Discussion Papers No. 389, September 2004
Statistics Norway, Research Department

Bente Halvorsen

Effects of norms, warm-glow and time use on household recycling

Abstract:
The aim of this paper is to quantify the relative importance of motivations based on warm-glow, social and moral norms and cost of time used recycling on household recycling efforts. We also test for crowding-out of intrinsic motivations when recycling is perceived as mandatory. We find that the most important variable increasing household recycling efforts is agreeing that recycling is a pleasant activity in itself, which may be interpreted as a warm-glow effect. The most important variable reducing household recycling is the opportunity cost of time spent recycling. We find no evidence of crowding-out of intrinsic motivation when recycling is perceived as mandatory. On the contrary, we find that governmental legislation increases household recycling efforts on most materials.

Keywords: Contingent valuation method, cost of time, household recycling, moral and social norms, ordered probit, simultaneous estimation of discrete- and continuous choice, warm-glow, crowding out.

JEL classification: C20, C35, D12, D60, H42, H79, Q29

Acknowledgement: The author is grateful to Gorm Kipperberg, Iulie Aslaksen, Karine Nyborg and Erling Holmøy for valuable comments on previous versions of this paper.

Address: Bente Halvorsen, Statistics Norway, Research Department. E-mail: btl@ssb.no

Discussion Papers	comprise research papers intended for international journals or books. A preprint of a Discussion Paper may be longer and more elaborate than a standard journal article, as it may include intermediate calculations and background material etc.

Abstracts with downloadable Discussion Papers
in PDF are available on the Internet:
http://www.ssb.no
http://ideas.repec.org/s/ssb/dispap.html

For printed Discussion Papers contact:

Statistics Norway
Sales- and subscription service
NO-2225 Kongsvinger

Telephone: +47 62 88 55 00
Telefax: +47 62 88 55 95
E-mail: Salg-abonnement@ssb.no

1. Introduction

If household behavior were motivated by economic self-interest only, voluntary contributions to public goods would be negligible. However, in real life, seemingly unselfish behavior is frequently observed and the extent of such non-economically motivated activities may be both time-consuming and costly. One example is Norwegian households' recycling activities. In Norway, household recycling is mainly voluntary with few economic incentives. During the late nineties, several municipalities started recycling programs for their inhabitants. Recycling bins for paper, organic waste etc. was placed at the curb and recycling containers for glass, metal, clothes, etc. were placed at public locations. The inhabitants may use these facilities free of costs with no official sanction possibilities for respondents who do not want to recycle. The programs vary in extension between municipalities, both with respect to the number of materials included and the collecting facilities (curbside, local or central drop-off stations for recycled materials). In 1998, half of the municipalities offered volume-based pricing linked to the remaining waste. Unfortunately, we do not know how much the fees differ, nor do we know how many households that use differentiated fees (Statistics Norway, 2001). Since the system was new in 1999, which is the year analyzed here, we have reason to believe that the number of households making use of the scheme with differentiated fees was low. Despite this, Norwegian households took on a considerable effort sorting, folding, washing, carrying and transporting sorted waste. Thus, the main motivations for household recycling efforts were presumably non-economic. The share of total waste recycled by households in 1998 was 50 percent for paper and cardboard, 62 percent for glass, 3 percent for plastic and 43 percent for metal (Statistics Norway, 2001, table G10).

So, why do households recycle when it is voluntary, the economic incentives are few and governmental sanctions are limited? Several hypotheses explaining the occurrence of seemingly non-selfish behavior have emerged in the psychological literature (se e.g. Andreoni, 1990, Rabin, 1998, Frey, 1994, Blamey, 1998, Deci and Ryan, 1985, Festinger, 1957, Schwartz, 1970). The literature

often distinguishes between intrinsic and extrinsic motivation. Intrinsically motivated behavior is mainly founded on the individual's view of his/her own worth and self-respect. Examples of intrinsically motivated behavior may be moral norms in the form of a rule of conduct, like the golden rule, or altruistic preferences. The pleasure of giving, also referred to as "warm-glow", is another hypothesis for intrinsically motivated behavior (see e.g. Andreoni, 1990). The argument is that of impure altruistic preferences, as individuals gain utility from contributing to a just cause. The existence of social norms give rise to extrinsically motivated behavior, as individuals may recycle to keep up appearance and gain respect in the community, or to express their attitude towards environmental issues (Blamey, 1998). Extrinsic motivations may also come in the form of economic incentives provided by the government to promote household recycling activities, e.g. through the price mechanism or making recycling mandatory. The problem with introducing economic incentives is that they may crowd-out the intrinsic motivation, as they may reduce self-image (Brekke et al., 2003) and/or raise questions of income distribution and fairness (Frey, 1997). Another explanation for seemingly unselfish behavior is that consumers may have multiple preferences, both concerning private welfare and the welfare of the community (Margolis, 1982, Nyborg, 2000, Sen, 1977). Much of the literature on norms is theoretical, but some empirical studies have been made based on real life data or on experiments (Blamey, 1998, Tögersen 1994, Davis and Holt, 1993, Roth et al., 1991, Eisenberger and Cameron, 1996, Deci, Koestner and Ryan, 1985).

The main focus in the empirical literature on household recycling is how various recycling programs and differentiated tariffs affect household recycling behavior (see e.g. Hong et al., 1993, Jenkins et al., 2000, Jankus et al., 1996, Tiller et al., 1997). Some empirical studies have been made examining the motivation for household recycling efforts and environmental behavior (Vining et al., 1990, and 1992, Pardini and Katzhev, 1984, Hornik et al., 1995, Hopper and Nielsen, 1991, De Young, 1986). The main aim of these studies is to give advice on how to increase the voluntary recycling effort. One empirical study discussing the motivations for household recycling as well as the effects of economic

incentives is Tögersen (1994). Tögersen finds evidence of re-framing and crowding-out of moral norms when economic incentives are introduced in the form of differentiated garbage fees.

While much of the existing empirical work is based on theoretical models of recycling as a household production activity, only a few studies explicitly recognize the time use and its associated cost in the household's recycling decisions. Two notable exceptions are Jakus et al. (1996) and Hong et al. (1993). The former analyzes drop-off recycling in a rural community while the latter analyzes curbside recycling in a metropolitan area. Both studies infer the wage rate from income data as a measure of the household's opportunity cost of time.

The aim of this paper is to quantify the importance of both intrinsic and extrinsic motivations for household recycling based on warm-glow, social and moral norms, in addition to the cost of lost leisure. We use data from a survey conducted in 1999, asking 1162 respondents drawn from the Norwegian population about their recycling efforts, their motivation for recycling and their willingness to pay (WTP) for leaving the recycling to others. In the data, we have information about household recycling activities on six materials: paper, cardboard, plastic, metal, glass and organic waste excess of yard waste. We also have information on various household characteristics such as household income and work hours. Descriptive analysis of household recycling efforts based on this data and a discussion of the motives is given in Bruvoll et al. (2002).

The main contribution of this analysis is how we model the opportunity cost of lost leisure using the properties of the compensating variation (CV) for reducing time spent recycling. Most studies assume the opportunity cost of time used recycling equals the wage rate (se e.g. Jakus et al., 1996, or Hong et al., 1993). Whether this is the case in real life is an empirical question, depending on the household's preferences and behavior. To estimate the compensating variation (CV) for all costs and benefits of household recycling efforts, we use the stated willingness to pay (WTP) from both an open-ended

(OE-) and a discrete choice (DC-) contingent valuation (CVM) question of leaving recycling to others. The response to the OE- and DC-CVM questions are estimated simultaneously, modifying a method suggested by Kealy and Turner (1993). This estimation is used to predict the opportunity cost of time used recycling. We also model how social and moral norms and other intrinsic and extrinsic motivations, in addition to the opportunity cost of time used recycling and household characteristics, affect household recycling behavior. This is done by estimating an ordered probit model on each of the six materials.

The paper is organized as follows: In section 2, we model household recycling behavior and discuss how it is affected by altruistic behavior, social and moral norms, and the opportunity cost of time used recycling. Then we discuss how to use the households compensating variation for leaving the household recycling efforts to a renovation firm to predict the opportunity cost of time used recycling. Then, in section 3, we describe the data and discuss the econometric specification of the model. The results from the estimations are presented in section 4, and in section 5 some concluding remarks are made. Descriptive statistics of all variables used in the estimations are given in the Appendix.

2. The model

Household utility is likely to be influenced by social and moral norms, since how we live up to these norms determine our sense of self-respect and the respect we gain, or sanctions we receive, from the community. We assume that the household gains utility (U_h) from the consumption of a vector of goods ($X_h = \{x_{1h}, ..., x_{Mh}\}$), leisure (l_h), and the consumption of non-economic goods and services such as environmental quality (G), self-respect and respect in the community (R_h) and the warm-glow of contributing to a just cause (WG_h), conditional on household characteristics (β_h). The household is also assumed to meet sanctions (S_h), mainly in the form of social sanctions from the community or renovation workers, if the household does not recycle sufficiently. The utility function is given by:

$$U_h = U_h(X_h, l_h, R_h, S_h, G, WG_h; \beta_h) \quad (1)$$

Household self-esteem (R_h) is assumed to increase, whereas the sanctions (S_h) are assumed to decrease with the quantity of waste recycled by household h (g_h). Environmental quality (G) is assumed to increase with the total quantity of recycling in society, defined as the sum of recycled quantity from household h (g_h) and from other households (g_{-h}). The warm-glow (WG_h) from contributing to a just cause is assumed to increase with the quantity of waste recycled by the household. Finally, we assume that the time spent recycling (e_h) increases with recycled quantity. We have:

$$\begin{array}{lll} R_h = R_h(g_h) & where & R' > 0 \\ S_h = S_h(g_h) & where & S' < 0 \\ G = G(g_h + g_{-h}) & where & G' > 0 \\ WG_h = WG_h(g_h) & where & WG' > 0 \\ e_h = e_h(g_h) & where & e' > 0 \end{array} \quad (2)$$

2.1 The household's optimization problem

In this model, we assume that household recycling is a short-term decision whereas the labor-supply location choice is viewed as a more long-term decision. This means that the labor supply is given in the short term, which has several implications. Fist, since the working hours are given, household income (Y_h) is given. We assume that the household uses all money income on consumption of goods: $Y_h = \sum_{i=1}^{M} p_i x_{ih}$, where p_i is the price on good i. Second, the total numbers of hours that can be used at leisure or in household production (LT_h) will also be given (equal to the number of waken hours excess of working hours). This time is allocated between recycling (e_h) and other household production or leisure activities, hereafter referred to as excess leisure time (l_h): $LT_h = l_h + e_h$. So, conditional on the labor supply, we analyze how leisure is divided between time spent on recycling and excess leisure.

The household is assumed to maximize utility with respect to the consumption of all goods (X_h), excess leisure time (l_h) and recycled quantity (g_h), subject to the time and money budget. This maximization problem gives rise to the following Lagrange function:

$$L_h = U_h\left(X_h, l_h, R(g_h), S(g_h), G(g_h), WG(g_h); \beta_h\right) - \eta_h\left\{\sum_{i=1}^{M} p_i x_{ih} - Y_h\right\} - \xi_h\{e_h(g_h) + l_h - LT_h\} \tag{3}$$

where η_h is the Lagrange multiplier for the money budget and ξ_h is the Lagrange multiplier for the time budget. This optimization problem gives the following first order conditions:

$$\frac{\partial L_h}{\partial l_h} = \frac{\partial U_h}{\partial l_h} - \xi_h \equiv 0$$

$$\frac{\partial L_h}{\partial x_{ih}} = \frac{\partial U_h}{\partial x_{ih}} - \eta_h\, p_i \equiv 0, \quad \forall i = 1,\ldots,M \tag{4}$$

$$\frac{\partial L_h}{\partial g_h} = \frac{\partial U_h}{\partial R_h} R' + \frac{\partial U_h}{\partial S_h} S' + \frac{\partial U_h}{\partial G_h} G' + \frac{\partial U_h}{\partial WG_h} WG' - \xi_h e_h' \equiv 0,$$

When considering excess leisure time, the household evaluates the utility effects of increased l_h for a given time budget. When deciding on consumption of good *i*, the household evaluate the direct utility effects against the cost of increased consumption for a given money budget. Finally, when deciding on recycled quantity, the household evaluates the utility effects of increased respect, feeling of warm-glow, increase in environmental quality and reduced sanctions for a given time budget. Thus, the Lagrange multiplier for the time budget (ξ_h) equals the utility effects of increased recycling per time unit and may thus be interpreted as the opportunity cost of time used on recycling. From these first order conditions we see that in optimum, the utility of a marginal increased excess leisure time must equal the utility effects of a marginal increase in time used recycling.

Solving all first order conditions of this maximization problem *except* one, using that both the time and money budget must be fulfilled in optimum, gives household recycling activities, excess leisure time and consumption of goods as a function of all prices (P), household income (Y_h), total leisure time (LT_h), recycling by other households (g_{-h}) and the opportunity cost of time used recycling (ξ_h), conditional on household characteristics (β_h).

$$\begin{aligned} g_h &= g_h\left(P, Y_h, LT_h, \xi_h, g_{-h}; \beta_h\right) \\ l_h &= L_h\left(P, Y_h, LT_h, \xi_h, g_{-h}; \beta_h\right) \\ x_{ih} &= x_{ih}\left(P, Y_h, LT_h, \xi_h, g_{-h}; \beta_h\right) \end{aligned} \tag{5}$$

The opportunity cost of time spent recycling in optimum (ξ_h^*) is found by solving all first order conditions with respect to the Lagrange multiplier for the time budget. This gives the opportunity cost of time as a function of all prices, household income, total time spent at leisure, and recycling by other households, conditional on household characteristics:

$$\xi_h^* = \xi_h\left(P, Y_h, LT_h, g_{-h}; \beta_h\right) \tag{6}$$

Inserting the opportunity cost of time in optimum into equation (5) gives the optimal recycling of waste, excess leisure time and consumption of goods for the household: $g_h^* = g_h\left(P, Y_h, LT_h, g_{-h}; \beta_h\right)$, $l_h^* = L_h\left(P, Y_h, LT_h, g_{-h}; \beta_h\right)$, and $x_{ih}^* = x_{ih}\left(P, Y_h, LT_h, g_{-h}; \beta_h\right)$. Inserting this into the utility function in (1), gives the household's indirect utility as a function of all prices, household income and optimal recycling, conditional on household characteristics:

$$V_h = V_h\left(P, Y_h, LT_h, g_{-h}, R_h\left(g_h^*\right), S_h\left(g_h^*\right), G\left(g_h^*\right), WG_h\left(g_h^*\right); \beta_h\right) \tag{7}$$

2.2 The cost of time used recycling

The optimal recycling activity depends on all factors determining utility from recycling, such as respect, sanction if the household do not comply, environmental quality, warm glow of contributing and the opportunity cost of time spent recycling in optimum. In this paper, we want to illustrate how these factors affect household recycling behavior. In particular, we are interested in how the opportunity cost of time used on recycling affects recycling behavior. In order to find a measure for the individual household's opportunity costs of time, we use the household compensated variation for leaving recycling to others (CV_h).[1]

The household's CV is defined as the reduction in expenditures necessary to sustain utility after the recycling effort is left to others. Thus, the CV is the reduction in income that makes the household indifferent between doing the recycling themselves and leaving recycling to others. If a renovation firm takes over the sorting of household waste, the households gain utility since they no longer need to spend time recycling ($e_h(0) = 0$) and it may use all its available leisure time as excess leisure time ($l_h = LT_h$). Additionally, the household does no longer feel a pressure to recycle in order to avoid sanctions, nor do they feel the sense of warm glow and/or self-respect from contributing to a just cause when the recycling is left to others ($S_h(0) = R_h(0) = WG_h(0) = 0$). The CV for leaving household recycling to others may either be positive or negative depending on household preferences concerning these factors. For simplicity, we assume that the prices (P) are not affected by the household's recycling decision, and they are thus left out of the indirect utility function. Inserting the time budget in the indirect utility function and using that $l_h = LT_h$ when the household does not recycle ($e_h(0) = 0$), the CV is defined by:

$$\Delta V_h = V_h\left(Y_h, e_h\left(g_h^*\right) + l_h^*, R_h\left(g_h^*\right), S_h\left(g_h^*\right), G\left(g_h^*\right), WG_h\left(g_h^*\right); \beta_h\right) - V_h\left(Y_h - CV_h, LT_h, 0, 0, \overline{G}, 0; \beta_h\right) = 0 \qquad (8)$$

where $\overline{G}$ is the environmental quality generated by the total amount of waste recycled by the firm. For simplicity, we assume that the same amount of waste is sorted regardless of who is doing the recycling, the household or a renovation firm. Thus, the environmental quality is equal in the two situations: $\overline{G} = G\left(g_h^* + g_{-h}\right)$. Solving this with respect to the CV gives the household compensating variation for leaving recycling to others as a function of household recycling in optimum, household income and total leisure time available, conditional on household characteristics:

$$CV_h = CV_h\left(g_h^*, Y_h, LT_h ; \beta_h\right) \tag{9}$$

We decompose the welfare effect of leaving recycling to others (ΔV_h) into the welfare effects of warm glow, reduced sanctions and self-respect ($\Delta V_h^{S,R,WG}$) and the welfare effects of reduced time spent recycling (ΔV_h^e), that is $\Delta V_h = \Delta V_h^{S,R,WG} + \Delta V_h^e$, defined by:

$$\begin{aligned}\Delta V_h = {} & V_h\left(Y_h, e_h^* + l_h^*, R_h^*, S_h^*, \overline{G}, WG_h^*; \beta_h\right) - V_h\left(Y_h, e_h^* + l_h^*, 0, 0, \overline{G}, 0; \beta_h\right) \\ & + V_h\left(Y_h, e_h^* + l_h^*, 0, 0, \overline{G}, 0; \beta_h\right) - V_h\left(Y_h, LT_h, 0, 0, \overline{G}, 0; \beta_h\right)\end{aligned} \tag{10}$$

where the first utility difference equals $\Delta V_h^{S,R,WG}$ and the second difference equals ΔV_h^e. Using the intermediate-value theorem, a welfare change equals the marginal utility of income, evaluated at some intermediate income $\overline{Y}_h \in \left(Y_h, Y_h - CV_h\right)$, times the compensating variation: $\Delta V_h = CV_h \overline{V'_{hY}}$ (see e.g. Johansson, 1993, equation 3.5). Using this and equation (10) we are able to decompose the total CV into the CV for reduced time recycling (CV_h^e) and the CV for all other factors ($CV_h^{S,R,WG}$), defined by:

[1] For a discussion of the Compensating Variation, see Varian (1997), Mas-Colell et al (1995) or Mitchell and Carson (1989).

$$CV_h = \frac{\Delta V_h^{S,R,WG} + \Delta V_h^{e}}{\overline{V'_{hY}}} = CV_h^{S,R,WG} + CV_h^{e} \qquad (11)$$

We see from equation (11) that the CV of time spent recycling equals the total CV minus the CV for the utility effects of warm-glow, respect and sanctions. Thus, if we assume that the household does not receive utility from respect, warm glow or sanction, the total *CV* equals the CV for time spent recycling since the total amount of waste recycled, and thus the environmental quality, is equal in the two situations. If leaving recycling to others affects utility due to warm-glow or respect from contributing, the total CV differ from the CV of time used recycling. In our estimations, we will use the property that the CV of time used recycling measures the opportunity cost of time used recycling (ξ_h) given the households recycling effort (see equations 4 and 11). That is, we use the household's stated maximum willingness to pay to leave their recycling to others as a proxy for the opportunity cost of time used recycling.

3. Econometric specification

3.1 The data

The data used in this analysis is part of a survey conducted by Statistics Norway in November and December 1999. Our sample includes 1162 respondents between the age of 16 and 79 years old drawn from the Norwegian population. The response rate was slightly less than 60 percent of the gross sample of 2000 respondents. For 76 percent of the sample, the respondent was interviewed in person in their own home, while the remainders of the interviews were conducted by telephone.

In the survey, the respondents were asked questions whether they recycle all, most of, some or none of six different materials: Paper, cardboard, glass, metal, plastic and organic waste excess of yard waste. The answers to these questions are used to approximate the households' recycling efforts. Then, the

respondents were told that a waste disposal firm would take over the recycling ("*Suppose that a recycling company can utilize your garbage. A new technology allows central source separation such that the environmental impact is the same. The company will collect your garbage at your home.*"), and asked if they would be willing to make use of the offer by the waste disposal firm if it came free of charge ("*Would you use this service if it did not cost you anything?" Or do you prefer to do your own recycling?*"). Then, the respondents who would make use of the firm were asked two Contingent Valuation questions.[2] First, they were asked a Dichotomous Choice Contingent Valuation (DC-CVM) question (*"Are you willing to pay x NOK yearly to a waste disposal firm so they can take over the recycling effort of your household?" x* = 50, 150, 250, 450, 600 NOK).[3] Then, they were asked an Open-Ended Contingent Valuation (OE-CVM) question: (*"What is the maximum yearly amount you are willing to pay in order for the waste disposal firm to take over your household's recycling?"*)

In order to determine the motivation for household recycling efforts, we included questions concerning attitudes towards the recycling activity. The respondents were asked if they agreed, partly agreed, partly disagreed or disagreed to the following statements: *I recycle because ….* a) *"I want to consider myself as a responsible person"*, b) *"I want others to consider me as a responsible person"*, c) *"I perceive the recycling effort as imposed by the government"*, d) *"Recycling is a pleasant activity in itself"*, e) *"I want to do what I whish others to do"* and f) *"I want to contribute to a better environment"*.

We also asked the respondents if they thought recycling contributed to a better environment and if they would think of it as an advantage or a disadvantage if the municipality increased the extent of the voluntary recycling programs. The survey also includes routine questions concerning household income and labor supply, and how densely populated the respondents place of residence is. Finally, we

[2] See e.g. Mitchell and Carson 1989 for more information on the Contingent Valuation method.
[3] One NOK is approximately $0.12 US.

have information concerning the number of household members and the place of residence. (Descriptive statistics of all variables included in the analysis is given in appendix table A1.)

In our estimation, we will use the answers to the motivational questions as indications of how norms and warm-glow elements influence household recycling activities. Question a) is interpreted as an indication of intrinsic motivation, whereas b) is an indication of extrinsic motivation to increase the respect gained from recycling. If perceiving recycling as mandatory (question c) reduces household recycling activities, it may be an indication of crowding-out effects of intrinsic motivations. Wanting to contribute to the environment (question f) is interpreted a "warm-glow" effect or the desire to express environmental concerns through recycling. There may, however, be other reasons for wanting to contribute to the environment, e.g. a sense of moral or social obligation to do so. If the motivation is warm-glow, question (f) should indicate a benefit of household recycling. However, if it is motivated by a sense of commitment, it will represent an obligation to recycle. Finding recycling a pleasant activity (d) may be an indication of warm-glow if the reason the activity is perceived as pleasant is the feeling of contributing to a just cause. Wanting to do what I which others to do (question e) is interpreted as an indication of respondents living and acting according to the Golden Rule, which is an indication of moral commitment. Living according to moral norms should represent a cost of recycling if the aim is to avoid sanctions. On the other hand, the household may also gain utility complying with moral norms if it increases self-respect or the respect the household gains in the community. Agreeing that it would be a disadvantage if the municipality increased the extent of the voluntary recycling programs is an indication of social pressure to avoid sanctions. Finally, respondents who recycle despite a belief that it has no effect on environmental quality must have other motivations for their recycling activity, based on warm-glow, social and/or moral norms.

In the survey, only respondents who reported to recycle at least one of the six materials were asked about their recycling efforts. The 7 percent of the sample who did not recycle at all are reported with

missing values for all questions concerning household recycling efforts and moral motivations. Thus, we are only able to explain the behavior of the 93 percent of the sample that engage in some kind of recycling activities. Furthermore, we do not have information about the type of waste collecting services offered by the municipalities, nor do we have information whether the municipalities offer volume-based tariffs or not.

3.2 Household recycling effort

We approximate the household recycling activities (g_h) described in equation (5), by a linear function of household income (Y_h), number of household members (N_h), cost of time used recycling (TC_h), variables describing the household's attitude towards recycling (D_{hk}), plus a random error term (ν_h) which is assumed to be normally distributed with a zero mean and a constant variance.

$$g_h^* = \alpha_0 + \alpha_N N_h + \alpha_{TC} TC_h + \alpha_Y Y_h + \sum_{k=1} \alpha_k D_{kh} + \nu_h = \alpha' X_h + \nu_h \qquad (12)$$

The attitude variables are used to approximate factors concerning respect, warm-glow, sanctions and environmental concern. The variables included are the respondents' response to questions a) to f) (see the description of the data page 12), if they thought recycling contributed to a better environment and if they would think of it as an advantage if the municipality increased the extent of the voluntary recycling programs so they can recycle more.

Unfortunately, we are not able to observe the household recycling of waste in volume units (g^*), as we have only four observable outcomes: The household recycles all, most of, some or none of their recyclable waste. Thus, the observable recycling effort ($\tilde{g}_h$) is given by:

$$
\begin{aligned}
&\tilde{g}_h = 0 \quad if \quad && g_h^* = 0 \\
&\tilde{g}_h = 1 \quad if \quad && 0 < g_h^* \le \kappa_1 \\
&\tilde{g}_h = 2 \quad if \quad && \kappa_1 < g_h^* \le \kappa_2 \\
&\tilde{g}_h = 3 \quad if \quad && \kappa_2 < g_h^*
\end{aligned}
\tag{13}
$$

where κ_1 and κ_2 are the limits where the respondents shift from recycling *some* to *most of the waste*, and from *most* to *all of the waste* respectively. The household recycling effort may thus be viewed as a latent multinomial decision model (see e.g. in Greene (1993) pp. 672 - 676).

The probability of observing different levels of household recycling efforts are given by:

$$
\begin{aligned}
&P(\tilde{g}_h = 0) = \Phi(-\alpha' X) \\
&P(\tilde{g}_h = 1) = \Phi(\kappa_1 - \alpha' X) - \Phi(-\alpha' X) \\
&P(\tilde{g}_h = 2) = \Phi(\kappa_2 - \alpha' X) - \Phi(\kappa_1 - \alpha' X) \\
&P(\tilde{g}_h = 3) = 1 - \Phi(\kappa_2 - \alpha' X)
\end{aligned}
\tag{14}
$$

where $\alpha' X$ follows from equation (12). Since we assume that the random error term (ν_h) is normally distributed, the probability of observing $\tilde{g}_h$ is given by the standard normal probability (Φ), estimating all parameters in this model (α, κ) applying an ordered Probit model. The α parameters give the effects on the optimal recycling effort of marginal changes in the explanatory variables.

3.3 The cost of time

The opportunity cost of time used recycling (TC_h) in equation (12) is endogenous to the respondents, and must thus be instrumented in order to avoid biased estimates. This is because the covariance between this variable and the error term differ from zero. We estimate an instrument for the opportunity cost of time in optimum (described by equation 6) based the household CV for leaving recycling to others (se the discussion in section 2.2). We use the stated willingness to pay (WTP) from

both the open-ended (OE-) and discrete choice (DC-) contingent valuation (CVM) questions as a proxy for household CV for the service. Then, we calculate the opportunity cost of time spent recycling as the predicted CV excess of variables indicating benefits and moral and social costs and benefits of recycling.

The household CV for leaving recycling to others (described by equation 9) is approximated by a linear function of household work hours (LS_h), household gross income (Y_h), the age of the head of the household (A_h), a set of variables indicating moral and social costs (MC_h^k) and benefits (B_h^k) from household recycling and a stochastic error term (ϖ_h) which is assumed to be normally distributed with a zero mean and a constant variance:

$$CV_h = \gamma_0 + \gamma_Y Y_h + \gamma_L LS_h + \gamma_A A_h + \sum_{j=1}^{3} \gamma_{MC}^{j} MC_h^k + \sum_{k=1}^{5} \gamma_B^k B_h^k + \varpi_h \qquad (15)$$

The variables indicating moral and social costs (MC_h^k) are the respondents response to: "*I want to consider myself as a responsible person", "I want others to consider me as a responsible person", "I perceive the recycling effort as imposed by the government", "I want to do what I whish others to do"* and if they would think of it as a disadvantage if the municipality increased the extent of the voluntary recycling programs. The variables indicating the benefits (B_h^k) are the respondents' response to: *"Recycling is a pleasant activity in itself"* and *"I want to contribute to a better environment"*. The CV is assumed to be a function of household gross income in order to correct for the household's ability to meet payments. We also include the age of the head of the household, as younger families often have small children, increasing expenditures and the cost of additional time spent on recycling.

Since the respondents were asked both an open-ended and a close-ended WTP question in the questionnaire, we estimate the WTP from both questions simultaneously, applying a method suggested by Kealy and Turner (1993).[4] In Kealy and Turner, the DC-CVM question was conditional on the OE-CVM question. In our data, the conditioning is the other way around, as the OE-CVM question was asked after the DC-CVM question. Thus, we need to modify the method suggested by Kealy and Turner (1993), making the OE-CVM question conditional on the DC-CVM question.

We assume that the compensated variation from the DC-CVM question (CV^{DC}) may be written as the sum of the expected CV (μ_{DC}) and a stochastic error term (ω_{DC}), where the expected CV is a linear function of a vector of explanatory variables (X): $CV^{DC} = \mu_{DC} + \omega_{DC} = \lambda' X + \omega_{DC}$. Likewise, the CV from the OE-CVM question (CV^{OE}) is written as the sum of the expected CV (μ_{OE}) and a stochastic error term (ω_{OE}): $CV^{OE} = \mu_{OE} + \omega_{OE} = \gamma' X + \omega_{OE}$. These CV functions are given by equation (12). Furthermore, we assume that the CV^{DC} and the CV^{OE} are simultaneously and normally distributed: $\left(CV^{DC}, CV^{OE}\right) \sim N\left(\mu_{DC}, \mu_{OE}, \sigma_{DC}^2, \sigma_{OE}^2, \rho\right)$, where ρ is the correlation coefficient between CV^{OE} and CV^{DC}, and σ_{OE}^2 and σ_{DC}^2 are the variances of CV^{OE} and CV^{DC}. In the DC-CVM question, the respondents were asked whether they were willing to pay the cost (C) for leaving the recycling to others or not. We define a dummy variable y that equals one if the CV^{DC} exceeds the cost C ($y = 1$ if $CV^{DC} > C$), and zero otherwise, that is, if the respondent does not accept the offer. Furthermore, we assume that the respondent's CV in the OE-CVM question is conditional on the answer they gave to the proceeding DC-CVM question. Thus, the conditional distribution of CV^{OE} is given by:[5]

$$f\left(CV^{OE} \mid CV^{DC}\right) = N\left[\mu_{OE} + \rho\sigma_{OE}\left(\frac{C - \mu_{DC}}{\sigma_{DC}}\right), \sigma_{OE}^2\left(1 - \rho^2\right)\right].$$

[4] See also Halvorsen and Sælensminde (1998) for a discussion of the method.

[5] See e.g. Greene (1993), pp. 72-73, for a discussion of the bivariate normal and the conditional normal distributions.

The simultaneous probability of observing the combined answers to the DC- and OE-CVM questions are given by the product of the conditional marginal probability of stating a maximum WTP equal to *x* and the probability of stating *i = yes* or *no* in the DC-CVM question: $P(CV^{OE} = x, y = i) = P(y=i)*P(CV^{OE} = x \mid y = i)$. Applying the simultaneous probability of observing the combined answers to the CVM questions, gives the following Log-likelihood function for the simultaneous choice:

$$Log(L) = \sum_{h=1}^{N} \log\left[(1-y)\Phi\left(\frac{C-\lambda' X}{\sigma_{DC}} \right) + y\left\{ 1-\Phi\left(\frac{C-\lambda' X}{\sigma_{DC}} \right) \right\} \right] + \sum_{h=1}^{N} \log\left[\frac{1}{\sqrt{\sigma_{OE}^2\left(1-\rho^2\right)}}\, \varphi\left\{ \frac{CV^{OE} - \gamma' X - \rho\sigma_{OE}\left(\frac{C-\lambda' X}{\sigma_{DC}} \right)}{\sqrt{\sigma_{OE}^2\left(1-\rho^2\right)}} \right\} \right] \quad (16)$$

This Log-likelihood function is maximized applying the MINIMIZE-procedure in Limdep, estimating all parameters simultaneously applying a FIML-procedure.[6] This estimation yield two estimates of the WTP, one from the OE- and one from the DC-CVM equation. We use the mean WTP from the two WTP-questions for each individual household as a proxy for household's opportunity cost of time in the ordered probit estimation of equation (12).

Here, we assume the respondents statements to the two CVM questions reflects their compensated variation of leaving recycling to others. In the literature on the contingent valuation method, one of the main controversies is whether different elicitation formats under- and/or overstates the respondents true CV. In the theoretical literature, it is often assumed that the open-ended format gives the respondents incentives to overstate their true WTP (see e.g. Arrow et al., 1993, for a discussion). Comparative empirical analyses, on the other hand, mainly obtain higher WTP estimates using the DC-CVM format as compared to the OE-CVM format (see e.g. Halvorsen and Sælensminde, 1998). In

this analysis, we apply the responses to both questions in order to extract as much information about the households WTP as possible, and hopefully avoid systematical bias in the results as a consequence of the chosen elicitation format.

4. Empirical results

First in this section, we present the estimates from the simultaneous estimation on the WTP statements from the OE- and DC-CVM questions. Then, we present the results from the ordered Probit model on the share of waste recycled on six materials.

4.1. Households' time cost

In table 1, we present the results from the simultaneous estimations on the OE- and DC-CVM questions. In the estimation, household income, work hours, age of the respondent and variables determining the households' motivation and attitudes towards recycling were used as independent variables explaining the stated WTPs from both the OE- and the DC-CVM question. The attitude variables may take four values; disagree = 0, partly disagree = 1, partly agree = 2 and agree = 3 to the statements. In the first column of the table we present the estimated coefficients. In the next column, we present the T-value and in the last column we present the P-value. In the first section of the table, we present the results from the OE-CVM equation, and in the second section we present the estimates from the DC-CVM equation. Finally, in the last section, we present the estimated standard deviations and correlation coefficients.

[6] See Greene (1995) for more information on the MINIMIZE procedure in Limdep.

Table 1: Results from the simultaneous Maximum Likelihood estimations on the willingness to pay for handing over household recycling efforts to others from a dichotomous choice- (DC-CVM) and an open-ended (OE-CVM) contingent valuation question

Variable	*Coefficient*	*T-value*	*P-value*
OE-CVM question (NOK):			
Constant	350.38	4.65	0.000
Household gross income (1000 NOK)	0.24	4.48	0.000
Work hours (hours per week)	1.50	2.34	0.019
Age of respondent (years)	-7.26	-6.94	0.000
I want to contribute to the environment (0, 1, 2, 3)	21.14	0.85	0.396
I find recycling is a pleasant activity in itself (0, 1, 2, 3)	-20.14	-1.83	0.068
I want to consider myself as a responsible person (0, 1, 2, 3)	-0.05	0.00	0.997
I want others consider me as a responsible person (0, 1, 2, 3)	6.17	0.50	0.616
I perceive recycling as mandatory (0, 1, 2, 3)	-15.42	-1.57	0.117
I which to do what I want others to do (0, 1, 2, 3)	14.40	0.92	0.356
I would think of it as a disadvantage if the municipality increased the extent of the voluntary recycling programs (0,1)	10.47	0.37	0.709
DC-CVM question (0, 1):			
Constant	491.35	3.01	0.003
Household gross income (1000 NOK)	0.30	1.90	0.057
Work hours (hours per week)	3.71	1.75	0.081
Age of respondent (years)	-11.03	-3.30	0.001
I want to contribute to the environment (0, 1, 2, 3)	18.75	0.58	0.562
I find recycling is a pleasant activity in itself (0, 1, 2, 3)	-17.62	-0.61	0.542
I want to consider myself as a responsible person (0, 1, 2, 3)	-0.17	-0.19	0.853
I want others consider me as a responsible person (0, 1, 2, 3)	0.49	0.53	0.593
I perceive recycling as mandatory (0, 1, 2, 3)	-19.93	-0.78	0.434
I which to do what I want others to do (0, 1, 2, 3)	18.57	0.63	0.529
I would think of it as a disadvantage if the municipality increased the extent of the voluntary recycling programs (0,1)	24.70	0.30	0.761
Standard deviations:			
Standard deviation from the OE-CVM question	327.06	19.56	0.000
Standard deviation from the DC-CVM question	557.75	4.93	0.000
Coefficient of correlation between the OE- Snd DC-CVM question	0.51	6.83	0.000

Looking at the results, we see that household income increases the WTP for leaving recycling to others significantly, both in the OE-CVM and the DC-CVM question, as the household's capacity to pay increases with income. Work hours have a significant positive effect on both the OE- and DC-CVM question, that is, households with long work hours have a higher WTP for leaving their recycling to others than households with more leisure time. This indicates that the cost of recycling increases with the work hours. This was as expected since leisure time becomes more valuable when the number of working hours increases. We also see that the age of the respondent have a significantly negative effect on the WTP-statements. There might be several reasons for this. One explanation is that younger families often have small children, increasing the marginal cost of time. Another explanation is that older people are more concerned with the moral obligation of contributing to the community, and that younger people are more willing to accept purchasing recycling services. Looking at the attitude variables, the only significant variable is finding recycling a pleasant activity, which reduces the WTP from the OE-CVM question. For the rest of the attitude variables, none of the coefficients differ significantly from zero. From the last section of the table, we see that the answers to the two WTP questions are not independent, as the estimated correlation coefficient (ρ) differs significantly from zero with an estimate of 0.51. Thus, assuming independence by calculating the WTP for each question separately will not include all information concerning the distribution of the WTP in the data.

In order to obtain an estimate of the households' cost of time used recycling, we use this estimation to predict the household's mean WTP from the OE- and DC-CVM questions *net of* all attitude variables. This estimate of the households' opportunity cost of time is then applied in the estimation of the recycling effort on the different materials.

4.2. Household recycling effort

In table 2, we present results from the ordered probit estimations on the share of the six materials recycled by the households. In the first column of table 2, we report the estimated coefficients in the ordered Probit model on the share of paper recycled by the households. In the next five columns, we present the coefficients from the estimated share of cardboard, plastic, metal, glass and organic waste. The dependent variables may take four values: Recycle none = 0, some = 1, most = 2 and all = 3 of the household's waste. In all estimations, the following variables were used as explanatory variables: household income, the estimated time costs, the number of household members, age of the respondent, living in a major city, living in a block of flats, variables determining the households' motivation and attitudes towards recycling, if they thought recycling contributed to a better environment and if they think it is an advantage for them if the municipality increased the extent of the voluntary recycling programs so they can recycle more. The attitude variables may take four values: disagree = 0, partly disagree = 1, partly agree = 2 and agree = 3 to the six statements (se statements a) -f) in the discussion of the data in section 3.1). In the last part of the table, estimates for κ_1 and κ_2 are included.

Table 2: Results from an ordered Probit estimation on the share of paper, cardboard, plastic, metal, glass and organic waste recycled by households. [a]

	Paper	Card-board	Plastic	Metal	Glass	Organic waste
Constant	1.3526 **	0.1321	-1.3767 **	-0.2702	-0.1333	0.2338
Household gross income (1000 NOK)	0.0007 **	0.0002	-0.0001	0.0003	0.0005 **	0.0003
Estimated opportunity cost of time spent recycling (NOK)	-0.0015 **	-0.0010 **	0.0000	-0.0008 **	-0.0011 **	-0.0012 **
Number of household members (N)	-0.0060	0.0557 *	0.0024	0.0150	0.0175	-0.0029
Age of the respondent (years)	-0.0007	-0.0097 **	-0.0017	0.0002	0.0044	-0.0099 **
Major city (0,1)	0.0047	-0.1106	-0.1361	-0.3958 **	-0.2499 **	-1.0889 **
Living in a block of flats (0,1)	0.1796	-0.1464	-0.2473 *	-0.1495	0.1461	-0.3535 **
I want to consider myself as a responsible person (0, 1, 2, 3)	0.0188	0.0425	0.0297	0.1405 **	0.0548	-0.0094
I want others consider me as a responsible person (0, 1, 2, 3)	0.0138	0.0138	0.1038 **	0.0390	0.0111	0.0684 *
I perceive recycling as mandatory (0, 1, 2, 3)	0.0117	0.0015	0.1385 **	-0.0237	-0.0440	0.1734 **
I find recycling is a pleasant activity in it-self (0, 1, 2, 3)	-0.0217	0.0958 **	0.0981 **	0.0960 **	0.0452	0.0671 *
I like to do what I want others to do (0, 1, 2, 3)	0.1256 **	0.1579 **	0.1022	0.0868 *	0.0706	0.0103
I want to contribute to the environment (0, 1, 2, 3)	-0.0918	0.0191	0.1097	-0.0363	0.1524 *	0.0482
I believe recycling contributes to a better environment (0,1)	0.0194	0.2935 **	0.1601	0.2050 *	0.4221 **	0.1046
I think it is an advantage if the municipality increases the extent of voluntary recycling programs so I can recycle more (0,1)	0.2089 **	-0.0612	-0.0934	-0.2092 **	-0.0525	-0.1833 **
κ_1	0.2428 **	0.3129 **	0.2170 **	0.3102 **	0.2966 **	0.1226 **
κ_2	0.8898 **	0.7071 **	0.5054 **	0.5793 **	0.7598 **	0.2922 **

[a] ** implies that the coefficient differ significantly from zero with a probability of falsely rejecting the zero hypothesis at less than 5 percent. * implies that the coefficient differ significantly from zero with a probability of falsely rejecting the zero hypothesis at less than 10 percent.

Looking at the attitude variables, their importance on household recycling efforts varies between materials. For instance, respondents who are more concerned with self-respect, recycle more metal than other respondents. Respondent who are concerned with the respect they receives from others recycle more plastic and organic waste than others. Even if recycling is essentially voluntary in Norway, some respondents perceive it as mandatory. If the respondent perceives recycling as mandatory, it increases household recycling of plastic and organic waste significantly while the coefficient is insignificant for the other materials. The estimated coefficient is negative on the recycling of paper and glass, but these coefficients are not significant. Thus, we do not find significant evidence of crowding-out of intrinsically motivated behavior in our data. Respondents who find recycling a pleasant activity recycle significantly more of cardboard, plastic, metal and organic waste, and respondents agreeing to the Kantian rule recycle more of paper, cardboard and metal than other respondents. Wanting to contribute to a better environment only had a significantly positive effect on the recycling of metal. Respondents who believe that recycling contributes to a better environment recycle significantly more of cardboard, metal and glass than other respondents. Finally, respondents who think it is an advantage if the municipality increased the extent of the voluntary recycling programs so they can recycle more, recycle significantly more of paper and less of metal and organic waste than other respondents. The reason for the negative signs of the coefficient may be that these are respondents with a high motivation for recycling who lives in communities that do not offer recycling programs for marginal materials such as metal and organic waste.

If we take an overall look at table 2, we see that the attitude variables have the largest impact on the recycling of the more marginal materials such as plastic and organic waste, and less on the recycling of paper and glass, where most municipalities has well-functioning recycling programs. We see that especially for the recycling of paper, which is the most common material for curbside recycling programs, only agreeing to the Kantian rule increases the effort significantly. For cardboard, enjoying the recycling activity in itself and the belief that recycling increases environmental quality also increase the effort, probably since the recycling of cardboard involve a lot of cleaning and folding of

milk cartons. We also see that enjoying the recycling activity in itself have a positive effect on the recycling effort of most waste fractions with the exception of paper and glass, where the effort of recycling is smallest.

5. Concluding remarks

Based on the findings from this study, we see that the most important variables explaining household recycling activities were finding recycling a pleasant activity, which may be interpreted as warm-glow, and the estimated opportunity cost of time spent recycling. Beyond this, the importance of the motivations varies with the nature of recycling the various materials. Furthermore, we find that perceiving recycling as mandatory does not seem to crowd-out other motivations for recycling. On the contrary, it seems like perceiving recycling as mandatory reduces the WTP for leaving recycling to others, increases the recycling effort and strengthens the moral motivation. This indicates that the households gain utility when the local government makes recycling mandatory, which may seem odd. One explanation may be that governmental legislation may influence the publics' attitude towards recycling, increasing awareness and emphasizing the importance of recycling. Another explanation is that households may expect the total recycling in the community to increase, resulting in a higher environmental quality, when recycling is a joint effort secured by legislation where everybody participates. A third explanation may be a sense of moral obligation to sort waste when recycling is perceived as mandatory. Thus, the respondents may see the alternative of leaving recycling to others as slinking away from their obligations as a citizen, reducing their WTP.

Market-based instruments to stimulate economic incentives are gaining popularity in the environmental policy. For instance, during the late nineties, most municipalities introduced various schemes to stimulate household recycling efforts. These mainly consisted of differentiated garbage fees, curbside recycling programs, and/or local and central drop-off facilities for various materials. The effectiveness of these incentives may depend on how they affect the motivation for household recycling behavior. In this study, we have not included variables describing the recycling programs

and differentiated garbage fees, as they were not available in our data. We have only tested if perceiving recycling as mandatory crowd out morally motivations for recycling, which we find no evidence of. This does not, however, exclude the possibility that for instance introducing differentiated garbage fees may crowd-out intrinsic motivation, which Thögersen (1994) find evidence of in Denmark. How different recycling programs stimulate the recycling of various materials is the main focus of our future research on this topic.

Appendix

Table A1: Descriptive statistics.

	Mean	*Std.Dev.*	*Minimum*	*Maximum*	*NumCases*
Willing to pay the cost (0, 1)	0.36	0.48	0	1	1162
Maximum WTP for leaving recycling to others (NOK)	175.97	276.32	0	2000	1059
Recycling effort on cardboard (0, 1, 2, 3)	1.69	1.31	0	3	1162
Recycling effort on paper (0, 1, 2, 3)	2.41	1.02	0	3	1162
Recycling effort on glass (0, 1, 2, 3)	2.14	1.19	0	3	1162
Recycling effort on metal (0, 1, 2, 3)	1.33	1.35	0	3	1162
Recycling effort on plastic (0, 1, 2, 3)	0.84	1.23	0	3	1162
Recycling effort on organic waste (0, 1, 2, 3)	1.35	1.43	0	3	1162
Household gross income (1000 NOK)	392.96	254.75	0	3000	1036
Work hours (hours per week)	25.83	19.73	0	100	1162
Number of household members (N)	2.79	1.42	1	13	1162
Age of the respondent (Years)	42.46	16.41	15	79	1162
Major city (0,1)	0.25	0.43	0	1	1162
Living in a block of flats (0,1)	0.13	0.33	0	1	1162
I want to consider myself a responsible person (0, 1, 2, 3)	1.98	1.11	0	3	1088
I want others consider me a responsible person (0, 1, 2, 3)	1.17	1.23	0	3	1086
I perceive recycling as mandatory (0, 1, 2, 3)	1.75	1.21	0	3	1093
I find recycling is a pleasant activity in it-self (0, 1, 2, 3)	1.11	1.14	0	3	1094
I like to do what I want others to do (0, 1, 2, 3)	2.48	0.85	0	3	1092
I want to contribute to the environment (0, 1, 2, 3)	2.82	0.50	0	3	1094
I believe recycling contributes to a better environment (0,1)	0.85	0.36	0	1	1162
It is an advantage if the municipality increases the extent of voluntary recycling programs so I can recycle more (0,1)	0.34	0.47	0	1	1162
It as a disadvantage if the municipality increased the extent of the voluntary recycling programs (0,1)	0.22	0.42	0	1	1162

References

Andreoni, J. (1990): "Impure Alturism and donations to public goods: A theory of warm-glow giving." *The Economic Journal*, 100, pp. 464-477.

Arrow, K., R. Sollow, P. R. Portney, E. E. Learner, R. Radner, H. Schuman (1993):"Report from the NOAA panel on Contingent Valuation", *Federal Register*, vol. 58, no 10.

Blamey, R. K. (1998): "Decisiveness, attitude expression and symbolic responses in contingent valuation surveys." *Journal of Economic Behaviour and Organization*, **34**, pp. 577-601.

Bruvoll, A., B. Halvorsen and K. Nyborg (2002): "Households' recycling efforts". Accepted for publication in *Resources, Conservation and Recycling*

Brekke, K. A., S. Kverndokk and K. Nyborg (2003): "An economic model of moral motivation." Accepted for publication in *Journal of Political Economy*.

Davis, D. D. and C. A. Holt (1993): "*Experimental Economics.*" Princeton: Princeton University Press.

Deci, E. L., Koestner and R. M. Ryan (1985): "Extrinsic rewards and intrinsic motivation: A clear and consistent picture after all." Mimeo, Dept. of Psychology, University of Rochester.

Deci, E. L. and R. M. Ryan (1985): "*Intrinsic motivation and self-determination in human behaviour*." New York: Plenum Press.

Eisenberg, R. and J. Cameron (1996): "Detrimental effects on reward: Reality or myth?" *American Psychologist*, **51**, pp. 1153-1166.

Festinger, L. (1957): ""*A theory of cognititve dissonance.*" Stanford: Stanford University Press.

Frey, B. S. (1994): "How intrinsic motivation is crowded out." *Rationality and Society*, **6**, pp. 334-352.

Frey, B. S. (1993): "Motivation as a limit to pricing." *Journal of Economic Psychology*, **14**, pp. 635-664.

Greene, W. H. (1995): 'Limdep 7, User's Manual', Econometric Software inc, Bellprot, N.Y.

Greene (1993): "*Econometric Analysis.*" MacMillan, New York.

Halvorsen, B. og K. Sælensminde (1998): 'Differences between Willingness-to-pay estimates from Open-Ended and Discrete Choice Contingent Valuation Method: The effect of hetroscedasticity', *Land Economics (May)*.

Hong, S., R. M. Adams, and H. A. Love (1993): "An economic analysis of household recycling of solid waste: The case of Portland, Oregon." *Journal of Environmental Economics and Management*, **25**, pp. 136-146.

Jakus, P. M., K. H. Tiller, and W. M. Park (1996): "Generation of recyclables by rural households." *Journal of Agricultural and Resource Economics*, **21** (1), pp. 96-108.

Jenkins, R. R., S. A. Martinez, K. Palmer, and M. J. Podolsky (2000): "The determinants of household recycling: A material specific analysis of recycling program features and unit pricing." *Discussion Paper 99-41-REV*, Resources for the Future.

Johansson, P.-O. (1993): *"Cost-benefit analysis of environmental change"*, Cambridge University Press, Cambridge.

Kealy, M. J., and R. W. Turner (1993): "A test of the equality of closed-ended and open-ended contingent valuation." *American Journal of Agricultural Economics*, **75**, pp. 321-331.

Magnolis, H. (1982): "*Selfishness, altruism and rationality*." Chicago: University of Chicago Press.

Mas-Colell, A., M. D. Whinston and J. R. Green (1995): *'Microeconomic Theory'*, Oxford University Press, New York.

Mitchel R. C., Carson R. T (1989): 'Using surveys to value public goods: The Contingent Valuation method', Resources for the Future, Washington D. C.

Nyborg, K. (2000): "Homo Economicus and Homo Politicus: Interpretation and aggregation of environmental values." *Journal of Economic Behaviour and Organization*, **42**, pp. 305-322.

Rabin, M. (1998): "Psychology and economics." *Journal of Economic Literature*, **XXXVI**, pp. 11-46.

Roth, A. E., V. Prasnikar, M. Okuno-Fujiwara and S. Zamir (1991): "Bargaining and market behaviour in Jerusalem, Ljubljana, Pittsburgh and Tokyo: An experimental study." *American Economic Review*, **81**, pp. 1068-1096.

Schwartz, H. (1970): "Moral decision making and behaviour." in J. Macaulay and L. Berkowitz: *Altruism and helping behaviour. Social Psychological studies of some antecedents and consequences.* New York and London: Academic Press. Pp. 127-141.

Sen, A. (1977): "Rational fools: A critique of the behavioural foundation of economic theory." *Philosophy and Public Affaires*, **6**, pp. 317-344.

Statistics Norway (2001): "Natural resources and the environment". *Statistical analyses no. 46*.

Tiller, K. H., P. M. Jakus, and W. M. Park (1997): "Household willingness to pay for dropoff recycling." *Journal of Agricultural and Resource Economics*, **22** (2), pp. 310-320.

Tögersen, J. (1994): "Monetary incentives and environmental concern. Effects of a differentiated garbage fee." *Journal of Consumer Policy*, **19**, pp. 125-143.

Varian, H. R. (1992): *'Microeconomic Analysis'*, W. W. Norton & Company, New York.

Recent publications in the series Discussion Papers

298 Taran Fæhn and Erling Holmøy (2001): Trade Liberalisation and Effects on Pollutive Emissions and Waste. A General Equilibrium Assessment for Norway

299 J.K. Dagsvik (2001): Compensated Variation in Random Utility Models

300 K. Nyborg and M. Rege (2001): Does Public Policy Crowd Out Private Contributions to Public Goods?

301 T. Hægeland (2001): Experience and Schooling: Substitutes or Complements

302 T. Hægeland (2001): Changing Returns to Education Across Cohorts. Selection, School System or Skills Obsolescence?

303 R. Bjørnstad: (2001): Learned Helplessness, Discouraged Workers, and Multiple Unemployment Equilibria in a Search Model

304 K. G. Salvanes and S. E. Førre (2001): Job Creation, Heterogeneous Workers and Technical Change: Matched Worker/Plant Data Evidence from Norway

305 E. R. Larsen (2001): Revealing Demand for Nature Experience Using Purchase Data of Equipment and Lodging

306 B. Bye and T. Åvitsland (2001): The welfare effects of housing taxation in a distorted economy: A general equilibrium analysis

307 R. Aaberge, U. Colombino and J.E. Roemer (2001): Equality of Opportunity versus Equality of Outcome in Analysing Optimal Income Taxation: Empirical Evidence based on Italian Data

308 T. Kornstad (2001): Are Predicted Lifetime Consumption Profiles Robust with respect to Model Specifications?

309 H. Hungnes (2001): Estimating and Restricting Growth Rates and Cointegration Means. With Applications to Consumption and Money Demand

310 M. Rege and K. Telle (2001): An Experimental Investigation of Social Norms

311 L.C. Zhang (2001): A method of weighting adjustment for survey data subject to nonignorable nonresponse

312 K. R. Wangen and E. Biørn (2001): Prevalence and substitution effects in tobacco consumption. A discrete choice analysis of panel data

313 G.H. Bjertnær (2001): Optimal Combinations of Income Tax and Subsidies for Education

314 K. E. Rosendahl (2002): Cost-effective environmental policy: Implications of induced technological change

315 T. Kornstad and T.O. Thoresen (2002): A Discrete Choice Model for Labor Supply and Child Care

316 A. Bruvoll and K. Nyborg (2002): On the value of households' recycling efforts

317 E. Biørn and T. Skjerpen (2002): Aggregation and Aggregation Biases in Production Functions: A Panel Data Analysis of Translog Models

318 Ø. Døhl (2002): Energy Flexibility and Technological Progress with Multioutput Production. Application on Norwegian Pulp and Paper Industries

319 R. Aaberge (2002): Characterization and Measurement of Duration Dependence in Hazard Rate Models

320 T. J. Klette and A. Raknerud (2002): How and why do Firms differ?

321 J. Aasness and E. Røed Larsen (2002): Distributional and Environmental Effects of Taxes on Transportation

322 E. Røed Larsen (2002): The Political Economy of Global Warming: From Data to Decisions

323 E. Røed Larsen (2002): Searching for Basic Consumption Patterns: Is the Engel Elasticity of Housing Unity?

324 E. Røed Larsen (2002): Estimating Latent Total Consumption in a Household.

325 E. Røed Larsen (2002): Consumption Inequality in Norway in the 80s and 90s.

326 H.C. Bjørnland and H. Hungnes (2002): Fundamental determinants of the long run real exchange rate:The case of Norway.

327 M. Søberg (2002): A laboratory stress-test of bid, double and offer auctions.

328 M. Søberg (2002): Voting rules and endogenous trading institutions: An experimental study.

329 M. Søberg (2002): The Duhem-Quine thesis and experimental economics: A reinterpretation.

330 A. Raknerud (2002): Identification, Estimation and Testing in Panel Data Models with Attrition: The Role of the Missing at Random Assumption

331 M.W. Arneberg, J.K. Dagsvik and Z. Jia (2002): Labor Market Modeling Recognizing Latent Job Attributes and Opportunity Constraints. An Empirical Analysis of Labor Market Behavior of Eritrean Women

332 M. Greaker (2002): Eco-labels, Production Related Externalities and Trade

333 J. T. Lind (2002): Small continuous surveys and the Kalman filter

334 B. Halvorsen and T. Willumsen (2002): Willingness to Pay for Dental Fear Treatment. Is Supplying Fear Treatment Social Beneficial?

335 T. O. Thoresen (2002): Reduced Tax Progressivity in Norway in the Nineties. The Effect from Tax Changes

336 M. Søberg (2002): Price formation in monopolistic markets with endogenous diffusion of trading information: An experimental approach

337 A. Bruvoll og B.M. Larsen (2002): Greenhouse gas emissions in Norway. Do carbon taxes work?

338 B. Halvorsen and R. Nesbakken (2002): A conflict of interests in electricity taxation? A micro econometric analysis of household behaviour

339 R. Aaberge and A. Langørgen (2003): Measuring the Benefits from Public Services: The Effects of Local Government Spending on the Distribution of Income in Norway

340 H. C. Bjørnland and H. Hungnes (2003): The importance of interest rates for forecasting the exchange rate

341 A. Bruvoll, T.Fæhn and Birger Strøm (2003): Quantifying Central Hypotheses on Environmental Kuznets Curves for a Rich Economy: A Computable General Equilibrium Study

342 E. Biørn, T. Skjerpen and K.R. Wangen (2003): Parametric Aggregation of Random Coefficient Cobb-Douglas Production Functions: Evidence from Manufacturing Industries

343 B. Bye, B. Strøm and T. Åvitsland (2003): Welfare effects of VAT reforms: A general equilibrium analysis

344 J.K. Dagsvik and S. Strøm (2003): Analyzing Labor Supply Behavior with Latent Job Opportunity Sets and Institutional Choice Constraints

345 A. Raknerud, T. Skjerpen and A. Rygh Swensen (2003): A linear demand system within a Seemingly Unrelated Time Series Equation framework

346 B.M. Larsen and R.Nesbakken (2003): How to quantify household electricity end-use consumption

347 B. Halvorsen, B. M. Larsen and R. Nesbakken (2003): Possibility for hedging from price increases in residential energy demand

348 S. Johansen and A. R. Swensen (2003): More on Testing Exact Rational Expectations in Cointegrated Vector Autoregressive Models: Restricted Drift Terms

349 B. Holtsmark (2003): The Kyoto Protocol without USA and Australia - with the Russian Federation as a strategic permit seller

350 J. Larsson (2003): Testing the Multiproduct Hypothesis on Norwegian Aluminium Industry Plants

351 T. Bye (2003): On the Price and Volume Effects from Green Certificates in the Energy Market

352 E. Holmøy (2003): Aggregate Industry Behaviour in a Monopolistic Competition Model with Heterogeneous Firms

353 A. O. Ervik, E.Holmøy and T. Hægeland (2003): A Theory-Based Measure of the Output of the Education Sector

354 E. Halvorsen (2003): A Cohort Analysis of Household Saving in Norway

355 I. Aslaksen and T. Synnestvedt (2003): Corporate environmental protection under uncertainty

356 S. Glomsrød and W. Taoyuan (2003): Coal cleaning: A viable strategy for reduced carbon emissions and improved environment in China?

357 A. Bruvoll T. Bye, J. Larsson og K. Telle (2003): Technological changes in the pulp and paper industry and the role of uniform versus selective environmental policy.

358 J.K. Dagsvik, S. Strøm and Z. Jia (2003): A Stochastic Model for the Utility of Income.

359 M. Rege and K. Telle (2003): Indirect Social Sanctions from Monetarily Unaffected Strangers in a Public Good Game.

360 R. Aaberge (2003): Mean-Spread-Preserving Transformation.

361 E. Halvorsen (2003): Financial Deregulation and Household Saving. The Norwegian Experience Revisited

362 E. Røed Larsen (2003): Are Rich Countries Immune to the Resource Curse? Evidence from Norway's Management of Its Oil Riches

363 E. Røed Larsen and Dag Einar Sommervoll (2003): Rising Inequality of Housing? Evidence from Segmented Housing Price Indices

364 R. Bjørnstad and T. Skjerpen (2003): Technology, Trade and Inequality

365 A. Raknerud, D. Rønningen and T. Skjerpen (2003): A method for improved capital measurement by combining accounts and firm investment data

366 B.J. Holtsmark and K.H. Alfsen (2004): PPP-correction of the IPCC emission scenarios - does it matter?

367 R. Aaberge, U. Colombino, E. Holmøy, B. Strøm and T. Wennemo (2004): Population ageing and fiscal sustainability: An integrated micro-macro analysis of required tax changes

368 E. Røed Larsen (2004): Does the CPI Mirror Costs.of.Living? Engel's Law Suggests Not in Norway

369 T. Skjerpen (2004): The dynamic factor model revisited: the identification problem remains

370 J.K. Dagsvik and A.L. Mathiassen (2004): Agricultural Production with Uncertain Water Supply

371 M. Greaker (2004): Industrial Competitiveness and Diffusion of New Pollution Abatement Technology – a new look at the Porter-hypothesis

372 G. Børnes Ringlund, K.E. Rosendahl and T. Skjerpen (2004): Does oilrig activity react to oil price changes? An empirical investigation

373 G. Liu (2004) Estimating Energy Demand Elasticities for OECD Countries. A Dynamic Panel Data Approach

374 K. Telle and J. Larsson (2004): Do environmental regulations hamper productivity growth? How accounting for improvements of firms' environmental performance can change the conclusion

375 K.R. Wangen (2004): Some Fundamental Problems in Becker, Grossman and Murphy's Implementation of Rational Addiction Theory

376 B.J. Holtsmark and K.H. Alfsen (2004): Implementation of the Kyoto Protocol without Russian participation

377 E. Røed Larsen (2004): Escaping the Resource Curse and the Dutch Disease? When and Why Norway Caught up with and Forged ahead of Its Neughbors

378 L. Andreassen (2004): Mortality, fertility and old age care in a two-sex growth model

379 E. Lund Sagen and F. R. Aune (2004): The Future European Natural Gas Market - are lower gas prices attainable?

380 A. Langørgen and D. Rønningen (2004): Local government preferences, individual needs, and the allocation of social assistance

381 K. Telle (2004): Effects of inspections on plants' regulatory and environmental performance - evidence from Norwegian manufacturing industries

382 T. A. Galloway (2004): To What Extent Is a Transition into Employment Associated with an Exit from Poverty

383 J. F. Bjørnstad and E.Ytterstad (2004): Two-Stage Sampling from a Prediction Point of View

384 A. Bruvoll and T. Fæhn (2004): Transboundary environmental policy effects: Markets and emission leakages

385 P.V. Hansen and L. Lindholt (2004): The market power of OPEC 1973-2001

386 N. Keilman and D. Q. Pham (2004): Empirical errors and predicted errors in fertility, mortality and migration forecasts in the European Economic Area

387 G. H. Bjertnæs and T. Fæhn (2004): Energy Taxation in a Small, Open Economy: Efficiency Gains under Political Restraints

388 J.K. Dagsvik and S. Strøm (2004): Sectoral Labor Supply, Choice Restrictions and Functional Form

389 B. Halvorsen (2004): Effects of norms, warm-glow and time use on household recycling