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Risk-Aversion and Willingness to Pay in Choice Experiments

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RISK-AVERSION AND WILLINGNESS TO PAY IN CHOICE EXPERIMENTS [*]

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ABSTRACT

This paper extends the linear utility model commonly used for estimating the willingness to pay for non-market goods to a non-linear model with decreasing marginal utility. The proposed approach relaxes the assumption of constant rate of substitution between income and non-market commodities, an assumption which can be especially restrictive in cases when the non-market good is a luxury commodity or a new good whose benefits are not completely known. The adopted non-linear formulation can therefore accommodate risk-averse behavior with respect to non-market goods particularly when the non-market attributes are measured by discrete variables. The proposed models have been applied to data from a choice experiment for energy efficiency measures in apartment buildings. The econometric specification is based on a fixed-effect logit model. The results suggest that ignoring consumers' risk-aversion toward new non-market goods could lead to an underestimation of the marginal willingness to pay. However, consistent with previous studies the non-linear effect of income does not have a considerable effect on the estimation results.

Keywords: choice experiment, willingness to pay, risk aversion, energy efficiency, housing

JEL classification: Q51, C25, D12, C91

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1. Introduction

The use of choice experiments in economic evaluation of environmental goods has become increasingly popular. In these methods data on stated preferences are used to estimate the individuals' willingness to pay (WTP) for a non-market commodity or its attributes (Louviere, Hensher and Swait, 2000; Holmes and Adamowics, 2003). The WTP approach can also be used for goods that have a limited or incomplete market (Bateman et al., 2002). WTP has been defined as the maximum amount that an individual is willing to bid for a public good while remaining on her indifference curve that is without losing any utility. Namely, the WTP is the foregone pecuniary value that equates the utility with and without the non-market good.

In most applications of the WTP approach the utility function is assumed to be linear. The linearity assumption facilitates the estimation of WTP, mainly because the effect of initial utility is canceled out and the WTP remains independent of the individual's income (Hanemann, 1984). In linear utility models, any individual's WTP is equal to her rate of substitution of non-market commodity with the numeraire market good or money (Heshner, Rose and Greene, 2005). This is often referred to as the marginal WTP, which can be directly obtained from a given utility function (Freeman, 2003). Random utility models (RUM) are used to estimate the individuals' marginal WTP by estimating their utility function (cf. Birol, Smale and Gyovai, 2006; Heshner, Shore and Train, 2005; Carlsson, 2001; Hanley, Mourato and Wright, 2001). In these models the utility function is elicited by comparing the random utility of chosen offers versus the not-chosen alternatives (Train, 2003; Ben-Akiva and Lerman, 1985).

The linear utility models are especially useful when individuals have different valuations of the non-market good. In such cases Hanemann (1984) shows that assuming linear utilities, the expected value of WTP can be directly obtained from the ratio between the coefficients in a logit regression of the individuals' binary response for accepting/rejecting offers with given costs.

The linearity assumption however might be unrealistic as it implies a constant rate of substitution between the non-market commodity and market goods. Especially in many cases, the marginal utility of the non-market good might decline drastically as the highest levels of consumption are attained. For instance, should the air pollution be reduced to its minimum feasible level the consumer's WTP for any additional measure against pollution would approach zero. Moreover, the consumer's attitude might be different while evaluating risks involved in new commodities that are not widely available in the markets as opposed to those related to market goods. Due to lack of information about the (private) benefits of new goods, consumers might take a relatively risk-averse behavior as compared to market goods.

Moreover, some of the widely observed disparity between WTP and willingness to accept (WTA)[1] can be related to the non-linearity of the utility function due to risk-aversion rather than loss-aversion or irrational behavior (Coursey et al., 1987). For instance a risk-averse individual, whose utility function is concave in income, will have a higher monetary equivalent for a given income gain than for a loss of the same magnitude, thus a greater WTA compared to WTP.

Although most empirical WTP studies use a linear utility function, a few papers have explored the possibility of non-linear effect of income. The evidence is rather mixed. Using several data sets Cooper (1991) reports that the estimated mean WTP could be sensitive to the adopted functional form. Another recent study is Aiew, Nagya and Woodward (2004) that estimates WTP for irradiated ground beef from a

[1] WTA is defined as the minimum monetary compensation that suffices to make an individual forgo a non-market benefit.

choice experiment. The authors use several functional forms for the income variable and show that the differences across different specifications are not statistically significant. Cooper (2002)[2] went a step further and used semi-parametric methods to estimate the WTP from choice data with dichotomous response. Semi-parametric methods allow a fully flexible functional form, but as Cooper (2002) points out, this flexibility comes at a loss of statistical efficiency and the difficulty in the economic interpretation of the estimated coefficients.

The non-linear effect of income variable in the utility function can be interpreted as risk-aversion with respect to income or market goods. Given that the WTP in practical examples of public goods is generally a rather small fraction of the person's income, one could expect that the non-linear effect of income should not be significant. That is, the small changes in the utility function due to costs of such non-market goods can be reasonably approximated by a linear function of income. Therefore, for all practical purposes to the extent that the WTP remains a sufficiently small fraction of the income, linearity (or risk-neutrality) with respect to income is a reasonable assumption. Such an argument however does not apply to the benefits of the non-market good, which are generally bounded. Often times, especially in environmental goods, the marginal value of such benefits diminish considerably. Moreover, for the benefits that are not fully well known to the consumers, one can expect a risk-averse behavior namely, concavity of the utility function with respect to those attributes. Such behavior can be considered as a relatively low marginal WTP for higher levels of attributes. For instance, a consumer who does not benefit from an adequate insulation might have a relatively high marginal WTP for an insulated

[2] Although Cooper (2002) applied the model to contingent valuation method, the proposed semi-parametric framework can also be used in choice experiments.

window system or an air renewal system separately, but she would be unlikely to have a high WTP to accumulate both systems.

Very few studies consider the risk-aversion behavior toward the benefits of the non-market good in the estimation of WTP. This might be due to the fact that in virtually all cases the non-market good involves a discrete choice and often not quantifiable with a continuous variable. This paper shows however that using some assumptions, the non-linearity can be readily implemented in the RUM framework. The proposed method has been applied to data from a choice experiment on energy efficient air renewal and insulation systems in residential buildings. Using several functional forms it has been shown that the estimates of marginal WTP can change significantly if the non-linear effects are taken into account. The results suggest that linear utility models could underestimate WTP.

The rest of the paper is organized as follows. The methodology and utility functional forms are presented in Section 2. Section 3 describes the data and the model specification. The estimation results are presented and discussed in Section 4 and Section 5 concludes the paper.

2. Models

Suppose that an individual with income y, and a vector of characteristics Z, faces a choice between two alternative offers labeled 1 and 0. These offers are characterized by two different rents denoted by R_1 and R_0, and two vectors of non-market attributes X_1 and X_0. Vectors X_i (i=0,1) are binary-valued vectors consisting of zeros and ones, with $X_i^k = 0$ representing an alternative in which attribute k does not exist and $X_i^k = 1$ indicating a situation where that attribute is present. The individual will choose alternative 1 if and only if $U(X_1, y-R_1; Z) > U(X_0, y-R_0; Z)$, where $U(x, y;$

Z) is the individual's utility function. Here income is considered as a composite market commodity or a numeraire good that is measured in money units. This is in contrast with many WTP studies that are based on "conditional" indirect utility as a function of income and unit prices (Small and Rosen, 1981).

In the RUM framework a stochastic term is added to the above inequality. At this stage for simplicity of the illustration and without loss of generality let us abstract from such random terms as well as the individual specific characteristics Z. Let vector m denote the monetary values corresponding to the attributes represented by vector X_i (i=0,1). The linear utility model assumes a constant rate of substitution between income and the non-market good. In this case U(.) can be replaced by a linear function and the condition for choosing alternative 1 can be written as: $m.X_1+y-R_1 > m.X_0+y-R_0$, or: $m.(X_1-X_0) > R_1-R_0$. In other words the alternative is chosen if the individual's monetary valuation of the change (improvement) outweighs the difference in rent.

An extension to the linear utility model is an additively separable utility function defined by the sum of two terms u(X)+w(y), which respectively represent the utility accrued from income (market goods) and that of the non-market good. The additive separability assumption is consistent with the recently published findings from experimental neuro-economics suggesting that the rewards associated with a good and the losses associated with prices are processed in two distinct parts of the brain and then are synthesized in a third part before individuals make a purchase decision.[3] The condition for accepting the offer will then reduce to $u(X_1)+w(y-R_1) > u(X_0)+w(y-R_0)$. In general both functions u(.) and w(.) can be non-linear. However, as

[3] The findings reported by Knutson et al. (2007) suggest that price assessment, product assessment and the synthesis are respectively associated with *insular cortex*, *nucleus accumbens* and *prefrontal cortex*.

we see later the general case creates some difficulties for the estimation of the econometric models.

Although a few authors have examined the case of non-linear function for w(.), very few have considered a non-linear form for utility of the non-market good u(.). In this paper however, both cases have been considered. In addition, a special case in which both functions are non-linear is also explored. This paper argues that the non-linearity in the utility of the non-market good can have a significant effect on the WTP results while the non-linearity of income can be neglected without considerable effects. The three cases will be described in the rest of this section.

Case I: Linear in income, non-linear in attributes

In the first case income is assumed to enter in a linear form, but the utility of the non-market good is an integer root function of the attributes, namely:

$$U(X, y) = (a_0 + a.X)^{1/p} + b(y - R) \qquad (1),$$

where *p* is a positive integer, a_0 is a scalar representing the utility with a zero level of attributes *X*, *a* is a non-negative[4] vector representing the marginal values corresponding to the attribute vector *X*, and *b* is a positive number representing the marginal utility of income. Four models have been considered in this paper, namely, by setting *p* equal to 1, 2, 3 and 4.

The integer root function is a concave function thus represents a type of risk-averse preferences. In this functional form $u(X) = (a_0 + a.X)^{1/p}$, the marginal utility of the attributes decreases with the level of attributes. Namely, for attribute *k* the marginal utility will be defined as: $\frac{\partial u}{\partial X^k} = \frac{a^k}{p}(a_0 + a.X)^{\frac{1-p}{p}}$, where a^k is the marginal

[4] It is assumed that all the attributes have non-negative values

value of attribute *k*. The risk-aversion factor measured by the Arrow-Pratt coefficient is $r(X) \equiv -\frac{u''}{u'} \equiv -\frac{\frac{\partial^2 u}{(\partial X^k)^2}}{\frac{\partial u}{\partial X^k}} = \frac{p-1}{p(a_0 + a.X)}$. This means that the degree of risk-aversion is proportional to the attributes level and that higher roots represent greater aversion to risks. At p=1, the linear from with no risk-aversion ensues while with greater values for p the marginal utility and risk-aversion factor are both more sensitive to the level of attributes.

Assuming that alternative 1 has a higher level of attributes and a higher rent, the decision between alternatives 1 and 0 will therefore reduce to comparing the following utilities:

$$\begin{aligned} U_1 &= (a_0 + a.X_1)^{1/p} + b(y - R_1) \\ U_0 &= (a_0 + a.X_0)^{1/p} + b(y - R_0) \end{aligned} \qquad (2)$$

The above functions can be identified up to a shift. In other words it is the difference of utilities: $\Delta U \equiv U_1 - U_0 \geq 0$, and not the levels, that is important in the decision process. In order to simplify the equations we assume that at the base alternative (i=0), the rent compensates the utility obtained from the attributes that is:

$$(a_0 + a.X_0)^{1/p} = b.R_0 \quad \text{or} \quad U_0 = b.y \qquad (3).$$

Using the above assumption, the utility difference can be written as: $\Delta U = (a_0 + a.X_1)^{1/p} - bR_1$. Thus the individual decides to adopt alternative 1 if the benefit $(a_0 + a.X_1)^{1/p}$ outweighs the costs bR_1 (possibly with a threshold that can be interpreted as other costs or disutilities). With a monotonic transformation this comparison will reduce to comparing $\frac{a_0 + a.X_1}{R_0^p}$ with $\left(b\frac{R_1}{R_0}\right)^p$. Therefore, the utility difference ΔU can be equivalently specified as:

$$\Delta U = \frac{a_0 + a.X_1}{R_0^p} - \left(b\frac{R_1}{R_0}\right)^p \qquad (4).$$

Considering assumption (3), and denoting $\Delta X \equiv X_1 - X_0$, Equation (4) can be re-written as:

$$\Delta U = b^p + \frac{a.\Delta X}{R_0^p} - \left(b\frac{R_1}{R_0}\right)^p \qquad (5),$$

and finally:

$$\Delta U = \alpha.\Delta X + \beta.\left[1 - \left(\frac{R_1}{R_0}\right)^p\right] \qquad (6),$$

where $\alpha = \frac{1}{R_0^p}a$ and $\beta = b^p$. Notice that a and α are vectors corresponding to the attribute vector *X*. The above equation can be specified as a regression model for a choice between alternatives 0 and 1, and in which the explanatory variables include the attribute differences between the two alternatives and an income variable defined by: $1 - \left(\frac{R_1}{R_0}\right)^p$, with α and β being the parameters to estimate.

The regression models also include individual fixed effects that capture the overall effects of individual characteristics on the probability of choosing alternative 1 over the base alternative. These effects can be included in the model thanks to repeated observations for the same individuals as will be seen in the data section.

In order to estimate the WTP for a given attribute X^k we compare the utility obtained from the base alternative 0, with an alternative 1 that is similar to the base alternative in all respects except attribute *k* and rent. Namely attribute *k* is not present in alternative 0 but it exists in alternative 1 which therefore has a higher rent. The willingness-to-pay (WTP) for attribute *k* (denoted by w^k) can be defined as the rent increase that makes the two utilities equal namely: $U_1 = U_0$. Using Equations (2) and (3), it can be shown that w^k must satisfy the following condition:

$$(a_0 + a.X_0 + a^k)^{1/p} + b(y - R_0 - w^k) = b.y \qquad (7).$$

Alternatively, these two alternatives with rents R_0 and $R_1 = R_0 + w^k$ must produce no utility difference, which using Equation (6) can be written as:

$$\Delta U = \alpha^k - \beta.\left[\left(\frac{R_0 + w^k}{R_0}\right)^p - 1\right] = 0 \qquad (8),$$

or:

$$\beta + \alpha^k = \beta.\left(1 + \frac{w^k}{R_0}\right)^p \qquad (9),$$

where $\alpha^k = \frac{1}{R_0^p} a^k$. Using the Taylor approximation around zero the above equation reduces to:

$$\beta + \alpha^k = \beta.\left(1 + p\omega + p(p-1)\omega^2 + ...\right) \qquad (10),$$

where $\omega = \frac{w^k}{R_0}$. Assuming that the WTP for an attribute in an apartment is a small fraction of the rent, the second-order term can be neglected, in which case a linear approximation of the WTP can be obtained by:

$$\omega^k = \frac{w^k}{R_0} \cong \frac{\alpha^k}{p.\beta} \qquad (11).$$

It should be noted that the linear approximation used in Equation (11) is equivalent to substituting WTP by the marginal willingness-to-pay (MWTP), that is the ratio of marginal utility of a given attribute to that of income: $MWTP^k \equiv \frac{\partial U}{\partial X^k} \Big/ \frac{\partial U}{\partial y}$.

Only in two simple cases where p is equal to 1 or 2, the WTP can be calculated without approximation. In the linear case $p = 1$, the WTP can be simply obtained from $\omega^k = \frac{w^k}{R_0} = \frac{\alpha^k}{\beta}$. In the quadratic case $p = 2$, Equation (9) reduces to the quadratic equation $\omega^2 + 2\omega - \alpha^k/\beta = 0$, whose only positive root will be the exact value of the WTP, that is:

$$\omega^k = \frac{w^k}{R_0} = \sqrt{1 + \frac{\alpha^k}{\beta}} - 1 \qquad (12).$$

Case II: Linear in attributes, non-linear in income

In this case, the utility of the non-market good is assumed to be linear, but the income utility is non-linear. The following general form has been considered:

$$U(X, y) = a_0 + a.X + b.u(y - R) \qquad (13),$$

where u is a non-linear function representing the utility of income and a_0, a and b are defined similar to those in Equation (1). Two functional forms have been considered: square root, $u(y) = \sqrt{y}$, and logarithmic form, $u(y) = \log(y)$. These utility functions represent a risk-averse behavior with respect to market goods (represented by income) and a risk-neutral attitude toward non-market goods.

The key assumption similar to Equation (3) in the previous case, is that at the base alternative the rent compensates the attributes in terms of utility, namely:

$$U_0 = a_0 + a.X_0 + b.u(y - R_0) = b.u(y) \qquad (14).$$

And the utility difference between the two alternatives $(\Delta U = U_1 - U_0)$ can be written as:

$$\Delta U = a.\Delta X + b\left[u(y - R_1) - u(y - R_0)\right] \qquad (15).$$

Assuming that the individual's income is ρ times their rent that is, $y = \rho R_0$, the above equation reduces to:

$$\Delta U = a.\Delta X + b.u(\rho - R_1/R_0) - b.u(\rho - 1) \qquad (16),$$

where *a* and *b* are the parameters to estimate and assuming a constant value for ρ and a functional form for *u*, the explanatory variables ΔX and $u(\rho - R_1/R_0)$ can be determined and the last term $-b.u(\rho - 1)$, is a constant that will be captured by the regression intercept.

The marginal WTP for attribute *k* can be estimated using the partial derivatives of Equation (13):

$$w^k = MWTP^k \equiv \frac{\partial U}{\partial X^k} \Big/ \frac{\partial U}{\partial y} = \frac{a^k}{b.u'(y - R_0)} \qquad (17).$$

Using the above equation and the income-rent proportionality assumption, $y = \rho R_0$, the marginal WTP for square-root and logarithmic functional forms can be obtained as:

$$\omega^k = \frac{w^k}{R_0} = \begin{cases} \dfrac{2a^k\sqrt{\rho - 1}}{b} & \text{for: } u(y) = \sqrt{y} \\ \dfrac{a^k(\rho - 1)}{b} & \text{for: } u(y) = \log(y) \end{cases} \qquad (18).$$

Case III: Non-linear in both attributes and income

Only one case with square-root function has been considered here. Similar to above, it is assumed that the utility is an additive separable function of non-market attributes and income, defined as:

$$U(X, y) = \sqrt{a_0 + a.X} + \sqrt{b.(y - R)} \qquad (19),$$

where all the parameters are defined above similar to those in Equation (1). Similarly, the marginal utility of income and that of attribute *k* are respectively obtained by: $\frac{\partial u}{\partial X^k} = \frac{a^k}{2\sqrt{a_0 + a.X}}$, and $\frac{\partial u}{\partial y} = \frac{b}{2\sqrt{b(y-R)}}$. With a decreasing marginal utility in both income and attributes, this functional form assumes risk-averse behavior regarding both market and non-market goods.

The utilities of alternatives 0 and 1 can be written similarly to Equation (2) in case *I*. Similarly, it is assumed that at the base alternative the rent compensates the utility obtained from the attributes that is:

$$U_0 = \sqrt{a_0 + a.X_0} + \sqrt{b.(y - R_0)} = \sqrt{b.y} \qquad (20).$$

Using the above assumption, the condition for the selection of alternative 1 over the base alternative 0, can be written as the following inequality:

$$U_1 = \sqrt{a_0 + a.X_1} + \sqrt{b.(y - R_1)} \ > \ U_0 = \sqrt{b.y} \qquad (21),$$

or alternatively:

$$a_0 + a.X_1 > b\left(\sqrt{y} - \sqrt{y - R_1}\right)^2 \qquad (22).$$

Using Equation (20) and noting that $X_1 = X_0 + \Delta X$, the above inequality reduces to:

$$a.\Delta X > b\left[\left(\sqrt{y} - \sqrt{y - R_1}\right)^2 - \left(\sqrt{y} - \sqrt{y - R_0}\right)^2\right] \qquad (23).$$

Assuming the proportionality of individual's income to rent that is: $y = \rho R_0$, the above inequality can be written as:

$$\frac{1}{R_0} a.\Delta X > b\left[\left(\sqrt{\rho} - \sqrt{\rho - R_1/R_0}\right)^2 - \left(\sqrt{\rho} - \sqrt{\rho - 1}\right)^2\right] \quad (24).$$

Therefore, the utility difference $\Delta U = U_1 - U_0$ can be equivalently defined as:

$$\Delta U = \alpha.\Delta X + b\left[\kappa - \left(\sqrt{\rho} - \sqrt{\rho - R_1/R_0}\right)^2\right] \quad (25),$$

where $\alpha = \frac{1}{R_0} a$ and b are the regression parameters to estimate; and $\kappa = \left(\sqrt{\rho} - \sqrt{\rho - 1}\right)^2$, which, assuming a constant value for ρ, will be captured by the regression intercept.

The marginal WTP for attribute k, evaluated at the base alternative (0) can be estimated using the partial derivatives of Equation (19):

$$w^k = MWTP^k \equiv \frac{\partial U}{\partial X^k} \bigg/ \frac{\partial U}{\partial y} = \frac{a^k \sqrt{b(y - R_0)}}{b\sqrt{a_0 + a.X_0}} \quad (26),$$

or by substituting $\sqrt{a_0 + a.X_0}$ using Equation (20) and dividing by R_0:

$$\omega^k = \frac{w^k}{R_0} = \frac{\alpha^k}{b} . \frac{\sqrt{\rho - 1}}{\left(\sqrt{\rho - 1} - \sqrt{\rho}\right)} \quad (27).$$

Seven models have been considered in this paper. The regression models based on linear utility and three non-linear models from case *I* are given in Equation (6). The two regression models with nonlinear utility for income (case *II*) are based on Equation (16) and the regressions for non-linear utility model (case *III*) are based on Equation (25). The regression models in all cases are specified as logit models with individual fixed effects.[5] The individual fixed effects capture the overall effect of the individual characteristics on responses.

3. Data and specification

The data used in this paper are extracted from the data collected through a choice experiment reported by Banfi et al. (2007) and Ott et al. (2006). This paper focuses on a sub-sample of that data set, consisting of the results of a choice experiment conducted on a sample of tenants of apartment buildings in Switzerland. The respondents were repeatedly offered an alterative housing with various levels of energy-saving systems and were asked if they would prefer the offered alternative to their status quo housing.

In each choice situation the respondent was provided with a choice card including the characteristics of the offered alternative along with those of her(his) status quo housing. These characteristics consist of monthly rent, window and facade insulation each defined in four levels (none, low, standard, enhanced) and ventilation (with or without air renewal). The alternatives are constructed by improving or deleting some of the actually available amenities in status quo. The alternative's monthly rent is specified based on the modifications of the status quo considering a decrease or increase of 0 to 25 percent of the actual rent (ranging mostly from -300 to 300 Francs per month). A factorial random design has been used to assign the levels of attributes and rents in various alternatives and the dominated alternatives have been excluded.[6]

[5] See Hsiao (2003) and Chamberlain (1980) for a detailed description of fixed-effect logit model. See also Ferrer-i-Carbonell and Frijters (2004) and Banfi et al. (2007) for applications of this model.
[6] See Banfi et al. (2007) for more details about the experiment design.

In order to avoid complications in modeling, this paper focuses on choice cards in which the alternative is unambiguously "superior" or "inferior" to the status quo regarding the energy-saving amenities. That is, the alternatives that are characterized by improvement in some aspects and deterioration in other aspects (e.g. better windows but worse ventilation system) are excluded from the sample. Moreover, the positive response is defined as the selection of the superior alternative in terms of energy-saving attributes.[7] It should be noted that the superior alternative in some cases is the status quo and in others is the offered hypothetical alternative.

This simplification allows a clearer distinction of WTP from WTA and a better interpretation of the individual fixed effects. In other words, the respondents who have a tendency to choosing better and more expensive alternatives are expected to have a greater intercept and those who have a preference for cheaper but environmentally less friendly options have a lower intercept. Given that the fixed effects model can only use the respondents that show some variation, the individuals who have always selected the "superior" or the "inferior" option are excluded from the sample. The final sample consists of 941 observations from 183 respondents.

The regression equations are specified as fixed effect logit models with a binary response variable that takes value of one (zero) if the respondent has selected the alternative with superior (inferior) amenities. The explanatory variables are specified in two groups: product attributes and income variables.[8] Table 1 provides the descriptive statistics of the main variables included in the analysis.

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[7] The alternative that is superior in terms of quality attributes is evidently more expensive. However, there are a few choice cards (total of 81 representing 8.6% of the sample) in which the prices are equal. In all these cases the hypothetical offer is superior to the status quo. These offers had a high positive response rate (72.8%), but still are not accepted by all respondents. This can be explained by the disutility that people could consider through moving or attachment to their status quo.

[8] Because of the individual fixed effects, the respondent's characteristics could only be included as interactions with variables that change across choice cards. Preliminary regressions showed that various interaction terms including available characteristics such as education and income proxies did

Table 1: Descriptive statistics

	Status Quo		Hypothetical Alternatives	
	Mean	Std Dev	Mean	Std Dev
Monthly rent (Swiss Francs)	1650	790	1724	828
Enhanced window insulation (triple glazing)	.142	.350	.301	.459
Standard window insulation (rubber sealing)	.661	.475	.414	.493
Low window insulation (old)	.164	.371	.162	.368
Non-insulated windows (very old)	.0328	.179	.123	.329
Enhanced facade insulation	.246	.432	.335	.472
Standard facade insulation	.355	.480	.433	.496
Low facade insulation (newly repainted)	.142	.350	.0723	.259
Non-insulated facade (old)	.257	.438	.160	.367
Ventilation (air renewal system)	.197	.399	.548	.498
New building (constructed after 1995)	.377	.486	–	–
Status quo amenities are superior to those offered in the hypothetical alternative (Dummy variable SQ)	–	–	.375	.484
Positive response (superior option selected)	–	–	.447	.497
Number of choice cards per respondent [a]	5.14	1.96	–	–
Number of choice cards with positive response	2.30	1.42	–	–
Number of observations	183		941	

[a)] Number of choice cards varies from 2 to 10 cards per respondent.

The attribute variables consist of the vector of differences in the system's attributes denoted by $\Delta X \equiv X_1 - X_0$, in the regression Equations (6), (16) and (25), where X_1 and X_0 are respectively the attributes of the alternatives with superior and inferior amenities. Therefore, each one of these variables represents the improvement between the corresponding dummies between the two alternatives. These variables are all binary variables that represent 4 types of window insulation, 4 types of facade insulation and two categories for ventilation system. The omitted base category is always defined as the lowest category with the minimum amenities. For ventilation system, an interaction term has been included to distinguish the effect of ventilation in old and new buildings. The income variables represent the income loss or the opportunity costs of improving the amenities. These variables are defined according

not have any statistically significant effect on the choice probabilities, suggesting that the fixed effects capture an important part of the respondents' heterogeneity.

to the second term of the regression Equations (6), (16) and (25), based on the ratio of the rents in the two alternatives $\left(R_1/R_0 \right)$, with R_1 and R_0 being respectively the rents associated with superior and inferior amenities. It should be noted that these variables are defined in such a way that their corresponding coefficient (*b* or β) represent the positive marginal utility of income denoted by *b*, in Equations (1), (13) or (19).

An asymmetry in the respondents' preferences observed in the experimental data used in this paper has been reported in Banfi et al. (2007), in that the individuals who are currently using an attribute show a relatively high valuation of that attribute. Moreover, individuals have a tendency to choose their status quo more often than expected suggesting that switching from status quo could create a disutility. These results are consistent with several previous studies (Horowitz and McConnell, 2002 and Sayman and Öcüer, 2005) that observed a disparity between WTP and WTA (monetary compensation in order for the individual to give up a good).

In this paper, assuming that the asymmetry effect is driven by attachment to status quo as well as a difference in marginal effects of attributes and income, the effect is modeled through differentiating the regression coefficients and intercept between the two cases.[9] Namely, a dummy variable denoted by *SQ* (Status Quo), is constructed to distinguish the choice cards in which the status quo provides the superior amenities. In these cases the average incidence of positive response and the marginal valuation of both income and attributes are expected to be relatively high. The binary variable and its interaction with all attributes and income variable are therefore included to capture these differences. All these variables are expected to have a positive coefficient.

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[9] See Scarpa, Ferrini and Willis (2005) for a discussion of various methods of modeling the status-quo effects.

Several preliminary regressions with various models have however shown that while the main effect is invariably significant and has the expected sign, the interaction terms with the attributes are consistently insignificant. The interaction term with income variable shows a mixed pattern, being positive across all models, but significant in some models. In the final specification in order to avoid additional estimation errors by including irrelevant variables and keep the number of parameters to sensible limits, the interaction terms with attributes have been excluded. It should be noted while pointing to some asymmetry in preferences the above results show that because of large estimation errors, with the available data a sensible estimation of WTA will be quite difficult. Therefore, in this paper the focus lies upon estimating the WTP.

Because of high number of missing values and invalid records, the available data does not provide a reliable measure of the respondents' incomes. This does not create any problem in the first four models as in Equation (1), where the utility is a linear function of income. The other three models that consider the non-linearity of income utility are based on the assumption that the household's income is approximately proportional to their apartment's rent. The income-rent ratio is assumed to be constant across all individuals. In the estimations, three different values (3, 4 and 5) have been considered. These estimations show that the results are not sensitive to the income-rent ratio. In the final estimations reported in this paper a value of 4 has been assumed.

4. Results

The regression results obtained from models 1 to 4 are provided in Table 2. Model 1 is the classical linear model. In other three models the utility of attributes is non-linear. The estimation results indicate a reasonable explanatory power for the adopted models. Comparing the estimation results across different models indicates that all four models show a more or less similar pattern. However, the coefficients vary rather significantly across various models. As expected, the coefficients of income variable and all energy-saving attributes are positive. Except for the low-insulation levels, all other attributes have a statistically significant marginal value. The valuation of air renewal systems is higher in new buildings but the difference is not statistically significant.

Table 2: Regression results (Case *I*: utility linear in income)

	Linear model	Utility nonlinear in attributes		
	Model 1 (p=1)	Model 2 (p=2)	Model 3 (p=3)	Model 4 (p=4)
Income variable	19.553** (2.51)	8.795** (1.13)	5.250** (.68)	3.509** (.46)
SQ * Income variable	5.069 (5.56)	5.553^ (3.16)	5.834* (2.41)	6.073** (2.08)
SQ (status quo amenities are superior)	6.485** (1.14)	6.804** (1.18)	7.138** (1.22)	7.489** (1.26)
Ventilation (air renewal system)	0.873* (.39)	0.917* (.39)	0.959* (.39)	0.998* (.39)
Ventilation * New building (constructed after 1995)	0.122 (.56)	0.081 (.56)	0.044 (.56)	0.011 (.56)
Enhanced window insulation (triple glazing) [a]	2.714** (.79)	2.720** (.79)	2.724** (.80)	2.726** (.80)
Standard window insulation (rubber sealing) [a]	2.461** (.71)	2.490** (.72)	2.518** (.72)	2.543** (.73)
Low window insulation (old) [a]	0.783 (.55)	0.760 (.56)	0.736 (.56)	0.712 (.56)
Enhanced facade insulation [b]	1.588** (.57)	1.627** (.57)	1.668** (.57)	1.711** (.57)
Standard facade insulation [b]	1.359** (.48)	1.420** (.48)	1.482** (.49)	1.545** (.49)
Low facade insulation (newly repainted) [b]	0.864^ (.51)	0.897^ (.52)	0.932^ (.52)	0.968^ (.53)
Log likelihood	-147.98	-148.31	-148.75	-149.31
Pseudo R-square	0.5989	0.5981	0.5969	0.5953

[a)] The omitted window category is non-insulated windows (very old).

[b)] The omitted facade category is non-insulated facade (old).

** significant at p<.01; * significant at p<.05; ^ significant at p<.1; Standard errors are given in parentheses.

Models are based on Equation (6), with the income variable defined as: $1-(R_1/R_0)^p$, R_1 and R_0 being the monthly rents with $R_1 \geq R_0$.

The results (Table 2) also suggest that when the status quo represents superior amenities compared to the offered alternative, the respondent is relatively more likely to choose the better option (positive effect of the Status Quo dummy). The interaction of SQ dummy with the income variable has also a positive effect but only borderline significant. This implies that the marginal utility of income is slightly higher when individuals consider alternative options that are lower than their actual choices. These results suggest an asymmetry in the responses: Individuals not only have a tendency to stick to their actual choices (status quo inertia) but they could also show different valuations before and after using a product. The positive interaction effect is not entirely consistent with the assumption that the individuals who have experienced a product have a better valuation of its attributes. However, as mentioned before, the identification of the latter kind of asymmetries is hardly possible with the available data. In fact, any asymmetric effect could be suppressed into the dominant inertia effect captured by the SQ dummy. The only consistent conclusion here is that when the attributes are assumed to have a linear effect on utility, the SQ shift is sufficient to capture all the asymmetric effect, whereas in non-linear cases the difference in slopes could also be considerable.

The regression results obtained from models 5 to 7 (non-linear in income) are provided in Table 3. In models 5 and 6 the utility function is linear in attributes, while in model 7 both income and attributes enter with a non-linear form. In general similar patterns can be observed. Comparing the results in Table 2Table 3 indicates similar coefficients for the attributes across all the seven models. However, the asymmetric effects in relation to the status quo are sensitive to the specification. Consistent with the previous results (Table 2), the results of Table 3 suggest that as long as the utility is linear in attributes the asymmetric effects can be completely represented by a shift in the utility function through the SQ dummy. However, assuming non-linearity in attributes changes the results in that not only will there be a shift, the function's derivatives could also change. In these cases, the asymmetry manifests as two separate but inter-related effects whose interpretation is quite difficult. Model 7 presents a clear example: In this model the SQ effect is negative, suggesting a counter-intuitive desire to deviate from the status quo. However, this effect might be counterbalanced by the positive and strong effect of the interaction effect of income variable.

Table 3: Regression results (Case *II* and *III*: utility non-linear in income)

	Linear in attributes		Non-linear in attributes
	Model 5 (log form)	Model 6 (square root)	Model 7 (square root)
Income variable	56.50** (7.25)	66.48** (8.53)	110.48** (14.21)
SQ * Income variable	20.92 (17.29)	20.85 (19.60)	81.29^ (42.03)
SQ (status quo amenities are superior)	153.71** (21.39)	272.93** (37.71)	-14.82** (2.48)
Ventilation (air renewal system)	0.890* (.39)	0.882* (.39)	0.929* (.39)
Ventilation * New building (constructed after 1995)	0.106 (.56)	0.114 (.56)	0.070 (.56)
Enhanced window insulation (triple glazing) [a]	2.720** (.79)	2.717** (.79)	2.723** (.79)
Standard window insulation (rubber sealing) [a]	2.475** (.71)	2.468** (.71)	2.500** (.72)
Low window insulation (old) [a]	0.778 (.55)	0.780 (.55)	0.756 (.56)
Enhanced facade insulation [b]	1.602** (.57)	1.595** (.57)	1.638** (.57)
Standard facade insulation [b]	1.382** (.48)	1.370** (.48)	1.437** (.48)
Low facade insulation (newly repainted) [b]	0.877^ (.51)	0.871^ (.51)	0.906^ (.52)
Log likelihood	-148.10	-148.04	-148.42
Pseudo R-square	0.5986	0.5988	0.5978

[a)] The omitted window category is non-insulated windows (very old).

[b)] The omitted facade category is non-insulated facade (old).

** significant at p<.01; * significant at p<.05; ^ significant at p<.1; Standard errors are given in parentheses.

Models 5 and 6 are based on Equation (16); Model 7 is based on Equation (25). The income variables are defined in those equations with R_1 and R_0 being the monthly rents with $R_1 \geq R_0$. Income-rent ratio ($\rho = y/R_0$) is set equal to 4.

The estimated values of WTP are listed in Table 4. These results point to several patterns regarding non-linear effects. First, the results obtained from the first four models indicate that the WTP estimates increase as the non-linearity effect becomes stronger. This is a general pattern that can be observed consistently across all attributes. This implies that if the utility is non-linear in terms of non-market goods, in other words if the respondents are risk-averse with respect to these goods, the mis-specification of the utility function with a linear model, will lead to an underestimation of marginal WTP. A similar result can be drawn by comparing the estimates between models 5 and 7. Model 7 is similar to model 5 in that both have a non-linear utility function with square root of income. The difference is that model 7 accounts for non-linearity in attributes, which result in a uniform increase in the WTP estimates.

Table 4: Estimates of the marginal willingness-to-pay

	Linear	Non-linear in attributes only			Non-linear in income only		Non-linear
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Window (Standard to Enhanced)	1.29	1.29	1.31	1.30	1.30	1.30	1.30
Facade (Standard to Enhanced)	1.17	1.17	1.18	1.18	1.17	1.17	1.18
Ventilation in new buildings [a]	5.09*	5.52*	6.37*	7.19*	5.29*	5.19*	5.85*
Ventilation in old buildings [b]	4.46*	5.08*	6.09*	7.11**	4.73*	4.59*	5.44*
Window (Low to Standard)	8.58**	9.40**	11.31**	13.05**	9.01**	8.80**	10.21**
Window (None to Low-insulation)	4.00	4.23	4.68	5.08	4.13	4.07	4.42
Facade (Low to Standard)	2.53	2.93	3.50	4.11	2.68	2.60	3.10
Facade (None to Low-insulation)	4.42^	4.98^	5.92^	6.90^	4.66^	4.54^	5.30^

[a)] Constructed after 1995.

[b)] Constructed in 1995 or before.

** significant at p<.01; * significant at p<.05; ^ significant at p<.1.

WTP estimates are given as percentage of the monthly rent.

The second pattern observed in Table 4, is related to non-linearity in income. Comparing models 1, 5 and 6 indicates that the WTP estimates, while being slightly higher in non-linear models, are generally similar across the three models. This suggests that the linear approximation in terms of income shows a quite reasonable performance. This result is consistent with the previous results reported by Aiew, Nagya and Woodward (2004).

5. Conclusion

This paper proposes a methodological framework to consider the non-linearity of the utility function in terms of non-market goods that are defined by qualitative discrete variables. This is the case of many non-market, public and environmental goods that are not divisible and are consumed only once. For instance, building insulation can only be measured by discrete variables. The proposed models have important applications in choice experiments conducted for the evaluation of new goods because the consumers could show a risk-averse behavior because of lack of information on the good's benefits. Moreover, such models can solve the general shortcoming of the linear models in assuming constant rate of substitution between non-market goods and other commodities. Such behaviors should be modeled by non-linear functional forms. In particular, the linearity assumption appears to be too restrictive for exploring some of the peculiarities observed in choice experiments such as disparity between willingness-to-pay and willingness-to-accept.

The proposed models have been applied to experimental data from a survey about the use of energy-saving insulation measures in residential buildings. Most of these systems are new goods that are not commonly available and used in the markets. The purpose of the exercise is to estimate the consumers' willing-to-pay for these systems. This application shows that the proposed models can be useful to explore the effects of non-linearity in market commodities (income) and that of non-market goods. Comparing the estimates across different models shows two important patterns that are consistently observed: First, assuming that utility function is linear in income appears to be a reasonably good approximation. The non-linearity in income does not affect the results significantly. Second, the non-linearity of utility function in non-market attributes has a considerable effect on the willingness-to-pay estimates. Mis-specification of risk-averse behavior with a linear model could lead to an underestimation of the willingness-to-pay.

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