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Is the Environment a Luxury? An Empirical Investigation using Revealed Preferences and Household Production

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Abstract - This paper addresses the issue of whether environmental quality is a luxury good meaning that its demand increases more than proportionally with respect to income. We use demand analysis combined with household production to estimate the marginal willingness to pay for improvements in air quality in Italy and the corresponding income elasticity of willingness to pay. Choice based data on Italian households' current consumption expenditures from January 1999 to December 2006 merged with an air quality index are used. We consistently find that the income elasticity of willingness to pay for environmental quality is very close to one across income groups and that it decreases as a percentage of income as income increases with interesting implications for environmental policy. Besides contributing to a strand of literature where there is very scant empirical evidence, this paper provides the first attempt at estimating willingness to pay and its income elasticity using revealed preferences combined with household production.

JEL Classification: H22, H23, D63
Key words: household production; mixed demand systems; integrability; income elasticity of willingness to pay.

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1 Introduction

Is environmental quality a luxury ? This paper addresses the issue of whether benefits from environmental policy are larger for the rich than for the poor. Distributional issues, in particular how the net benefits of environmental improvements will be distributed by income levels, are very important when evaluating reforms, like the Kyoto protocol, that will affect other countries or generations or different groups of citizens within a country. Depending upon the distribution of costs and benefits, environmental policies may favor the rich in the sense that net benefits are larger for individuals with high incomes than for those with low incomes. The degree of progressiveness of environmental benefits may limit a policy's political appeal. If environmental benefits are progressively distributed, opponents of environmental policies, both at the micro and macro levels (think of the U.S. refusal to ratify the Kyoto protocol), could ground their arguments on distributional issues because, in the words of Beckerman (1974): *"...excessive concern with the environment is basically middle class "* and, paradoxically, it could be argued that further implementation of environmental policies could result in a redistribution against lower income groups. Correctly measuring the incidence of environmental policies is therefore crucial for assessing their distributional effects and has very important economic and political consequences. In general, measures producing positive and large net benefits across income groups are likely to receive the largest political support.

It is widely hypothesized that environmental quality is a luxury and its demand increases more than proportionally with respect to income. In this case extra provision of environmental quality will benefit the rich more than the poor (Baumol and Oates, 1988; McFadden, 1994) meaning that the rich are willing to pay more than the poor for environmental quality improvements. Also, the inverted "U" findings linking income to environmental quality (Environmental Kuznets Curve) offer some evidence that the net benefits of environmental regulation increase at higher income levels, so that economic growth can be considered a general cure for environmental damage (Grossman and Krueger, 1995). However, the observed trends for environmental quality demand are the results of social choice processes rather than of individual preferences (Flores and Carson, 1997).

Environmental benefits, expressed as a fraction of income, are progressively distributed when they rise with income. In this case environmental policies are pro-rich. Environmental benefits are, instead, regressively distributed, and environmental policies are pro-poor, when they fall with income[1].

A crucial parameter to measure incidence is the income elasticity of demand. This is the percentage variation in the quantity demanded of a good following a one percent variation in income. Because of their public good nature, the quantity of most environmental goods is rationed and a different elasticity is the relevant parameter: the income elasticity of willingness to pay (WTP) for a fixed quantity of the public good.

[1]Turning to environmental costs, rather than benefits, they will be progressively (pro-poor) distributed when they rise with income and regressively (pro-rich) distributed when they fall with income.

The relationship between these two elasticities is not determinate (Flores and Carson, 1997). When more than one public good is involved it may well be that a good with an income elasticity of demand greater than one (a luxury) has an income elasticity of WTP that is substantially less than one. The intuition of such values of the two relevant elasticities is best expressed by Flores and Carson (1997, p. 294): *"the rich man may buy proportionately more loaves of bread than the poor, but this does not imply he is willing to pay proportionately more for the same loaf"* . Turning to environmental issues, it may well be that the rich man demands proportionately more clean air than his poorer counterpart, but this does not necessarily imply that he is willing to pay proportionately more than the poor for an additional unit of clean air. This turns out to be exactly our finding.

When the income elasticity of willingness to pay is considered as the incidence measure, one finds some evidence against the common conviction that the income elasticity of demand is greater than one and the environment is thus a luxury. Kriström and Riera (1996) estimated the income elasticity of willingness to pay for environmental improvements for a number of European data sets finding that the value of this parameter is consistently less than one. A related and striking example comes from the literature on donations, also quoted in Kriström and Riera. Data on donations in the U.S. show that people in lower income brackets report higher donations relative to income than their richer counterpart, i.e. they are willing to pay proportionately more. The same holds true when corporate donations are examined (Navarro, 1988): donations from corporate institutions are income inelastic independently of the recipient of the donation.

Our purpose is to provide estimates of the WTP and of the income elasticity of WTP for improvements in air quality in Italy using a new methodological approach, suggested by Ebert (2007), and a new data set. Besides contributing to a strand of literature where there is surprisingly little empirical evidence, this is the first attempt at using demand analysis combined with the household production framework to estimate WTP for a non market good. To this aim we combine data on households monthly current expenditure and a unique data set containing physical data on air pollution concentrations and we estimate a complete conditional demand system for market goods augmented by a WTP function.

We find an income elasticity of WTP not significantly different from one across income groups. We also find that WTP for marginal improvements in air quality rises less than proportionally with respect to income. This may be because richer people use environmental substitutes to a larger extent that poorer people do. Therefore, they may be willing to pay less, in relation to income, than their poorer counterpart. Low income members of society seem to attach a higher value to environmental benefits and goods maybe because less substitutes are available to them: clean public beaches mean more to the man who cannot afford paying to go to a private uncontaminated beach than to the man who can. This intuition is likely to hold for most environmental goods, but also for other public goods (Aaron and McGuire, 1970): public swimming pools mean less to the man who owns a pool than to the man who doesn't.

This finding has important policy implications. Growth in income and in environmental quality could be decoupled, as higher income groups would not show stronger preferences for environmental quality than lower income groups do. Cost-benefit analysis of environmental project would also be affected, because ignoring the real incidence of social projects may produce decisions that are ”biased” against the poor[2]. Moreover, the income elasticity of environmental benefits is important for shaping efficient environmental policies. Chichilnisky and Heal (1994) show that, in international agreements for curbing carbon-dioxide emissions, poorer countries should be allocated larger shares of the total number of emissions' rights at an efficient allocation, if the income elasticity of WTP is between zero and one. Finally, the political appeal of environmental policies would be increased rather than limited, since low income groups would benefit from environmental improvements in a proportional way.

The remainder of the paper is structured as follows. Section 2 reviews the literature on the methods for estimating the demand for non market goods and on the measures of incidence of environmental benefits. Section 3 introduces the approach based on revealed preferences and household production used to estimate the willingness to pay for air quality improvements. The specification of the demand system, the data, the estimation strategy and the results are presented in sections 4 and 5. Section 6 contains a discussion of the main findings. Section 7 concludes.

2 Demand for Non Market Goods and Measures of Benefits Incidence

We face two main problems when trying to evaluate environmental goods: first they are not traded in markets, therefore it is not possible to observe prices. Second, even though prices were observable, they might not reflect the consumer's marginal willingness to pay, because the quantity of an environmental good is typically rationed and cannot be modified by consumers, at least in the short run. Because of the public good nature of environmental commodities, the relevant incidence measure is not the income elasticity of demand, but the income elasticity of willingness to pay (Kriström and Riera, 1996). In this section we review both issues: how to estimate WTP and how to measure benefits incidence.

Different approaches have been adopted since the seventies for estimating the demand for public goods. The first was a collective choice approach based on the median voter theorem (Boercherding and Deacon, 1972; Bergstrom and Goodman, 1973). It assumes that political decisions about the level of expenditures on public goods will be identical to the quantity demanded by the median voter. The expenditure of any mu-

[2]Given the use of the Hicks-Kaldor compensation criterion, a project resulting in a regressive distribution of environmental benefits is less likely to pass than a project that would primarily benefit high income groups. This is because the social profitability of the project is decided by the sum of WTPs and rich people have a higher WTP than poor people (Hökby and Söderqvist, 2003). Therefore, the finding that environmental benefits are regressively distributed suggests the need to use appropriate weights taking into account the distribution of costs and benefits of projects.

nicipality on a public good is assumed to be an observation on the demand curve for the consumer characterized by the median income of that municipality. This approach has been partially outdated in recent years. Champ et al. (2003), Freeman (2003), and Mäler and Vincent (2005) provide useful and broad overviews.

The hedonic and location choice approaches have been widely used, since the seminal paper by Rosen (1974), for measuring the value of public goods, including clean air, especially in the United States. The appeal of this approach is given by the use of observed behavior in the housing and labor markets to infer the value of non-market goods. The marginal willingness to pay for public goods is measured, in this case, by their implicit prices, as reflected in housing prices and wages. Recent methodological innovations can be found in Bajari and Benkard (2005), Ekeland et al. (2004), and Bayer and Kehoane (2009). In particular, Bayer and Kehoane (2009) show how migration costs can be incorporated into a hedonic analysis, including migration into the canonical wage-hedonic model (Roback, 1982).

Another important survey based approach was introduced by Bergstrom et al.(1982) who fitted demand equations for local public services on data from a household survey on demands for public spending supplied by the University of Michigan. This was followed by the flourishing of contingent valuation (CV) studies using stated preferences to estimate WTP for public goods, such as Ktristrom and Reira (1997), Alberini et al. (1997), Hokby and Söderqvist (2003), Schläpfer (2006) to cite a few.

Finally, the averting behavior approach employs the demand for market goods as a proxy for environmental goods or services (Costa, 1997; Pereyra and Rossi, 1998; Ghalwash, 2006). Several studies - such as Berger et al. (1987), Dickie and Gerking (1991), Bresnahan et al. (1997) and Mansfield et al. (2006) among others - used averting behavior to obtain WTP values for a reduction in exposure to air pollutants or in the symptoms that result from it. Dickie and Gerking (1991), for example, present an application of the household production approach to valuing public goods. Technical relationships are estimated between health attributes, private goods that affect health, and air quality and results show that individuals equate marginal rates of technical substitution in household production with relevant price ratios. Differently, Mansfield et al. (2006) combine stated preference and averting behavior data to estimate parents' WTP for a decrease in children exposure to ozone pollution. Berger et al. (1987) develop a model to evaluate changes in risks to human health and derive the willingness to pay using both cost of illness and averting expenditures including air conditioners.

This work does not fall in either of the previous groups. It is instead more in line with the works of Harrison and Rubinfeld (1978a, 1978b) who used a revealed preference approach - housing values - and market data to estimate the WTP for marginal improvements in air quality in the area of Boston. We use averting behavior combined with demand analysis. More precisely, we adopt the approach proposed by Ebert (2007), dealing with the possibility of recovering the consumer underlying preference ordering from observed behavior when non market goods are employed in household production. In this case preferences can be recovered if a corresponding mixed demand system can be integrated.

Our main and final purpose is to produce measures of incidence of environmental quality improvements. Flores and Carson (1997) and Ebert (2003) adopt a standard rationed model of consumption (Deaton and Muellbauer, 1980a). Here consumers, who possess the same preference ordering, have convex preferences over n market goods, denoted by the vector x and k public goods, denoted by the vector q. Consumers may freely choose the levels of x, but face quantity rationing over the levels of q. Virtual prices are defined (Flores and Carson, 1997) as those that would induce choosing the same levels of x and q as those resulting under rationing of $q : p^v$. Thus a virtual price is an inverse demand function that depends on the levels of p, q and u when utility is held constant and on p, q and y when income is held constant.

If we are interested in the degree to which these virtual prices change when income increases, the income elasticity of the virtual price can be calculated as[3]:

$$\eta_i^v = \frac{\partial p_i^v(p,q,y)}{\partial y}\frac{y}{p_i^v} \tag{1}$$

whereas the income elasticity of demand is [4]:

$$\eta_i^d = \frac{\partial q_i^m(p,p^v,e^v)}{\partial y}\frac{e^v}{q_i^m} \tag{2}$$

The two elasticities are different but related. When just one public good is involved Ebert (2003) showed that the relationship between η_1^v and η_1^d is (Ebert, 2003, equation $R6c$ and Hanemann, 1991, equation $16'$):

$$\eta_1^v = -\frac{\eta_1^d}{\sigma_{11}^d}\frac{y}{e^v} \tag{3}$$

This income elasticity depends on the own (compensated) price elasticity of demand, σ_{11}^d, and on the income elasticity of demand, η_1^d. The subscript 1 denotes the presence of only one public good. Since the own price substitution effect is always negative, the sign of this income elasticity is given by the sign of the income elasticity of demand. Flores and Carson (1997) further show that the income elasticity of willingness to pay, defined as $\eta^{WTP} = \frac{\delta WTP}{\delta y}\frac{y}{WTP}$ lies between the minimum and the maximum virtual price income elasticity.

Whether environmental benefits are regressively (pro-poor), proportionally or progressively (pro-rich) distributed depends on whether $\eta^{WTP} \gtreqless 1$.

Our purpose is to produce estimates of η^{WTP} for a marginal improvement in air quality. To this end we will first estimate the marginal WTP function for air quality adopting the theoretical framework developed by Ebert (1998, 2007).

[3]When q_i^m, the marshallian demand of good i, varies, total virtual expenditure e^v varies as well, this is why the derivative of q_i^m wrt income is multiplied by the ratio between e^v and q_i^m .

[4]The case of more than one public good is more complex and the corresponding measures of benefits incidence are derived by Flores and Carson (1997) and Ebert (2003).

3 Household Production and Demand Analysis

Household production[5] implies there is a market good Y, included in the vector of market goods x, being used in the household production process. This employs inputs Y and q[6] to produce another commodity, Z, the consumer's personal level of environmental quality. While x yield utility directly, Y and q yield utility only indirectly through the commodity Z. The level of air pollution q is combined with air conditioning, Y, to obtain Z the consumer's personal level of air quality. We thus have a model of averting behavior (Bartik, 1988; Courant and Porter,1981; Harford, 1984) where Y is the quantity of averting or defensive good. The technology is described by a twice continuously differentiable production function $Z = F(Y, q)$ strictly increasing and concave in Y and q. The consumer's preferences for market goods x and the commodity Z are represented by a twice continuously differentiable direct utility function. Taking into account household production and the fact that the level of q is determined exogenously she maximizes her utility subject to the budget constraint: $max\ U(x,\ F(Y, q))$, such that $p_x x + p_Y Y = y$ with q fixed. Assuming a weakly separable utility function and an exogenously given specification for the household production function $F(Y, q)$ (see Ebert, 2007, for a discussion of these assumptions), the solution to this maximization problem is described by the conditional demand system:

$$x^m = x^m(p, q, y) \tag{4}$$

and

$$Y = Y(p, q, y) \tag{5}$$

where $p = (p_x, p_Y)$. Because of weak separability of the utility function the marginal rate of substitution between q and Y is simply:

$$MRS_{qY}(Y, q) = \frac{\frac{dF}{dq}}{\frac{dF}{dY}} = \frac{F_q(Y, q)}{F_Y(Y, q)} \tag{6}$$

where F_q and F_Y denote partial derivatives. The marginal willingness to pay for the environmental good q is implicitly defined by $MRS_{qY} = w_q/p_Y$ from which we obtain:

$$w_q = p^v = p_Y\ MRS_{qY} = -C_q(p_Y, q, F(Y(p, q, y), q)) = p_Y \frac{F_q(Y, q)}{F_Y(Y, q)} \tag{7}$$

The dual minimization problem of choosing both q and x so as to minimize total expenditure subject to prices p and p^v and to the utility level U would also produce the conditional mixed demand system defined by equations (4), (5) and (7) by application of Shepard's Lemma. The MWTP function can therefore be determined from the observed demand functions for market goods x, from the household production function

[5] This section relies on Ebert (1998) and (2007).

[6] We assume, for simplicity, that there is only one non market good q which is the level of outdoor air quality.

and from the maintained hypothesis. It has to be emphasized at this stage that this approach does not require further assumptions (see Ebert, 2007, p. 278 for an in depth discussion of this point) and it provides a useful and operational basis for recovering preferences. Its starting points are the "observed" demand functions for market goods and the household production functions. Conditions like weak complementarity or the essentiality of inputs are not required, nor is required the imposition of the Willig condition to derive exact welfare measures.

In practice we have a conditional demand system for x, to be estimated, augmented by the MWTP function (7). We do not know, at this stage, whether the conditional demand system (4) and (5) supplemented by the MWTP function (7) are consistent with utility maximization (Ebert, 1998, p. 248). Stated differently, we do not know whether there is a quasi-concave utility function from which the mixed demand system (4), (5) and (7) can be derived, or equivalently, whether there is exactly one generating preference ordering that can be recovered uniquely.

Ebert (2007, p. 283) sets out the necessary and sufficient conditions for integrability of this conditional demand system supplemented by a MWTP function. The first three conditions are symmetry conditions of the Slutsky matrix for the augmented demand system:

$$s_{xY} = \frac{\delta x}{\delta p_Y} + Y \frac{\delta x}{\delta y} = \frac{\delta Y}{\delta p_x} + X \frac{\delta Y}{\delta y} = s_{Yx} \tag{8}$$

$$s_{xq} = \frac{\delta x}{\delta q} - w_q \frac{\delta x}{\delta y} = - \left(\frac{\delta w_q}{\delta p_x} + x \frac{\delta w_q}{\delta y} \right) = -s_{qx} \tag{9}$$

$$s_{Yq} = \frac{\delta Y}{\delta q} - w_q \frac{\delta Y}{\delta y} = - \left(\frac{\delta w_q}{\delta p_Y} + Y \frac{\delta w_q}{\delta y} \right) = -s_{qY} \tag{10}$$

Condition (**??**) is satisfied by assumption, because x and Y form a conditional demand system, but conditions (**??**, **??**) have to be checked. In addition the Slutsky matrix of substitution effects for the market goods x and Y must be negative semidefinite and, finally,

$$s_{qq} = \frac{\delta w_q}{\delta q} - w_q \frac{\delta w_q}{\delta y} < 0 \tag{11}$$

If conditions (**??**) - (**??**) are satisfied the mixed demand system with household production defined by (**??**), (**??**) and (**??**) is integrable. Although this is an interesting and theoretically sound approach, to our knowledge no application of it has been produced so far.

4 Specification and Estimation of a Conditional Demand System with Household Production

4.1 A Conditional Censored Almost Ideal Demand (CCAID) System

Conditional demand functions can be used to deal with non market goods, such as environmental goods or bads. Air quality, for instance, enters each utility function and no one consumer can control the amount she consumes. The level of environmental quality provided without charge to the user may affect the individual's consumption of goods available in the market. Thus, a given level of air quality may affect the way an individual allocates a given total expenditure between air conditioners and other goods. Since consumption of air quality is fixed, it is the conditional demand functions which are appropriate for the analysis of an individual demand for goods and services in the short run (Pollak, 1969). The functional form chosen to specify our model is the Almost Ideal Demand System (AIDS, Deaton and Muellbauer, 1980b). To obtain the system of conditional uncompensated shares equations we use a logarithmic *conditional* cost function, for household h, which implies PIGLOG preferences (Pollack and Wales, 1992):

$$ln\ C(u, \mathbf{p}, d^h, q) = ln\ a(\mathbf{p}, d^h, q) + u\ b(\mathbf{p}) \tag{12}$$

Where $a(\mathbf{p}, d^h, q)$ and $b(\mathbf{p})$ are functions of prices, ln indicates the natural logarithm, d^h are demographic variables and q is the fixed quantity of the non market good. $a(\mathbf{p}, d^h, q)$ is increasing and homogenous of degree one in $\mathbf{p}$ and $b(\mathbf{p})$ is increasing and homogenous of degree zero in $\mathbf{p}$. $C(u, \mathbf{p}, d^h, q)$ is the *conditional cost function*, i.e. the minimum cost necessary to achieve utility level u, given the price vector p, given demographics d^h and when the quantity q of the non market good is given. The corresponding system of conditional Marshallian demand functions for household h expressed in a expenditure share form is given by:

$$w_i^h = \alpha_i + \sum_j c_{ij}\ ln\ p_j + b_i\ ln\left[\frac{y^h}{P^h}\right] + \sum_i (\alpha_i + \alpha_{ik} d_k^h + g_i q)\ ln\ p_i \tag{13}$$

where y^h is total expenditure of household h, the parameters c_{ij} are defined as $c_{ij} = \frac{1}{2}(c_{ij}^* + c_{ji}^*) = c_{ji}$ and α_{ik} are the coefficients of the translating intercepts $d^h = d_1^h ... d_k^h$ which in this model include households' types, households' location and an annual time trend. Finally,

$$P^h = \alpha_0 + \sum_i (\alpha_i + g_i q + \alpha_{ik} d_k^h)\ ln\ p_i + \frac{1}{2} \sum_i \sum_j c_{ij}^*\ ln\ p_i\ ln\ p_j \tag{14}$$

These demand functions satisfy integrability, i.e. are consistent with utility maximization, when the following parametric restrictions hold: $\sum_i \alpha_i = 1, \sum_i b_i = \sum_j c_{ij}^* = 0$, $\sum_i \alpha_{ik} = 0\ \forall k$ (Adding-up); $\sum_j c_{ij} = 0$ (Homogeneity); $c_{ij} = c_{ji}$ for all i, j (Symmetry).

The presence of zeros in the dependent variables is quite important for our specific sample. To deal with this problem we use the two-step estimator proposed by Shonkwiler and Yen (1999) which involves probit estimation in the first step and a selectivity-augmented equation system in the second step[7]. The system of equations (13) is thus estimated in the following form:

$$s_i = \Phi(z_i^{'}\tau_i)w_i(p, y; \theta) + \delta_i\phi(z_i^{'}\tau_i) + \xi_i \tag{15}$$

where s_i is the observed expenditure share; z_i is a vector of exogenous variables; τ_i is a parameter vector; θ is a vector containing all parameters (α_i, α_{ik}, b_i, g_i and c_{ij}) in the demand system, $\xi_i = s_i - E(s_i)$ and where $\phi(\cdot)$ and $\Phi(\cdot)$ are the standard normal probability density (pdf) and distribution (cdf) functions, respectively. The system of equations (15) is estimated in two-steps: (i) we obtain ML probit estimates $\hat{\tau}_i$ of τ_i using the binary outcome $s_i = 0$ and $s_i > 0$; (ii) we calculate $\Phi(z_i^{'}, \hat{\tau}_i)$, $\phi(z_i^{'}\hat{\tau}_i)$ for all i and estimate $\theta, \delta_1, \delta_2, ..., \delta_n$ in the augmented system (15) by ML. Such two-step estimator is consistent, but the error terms are heteroscedastic, thus the estimated elements of the second-step conventional covariance matrix are inefficient. For simplicity, we empirically calculate the standard errors of WTP and elasticities using bootstrapping and running 500 replications. This ensures that the standard errors of these derived parameters are correct.

Differentiation of equation (15) gives demand elasticities for the first $n - 1$ goods and elasticities for the nth good are obtained exploiting the Cournot and Engel restrictions (Deaton and Muellbauer, 1980a, p. 16). Denoting the Marshallian, Hicksian and expenditure elasticities for good i as σ_{ij}^h , σ_{ij}^{*h} and σ_i^h, respectively, then σ_{nj}^h , σ_{nj}^{*h} and σ_n^h can be calculated using the Cournot restriction $\sum_{i=1}^n w_i^h \sigma_{ij}^h + w_j^h = 0$ and the Engel restriction $\sum_{j=1}^n \sigma_{ij}^h + \sigma_i^h = 0$.

Exogenous variables used in the first-step probit estimates are: total expenditure, dummies indicating household location, whether the household resides in a big town, seasonality and the annual time trend in logarithms. The dependent variable in the first-step probit estimates is the binary outcome defined by the expenditure in each good. The proportion of consuming households for Food, Housing and Communication all exceed 95%, which prevents reliable probit estimates. Thus, probit is estimated only for the remaining commodities, for which the predicted pdf and cdf are included in the second step of the procedure (see Yen, Lin and Smallwood, 2003, p. 464). In all the estimates we impose homogeneity and symmetry. Economic theory also requires the matrix of the substitution effects to be negative semi-definite. Such a requirement is satisfied by adopting a Cholesky decomposition procedure of the price coefficients. Finally, we drop the "other goods and services" equation to accommodate adding up.

[7]Shonkwiler and Yen (1999); Yen, Lin and Smallwood (2003) and Yen and Lin (2006) provide useful literature review on estimation procedures for censored demand systems.

4.2 Data

We use monthly cross-sections, from January 2002 to December 2006, of individual Italian households' current expenditures collected by the Istituto Nazionale di Statistica (ISTAT) through a specific and routinely repeated survey, which was completely renewed in 1997[8]. Current expenditures are classified in about two hundred elementary goods and services, with the exact number changing from year to year due to minor adjustments in the item's list[9]. The survey also includes detailed information on the household structure, so that relevant data on demographic characteristics (such as location on a regional basis, number of household members, ownership of air conditioners) are available. All annual samples are independently drawn according to a two-stage design[10].

A sub-sample of 10,671 observations has been selected considering only households owning air conditioners[11] and living in eight regions of Italy: Friuli-Venezia Giulia, Trentino Alto Adige, Liguria, Lombardia, Toscana, Lazio, Sardegna and Sicilia representing four macro-regions: North East (NE), North West (NW), Centre (CE), South and the Islands (SI). We estimate a ten commodities demand system: (1) Food and beverages; (2) Housing excluding rent; (3) Air Conditioners; (4) Clothing; (5) Health Care; (6) Transports; (7) Communication; (8) Recreation; (9) Alcohol and Tobacco; (10) Other goods and services[12]. Each commodity has been obtained as an aggregate of detailed current expenditures on more than two hundred elementary goods and services[13].

These commodities are chosen according to availability of monthly and regional consumption price indices also supplied by ISTAT, which are included in the data set. These prices have been extracted from the Consumer Price Index (1998=100), also published by ISTAT. Specifically we use the Consumer Price Index for the whole nation (NIC) which monitors sales prices every month in all Italian provinces. NIC is divided into 12 expenditure categories entering the national index with a specific weight reflecting the relative importance of the concerned good on total consumption. Many of these categories coincide with the commodities in our demand system. Some

[8]A different sample of households is interviewed during each month; the item list includes also non current expenditures, with a total number of about 280 goods and services.

[9]We implicitly assume strong separability in consumers' preferences between current and other expenditures.

[10]Details on the sampling procedure used to collect these data can be found in ISTAT, *Indagine sui Consumi delle Famiglie. File standard. Manuale d'uso. Anni 1997-2006.*

[11]This choice is explained by the fact that air conditioners are an essential input in the household production function to produce the household level of air quality (see Paragraph 4.4 for a detailed description of the household production function adopted).

[12]The rationale for choosing to include home related expenditures (aggregate (3)) is that a substitution relationship is likely to exist between air conditioning and other goods and services purchased by the household (by way of example, the need of air conditioning is likely to diminish in better insulated houses).

[13]Aggregation is possible assuming, as it is usually done, that goods within each group are consistent with the Hicks and Leontief Composite Commodity Theorem (Deaton and Muellbauer, 1980a, pp.120-121).

of them have been aggregated in order to obtain the aggregate prices of the remaining goods in our demand system. In addition, we consider expenditures on air conditioning and the corresponding elementary price index also supplied by ISTAT. We have identified the expenditure on conditioners as the best proxy of defensive expenditure against air pollution and climate change collected in the Survey on Households Expenditures. ISTAT records expenditure on air conditioners by Italian households on a monthly basis. We select only household owning air conditioners for two main reasons: first, this allows us to estimate the household production function (for which otherwise a relevant input would have been equal to zero); second, by assuming that households purchased air conditioners in a previous stage, the expenditure recorded by ISTAT can be considered as having a semi-durable nature, as it is mainly given by operating and maintenance costs. The North West (NW) region has the highest expenditure share on air conditioners (see appendix table A1), followed by the South (SI); conditioners expenditure turns out to be slightly lower in the North East and it's the lowest in the Centre (CE). Thus a marked geographical trend does not exist: living in the NW produces a positive effect on conditioners expenditure share, but this is also true in the South. Conditioners' demand does not increase proportionally with total expenditure, but it also depends on household location.

To summarize, the sample used in our estimations consists of 10,671 household observations collected for 8 regions over 12 months for 5 years. Using r to indicate the region, m the month and y the year, the data have been organized by lining up monthly data ($m = 1 - 12$) on each macro-region ($r = 1 - 4$) for each year ($y = 1 - 5$) in a vector of 10,671 observations. A set of dummy variables is included to account for the macro-area in which the household lives (NW, NE, CE, SI). In order to take into account the relevant role played by external temperature - and then the likely seasonality in air conditionings expenditure we include a dummy variable (SEASON) equal to 1 for the warmest months of the year: June, July, August and September. and for the likely seasonality in air conditioners' purchase, (SEASON) equal to 1 for the warmest months of the year: June, July, August and September. We have also added a categoric variable (LOC) for whether the household lives in a town with more than 50,000 inhabitants (1), less than 50,000 inhabitants (2) or in a small village (3) and a logarithmic annual time trend.

We combine these data with information on air concentrations of three pollutants: Ozone (O_3), Particulate (PM_{10}) and Nitrogen Dioxide (NO_2). These have been used to compute a categorically continuous index of air quality (IQA see Appendix), also used as an input in the household production function. The index is calibrated on a $1 - 7$ scale, where 1 corresponds to a very bad air quality and 7 to a very good air quality. Summary statistics of the data are shown in Table 1.

Table 1: The Data

No. of households: 10,671

	mean	std dev	min	max
Current Expenditures (Euro/month)				
Total Expenditure	1,784.705	1,063.757	250.019	6,958.370
Food From Stores	485.747	283.304	0.000	2,374.739
Alcohol and Tobacco	44.466	58.495	0.000	551.480
Clothing	190.509	285.023	0.000	4,387.530
Household Operation	210.760	154.237	0.000	3,501.580
Air Conditioners	12.315	82.999	0.000	1028.930
Health	112.068	278.392	0.000	5,228.750
Transports	162.021	129.441	0.000	1,042.620
Communication	64.838	50.950	0.000	652.949
Recreation	52.934	85.197	0.000	1,597.560
Other Goods and Services	458.282	530.354	0.000	5,228.920
Price indices (1998=1)				
Food from Stores	1.135	0.034	0.826	1.337
Alcohol and Tobacco	1.247	0.115	0.826	1.436
Clothing	1.127	0.040	0.824	1.364
Housing	1.145	0.053	0.821	1.365
Air Conditioners	0.964	0.040	0.869	1.074
Health	1.095	0.034	0.816	1.365
Transports	1.190	0.068	0.815	1.392
Communication	0.842	0.083	0.701	1.393
Recreation	1.101	0.030	0.813	1.393
Other Goods and Services	1.185	0.052	0.809	1.393
Other exogenous variables				
IQA	5.630	1.232	1.000	7.000
NW	0.279	0.448	0.000	1.000
NE	0.108	0.311	0.000	1.000
CE	0.219	0.414	0.000	1.000
SI	0.393	0.488	0.000	1.000
LOC	1.158	0.446	1.000	3.000
SEASON	0.346	0.476	0.000	1.000
Annual time trend	3.183	1.378	1.000	5.000

4.3 Results

Table A2 shows first-step probit estimates along with their asymptotic standard errors. Many of the variables included are significant at the 5% level in each expenditure share equation. Income plays a positive role in explaining the budget share of all goods. Seasonality and the annual time trend also play a significant role in the probability of consumption of many of the commodities. The index of air quality is also significant in explaining the decision to purchase air conditioners and has the expected sign. Going from a big to a small town (*LOC* variable) has a negative role in determining air conditioners' purchase, probably because big cities are more polluted. Going from a big to a small town also plays a positive and significant role in explaining Transports and Alcohol/Tobacco choices, but has a negative and significant role, as expected, in explaining recreation choices. Table A3 shows second-step estimates of the CCAID system. Standard errors have been computed from a heteroscedastic-consistent matrix using the White correction.

Hicksian (compensated) elasticities, based on parameters of the second-step, are computed at the sample mean as:

$$\sigma_{ij}^{*h} = \sigma_{ij}^{h} + \sigma_{i}^{h} w_{j}^{h} \tag{16}$$

where σ_{ij}^{h} is the uncompensated price elasticity of good i with respect to price j and σ_{i}^{h} is the expenditure elasticity of good i. These elasticities are shown in Table A4 along with expenditure elasticities for all goods and the estimated budget shares. All expenditure elasticities are significantly different from zero. Air conditioners appear to be luxury goods, with an income elasticity equal to 1.30. As to the budget shares, Food, Housing, Transports and Clothing are the consumption categories on which the largest part of the monthly expenditure is allocated. This is in line with similar works on Italian household consumption (Moschini and Rizzi, 1997; Balli and Tiezzi, 2009). All the compensated own price elasticities, calculated at the sample means of variables, have the correct sign and are statistically significant. Air conditioners display a very high and significant compensated own price elasticity (1.80), but none of the cross-price elasticities are significant. Some of the other compensated own price elasticities are greater than one: Food, Clothing, Health, Transport and Communication. The high level of own price elasticity for Health is in line with other empirical works referred to Italy. A possible interpretation of this result is the introduction of low cost drugs as substitutes for high quality drugs which has taken place in Italy over the last decade.

4.4 Household Production and WTP for Air Quality Improvements

To model the WTP function for air quality we start from the class of household production functions introduced by Ebert, 2007, p. 285:

$$Z = F_{\epsilon}(Y, q) = (Y^{1/2} + 1)q^{\epsilon} \tag{17}$$

Table 2: Integrability conditions (sample mean)

Conditions	Estimate
$S_{x_1,q} + S_{q,x_1} = 0$	0.000529
$S_{x_2,q} + S_{q,x_2} = 0$	-0.024384
$S_{x_3,q} + S_{q,x_3} = 0$	0.369060
$S_{x_4,q} + S_{q,x_4} = 0$	-0.121260
$S_{x_5,q} + S_{q,x_5} = 0$	-0.036447
$S_{x_6,q} + S_{q,x_6} = 0$	-0.036262
$S_{x_7,q} + S_{q,x_7} = 0$	-0.024694
$S_{x_8,q} + S_{q,x_8} = 0$	-0.036455
$S_{x_9,q} + S_{q,x_9} = 0$	-0.036107
$S_{q,q} < 0$	-0.259180

for $\epsilon \in (0, 1/2]$. Y is the quantity of air conditioners used as an input into the household production of Z, the internal level of air quality chosen by the household, and q is our index of air quality. In this household production function Y is a nonessential good[14]. The corresponding WTP function is:

$$w_q(\mathbf{p}, q, y) = 2\epsilon p_Y (Y^{1/2} + 1) Y^{1/2}/q \qquad (18)$$

We consider three values of ϵ: $\epsilon = 0.1$, $\epsilon = 0.35$ and $\epsilon = 0.5$ and we test whether the household production function in (17) is consistent with our conditional demand system by checking that conditions (8) - (11) are satisfied. Integrability conditions have been checked at the sample mean and results for $\epsilon = 0.5$ are shown in Table 2. All conditions are satisfied, therefore the mixed demand system with household production defined by the conditional demand system (13) augmented with the WTP equation (18) is integrable. WTP and its income elasticity calculated at the sample mean of exogenous variables, along with their standard errors, are shown in table $3-4$. All standard errors have been obtained using bootstrapping and 500 replications.

Household marginal WTP for improvements in air quality in Euro/month for five income groups are shown in Table 3 for three values of ϵ. The WTP density function for $\epsilon = 0.5$ and $\epsilon = 0.1$ is shown in figures 1 and 2. WTP is smaller than 10 euros for the majority of households, in particular a value around 3 euros has a very high frequency. Very few households have a WTP greater than 20. Changing the value of ϵ from 0.5 to 0.1 implies a very small impact on the WTP distribution. WTP is positively correlated to household income revealing that the rich value air quality improvements more highly than the poor. Nevertheless when expressed as a fraction of household income WTP increases only slightly with income for any value of ϵ. For higher income

[14] Y is not necessarily required to produce Z given q. See Ebert, 2007, footnote 11, for an interpretation of this property.

Table 3: WTP for Air Quality Improvements (Euro/month)

Income Level	$\epsilon = 0.15$	$\epsilon = 0.35$	$\epsilon = 0.5$
Overall sample mean	**0.687**	**1.602**	**2.290**
(10,671)	*0.025*	*0.062*	*0.087*
$y \leq 800$	**0.141**	**0.329**	**0.470**
(1,016)	*0.018*	*0.044*	*0.062*
$y \leq 2000$	**0.475**	**1.108**	**1.582**
(4,993)	*0.022*	*0.049*	*0.070*
$y \leq 4000$	**1.476**	**3.444**	**4.920**
(2,808)	*0.059*	*0.140*	*0.194*
$y \leq 6000$	**2.260**	**6.207**	**8.867**
(401)	*0.253*	*0.587*	*0.870*
$y > 6000$	**2.296**	**5.357**	**7.652**
(72)	*0.484*	*1.071*	*1.568*

Note: Standard Errors in Italics below coefficients. Bold entries correspond to rejection of $H_0 : e = 0$ at the 5% significance level for a two tailed test.
y = household disposable income proxied by total current expenditure.

levels WTP as a fraction of income decreases from 0.25% for $y <= 6000$ to 0.13% for $y >= 6000$. The fact that households in lower income groups have a relatively higher WTP for air quality improvements is consistent with findings by Kriström and Riera (1996) and Söderqvist (2003). This may be because higher income households live on average in areas with relatively low levels of air pollution and therefore experience a smaller physical improvement in air quality in comparison with low income households do. A lower WTP for richer households may also be due to the fact that they can afford a larger set of substitution possibilities.

5 Income Elasticities of WTP for Air Quality Improvements

The main problem in estimating the income elasticity of WTP is that we cannot directly observe individual demand and prices for a public good. Different approaches have been adopted in the literature. The main one uses stated preference data based on contingent valuation (CV) survey (Ktriström and Reira, 1997, Hökby and Söderqvist, 2003, Schläpfer, 2006). Studies based on this approach consistently find a very low income elasticity of willingness to pay in the range 0.1 – 0.5. McFadden and Leonard (1993) and McFadden (1994) argued that income elasticities in *CV* surveys are too low according with economic intuition. Schläpfer (2006, p. 16) emphasizes that income elasticities of WTP based on CV studies may be biased by *"a peculiar combination of random bid levels and well-specified, realistic survey scenarios in CV surveys"*. Moreover, these elasticities contrast in magnitude with those calculated from collective choice-based studies for various public goods (Boercherding and Deacon, 1972; Bergstrom and Goodman, 1973) where elasticities are greater than one; and from averting behavior approaches using the demand for market goods as a proxy for environmental goods or services (Costa, 1997; Pereyra and Rossi, 1998; Ghalwash, 2006). Both the collective choice approach and the averting behavior approach have weaknesses though. As emphasized earlier, social choice processes are difficult to link to individual preferences. Averting behavior approaches, on the other hand, only allow for the calculation of the income elasticity of demand and not of the income elasticity of WTP. Flores and Carson (1997, p. 294) explain that the two may well diverge and that *"discussing the issue in terms of the income classification of demands may have little, if any, relevance when quantity rationing applies"*. So the income elasticity of WTP for a public good remains an unresolved issue even though the distribution of benefits by income is clearly important for policy design.

An increasing pattern of the absolute level of WTP with respect to household income signals that the demand functions for clean air have positive income elasticities. We consistently find a positive income elasticity of WTP. Thus the richer a country, the larger is the absolute level of WTP for air quality in comparison with a poorer country. This might be important for environmental plans with long time horizons, as it indicates that, as societies become richer, they tend to value environmental quality more highly.

We calculate:

$$\eta^{WTP} = \frac{\delta WTP}{\delta y}\frac{y}{WTP} \tag{19}$$

for the entire sample and for five income groups. The overall sample mean elasticity is equal to 1.164, thus a percentage income increase would imply an increase in WTP of slightly more than one percent. Therefore, WTP is basically income-neutral and an income variation is almost completely transferred on the income assigned to WTP. This result is coherent with other studies finding a WTP for environmental goods being an increasing function of income (Harrison and Rubinfeld, 1978a; Kristrom and Riera, 1996; Hökby and Söderqvist, 2003). Since the income elasticity of higher income groups may be different from that of lower income groups, we have computed this elasticity for different income classes (Table 4). The elasticity of WTP seems to be slightly decreasing with income. For a given increase in income, the lower the income level the higher the increase in WTP. This should not be confused with progressivity or regressivity in the WTP distribution and it simply means that in our sample WTP of lower income households is more responsive to income variations, maybe because they live in more polluted areas or in warmer regions[15].

[15]In Italy the South is poorer than the North.

Table 4: Income Elasticity of WTP for Air Quality Improvements

Income Level	η^{WTP}
Overall sample mean	**1.164**
(10,671)	*0.245*
$y \leq 800$	**1.234**
(1,016)	*0.311*
$y \leq 2000$	**1.165**
(4,993)	*0.266*
$y \leq 4000$	**1.128**
(2,808)	*0.178*
$y \leq 6000$	**1.174**
(401)	*0.155*
$y > 6000$	**1.345**
(72)	*0.258*

Note: Standard Errors in Italics below coefficients. Bold entries correspond to rejection of $H_0 : e = 0$ at the 5% significance level for a two tailed test. y = household disposable income proxied by total current expenditure.

Given very small differences in the income elasticity of WTP across income groups we test whether this elasticity is significantly different from one across the sample distribution of income. The test we carry out is based on the difference: $TTest = \eta^{WTP} - 1$. The value of this difference calculated at the sample mean of variables is not significantly different from zero: 0.164 with a standard error of 0.245.

6 Discussion

A widespread idea in economics is that a better environmental quality is mainly demanded by the privileged groups of society (Pearce, 1980). If environmental quality is a luxury higher income groups are willing to pay a higher share of their income to reduce environmental degradation. This is also the idea behind the widely investigated Environmental Kuznets Curve, an important driver of which is the effect of income growth on the demand for environmental quality. If the income elasticity of environmental quality is greater than one, environmental quality will grow disproportionately quickly as incomes rise. Rising prosperity will eventually be accompanied by falling pollution levels, after an earlier growth period during which pollution is increasing (Turner et al., 2009).

In general, η^{WTP} expresses how much income households are relatively willing to pay for an increased provision of an environmental good. η^{WTP} can be used to identify the distributional pattern of WTP, i.e. which groups in society benefit the most from environmental improvements. The environmental good is said to be regressively distributed if $\eta^{WTP} < 1$, proportionally distributed if $\eta^{WTP} = 1$ and progressively distributed if $\eta^{WTP} > 1$.

In our data benefits from improvements in air quality are proportionately distributed. The hypothesis that environmental quality is a luxury good is not supported by the data. The income elasticities of WTP are very close to one even for the lowest income groups. This implies that growing richer does not necessarily translates in cleaner environments and, more important, that environmental policies do not benefit the rich more than the poor. The proportion of income that is assigned as WTP for an increase in environmental quality slightly decreases when income increases. The lowest income groups will translate a 1% increase in income into a proportionally higher WTP and the proportion of income they are willing to translate into WTP is only slightly lower than that of the richest groups in society. Thus projects which promote environmental quality improvements bring proportional benefits to low and high income groups.

Applying our methodology to different countries and obtaining a complete range of WTP for air quality could shed some light into the complex climate change question. The income elasticity of WTP suggests the amount people in different countries would be willing to spend to improve air quality and to reduce the risk of global warming. Investigating the role of income in determining WTP for air quality could contribute to the success of future climate negotiations. In particular, for countries such as China and India, information about the incidence of benefits for air quality improvements seems really crucial. Such information has not always been precise in the literature. A very common approach in estimating benefits of environmental quality is given by transferring mean unit value (Alberini et al., 1997; World Bank, 2002; Rozan, 2004), i.e. calculating the benefits of a policy for a given site based on the mean of WTP from another place, the study site. This is equivalent to implicitly assume that the elasticity of WTP for different countries with different income levels is equal to one. Such a procedure is likely to be misleading (Cropper et al., 1997) since it hypothesizes that preferences for environmental quality are similar among different households or countries and they are largely determined by income. Our approach avoids these simplifications and allows to directly compute the income elasticity of WTP taking into account households heterogeneity.

Our findings suggest that distributional issues should be carefully considered when designing policy instruments to deal with global environmental problems such as climate change. If the social profitability of a project is decided on the basis of the sum of WTPs (Hicks-Kaldor compensation criterion) a project that would result in a regressive distribution of environmental benefits is less likely to pass than a project that would primarily benefit high-income groups, because those in lower income groups have a lower WTP even though they are willing to spend a higher share of their income. In this case using appropriate weights could turn an unprofitable project (under the Hicks - Kaldor criterion) into a socially profitable one. If distributional concerns are considered paramount, Harberger (1978) and Johansson-Stenman (2005) provide some suggestions on the use of social weights when conducting benefit-cost analysis.

Our estimates are likely to be sensitive to the specification of the household production function, as already emphasized by Ebert (2007). Different classes of household production functions should be explored. The use of household production combined with demand analysis displays a number of advantages over other approaches. First, it is not exposed to the biases of stated preferences approaches emphasized earlier because only choice-based data are used. Second, it could be used, at a low cost, in any country where detailed micro-data on consumption behavior are available. In addition, the availability of demographic characteristics allows to account for households heterogeneity in WTP such as location, number of household members and gender. Third, it allows flexibility both in the specification of the demand system and in the specification of the household production function. Different environmental goods could be considered and more than one of them could be included in the demand system.

7 Concluding Remarks

This paper makes three distinct contributions to the literature. First, it operationalizes the approach developed by Ebert (2007) for recovering the underlying preference ordering from observed behavior when nonmarket goods are employed in household production. Second, it uses a unique dataset, where household consumption data are combined with an index of air quality, to estimate the marginal willingness to pay for air quality improvements in Italy. Third, it provides estimates of the income elasticity of willingness to pay for air quality improvements for five income groups. Air quality does not turn out to be a luxury good according to our findings. It is a normal good, the demand for which increases with income, and it is income neutral, because households are willing to spend a proportional share of their income as income grows. Environmental improvements are not progressively distributed, despite willingness to pay rising with income. Finally, the methodology we adopt is operational, avoids many drawbacks of alternative approaches and could be used, at a low cost, in any country where micro-data on household consumption are available.

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Appendix: A Regional Air Quality Index (IQA) for Italy

As a measure of outdoor air quality we use a regional and monthly air quality index (IQA), a standardized indicator of air quality in a given location. Following the definition given by the National Agency for the Protection of the Environment (APAT) according to European guidelines, the index is constructed as a weighted average of data on hourly concentrations of three air pollutants supplied by APAT[16]. The weights were provided by each of the regional agencies in charge of calculating the air quality indices on a regional basis.

Data on hourly concentrations of Ozone (O_3), Particulate (PM_{10}) and Nitrogen Dioxide (NO_2) were available from January first 2002 to December 31st 2006. For each Italian region hourly pollutants concentrations have been collected from a very large number of stations located in a Traffic, Industrial or Background area. We consider concentrations from Traffic and Background stations only in order for them to be merged with consumption expenditures of households living in an Urban or Background area. Due to missing data over the investigation period, only eight Italian regions have been considered: Lombardia, Liguria, Friuli Venezia Giulia, Trentino Alto Adige, Lazio, Toscana, Sicilia and Sardegna.

Starting from a total of 1,596,938 hourly observations, a daily regional IQA_d has been obtained as the average of two indices of pollutants' concentrations: $IQA_d = \frac{I_1+I_2}{2}$ where the subscript d indicates the day. The first sub-index, I_1, is given by: $I_1 = (\frac{PM_{10}}{P\bar{M}_{10}}) \times 100$ where PM_{10} is the mean daily particulate concentration and $P\bar{M}_{10}$ is the threshold value for particulate concentrations admitted by the law[17] (in Italy $50\mu g/m^3$). The second sub-index, I_2, is simply the highest between Nitrogen Dioxide and Ozone concentrations: $I_2 = max(NO_2; O_3)$. Threshold values for NO_2 and O_3 concentrations in Italy are, respectively, $200\mu g/m^3$ and $120\mu g/m^3$.

Daily IQAs have been averaged over each month to obtain monthly indices. As a result, our regional IQA is given by a sample of 960 observations (12 months $\times$ 5 years $\times$ 16 areas). Figures 1 and 2 show the pattern over time of the national and regional monthly IQA. These monthly indices have then been used to construct a categorical variable varying between 1 (low air quality) to 7 (high air quality) to be used in our estimations.

[16] Data on air pollutants concentrations are freely downloadable at www.apat.it. The same data are available from the European Air Quality Database of the European Environmental Agency.

[17] D.M. 60/02

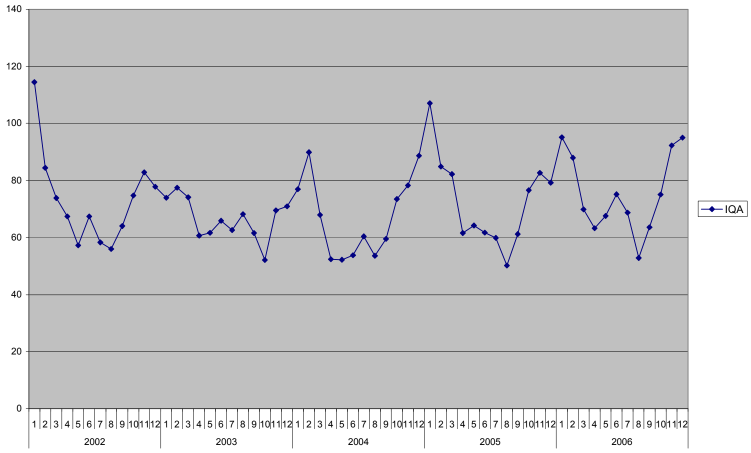

Figure 1: The Index of Air Quality in Italy 2002-2006

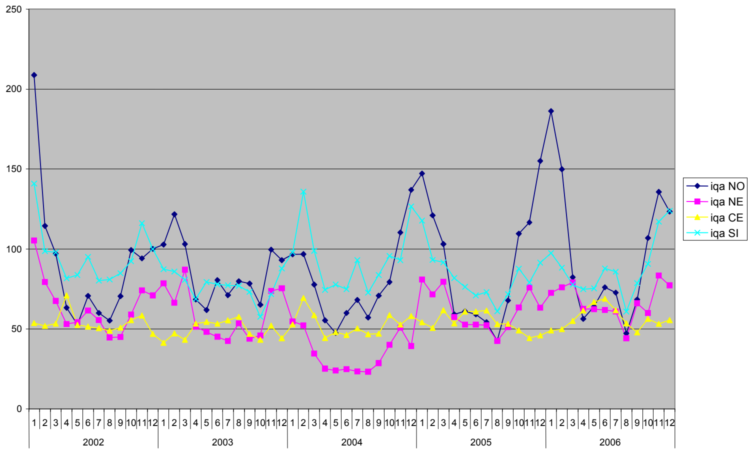

Figure 2: The Index of Air Quality by region 2002-2006

Table A1: Descriptive Statistics

Expenditure share	Mean	Std. Dev.	Min	Max	Macro-regions (mean values)			
					NO	NE	CE	SI
food and beverages	0.300	0.127	0.000	0.845	0.277	0.272	0.283	0.333
home expenditures	0.137	0.090	0.000	0.831	0.144	0.150	0.143	0.126
conditioners	0.006	0.037	0.000	0.628	0.007	0.006	0.006	0.004
health	0.054	0.090	0.000	0.907	0.064	0.065	0.048	0.046
transport	0.095	0.071	0.000	0.746	0.089	0.084	0.096	0.103
communications	0.042	0.032	0.000	0.357	0.038	0.043	0.044	0.043
recreation	0.027	0.037	0.000	0.519	0.030	0.029	0.031	0.022
clothing	0.093	0.105	0.000	0.860	0.087	0.092	0.093	0.097
alcohol and tobacco	0.026	0.034	0.000	0.331	0.026	0.020	0.024	0.029
other goods and services	0.219	0.141	0.000	0.868	0.237	0.238	0.231	0.195
Total expenditure	1,793.941	1,069.632	250.02	6,958.37	2,030.85	1,802.772	1,889.711	1,570.21

NO = North West; NE = North East; CE = Centre; SI = South and the Islands.

Table A2: First-step probit estimates

	Goods					
n. obs. = 10,671	$i = 3$ Air Conditioners	$i = 4$ Clothing	$i = 5$ Housing	$i = 6$ Transport	$i = 8$ Recreation	$i = 9$ Alc./Tab.
Constant	**-2.31089**	**-2.223189**	**-0.273782**	**0.305451**	**-0.10744**	0.036938
	0.052149	*0.030557*	*0.026787*	*0.034357*	*0.030894*	*0.026971*
Income	**0.35108**	**0.985871**	**0.624047**	**0.949924**	**0.897164**	**0.524992**
	0.035823	*0.032160*	*0.024951*	*0.038235*	*0.032454*	*0.025117*
NE	-0.136346	0.01096	0.011092	-0.013062	**-0.167920**	**-0.201669**
	0.095070	*0.054493*	*0.049739*	*0.059706*	*0.055830*	*0.050095*
NW	-0.046520	0.03251	**0.159532**	**-0.137643**	-0.042201	0.022482
	0.067357	*0.040594*	*0.036888*	*0.046737*	*0.042147*	*0.037690*
SI	**-0.279650**	0.005593	-0.056621	**0.294275**	**-0.29642**	0.056652
	0.073988	*0.041384*	*0.037855*	*0.049493*	*0.042240*	*0.039231*
LOC	-0.017661	-0.01439	-0.027704	**0.279807**	**-0.129643**	**0.130386**
	0.091733	*0.052728*	*0.048059*	*0.066572*	*0.052518*	*0.050459*
SEASON	**0.404687**	**-0.100387**	-0.128067	-0.02515	**-0.139139**	**0.064412**
	0.050421	*0.029482*	*0.027122*	*0.034511*	*0.029847*	*0.028129*
LTrend	-0.069255	**-0.074566**	0.013046	**-0.06303**	**-0.122640**	**-0.004166**
	0.046642	*0.025875*	*0.023626*	*0.030016*	*0.026298*	*0.024221*
LQ	**-0.215504**	-0.009866	-0.066255	0.063225	**-0.153797**	**-0.078265**
	0.066753	*0.038757*	*0.035390*	*0.043823*	*0.039883*	*0.036113*
mean of dep. var.	0.032	0.746	0.627	0.862	0.763	0.703
Log Likelihood	-1401.06	-5418.99	-6630.24	-3822.81	-5260.13	-6216.29
Scaled R − squared	0.182	0.117	0.077	0.085	0.109	0.051
Predicted power	0.968	0.756	0.666	0.862	0.770	0.705

Note: Standard Errors in Italics below coefficients. Bold entries correspond to rejection of $H_0 : e = 0$ at the 5% significance level for a two tailed test.

Table A3: Second-step AIDS estimates (2002-2006)

Coefficients	Goods								
	$i = 1$ Food	$i = 2$ Housing	$i = 3$ Air Conditioners	$i = 4$ Clothing	$i = 5$ Health	$i = 6$ Transport	$i = 7$ Communication	$i = 8$ Recreation	$i = 9$ Alc./Tab.
α_i	**0.28987**	0.12498	0.00245	-0.01288	**0.16263**	**-0.05724**	0.03962	-0.00402	0.01329
	0.00124	*0.80520*	*0.23926*	*0.01662*	*0.02160*	*0.01250*	*0.30511*	*0.61154*	*0.67938*
β_i	**-0.08086**	**-0.06943**	**-0.00204**	**0.11421**	**-0.03206**	**0.06111**	**-0.01970**	**0.02413**	**-.18195**
	0.00207	*0.00155*	*0.00141*	*0.00854*	*0.01048*	*0.00769*	*0.00056*	*0.00333*	*0.00413*
e_i			-0.00044	**0.32502**	**-0.18910**	**0.42548**		**0.09475**	**0.05268**
			0.00512	*0.036563*	*0.046698*	*0.027660*		*0.013610*	*0.014986*
$\alpha_{i,NE}$	**-0.02342**	**-0.01232**	**0.00118**	-0.00945	**0.05670**	**-0.04014**	**-0.00392**	**-0.00521**	**-0.00636**
	0.00582	*0.00376*	*0.00085*	*0.00734*	*0.00894*	*0.00491*	*0.00143*	*0.00279*	*0.00242*
$\alpha_{i,NO}$	-0.00117	-0.00051	**0.00096**	**-0.01213**	0.02162	-0.00180	-0.00007	**0.00230**	**0.00351**
	0.00406	*0.00254*	*0.00036*	*0.00423*	*0.00464*	*0.00277*	*0.00094*	*0.00182*	*0.00136*
$\alpha_{i,NSI}$	**0.02963**	**-0.04259**	0.00047	**0.02954**	-0.00274	**0.02190**	**-0.00314**	-0.00314	**0.00769**
	0.00477	*0.00302*	*0.00037*	*0.00461*	*0.00528*	*0.00332*	*0.00118*	*0.00197*	*0.00169*
$\alpha_{i,CO}$	**-0.01091**	**-0.00771**	**0.07236**	-0.00643	0.00072	**-0.01131**	-0.00017	-0.00355	-0.00172
	0.00565	*0.00393*	*0.00335*	*0.00651*	*0.00700*	*0.00427*	*0.00154*	*0.00257*	*0.00228*
$\alpha_{i,LT}$	**0.01373**	-0.00304	0.00016	**-0.03484**	0.00065	0.00177	**0.00255**	**-0.00492**	0.00121
	0.00360	*0.00231*	*0.00054*	*0.00403*	*0.00419*	*0.00248*	*0.00085*	*0.00146*	*0.00136*
$\alpha_{i,LOC}$	**0.010344**	-0.00461	-0.00034	-0.00285	**-0.02317**	**0.02218**	0.00025	**-0.00511**	**0.00368**
	(0.00423	*0.00303*	*0.00051*	*0.00506*	*0.00433*	*0.00337*	*0.00107*	*0.00160*	*0.00168*
$\alpha_{i,IQA}$	0.00230	**-0.01098**	-0.00027	**0.01499**	-0.00022	**0.00828**	**0.00103**	**0.00330**	**0.00350**
	0.00303	*0.00226*	*0.00031*	*0.00378*	*0.00372*	*0.00243*	*0.00085*	*0.00138*	*0.00130*
$\alpha_{i,SEAS}$	0.00269	**-0.01325**	-0.00024	**-0.00683**	**-0.01394**	**0.01689**	**-0.00698**	**-0.00366**	**0.00312**
	0.00247	*0.00168*	*0.00035*	*0.00349*	*0.00355*	*0.00248*	*0.00060*	*0.00125*	*0.00121*

Note: Standard Errors in Italics below coefficients. Bold entries correspond to rejection of $H_0 : e = 0$ at the 5% significance level for a two tailed test.

Table A4: Mean household Budget Shares, w_j, expenditure elasticities, e_j and Hicksian elasticities e^*_{ij}

	Goods									
	$j=1$ Food	$j=2$ Housing	$j=3$ Air Conditioners	$j=4$ Clothing	$j=5$ Health	$j=6$ Transport	$j=7$ Recreation	$j=8$ Communication	$j=9$ Alc./Tab.	$j=10$ Other Goods
w_j	0.300	0.137	0.006	0.093	0.054	0.095	0.042	0.027	0.026	0.219
e_j	**0.731**	**0.495**	**1.334**	**1.860**	**0.575**	**1.438**	**0.534**	**1.619**	**1.004**	**1.235**
	0.006	*0.010*	*0.256*	*0.065*	*0.134*	*0.056*	*0.012*	*0.085*	*0.107*	*0.036*
e^*1j	**-1.43973**	-0.13781	0.064227	**0.36186**	**0.54256**	0.0033876	**-0.17171**	**0.47933**	0.037662	0.26022
	0.25028	*0.11543*	*0.056169*	*0.19004*	*0.15511*	*0.13920*	*0.042823*	*0.099551*	*0.077559*	*0.24324*
e^*2j	-0.30082	**-0.67560**	-0.046176	0.078662	0.78293	**0.34125**	**0.13980**	**0.33572**	-0.011005	**-0.64475**
	0.25464	*0.18929*	*0.048882*	*0.17248*	*0.17825*	*0.13867*	*0.053010*	*0.11493*	*0.071864*	*0.20992*
e^*3j	2.56948	-0.64935	**-1.79594**	-0.37681	0.51092	0.84023	0.66366	-0.22567	-0.050073	-1.48645
	2.01833	*0.83910*	*0.60455*	*0.67622*	*1.06523*	*0.63864*	*0.45539*	*0.25455*	*0.37073*	*1.46014*
e^*4j	**0.98277**	0.18620	-0.016348	**-1.05004**	-0.25477	**0.29090**	**0.14109**	-0.13747	0.025332	-0.16766
	0.43469	*0.18084*	*0.040159*	*0.22567*	*0.24776*	*0.12862*	*0.078303*	*0.14544*	*0.050477*	*0.22943*
e^*5j	**2.09352**	**1.34123**	0.053784	-0.31867	**-1.61291**	-0.31298	-0.12520	-1.21510	-0.0007199	0.097050
	0.60650	*0.34166*	*0.11593*	*0.44106*	*0.71233*	*0.31392*	*0.13619*	*0.21871*	*0.18911*	*0.61834*
e^*6j	0.19285	**0.46873**	0.051631	0.20049	-0.18845	**-1.44273**	-0.062360	-0.000584	0.055461	0.72497
	0.30653	*0.14672*	*0.038387*	*0.11731*	*0.17693*	*0.17282*	*0.059481*	*0.12042*	*0.046220*	*0.24424*
e^*7j	**-1.22198**	**0.45575**	0.12037	0.34716	-0.19538	-0.31724	**-0.39169**	0.19966	0.057140	**0.94622**
	0.29979	*0.18127*	*0.088051*	*0.25650*	*0.25084*	*0.20129*	*0.10584*	*0.15342*	*0.10376*	*0.29944*
e^*8j	**3.87154**	**1.29323**	-0.043033	-0.49604	**-2.44212**	0.045537	0.24723	**-2.47753**	**0.001133**	0.000053
	0.77729	*0.40008*	*0.13701*	*0.52801*	*0.44986*	*0.39586*	*0.17605*	*0.47504*	*0.20944*	*0.62206*
e^*9j	0.42129	0.026504	-0.011836	0.047212	0.010303	0.17968	0.084268	-0.007728	**-0.64092**	-0.10878
	0.61402	*0.26424*	*0.053509*	*0.17811*	*0.38620*	*0.16283*	*0.11637*	*0.21379*	*0.17479*	*0.38194*
e^*10j	**0.77935**	-0.23473	-0.057277	-0.10860	-0.32039	**0.37510**	**0.16235**	-0.23313	-0.012292	-0.35039
	0.26871	*0.12431*	*0.054904*	*0.15354*	*0.17781*	*0.14303*	*0.051167*	*0.11119*	*0.073206*	*0.32460*

Note: Standard Errors in Italics below coefficients. Bold entries correspond to rejection of $H_0 : e = 0$ at the 5% significance level for a two tailed test.

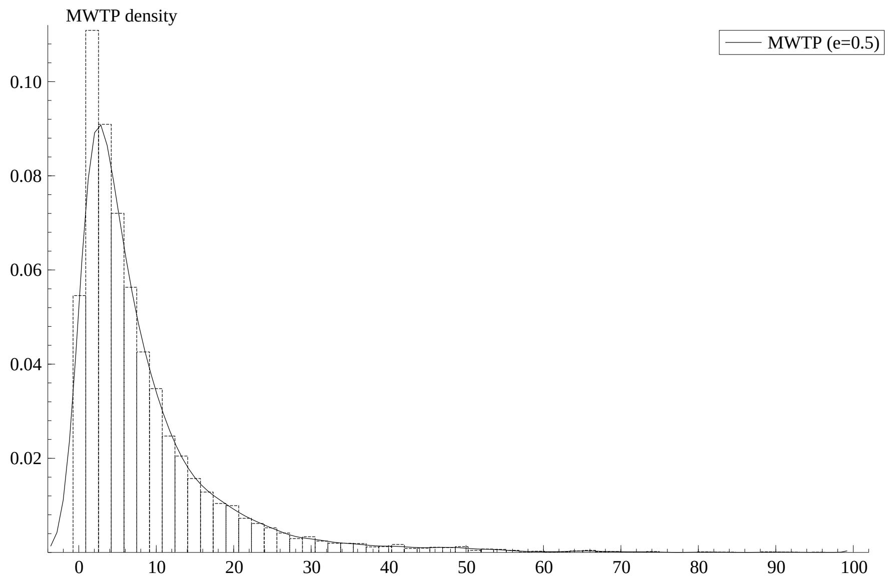

Figure 3: MWPT density function, e=0.5

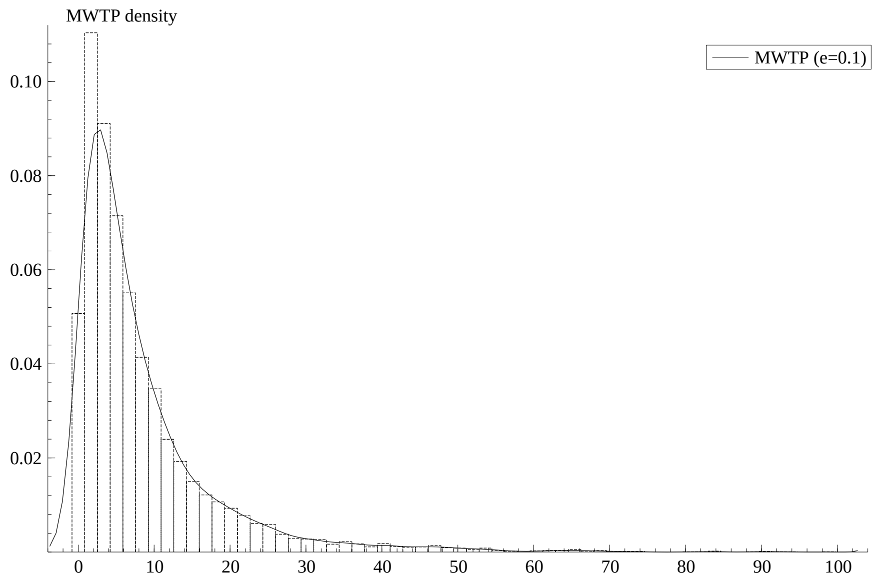

Figure 4: MWPT density function, e=0.1