL}\theta U_{RC} - \theta U_{RL}U_{LC}\right]$$

Notice that the only difference between this cofactor and the cofactor in the no-tax case is the tax and the impact of the tax is found in the second term $-(-w - t\frac{\partial f(T_R)}{\partial T_R})\left[U_{LL}U_{CC} - U_{CL}^2\right]$.

In the case of new positive information, i.e. when θ is greater than zero, the cofactor is positive and is larger by the effect of the tax. In the case of new negative information on the other hand, i.e. when θ is less than zero, the cofactor is smaller by the effect of the tax. Notice that this is exactly opposite of what we got in the subsidy case and the sign on the cofactor stays the same.

7.1.3.1.4.2 The cofactor K_{23}^T

$$K_{23}^T = \begin{bmatrix} 0 & -w & -\mathbf{P} \\ -w - t\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \theta U_{RC} \\ -\mathbf{P} & U_{CL} & U_{CC} \end{bmatrix} = -(-w - t\frac{\partial f(T_R)}{\partial T_R})\left[(-w)U_{CC} - (-\mathbf{P})U_{CL}\right] + (-\mathbf{P})\left[(-w)\theta U_{RC} - (-\mathbf{P})\theta U_{RL}\right]$$

Notice that the change in the cofactor comes from the tax and that the effect can be seen in the first term of the cofactor $-(-w-t\frac{\partial f(T_R)}{\partial T_R})\left[(-w)U_{CC}-(-\mathbf{P})U_{CL}\right]$. In the case of new positive information, i.e. when θ is greater than zero, the cofactor is negative for small values of *w* and *w* equal to zero and becomes positive as *w* increases. We see that the tax effect is positive and that the cofactor is likely to become positive at a lower wage rate than in the no-tax case.

In the case of new negative information, i.e. when θ is less than zero, the last term becomes negative as the wage rate increases. However, the cofactor is unlikely to be negative because the first term is positive for all *w* and *t* greater than zero.

7.1.3.1.4.3 The cofactor K_{43}^{T}

$$K_{43}^{T}=\begin{bmatrix} 0 & -w & -\mathbf{P} \\ -w & U_{LL} & U_{LC} \\ -w-t\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \theta U_{RC} \end{bmatrix}=-(-w)\left[(-w)\theta U_{RC}-(-\mathbf{P})\theta U_{RL}\right]+(-w-t\frac{\partial f(T_R)}{\partial T_R})\left[(-w)U_{LC}-(-\mathbf{P})U_{LL}\right]$$

Notice that the only difference between this cofactor and the cofactor in the no-tax case is the tax. The effect of the tax can be seen in the second term of the cofactor $-(w-t\frac{\partial f(T_R)}{\partial T_R})\left[(-w)U_{LC}-(-\mathbf{P})U_{LL}\right]$.

In the case of new positive information, i.e. when θ is greater than zero, the cofactor is positive, although the first term becomes negative as *w* increases. The positive effect of the tax makes it more likely that the cofactor stays positive. In other words it will stay positive for a higher wage rate.

In the case of new negative information, i.e. when θ is less than zero, the cofactor is positive because the first term becomes positive as *w* increases and the second term is positive regardless. The positive effect of the tax strengthens the assumption that this cofactor is positive

7.1.4 A tax versus a subsidy

This section discusses the effect of a tax versus a subsidy on the shadow price of time.

7.1.4.1 The change in the shadow price of time from a change in the subsidy rate

The comparative static $\partial\lambda^*/\partial s$ is found by solving the following matrix by Cramer's rule and evaluating the relevant cofactors and shows how the shadow price of time changes when the subsidy rate changes.

$$F_{Y14}^{S} = \begin{bmatrix} -f(T_R) & -w & -w - t\dfrac{\partial f(T_R)}{\partial T_R} & -\mathbf{P} \\ 0 & U_{LL} & \theta U_{LR} & U_{LC} \\ -\lambda\dfrac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \\ 0 & U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix}$$

$$\partial\lambda^*/\partial s = \frac{+(-f(T_R))K_{11} + (-\lambda\dfrac{\partial f(T_R)}{\partial T_R})K_{31}}{\det \bar{H}} \tag{7.26}$$

Remember that when θ is zero the determinant of the bordered hessian matrix is less than zero.

$$K_{11} = \begin{bmatrix} U_{LL} & \theta U_{LR} & U_{LC} \\ \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \\ U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix} = U_{LL}\left[\theta U_{RR}U_{CC} - U_{CR}^2\right] - \theta U_{RL}\left[\theta U_{LR}U_{CC} - \theta U_{CR}U_{LC}\right] + U_{CL}\left[\theta U_{LR}\theta U_{RC} - \theta U_{RR}U_{LC}\right]$$

From the cofactor K_{11} we see that when θ equals zero the entire cofactor equals zero. Other values of θ are not necessary because information is held constant and does not change.

$$K_{31} = \begin{bmatrix} -w & -w + s\dfrac{\partial f(T_R)}{\partial T_R} & -\mathbf{P} \\ U_{LL} & \theta U_{LR} & U_{LC} \\ U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix} = +(-w)\left[\theta U_{LR}U_{CC} - \theta U_{CR}U_{LC}\right] - (-w)\left[U_{LL}U_{CC} - U_{CL}^2\right] - (+s\frac{\partial f(T_R)}{\partial T_R})\left[U_{LL}U_{CC} - U_{CL}^2\right] + (-\mathbf{P})\left[U_{LL}\theta U_{CR} - U_{CL}\theta U_{LR}\right]$$

From the cofactor we see that when θ is zero the first and last term becomes zero, and we are left with the second and third. This cofactor is positive if $w > s\frac{\partial f(T_R)}{\partial T_R}$.

Now if we substitute in the expression for λ and drop the first term of the numerator that is zero the comparative static looks like this:

$$\partial\lambda^*/\partial s = \frac{-\frac{\partial U^*}{\partial w}\frac{\partial f(T_R)}{\partial T_R})K_{31}}{\det \bar{H}(T - T_L - T_R)} \tag{7.27}$$

We see that the comparative static is positive and that a subsidy has the expected effect on the shadow price of time.

7.1.4.2 The change in the shadow price of time when the tax rate changes

Now we turn our attention to the case of a tax and solve the following matrix by Cramer's rule and obtain the comparative static $\partial\lambda^*/\partial t$.

$$F^T_{Y14} = \begin{bmatrix} f(T_R)-1 & -w & -w - t\frac{\partial f(T_R)}{\partial T_R} & -\mathbf{P} \\ 0 & U_{LL} & \theta U_{LR} & U_{LC} \\ \lambda\frac{\partial f(T_R)}{\partial T_R} & \theta U_{RL} & \theta U_{RR} & \theta U_{RC} \\ 0 & U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix}$$

$$\partial\lambda^*/\partial t = \frac{(f(T_R)-1)K_{11} + \lambda\frac{\partial f(T_R)}{\partial T_R}K_{31}}{\det \bar{H}} \tag{7.28}$$

Let us evaluate the cofactors. The cofactor K_{11} is the same as in the subsidy case and consequently zero. The second cofactor looks like this:

$$K_{31}=\begin{bmatrix} -w & -w-t\frac{\partial f(T_R)}{\partial T_R} & -\mathbf{P} \\ U_{LL} & \theta U_{LR} & U_{LC} \\ U_{CL} & \theta U_{CR} & U_{CC} \end{bmatrix}=+(-w)\left[\theta U_{LR}U_{CC}-\theta U_{CR}U_{LC}\right]-(-w)\left[U_{LL}U_{CC}-U_{CL}^2\right]-(-t\frac{\partial f(T_R)}{\partial T_R})\left[U_{LL}U_{CC}-U_{CL}^2\right]+(-\mathbf{P})\left[U_{LL}\theta U_{CR}-U_{CL}\theta U_{LR}\right]$$

We see that the first and last term becomes zero and we are left with the second and third term.

Now if we substitute in the expression for λ and drop the first term of the numerator that is zero the comparative static looks like this:

$$\partial\lambda^*/\partial t=\frac{\frac{\partial U^*}{\partial w}\frac{\partial f(T_R)}{\partial T_R})K_{31}}{\det\bar{H}(T-T_L-T_R)} \tag{7.29}$$

We see that the comparative static is negative and a tax has the expected sign on the shadow price of time.

Comparing the absolute value of $\partial\lambda^*/\partial s$ and $\partial\lambda^*/\partial t$ we see that a tax has a stronger effect than a subsidy.

$$\left|\partial\lambda^*/\partial t\right|>\left|\partial\lambda^*/\partial s\right| \tag{7.30}$$

7.2 The interpretation of lambda

7.2.1 The case of private provision – no tax and no subsidy

Evaluated at the optimal point $(\lambda^*, T_L^*, T_R^*, \mathbf{C}^*)$ the solution to the first order conditions is a function of the exogenous variables $(w, \mathbf{P}, \theta)$. $U^*(T_L^*, T_R^*, \mathbf{C}^*)$ is expressed in terms of the exogenous variables and we can differentiate with respect to the wage rate and obtain the following equation (Baxley):

$$\frac{\partial U^*}{\partial w} = \frac{\partial U^*}{\partial T_L}\frac{\partial T_L}{\partial w} + \theta \frac{\partial U^*}{\partial f(T_R)}\frac{\partial f(T_R)}{\partial T_R}\frac{\partial T_R}{\partial w} + \frac{\partial U^*}{\partial \mathbf{C}}\frac{\partial \mathbf{C}}{\partial w} \tag{7.31}$$

We can now use the first-order conditions to obtain:

$$\frac{\partial U^*}{\partial w} = \lambda\left[w\frac{\partial T_L}{\partial w} + w\frac{\partial T_R}{\partial w} + p\frac{\partial \mathbf{C}}{\partial w}\right] \tag{7.32}$$

From the budget constraint:

$$wT = wT_L + wT_R + \mathbf{PC} \tag{7.33}$$

Differentiating this with respect to *w* on both sides of the equation we get:

$$T = T_L + w\frac{\partial T_L}{\partial w} + T_R + w\frac{\partial T_R}{\partial w} + \mathbf{P}\frac{\partial \mathbf{C}}{\partial w} \tag{7.34}$$

Rewriting gives us:

$$T - T_L - T_R = w\frac{\partial T_L}{\partial w} + w\frac{\partial T_R}{\partial w} + \mathbf{P}\frac{\partial \mathbf{C}}{\partial w} \tag{7.35}$$

We can now substitute this into B.1.3 and get:

$$\frac{\partial U^*}{\partial w} = \lambda\left[T - T_L - T_R\right] \tag{7.36}$$

And solve for lambda

$$\lambda = \frac{\partial U^*}{\partial w}\frac{1}{\left[T - T_L - T_R\right]} \tag{7.37}$$

Lambda can be interpreted as the marginal utility of the wage rate for working more.

7.2.2 The case of government provision – a subsidy

$$\frac{\partial U^*}{\partial w} = \frac{\partial U^*}{\partial T_L}\frac{\partial T_L}{\partial w} + \theta \frac{\partial U^*}{\partial f(T_R)}\frac{\partial f(T_R)}{\partial T_R}\frac{\partial T_R}{\partial w} + \frac{\partial U^*}{\partial \mathbf{C}}\frac{\partial \mathbf{C}}{\partial w} \tag{7.38}$$

We can now use the first-order conditions to obtain:

$$\frac{\partial U^*}{\partial w} = \lambda\left[w\frac{\partial T_L}{\partial w} + (w - s\frac{\partial f(T_R)}{\partial T_R})\frac{\partial T_R}{\partial w} + \mathbf{P}\frac{\partial \mathbf{C}}{\partial w}\right] \tag{7.39}$$

And with some rewriting:

$$\frac{\partial U^*}{\partial w} = \lambda\left[w\frac{\partial T_L}{\partial w} + w\frac{\partial T_R}{\partial w} + \mathbf{P}\frac{\partial \mathbf{C}}{\partial w} - s\frac{\partial f(T_R)}{\partial T_R}\frac{\partial T_R}{\partial w}\right] \tag{7.40}$$

From the budget constraint:

$$wT + sf(T_R) = wT_L + wT_R + \mathbf{PC} \tag{7.41}$$

Differentiating this with respect to *w* on both sides of the equation we get:

$$T + s\frac{\partial f(T_R)}{\partial T_R}\frac{\partial T_R}{\partial w} = T_L + w\frac{\partial T_L}{\partial w} + T_R + w\frac{\partial T_R}{\partial w} + \mathbf{P}\frac{\partial \mathbf{C}}{\partial w} \tag{7.42}$$

Rewriting gives us:

$$T - T_L - T_R = w\frac{\partial T_L}{\partial w} + w\frac{\partial T_R}{\partial w} + \mathbf{P}\frac{\partial \mathbf{C}}{\partial w} - s\frac{\partial f(T_R)}{\partial T_R}\frac{\partial T_R}{\partial w} \tag{7.43}$$

We can now substitute this into B.2.3 and get:

$$\frac{\partial U^*}{\partial w} = \lambda\left[T - T_L - T_R\right] \tag{7.44}$$

And solve for lambda

$$\lambda = \frac{\partial U^*}{\partial w}\frac{1}{\left[T - T_L - T_R\right]} \tag{7.45}$$

Lambda can be interpreted as the marginal utility of the wage rate for working more, and the interpretation is the same as in the no-subsidy case.

7.2.3 The case of government provision – a tax

$$\frac{\partial U^*}{\partial w} = \frac{\partial U^*}{\partial T_L}\frac{\partial T_L}{\partial w} + \theta\frac{\partial U^*}{\partial f(T_R)}\frac{\partial f(T_R)}{\partial T_R}\frac{\partial T_R}{\partial w} + \frac{\partial U^*}{\partial \mathbf{C}}\frac{\partial \mathbf{C}}{\partial w} \tag{7.46}$$

We can now use the first-order conditions to obtain:

$$\frac{\partial U^*}{\partial w} = \lambda\left[w\frac{\partial T_L}{\partial w} + (w + t\frac{\partial f(T_R)}{\partial T_R})\frac{\partial T_R}{\partial w} + \mathbf{P}\frac{\partial \mathbf{C}}{\partial w}\right] \tag{7.47}$$

And with some rewriting:

$$\frac{\partial U^*}{\partial w} = \lambda\left[w\frac{\partial T_L}{\partial w} + w\frac{\partial T_R}{\partial w} + \mathbf{P}\frac{\partial \mathbf{C}}{\partial w} + t\frac{\partial f(T_R)}{\partial T_R}\frac{\partial T_R}{\partial w}\right] \tag{7.48}$$

From the budget constraint:

$$wT - t(1 - f(T_R)) = wT_L + wT_R + \mathbf{PC} \tag{7.49}$$

Differentiating this with respect to *w* on both sides of the equation we get:

$$T - t\frac{\partial f(T_R)}{\partial T_R}\frac{\partial T_R}{\partial w} = T_L + w\frac{\partial T_L}{\partial w} + T_R + w\frac{\partial T_R}{\partial w} + \mathbf{P}\frac{\partial \mathbf{C}}{\partial w} \tag{7.50}$$

Rewriting gives us:

$$T - T_L - T_R = w\frac{\partial T_L}{\partial w} + w\frac{\partial T_R}{\partial w} + \mathbf{P}\frac{\partial \mathbf{C}}{\partial w} + t\frac{\partial f(T_R)}{\partial T_R}\frac{\partial T_R}{\partial w} \tag{7.51}$$

We can now substitute this into B.3.3 and get:

$$\frac{\partial U^*}{\partial w} = \lambda\left[T - T_L - T_R\right] \tag{7.52}$$

And solve for lambda

$$\lambda = \frac{\partial U^*}{\partial w}\frac{1}{\left[T - T_L - T_R\right]} \tag{7.53}$$

Lambda can be interpreted as the marginal utility of the wage rate for working more, and the interpretation is the same as in the no-tax case.

7.3 Results from the questionnaire

In this appendix you will find all the tables and statistics used both directly and indirectly in Chapter 4. Do-files, datasets and more are available upon request but will not be put in the appendix to save space and keep it relevant.

Table 7-1 Description of relevant variables

Variable	Description
Infoimportant	I have received information about the importance of recycling. 1= Totally disagree 2=disagree 3=agree 4=totally agree
Infowhat	I have recieved information about what to recycle and how to recycle. 1= Totally disagree 2=disagree 3=agree 4=totally agree
Receiveinfowhat	I have received information about what to recycle and how to recycle. 1=yes 0=no
Infojudgewhat	How would you judge the information that you received about what to recycle. 1=very bad 2=bad 3= good 4=very good
Infowhenwhat	When did you receive information about what to recycle and how. 1=less than a month 2=less than six months 3=less than a year 4=more than a year
Receiveinfofrac	I have received information about the fraction of waste that is recycled in my municipality. 1=yes 0=no
Infojudgefrac	How would you judge the information that you received about the fraction of waste that is recycled. 1=very bad 2=bad 3=good 4=very good
Infowhenfrac	When did you receive information about the fraction of waste. 1=less than a month 2=less than six months 3=less than a year 4=more than a year
Munirecycle	Does your municipality have a recyclingprogram? 1=yes 0=no
Judgerecycling	How would you judge the recycling program? 1=very bad 2=bad 3=good 4=very good
Muniserious	Do you feel that your municipality takes recycling seriously? 1=yes 0=no
Doyouknow	Do you know how the recycling program works? 1=yes 0=no
Knowsort	I know how the waste is sorted. 1=yes 0=No
Neighborthink	I recycle because I want my neighbors to think of me as a responsible person. 1= Totally disagree 2=disagree 3=agree 4=totally agree
Neighbordo	I recycle because most of my neighbors recycle. 1= Totally disagree 2=disagree 3=agree 4=totally agree
Neighborstarted	I recycle because my neighbors have started to recycle. 1= Totally disagree 2=disagree 3=agree 4=totally agree
Neighborrecycle	Do you think that your neighbors recycle? 1=yes 0= no
Neighborresponsible	Do you think of your neighbors as responsible people? 1=yes 0=no
Neighborhoodrecyc	Does your neighborhood have a local recycling program? 1=yes 0=no
Sex	Sex. 1=male 0=female
Age	Age
Housetype	1=detached house without neighbors 2=detached house in a neighborhood 3= townhouses 4=duplex 5=apartment complex
Kindergarden	How many kids in kindergarden
Inelementary	How many kids in elementary school
Inmiddleschool	How many kids in middle school
Inhighschool	How many kids in highschool
Education	What is your highest attained education. 1= Basic education 2=high school 3= 3 years or less of higher education 4= 4 years or more of higher edu 5=other
Hhincome	What is the total household income
Vote	Did you vote at the last election. 1=yes 0=no
Environmentalorg	Is one or more members of the household member of an organization with an environmental agenda. 1=yes 0=no
Folloren	If folloren =1 then you live in a municipality in which Follo ren runs the recycling program. If =0 then Indre Østfold Renovasjon IKS runs the program.

Table 7-2 Summary statistics of relevant variables

Variable	N	Mean	Std. Dev.	Min	Max
Time	148	6.236486	6.488463	1	45
Recycle	160	0.925	0.2642183	0	1
Hhincome	141	1266709	2260620	0	17 500 000
Sex	160	0.325	0.4698454	0	1
Age	160	43.3875	5.978986	25	63
Basic education	160	0.03125	0.1745389	0	1
Highschool education	160	0.25	0.4343722	0	1
University, 3 years or less	160	0.3625	0.4822314	0	1
University, 4 years or more	160	0.3375	0.4743416	0	1
Other education	160	0.01875	0.1360667	0	1
Environmental organization	160	0.4375	0.4976359	0	1
Folloren	154	0.6038961	0.4906822	0	1
Children in kindergarden	160	0.26875	0.4447015	0	1
Children in Elementary school	160	0.81875	0.3864347	0	1
Children in Middle school	160	0.46875	0.5005893	0	1
Children in High school	160	0.21875	0.4146966	0	1
Number of children in kindergarden	158	0.3734177	0.7269531	0	4
Number of children in elementary school	158	1.253165	0.9164923	0	6
Number of children in middle school	158	0.5063291	0.5837157	0	2
Number of children in high school	158	0.221519	0.4461215	0	2

Table 7-3 The comparison of sample median household income with the median houshold income of the different municipalities (SSB, 2011, SSB, 2010, SSB, 2009)

Municipality	Median Income net of taxes 2009*	Average wage growth 2009-2011**	Median income net of taxes 2011***	Sample median household income	Obs
Nesodden	460 000	1.076	494 954	850 000	10
Frogn	473 000	1.076	508 942	1050 000	12
Oppegård	507 000	1.076	545 526	825 000	4
Ski	492 000	1.076	529 386	900 000	45
Ås	437 000	1.076	470 207	1200 000	5
Spydeberg	425 000	1.076	457 295	850 000	39
Hobøl	431 000	1.076	463 751	850 000	21

* SSB Emne 05: Personlig økonomi og boforhold - Tabell 06944 Inntekt etter skatt, etter husholdningstyper. Antall Husholdninger og Median (K)(B)
**SSB Emne 06: Arbeidsliv, yrkesdeltaking og lønn - Tabell 08053 Gjennomsnittlig, median og kvartil månedslønn for heltidsansatte etter næringsvirksomhet og lønn (SN2007)
*** Median income 2009 multiplied by average growth in medium income
****SSB Emne 05: Personlig økonomi og boforhold - Tabell 08564: Oversiktstall fra skatteligningen for alle personer
NB! The median income net of taxes 2011 is not directly comparable to sample median householdincome because the latter includes taxes. The data for taxes paid 2011 is not yet available, however, average tax payment in 2010 was 100 900,-****. Under the assumtion that this number does not differ substantially from taxes paid 2011, we see that the sample median household income is still higher than the median household income in the respective municipalities

Table 7-4 Comparing the education level of the sample with the education level lin the municipalities(SSB)

		Comparing education	
Municipality	**Highest attained degree**	**Percentage of population***	**Sample****
Nesodden	Basic	23.1	8.3
N=12	Highschool	38.1	8.3
	University, 3 years or less	27.2	33.3
	University, 4 years or more	11.7	50
Frogn	Basic	24.5	0
N=16	Highschool	43.5	6.3
	University, 3 years or less	24.2	50
	University, 4 years or more	7.8	43.7
Oppegård	Basic	21.6	0
N=5	Highschool	40.5	0
	University, 3 years or less	27.3	20
	University, 4 years or more	10.6	80
Ski	Basic	26	0
N=54	Highschool	43	22.2
	University, 3 years or less	23.2	42.6
	University, 4 years or more	7.7	31.5
Ås	Basic	24.6	0
N=6	Highschool	38.9	16.7
	University, 3 years or less	22.1	50
	University, 4 years or more	14.4	33.3
Spydeberg	Basic	32.6	7.7
N=39	Highschool	47.5	35.9
	University, 3 years or less	16.2	33.3
	University, 4 years or more	3.7	20.5
Hobøl	Basic	35.5	4.5
N=22	Highschool	44	36.4
	University, 3 years or less	16.3	18.2
	University, 4 years or more	4.2	40.9

*SSB Emne 04: Utdanning - Tabell 09429: Personer 16 år og over, etter kjnn og befolkningens utdanningsnivå (Ny nivå inndeling)(K)
**Might not add to a 100 because of rounding and missing "other" education

Table 7-5 Cross tabulation between time spent on recycling and information about the importance recycling

How much time do you spend on recycling per day? In minutes	I have received information about how important recycling is. Totally Disagree	Disagree	Agree	Totally Agree	Total
1	0	1	2	2	5
2	5	2	2	3	12
3	3	3	5	3	14
4	3	2	1	1	7
5	7	8	16	13	44
7	0	0	4	1	5
8	0	0	2	0	2
10	3	1	6	4	14
20	0	0	2	0	2
30	0	0	0	2	2
45	0	1	0	0	1
Total	21	18	40	29	108

Table 7-6 Cross tabulation between time spent on recycling and information about what to recycle

How much time do you spend on recycling per day? In minutes	I have received information about what to recyclie and how to recycle.				
	Totally Disagree	Disagree	Agree	Totally Agree	Total
1	0	2	2	1	5
2	3	1	5	3	12
3	2	5	3	3	13
4	0	1	3	3	7
5	6	8	13	17	44
7	0	0	2	3	5
8	0	0	0	2	2
10	2	1	6	5	14
20	0	0	2	0	2
30	0	0	1	1	2
45	0	1	0	0	1
Total	13	19	37	38	107

Table 7-7 Cross tabulation between time spent on recycling and whether or not you have received information about what and how to recycle

How much time do you spend on recycling per day? In minutes	Do you receive information about what to recycle and how to recycle?		
	No	Yes	Total
1	3	5	8
2	7	10	17
3	3	17	20
4	2	4	6
5	14	40	54
6	1	0	1
7	1	3	4
8	0	1	1
10	5	13	18
15	1	1	2
20	1	3	4
30	0	2	2
45	1	1	2
Total	39	100	139

Table 7-8 Cross tabulation between time spent on recycling and how you judge the information that you have received

How much time do you spend on receycling per day? In minutes	How would you judge the information you received about what to recycle and how to recycle?			
	Bad	Good	Very good	Total
1	1	3	1	5
2	0	7	3	10
3	2	9	6	17
4	0	3	1	4
5	2	24	14	40
7	0	0	3	3
8	0	1	0	1
10	0	9	4	13
15	0	1	0	1
20	0	3	0	3
30	0	1	1	2
45	0	0	1	1
Total	5	61	34	100

Table 7-9 Cross tabulation between time spent on recycling and when did you last receive information about what and how to recycle

How much time do you spend on recycling per day? In minutes	When did you last reiceive information about what to recycle and how to recycle?				
	In the last month	In the last six months	In the last year	More than a year	Total
1	0	3	1	0	4
2	0	3	2	0	5
3	0	7	7	1	15
4	0	2	1	0	3
5	2	25	10	0	37
7	0	3	0	0	3
8	0	1	0	0	1
10	1	9	2	1	13
15	0	1	0	0	1
20	0	1	2	0	3
30	1	1	0	0	2
45	0	1	0	0	1
Total	4	57	25	2	88

Table 7-10 Cross tabulation between time spent on recycling and whether or not you receive information about the fraction of waste that is recycled in your area

How much time do you spend on recycling per day? In minutes	Do you receive information about how much waste is recycled in your municipality?		
	No	Yes	Total
1	8	0	8
2	13	0	13
3	12	1	13
4	7	0	7
5	42	3	45
6	1	0	1
7	2	0	2
8	1	0	1
10	11	1	12
15	1	1	2
20	2	0	2
30	0	1	1
45	1	0	1
Total	101	7	108

Table 7-11 Cross tabulation between time spent on recycling and does your municipality have a recycling program

How much time do you spend on recycling per day? In minutes	Does your municipality have a recycling program?		
	No	Yes	Total
1	1	7	8
2	2	15	17
3	2	19	21
4	0	7	7
5	10	45	55
6	0	1	1
7	0	5	5
8	0	2	2
10	3	15	18
15	0	2	2
20	0	4	4
30	0	2	2
45	0	2	2
Total	18	126	144

Table 7-12 Cross tabulation between time spent on recycling and how would you judge the recycling program in your municipality

How much time do you spend on recycling per day? In minutes	How would you judge the recycling program in your municipality?			
	Bad	Good	Very Good	Total
1	3	1	2	6
2	1	8	2	11
3	6	9	2	17
4	1	4	1	6
5	5	17	16	38
7	0	1	2	3
8	0	0	1	1
10	3	6	5	14
15	1	1	0	2
20	2	2	0	4
30	0	0	2	2
45	0	1	1	2
Total	22	50	34	106

Table 7-13 Cross tabulation between time spent on recycling and do you feel that your municipality takes recycling seriously

How much time do you spend on recycling per day? In minutes	Do you feel that your municipality takes recycling seriously?		
	No	Yes	Total
1	3	5	8
2	2	11	13
3	8	11	19
4	2	4	6
5	15	38	53
6	1	0	1
7	0	4	4
8	1	1	2
10	5	10	15
15	1	1	2
20	2	1	3
30	0	2	2
45	1	1	2
Total	41	89	130

Table 7-14 Cross tabulation between time spent on recycling and do you know how the recycling program works

How much time do you spend on recycling per day? In minutes	Do you know how the recycling program works?		
	No	Yes	Total
1	1	6	7
2	3	11	14
3	0	17	17
4	1	6	7
5	3	38	41
6	1	0	1
7	1	3	4
8	1	1	2
10	0	14	14
15	0	2	2
20	0	4	4
30	0	2	2
45	0	2	2
Total	11	106	117

Table 7-15 Cross tabulation between time spent on recycling and do you know how to sort the waste

How much time do you spend on recycling per day? In minutes	Do you know how to sort the waste?		
	No	Yes	Total
1	1	6	7
2	0	15	15
3	0	19	19
4	0	7	7
5	0	45	45
6	0	1	1
7	0	5	5
8	0	2	2
10	0	15	15
15	0	2	2
20	0	4	4
30	0	2	2
45	0	2	2
Total	1	125	126

Table 7-16 Cross tabulation between time spent on recycling and I want to think of myself as a responsible person

How much time do you spend on recycling per day? In minutes	I recycle because I want my neighbors to think of me as a responsible person				
	Totally Disagree	Disagree	Agree	Totally Agree	Total
1	5	2	1	0	8
2	12	3	2	0	17
3	17	3	2	0	22
4	6	0	0	1	7
5	33	16	7	0	56
6	1	0	0	0	1
7	3	2	0	0	5
8	1	1	0	0	2
10	13	2	2	1	18
15	2	0	0	0	2
20	3	0	1	0	4
30	0	1	0	1	2
45	1	0	1	0	2
Total	97	30	16	3	146

Table 7-17 Cross tabulation between time spent on recycling and I recycle because my neighbors recycle

How much time do you spend on recycling per day? In minutes	I recycle because most of my neighbors reycle				
	Totally Disagree	Disagree	Agree	Totally Agree	Total
1	6	1	1	0	8
2	13	2	2	0	17
3	17	2	1	0	20
4	6	1	0	0	7
5	38	12	4	0	54
6	1	0	0	0	1
7	3	2	0	0	5
8	1	1	0	0	2
10	12	2	1	1	16
15	2	0	0	0	2
20	3	1	0	0	4
30	0	1	0	0	1
45	1	0	1	0	2
Total	103	25	10	1	139

Table 7-18 Cross tabulation between time spent on recycling and I recycle because I see that my neighbors has started to recycle

How much time do you spend on recycling per day? In minutes	I recycle because I see that my neighbors have started to recycle				
	Totally Disagree	Disagree	Agree	Totally Agree	Total
1	4	1	0	0	5
2	11	1	0	0	12
3	11	3	0	0	14
4	6	0	1	0	7
5	35	7	1	2	45
7	4	1	0	0	5
8	1	1	0	0	2
10	8	3	1	1	13
20	1	1	0	0	2
30	2	0	0	0	2
45	1	0	0	0	1
Total	84	18	3	3	108

Table 7-19 Cross tabulation between time spent on recycling and do you think your neighbors recycle

How much time do you spend on recycling per day? In minutes	Do you think that your neighbors recycle?		
	No	Yes	Total
1	2	2	4
2	1	9	10
3	1	12	13
4	0	5	5
5	2	39	41
7	0	3	3
8	0	2	2
10	1	9	10
15	0	1	1
20	0	2	2
30	0	1	1
Total	7	85	92

Table 7-20 Cross tabulation between time spent on recycling and do you think of your neighbors as responsible people

How much time do you spend on recycling per day?	Do you think of your neighbors as responsible?		
	No	Yes	Total
1	2	2	4
2	2	5	7
3	2	10	12
4	2	3	5
5	11	27	38
7	0	2	2
8	0	2	2
10	4	6	10
15	1	0	1
20	1	1	2
30	0	1	1
Total	25	59	84

Table 7-21 T-test comparing the mean household income of households belonging to Follo Ren's recycling program and those belonging to Indre Østfold Renovasjon IKS'

Two-sample t-test with equal variances						
Variable	**Obs**	**Mean**	**St. Err.**	**Std. Dev.**	**95% confidence interval**	
Housholdincome IOR	60	1296000	355605.3	2754507	584435.5	2007565
Housholdincome Follo Ren	76	1280211	215617.5	1879710	850678.4	1709743
Combined	136	1287176	197017.2	2297596	897537.1	1676816
Difference		15789.52	398265.4		-771910	803489.1
	H0: Difference = 0					
	Ha: Difference < 0		Ha: Difference != 0		Ha: Difference > 0	
	Pr(T<t) = 0.5158		Pr(T>t) = 0.9684		Pr(T>t) = 0.4842	
T= 0.0396						
Degrees of Freedom = 134						

Table 7-22 T-test comparing the mean education level of households belonging to Follo Ren's recycling program and those belonging to Indre Østfold Renovasjon IKS'

Two-sample t-test with equal variances						
Variable	**Obs**	**Mean**	**St. Err.**	**Std. Dev.**	**95% confidence interval**	
Housholdincome IOR	91	3.208791	0.0789375	0.7530159	3.051968	3.365614
Housholdincome Follo Ren	61	2.819672	0.1248129	0.9748196	2.570009	3.069335
Combined	152	3.052632	0.0703459	0.8672822	2.913642	3.191621
Difference		0.3891191	0.1404435		.111616	.6666221
	H0: Difference = 0					
	Ha: Difference < 0		Ha: Difference != 0		Ha: Difference > 0	
	Pr(T<t) = 0.9968		Pr(T>t) = 0.0063		Pr(T>t) = 0.0032	
T= 2.7706						
Degrees of Freedom = 150						

7.4 The questionnaire

This questionnaire is part of a M.Sc. thesis at the Department of Economics and Resource Management at the Norwegian University of Life Sciences. The purpose of the survey is to ascertain your knowledge of and behavior towards recycling, and how much your household recycles, if anything. This information is useful to look at the differences in how much waste is recycled in municipalities that provide information about recycling and those with different recycling programs. Further, I want to know how this information affects you, and if it affects how much you recycle.

The results can be made available to the municipalities in which the questionnaire is distributed and therefore you can have an impact on the recycling program where you live.

The questionnaire takes between 5-10 minutes to complete. Your opinion is important, and I appreciate that you take the time to answer. Your answer is anonymous.

1) Does your household recycle?	Yes No

2) Does your municipality have a recycling program?	Yes No I don't know

3) Do you know how the recycling program works?	Yes No I don't know

4) How would you judge the recycling program?	Very bad Bad Good Very good I don't know

5) Would you use a recycling program if one existed?	Yes No I don't know

6) Do you feel that your municipality takes recycling seriously?	Yes No I don't know

7) How much time do you spen on recycling per day? Please give your answer in minutes

8) How much, of the following types of waste, do you recycle?	0%	ca. 25%	ca 50%	ca 75%	ca 100%	I don't know
Paper/Newspaper						
Cardboard						
Plastic						
Glass						
Metal						
Food						
Batteries						
Lightbulbs						

9) Does your municipality have a recycling program to handle the following types of waste?	Yes	No	I don't know
Paper/Newspaper			
Cardboard			
Plastic			
Glass			
Metal			
Food			
Batteries			
Lightbulbs			

10) What do you think of how the municipality handles the following types of waste?	Very bad	Bad	Good	Very Good
Paper/Newspaper				
Cardboard				
Plastic				
Glass				
Metal				
Food				
Batteries				
Lightbulbs				

11) What is your opinion of the size of the waste bin?	Too small Ok Too big I don't know

12) How is recycling and sorting where you live?	Yes	No	I don't know
I know how the waste is sorted			
Sorted waste gets picked up at my house and deposited at a central recycling station			
There is a recycling station in my neighborhood			
There is a central recycling station for the municipality			
If there is no central recyclingstation in the municipality is all sorted waste picked up locally?			

13) How do you stand on the following statements?	Totally disagree	Disagree	Agree	Totally agree	Recycle almost everything
I would recycle more if I received better information about what and how to recycle?					
I would recycle more if the municipality picked up sorted waste at my house					
I would recycle more if the municipality set up a recycling station in my neighborhood					
I would recycle more if the municipality had a central recyclingstation					

14) Why do you recycle? Please indicate how you stand on the following statements	Totally disagree	Disagree	Agree	Totally agree	I don't know
I recycle because I feel I contribute to a cleaner environment					
I recycle because I wish to look at myself as a responsible person					
I recycle because I find it to be a nice activity in itself					
I recycle because I feel it is a chore that has to be done					
I recycle because I feel it is a requirement by the municipality					
I recycle because I want my neighbors to think of me as a responsible person					
I recycle because most of my neighbors recycle					

15) Do you recycle more or less now , than you did five years ago?
More
The same
Less
I don't know

16) If you recycle more, what do you think the reason is?	Totally disagree	Disagree	Agree	Totally agree	I don't know
I have received information about how important recycling is for the environment					
I have received information about what and how to recycle					
I believe that recycling is important to reduce the amount of GHG emitted					
I believe that recycling contributes to a better and cleaner environment					
My neighbors recycle more, therefore I recycle more					
Over the last five years the municipality has introduced a recycling program					
If there is another reason, please write it in the textbox below.					

17) If you recycle less, what do you think the reason is?	Totally disagree	Disagree	Agree	Totally agree	I don't know
I do not think that my contribution has any effect					
I see that my neighbors recycle less, therefore I recycle less					
I have less time now than I didd five years ago and recycling is not one of my priorities					
I think the quality of the recycling program is not good enough					
If there is another reason, please write it in the textbox below					

18) Do you think your neighbors recycle?
Yes
No
I don't know

19) Do you think of your neighbors as environmentally conscientious?
Yes
No
I don't know

20) Does your neighborhood have a private/local recycling program?
Yes
No
I don't know

21) Do you receive information about what and how to recycle?
Yes
No
I don't know

22) How would you judge the information you received about what and how to recycle?
Very bad
Bad
Good
Very Good

23) When was the last time you received information about what and how to recycle?
In the last month
In the last six months
In the last year
More than a year
I don't know

24) How did you recieve the information? Please check all that applies
Mail
E-mail
Internet
Radio
Tv
Fliers
Other

25) Do you receive information about the fraction of waste that is recycled in your area?
Yes
No
I don't know

26) How would you judge the information you received about the fraction of waste that is recycled in your area?
Very bad
Bad
Good
Very Good
I don't know

27) When was the last time you received information about the fraction of waste that is recycled?
In the last month
In the last six months
In the last year
More than a year
I don't know

28) Of the following statements, how would they affect whether you recycle more or less?	Less	The same	More	I don't know
If you receive information that only a small fraction of the waste in your area was recycled. Would you recycle more or less?				
If you receive information that a large fraction of the waste in your area was recycled. Would you recycle more or less?				
If you know that you recycle more than your neighbor, and he/she cannot observe your actions. Would you recycle more or less?				
If you know that you recycle less than your neighbor, and he/she cannot observe your actions. Would you recycle more or less?				
If you know that you recycle more than your neighbor, and he/she can observe your actions. Would you recycle more or less?				
If you know that you recycle less than your neighbor, and he/she can observe your actions. Would you recycle more or less?				

29) Sex?	Male	Female

30) What year are you born?

31) What is your housing situation?	Detached house without close neighbors
	Detached house with close neighbors
	Townhouse
	Duplex
	Apartment complex

32) What municipality do you live in?

33) How many people in your household, including yourself?

34) How many children in kindergarden, pre-school, or at home?

35) How many children in elementary school?

36) How many children in middle shcool?

37) How many children in highschool?

38) How many adults?

39) What is your highest attained education?	Basic education
	High school
	University/College, 3 years or less
	University/College, 4 years or more
	Other

40) What was total household income in 2011?

41) Is one or more individuals in the household member of one or more of the following organizations?	NSF
	KFUM/KFUK
	DNT
	Naturvernforbundet
	Bellona
	Natur og Ungdom
	WWF
	Other
	No

42) Did you vote at the last election to parliament?	Yes
	No