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Summary: The paper estimates the cost of maintaining a child, of different ages, the cost of being a single and the cost of additional adults present in a family with the aim of making the income levels of different households comparable. The study investigates the issue of econometric identification of equivalence scales within a demand system modified to include demographic characteristics consistently with economic theory. It shows that a robust estimation of equivalence scales must take into formal consideration the problem of econometric identification. The estimation also proposes an encompassing demographic specification which permits isolation of the costs due to differences in needs and differences in household life-styles and scale economies.

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Keywords: Equivalence scales, identification, interhousehold comparisons, economies of scale

1. Introduzione

Equivalence scales answer the question "what is the level of additional income needed by a family composed by two adults and a child compared to a family without children to enjoy the same level of economic well-being." If the demographic profile varies only in relation to the number of children, the equivalence scale corresponds to the cost of the characteristic "child" (Lewbel 1989, 1991, 1993) associated with the presence of a child in the family; if the profile varies in relation to the number of elderly persons present in the family, then the equivalence scale represents the cost of an elderly.

The equivalence scale is an index number converting households of different composition into identical individuals thus making inter-household comparisons admissible. Welfare comparisons are implicitly made any time that we intend to establish, for example, whether a family is poorer than another or the most preferable policy scenario on the basis of the impact on households' well-being. The cost of household characteristics are therefore fundamental for the correct measurement of poverty and inequality and for the construction of indicators of the economic situation based on equivalent incomes, that is incomes corrected for differences in household composition dividing by the equivalence scales. Further, the cost of living indexes associated with the households' characteristics are an appropriate tool to account for household differences in designing schemes of fiscal imposition and to implement means tests capable to define fair criterions for accessing welfare programs.

The estimation of equivalence scales assumes a special relevance in those societies adopting a fiscal system based on household rather than individual incomes through the computation of a quotient. In the household based fiscal systems the tax brackets are computed on equivalent incomes. This method incorporates the principle of horizontal equity recognizing that, at a given income, the larger household is relatively poorer and corrects the distortion implicit in fiscal system based on separate taxation which penalizes the tax-payers supporting a relatively lager number of family members and families with a single wage-earner. When the interest is to compare the costs associated with an individual based fiscal system recognizing family allowances to account for differences in family composition and a fiscal system based on a quotient, we are in fact comparing a system adopting an equivalence scale expressed in absolute monetary terms and a system adopting an equivalence scale in relative terms. If the scale is measured correctly, the costs of the two systems should be similar. The robustness of the comparison critically depends upon the quality of the estimation of the scale.

Another relevant measurement issue is associated with the estimation using stated or objective data. Recent studies conducted by Koulovatianos, Schröder, and Schmidt (2005, 2009) have estimated the cost of a child asking direct questions through interviews. Considering that both estimation strategies intend to estimate equivalence scales, it is crucial that the estimation techniques are as robust and precise as possible if the estimates are to be compared.

These measurement concerns are the core of the motivation of the present study where we address the issue of the econometric identification of equivalence scales, which is not to be confused with the fundamental identification problem of the cost of a child. The econometric identification issue addressed in this study is about the identification of the parameters of the demographic modifying functions used to estimate equivalence scales (Singh and Nagar 1973, Muellbauer 1977, Perali 2003:119). Interestingly, this problem is akin to the identification problem of the sharing rule within collective household models (Chiappori, Fortin, and Lacroix 2002).

The cost of a child should be intended as the cost of maintaining a child (Ebert 1997, Ebert and Moyes 2003, Ebert and Moyes 2009) as it can be deduced from the expenditures for child necessities such as food, clothing and housing. In line with Browning's (1992) fundamental clarification between the needs and expenditure question related to the presence of children in a household, the cost of maintaining a child should be clearly distinguished from the cost of raising a child. The latter accounts also for other costs associated with non necessary expenditures for children, the value of time devoted by parents to children, and the value of other investments on child quality. For this reason, it is natural to think that the cost of raising or "producing" a child varies significantly with income, which is not necessarily the case for the cost of maintaining a child. While the costs of maintaining a child are useful to operate inter-household comparisons, the estimates of the cost of raising children are appropriate to explain fertility choices and should not be used to operate inter-household comparisons and to correct estimates of poverty and inequality.

The estimation of the cost of maintaining a child (cost of a child, from hereafter) implies to make comparisons of different households in different situations. Suppose, for example, that we are interested in comparing the cost of a child living in a poor household with the cost of a child living in a rich household. If we think at the composition of the toy basket of a child living in a poor household, we recognize that it is certainly smaller than the one of a child living in a rich household. Further, the content of the two baskets is much different. In the basket of the less affluent family, we do not find, for example, expensive electronic toys. The child living in a poor family does not take piano lessons. Also the clothing basket is likely to differ both for its dimension and the clothing quality. These considerations can be extended to other necessities such as food quality and the characteristics of the house in which they live. Rich parents, and their children, consume more leisure. It follows that it is possible to operate comparisons among children or persons living in rich and poor families, but it is crucial to confine the attention to "baskets" of similar dimensions containing necessary goods. In other words, it is fundamental to base comparisons only on expenditures for necessities forming the cost for maintaining a child as we do in the present study by adopting a needs-based data selection rule.

The objective of estimating equivalence scales strictly on a needs basis also requires to deal with two aspects. As exemplified by Blackorby and Donaldson (1991), the first concerns the fact that different households contain different numbers and types of people (adults, children, disabled people, and so on), and therefore have different preferences and needs. The second concerns the fact that there are economies of scale in household consumption due to public and semi-public consumption within the household.

The study uses an extended concept of equivalence scales which models household heterogeneity controlling for differences in needs and differences in scale economies due to differing life styles and associated household technologies or the sharing of household public goods. We also show that a modified cost function can also host a collective specification (Chiappori 1988, 1992, Chiappori, Fortin and Lacroix 2002). The proposed model encompasses demographic translating and scaling and Ray's generalized scaling (Ray 1996) where differences in needs are captured by a generalized scaling term and differences in scale economies by demographic translating and scaling (Lewbel 1985, Browning, Chiappori and Lewbel 2008, Lewbel and Pendakur 2008). In sum, the present study addresses the issue of econometric identification of the parameters of a demographically modified demand system used to estimate equivalence scales on a needs basis while separating differences in size from differences in scale economies.

The paper is organized as follows. The second section introduces a general theoretical background at the basis of equivalence scales accounting for both differences in needs and household technologies. The third section presents the econometric specification of the encompassing demand system, lending special attention to the demographic transformations capable to separate compositional from household life styles and related technologies, and shows how the model is econometrically identified. The fourth section describes the data and the aggregation choices. The subsequent section describes the estimation method, the results and the appropriateness of the estimated cost of the characteristics associated with the presence of children of different ages, of additional adults and of being singles. The conclusions discuss important practical aspects related to the econometric identification of a modified demand system and of the associated equivalence scales.

2. An Extended Theory of Equivalence Scales

The equivalence scale is an index number that converts families with different composition into identical individuals accounting for the associated differences in needs.

The scale depends on the quantity of "public goods" consumed by the family which directly influences economies of scale and on the distribution rule of both monetary and time resources within the family. Traditionally, it is assumed that resources are distributed equally across household members (Ebert and Moyes 2003). It follows that comparing the cost of living of a comparison household, indexed with superscript 1, with the cost of a reference household, indexed with the superscript 0, it is important also to condition the estimates of the cost function accounting for differences in life style, scale economies deriving from the sharing of household public goods such as housing and for the rule governing the allocation of resources within the household. For example, a childless couple can belong to a young or old cohort. Likewise, the choice of a single or a couple as a reference household has relevant consequences in terms of life styles and associated household technologies, scale economies and sharing behavior.

The cost associated with the characteristic d is therefore given by the ratio between the two cost functions keeping the level of utility, of prices and of life style constant:

$$ES_R = \frac{C\left(u,p,d^1;\eta,\sigma,\phi\right)}{C\left(u,p,d^0;\sigma\right)} \tag{1}$$

where η is the degree of public sharing of household goods, σ is the life style, and ϕ is the intra-household rule governing the distribution of resources between adults and children. We assume that the reference household does not have economies of scale associated with the public sharing of the household good and with the number of members who would enjoy the good. The sharing rule between adults and children of a reference household, because it is a couple without children, is trivially known. In comparing the reference and the comparison household, the life style σ is maintained constant to ensure, for example, that the reference childless couple be in reproductive age and does not lead a lifestyle characterized by household technologies typical of elderly couples.

Household economies of scale η are produced by the public dimension of living together and increase proportionally to the household dimension (Lewbel and Pendakur 2008). Some goods are fully public, as in the case of housing and heating; others are only partly public, such as listening to music either alone or in company, using the car to go to work or to go on vacation with the family, or the use of the telephone. Recently, Browning, Chiappori, and Lewbel (2008) have suggested to estimate these economies of scale using the scaling demographic functions *a la* Barten (1964) which considers each good as potentially either private or public in different degrees. A cloth that is used only for one child, can be considered a private good. If it is reused for a second child, the same cloth becomes to a certain extent public. It is as if the family had bought the same cloth at half of the price. In a sense, the family is getting more out of the same quantity of good. Similarly, eating alone or with other members of the family generates higher utility as if the food were of better quality and with a lower shadow price.

The incidence of household economies of scale is affected also by the rule ϕ managing the distribution of resources within the household (Perali 2003, Arias *et al.* 2003, Lise and Seitz 2004). Further, it is important to control the measurement of equivalence scales also for differences in life-styles σ characterized by specific household technologies related, for example, to single or double-income households, families with a head employed in the state sector and many other situations (De Santis and Maltagliati 2003).

The information content of a relative scale can also be expressed in absolute terms as a measure of consumer surplus:

$$ES_A = C\left(u, p, d^1; \eta, \sigma, \phi\right) - C\left(u, p, d^0; \eta, \sigma, \phi\right).$$

The absolute scale ES_A expresses the monetary compensation needed to restore the level of welfare enjoyed by the household before the birth of the child in an analogous fashion to the concept of compensating or equivalent variation.

3. Econometric Specification of the Demand Model: The Almost Ideal Quadratic Demand System modified *a la* Lewbel-Barten-Gorman

This section describes the specification of a complete demand system allowing the researcher to identify equivalence scales under an econometric point of view. The model assumes that consumers' preferences are PIGLOG (Gorman 1976, Muellbauer 1974, Deaton and Muellbauer 1980) at the basis of the almost ideal demand system. The base model, which is linear in the logarithm of income, can be extended to a quadratic specification in the logarithm of income (Banks, Blundell, and Lewbel 1997) if the model is applied to data that are sufficiently nonlinear. The base specification is expressed in terms of prices and income and must be extended to host other exogenous factors affecting demand such as demographic characteristics (Lewbel 1985).

3.1. The demographic transformation describing equivalence scales and household technologies

In general, demographic characteristics in modified cost functions interact multiplicatively both with prices and income while maintaining the theoretical plausibility of the model (Lewbel 1985). The interaction with prices captures the Barten substitution effects (Barten 1964).[1] The interactions with income can involve only demographic characteristics or can involve a function of both prices and demographics. In this case, the function describes fixed costs (Gorman 1976), which represent the sum of the values of the quantities committed to guaranteeing the household survival in cases of a full loss of earnings, and generate at the demand level a demographically varying translating term.

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[1] The demographic transformations of a demand system can be grouped into two types: a) modification without structure which consists in transforming the parameters associated with prices and incomes into linear functions of socio-demographic variables; this transformation is the same as adding to the demand system interaction variables obtained by multiplying either demographics and prices or demographics and income (Blundell, Pashardes, and Weber 1993, Donaldson and Pendakur 2004), b) modification with structure consisting in defining modifying functions *per se* with arguments prices and demographic characteristics interacting with prices and incomes. This is the approach introduced by Barten (1964), Gorman (1976), Pollak and Wales (1981), and Lewbel (1985) and is the modifying technique followed in this work because it is deemed as more interesting under a behavioral point of view. The two approaches can coexist within an *encompassing model*. The testing of the best functional specification under a statistical point of view will be considered in a future stage of the research program.

Using the notation introduced by Lewbel (1985) and dividing the set of demographic characteristics into two subsets D = (r,d), we can define the following demographically modified cost function:

$$y = C(u, p; r, d) = f\left(C^*\left(u, p^*\right), p, r, d\right) \qquad and$$
$$p_i^* = m_i(r, d),$$

where y = $C(u,p;r,d)$ is the income corrected by the equivalence scale, y^* = $C^*(u, p^*)$ is the observed income and p_i^* = $m_i(r,d)$ is the Barten price scaling function for each good i. The functions $m_i \geq 0$ for all i and strictly positive for at least one i, and f are continuous and at least twice differentiable. The function f describes the interactions between both demographic variables and total expenditure, while all the f and m_i functions allow interactions of demographic variables with prices. As shown by Lewbel (1985, Therem 8), a plausible form for the modifying function f is:

$$y = y^*\left[B(r)P^T\left(p^*, d\right)\right] = y^*\wp^T\left(p^*, r, d\right)$$

with

$$y^* = \frac{y}{\wp^T\left(p^*, r, d\right)}.$$

The term $\wp^T\left(p^*, r, d\right) = \left[B(r)P^T\left(p^*, d\right)\right]$ represents a sub-cost function composed by the Lewbel's income scale component $B(r)$ and Gorman's fixed cost component $P^T\left(p^*, d\right)$, which also scales income at the cost function level. At the level of the associated demand, the fixed cost term generates the translating demographic function which has only demographic characteristics as arguments. The Gorman's (1976) translating component $P^T\left(p^*, d\right)$ depends on prices and demographic characteristics d of the household. According to this transformation, the Gorman effect $P^T(p,d)$ represents a price index which interacts with the income scaling term $B(r)$ and controls for regional differences or for other household characteristics d not related to household composition r.

The function $B(r)$ is independent of prices. It includes variables related to household composition r from which the cost of household characteristic is derived. Note that $r \in B$ and $d \in P^T$, otherwise it is not possible to econometrically identify equivalence scales as it is shown in Section 4. Remarkably, the income scaling function $B(r)$ is analogous to the sharing rule of collective household models (Chappori, Fortin, and Lacroix 2002).

The question that we address in this study is the following: given the choice of the demographic transformation *f*, can we identify the parameters associated with the function $B(r)$ separating differences in size from economies of scale η captured by Barten prices p^* and life style effects σ as described by the translating term $P^T\left(p^*,d\right)$?

If the modified cost function $y = C(u,p;r,d)$ then is known because all the demographic parameters are identified, it is then possible to derive the equivalence scale associated with the cost of living index related to the demographic characteristic *r* (Pollak 1989, Lewbel 1991, Lewbel 1997):

$$ES_R = \frac{y_1}{y_0} = \frac{C\left(u,p,r^1,d^0;\eta,\sigma,\phi\right)}{C\left(u,p,r^0,d^0;\sigma\right)} = \frac{C\left(u,p^*,d^0\right)\wp^T\left(p^*,r^1,d^0\right)}{C\left(u,p^*,d^0\right)\wp^T\left(p^*,r^0,d^0\right)}.$$

Equivalence scales suffer of a fundamental identification problem. Different equivalence scales can be consistent with the same preferences described by observing consumers' behavior (Pollak and Wales 1979, Pollak 1991, Perali 2007). This indeterminacy implies that comparisons can change arbitrarily and the observation of consumer behavior is not sufficient to learn something about inter-household comparisons.

Definition 1. *Fundamental identification problem of equivalence scales. The same conditional demands $q(p,y|r,d)$ can be derived from the class of cost functions $C\left(u,p;r,d\right) = G\left(u,p,d\right)m_0\left(p,r,d\right)$ where $G\left(u,p,d\right) = \min\left\{p'q \middle| \Im\left(U'\left(q|r,d\right),r,d\right) \geq u\right\}$ and $\Im\left(u,r,d\right)$ is any function monotone in u such that $U\left(q,r,d\right) = \Im\left(U'\left(q|r,d\right),r,d\right)$. It follows that different equivalence scales are consistent with the same preferences.*

In the case of non conditional preferences, demographic attributes affect the utility function both directly through the term $\Im\left(u,r,d\right)$ and indirectly affecting consumption choices and the level of direct utility $U'\left(q|r,d\right)$ (Perali 2003). The presence of a child in the household induces a reallocation of expenditures if the level of income does not change, but the presence of a child affects *per se* the level of utility of the household, positively when the child smiles and negatively when the child cries. From consumption data it is possible to identify only conditional preferences.

Nonetheless, the fundamental identification problem does not imply that equivalence scales cannot be estimated uniquely.

Property 1. *Base Independence (IB) or Equivalence Scale Exactness (ESE)*. A household equivalence scale or cost of characteristics index is independent of the choice of the income or utility level upon which interpersonal comparisons are based, namely is IB (Lewbel 1989, 1991) or ESE (Blackorby and Donaldson 1991), if it depends on prices and demographic characteristics but it does not depend on the income level chosen to make inter-household comparisons.

If two adjacent Engel curves referring to household typologies differing for a single characteristic are *shape invariant* (Pendakur 1999, Perali 2003), then the two Engel curves are also parallel. Equivalence scales are therefore exact in the sense that are independent of the income level chosen for comparisons. It is important to underline that the IB/ESE property can be rejected, but the analysis of the observed demands is not sufficient to confirm the IB/ESE hypothesis because it is not possible to test if monotonic transformations are independent of household characteristics.

As a consequence of the IB/ESE property, it is possible to separate the cost function in a sub-cost function $G(u,p)$, equal for all households confronting same prices, and in a function $m_0(p,r,d)$ grouping all demographic modifying functions such as the Barten price scaling function $m(p,d)$, the Gorman's translating function $P^T(p^*,d)$ and Lewbel's income scaling function $B(r)$ (Ferreira and Perali 1992):

$$y = C(u,p,r,d) = G(u,p)m(p,d)\wp^T(p^*,r,d) = G(u,p)m_0(p,r,d).$$

From this expression, if we deflate household income y by the (equivalence) scale factor $m_0(p,r,d)$ summarizing the needs specific to each household, we obtain a cardinal money measure of welfare u cardinally fully comparable (Perali 1999, 2003):

$$\frac{y}{m_0(p,r,d)} = G(u,p),$$

corresponding to the definition of equivalent income. Being cardinally comparable, this measure is appropriate to implement inter-household comparisons that are commonly made when identifying the beneficiaries of welfare policies or when measuring poverty and inequality.

Thanks to the possibility to separate demographic information and the interaction terms between prices and demographic variables from the sub-cost function $G(u,p)$, an IB/ESE equivalence scale can be written independently from the level of utility u chosen as reference:

$$ES_R = \frac{y_1}{y_0} = \frac{C\left(u,p,r^1,d^0;\eta,\sigma,\phi\right)}{C\left(u,p,r^0,d^0;\sigma\right)} = \frac{G(u,p)m\left(p,d^1\right)\wp^T\left(p^*,r^1,d^0\right)}{G(u,p)m\left(p,d^0\right)\wp^T\left(p^*,r^0,d^0\right)} = \frac{m\left(p,d^1\right)\wp^T\left(p^*,r^1,d^0\right)}{m\left(p,d^0\right)\wp^T\left(p^*,r^0,d^0\right)}.$$

The IB/ESE property permits recovering equivalence scales uniquely, but it does not contribute to solve the fundamental (economic) identification problem of equivalence scales because it does not add information related to non conditional preferences. It is worth remarking that the above equivalence scale enjoys the following property (Ebert and Moyes 2003) :

Property 2. *Independence from the choice of the reference household.* The equivalence scale is independent from the choice of the reference household if the ranking order of the distribution of welfare, expressed in terms of equivalent incomes, does not change as the reference household, for example the childless couple or the single, changes.

By separating the source of heterogeneity related to household size and composition *r* from other household characteristics *d*, we can control comparisons across households not only on the same price basis, but also on the basis of similar demographic characteristics. These properties have been incorporated in the specification of the demand system which is presented in the next section.

3.2. Specification of the Demand System

Assume that the indirect utility function of the household is PIGLOG

$$\ln V\left(y,p,r,d\right) = \left[\left(\frac{\ln y^* - \ln a\left(p,d\right)}{b\left(p,d\right)}\right)^{-1} + \lambda\left(p,d\right)\right]^{-1}, \qquad (2)$$

where $a(p,d)$ and $b(p,d)$ are price aggregator functions and the logarithm of total expenditure is specified *a la* Lewbel-Barten-Gorman as discussed before:

$$\ln y^* = \ln y - \ln \wp^T\left(p^*,r,d\right),$$

and

$$\wp^T\left(p,r,d\right) = B\left(r\right)P^T\left(p^*,d\right).$$

The term $\lambda(p,d)$ is a differentiable function homogeneous of degree zero in prices *p.* When this function is independent of both prices and demographic characteristic *d*, then we obtain the AIDS model linear in income. Prices are scaled using Barten's (1964) technique to obtain the shadow prices:

$$\ln p_j^* = \ln p_j + \ln m_j(d).$$

The vector of demographic characteristics d is an argument of the scaling function $m_j(d)$ describing the household technology *a la* Barten. To the shadow prices there corresponds, in the dual space, the shadow quantities $q_j^* = q_j/m_j(d)$. The value of the scaling function $m_j(d)=q_j/q_j^*$ reveals the individual differences in transforming the consumption of a certain good in utility units. The transformation technology differ both among households and individuals within the same family.

The income committed to survival, when for example a household head loses the job, is a fixed cost which translates the income composed by the sum of basic expenses for the single goods $t_j(d)$:

$$\ln \wp^T(p,r,d) = \ln B(r) + \ln P^T(p^*,d) = \sum_{k=1}^{R} \rho_k r_k + \sum_{j=1}^{N} t_j(d) \ln p^*_j,$$

with $B(r) = \exp\left(\sum_{k=1}^{R} \rho_k r_k\right)$ and $P^T(p^*,d) = \exp\left(\sum_{j=1}^{N} t_j(d) \ln p^*_j\right)$.[2]

It is relevant to note that changes in life styles σ and economies of scale η are captured by the presence of demographic control variables transforming prices and incomes by means of household technologies *a la* Barten and Gorman (Bollino, Perali and Rossi 2000, Perali 2003). Further, note that this encompassing specification of the equivalence scale unifies the approach by Blacklow and Ray (2000), Lancaster, Ray, and Rebecca (1999), and Ray (1983) who use only the function $B(r)$ and of Blundell and Lewbel (1991), Lyssiotou (1997, 2003), Pashardes (1995), and Phipps (1998) who estimate the scale by specifying only the translating term $P^T(p,d)$.

The term related to fixed costs $ln\ P^T(p^*,d)$ is homogeneous of degree zero in p. Analogously to the Slutsky decomposition into the substitution and income effect, the household technology *a la* Barten-Gorman, modifying the effective prices through the scaling substitution effect, rotates the budget constraint and translates the expenditure through the translating fixed cost effect. The equivalence scale function, $B(r)$, scales both fixed costs and total expenditure at the same time.

The cost function associated with the indirect utility function (2) is

$$\ln C(u,p,r,d) = \ln a(p,d) + \left(\frac{v(u)\,b(p,d)}{1 - v(u)\,\lambda(p,d)}\right) + \ln \wp^T(p,d). \tag{3}$$

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[2] Note that the specification of the income scale function $B(r)$ can also be written $B(r)^* = 1 + \sum_{k=1}^{R} \rho_k r_k$ considering that for sufficiently small parameters we have that $\ln B(r) \approx \ln B(r)^*$. This expression is generally adopted by Ray (1983), Lancaster, Ray, and Rebecca (1999), Blacklow and Ray (2000), and Perali (1999).

In the tradition of the literature on demographic modifications of demand systems (Lewbel 1985), prices are scaled while income is translated. In the demographic transformation adopted in the present study, income is both scaled by the term $B(r)$ to estimate the equivalence scale, and translated by the term $P^T(p^*,d)$. The translating method used to introduce demographic information in the demand system is IB by construction (Perali 2003).

Considering that the main objective of the study is the estimation of the equivalence scale and not the estimation of household technologies and economies of scale associated with the different degree of sharing of the public goods described by the interactions of demographic effects with prices, we do not adopt here the Barten transformation. In line with our objectives, we deem important to concentrate on the issue of identifying the parameters of the $B(r)$ income scaling function separately from the issue of identifying the price scaling function $m(p,d)$. This latter issue has been already considered in the literature (Muellbauer 1977, Ferreira and Perali 1992, Perali 2003). Hence, $p = p^*$.

The price aggregator is specified as a Translog function

$$\ln a(p) = \alpha_i + \sum_{j=1}^{N} \gamma_j \ln p_j + \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma_{ij} \ln p_i \ln p_j ,$$

while the price function is Cobb-Douglas

$$b(p) = \prod_{i=1}^{N} p_i^{\beta_i} .$$

The term $\lambda(p,d)$ is also independent of demographic characteristics because prices are not modified by demographic variables:

$$\lambda(p) = \prod_{i=1}^{N} p_i^{\lambda_i} .$$

The translating demographic transformation is instead maintained.

The application of Roy's identity gives the system of demand equations expressed in shares:

$$w_i = \alpha_i + \tau_i(d) + \sum_{i=1}^{N} \gamma_i \ln p_i + \beta_i \left(\ln y^* - \ln a(p)\right) + \frac{\lambda_i}{b(p)} \left(\ln y^* - \ln a(p)\right)^2 . \quad (4)$$

Relationship (4) describes the specification of the estimated demand system.

The equivalence scale for the QAIDS demand system demographically modified using Gorman translating described in equation (4) is the same regardless to the linear or quadratic in income specification when the IB/ESE property is imposed:

$$ES^{IB}(u,p,r,d)=\frac{C(u,p,r^1,d^0)}{C(u,p,r^0,d^0)}=\frac{G(u,p)m_0(p,r^1,d^0)}{G(u,p)m_0(p,r^0,d^0)}= \\ =\frac{\wp^T(p,r^1,d^0)}{\wp^T(p,r^0,d^0)}=\frac{B(r^1)P^T(p,d^0)}{B(r^0)P^T(p,d^0)}=\frac{B(r^1)}{B(r^0)}. \qquad \textbf{(5)}$$

Recall that when the Barten substitution effects are absent, as in our case, the equivalence scales derived uniquely from the translated demographic effects and from the income scaling function is IB by construction. Given the specification of the equivalence scale adopted in the estimation, the cost of characteristic index is obtained as follows:

$$\frac{C(u,p,r^1,d^0)}{C(u,p,r^0,d^0)}=\frac{B(r^1)}{B(r^0)}=\exp\left(\rho_k {r^1}_k\right) \quad \textbf{(6)}$$

where $B(r^0)=1$ because for the reference family, being a childless couple, $r^0=0$ in order to ensure the property of independence of the equivalence scale from the choice of the reference household. Now we show that the parameters of the generalized income scale term $B(r)$ can be identified.

4. Econometric Identification of the Equivalence Scales

Dealing with equivalence scales it is important to distinguish between the issue of econometric identification (Lewbel and Pendakur 2008) and the fundamental identification problem raised by Pollak and Wales (1979), which is due to the fact that two families with similar characteristics and conditional preferences with respect to the characteristics for consumption goods, can have different unconditional preferences and equivalence of scales.

This section is concerned with the source of the econometric identification problem associated with the estimation of a demographically modified demand system *a la* Lewbel-Gorman (equation (4)). The system of equation (4) is reproduced here in a simplified linear version of an AIDS demand equation:

$$w_i=\alpha_i+t(d)+\beta_i\left(\ln x-B(r)-P^T(p,d)\right)= \\ =\alpha_i+\delta_i d+\beta_i\left(\ln x-\rho r-\delta_i(d\ln p_i)\right),$$

where

$$t(d)=\delta_i d;\;\; B(r)=\rho r;\;\; P^T(p,d)=\delta_i(d\ln p_i),$$

and w_i denotes the budget share of good i = 1,2, p is the vector of associated market prices, x is total expenditure, d denotes a household characteristic such as the age of the household head, and r denotes a characteristic such as family size. The econometric identification of equivalence scales can be extended to the case of a demand system quadratic in total expenditure following the same line of proof described here for the linear case that we chose for the sake of expositional convenience. We are not proposing the proof for the quadratic system, because it does not add useful information to the comprehension of the estimation problem. The number of goods in the basket has been limited to two for illustrative purposes.

The objective is to verify the identifying conditions for the parameter ρ argument of the scaling function $B(r)$. Interestingly, this line of proof is similar to the one used by Chiappori, Fortin, and Lacroix (2002) to prove the identification of the parameters of the sharing rule, because the sharing rule is a function that scales income as the function $B(r)$ does and in Perali (2003:119) for the identification of the demographic parameters of a Barten-Gorman model.

Proposition 1. *Given a structural functional form and the corresponding reduced form, both continuously differentiable, if there exists an one-to-one correspondence between the elements of the Jacobian matrixes, or the Hessian matrixes, of the structural and the reduces form, then the demand equation w_i is the solution of the utility maximization program and all parameters of the demand equation are identifiable.*

Proof. Consider the following functional structural specification and the associated reduced form

Structural Form	***Reduced Form***
$w_1 = \alpha_1 + \delta_1 d + \beta_1 \left(\ln x - \rho r - \delta_1 \left(d \ln p_1\right)\right)$	$w_1 = a_0 + a_1 d + a_2 r + a_3 \ln p_i + a_4 d \ln p_i + a_5 \ln x$
$w_2 = \alpha_2 + \delta_2 d + \beta_2 \left(\ln x - \rho r - \delta_2 \left(d \ln p_2\right)\right)$	$w_2 = b_0 + b_1 d + b_2 r + b_3 \ln p_f + b_4 d \ln p_f + b_5 \ln x$

the one-to-one correspondence between the coefficients of the structural and reduced forms is found by differentiating the elements of the Jacobian matrix of the unrestricted reduced form and the elements of the Jacobian matrix of the structural form that describes the theoretical restrictions that link the reduced form to the structural one

Structural Form	***Reduced Form***
$\dfrac{\partial w_1}{\partial d} = \delta_1 - \beta_1 \delta_1 \ln p_1$	$\dfrac{\partial w_1}{\partial d} = a_1 + a_4 \ln p_1$
$\dfrac{\partial w_1}{\partial r} = \beta_1 \rho$	$\dfrac{\partial w_1}{\partial r} = a_2$
$\dfrac{\partial w_1}{\partial \ln x} = \beta_1$	$\dfrac{\partial w_1}{\partial \ln x} = a_5$
$\dfrac{\partial w_1}{\partial \ln p_1} = \beta_1 \left(-\delta_1 d\right)$	$\dfrac{\partial w_1}{\partial \ln p_1} = a_3 + a_4 d.$

Because first and second elements of the Jacobian matrix are not linear in the parameters, we proceed with the second derivatives. The two non zero elements of the Hessian matrix are equal to

Structural Form	***Reduced Form***
$\frac{\partial w_1}{\partial d \partial \ln p_1} = -\beta_1 \delta_1$	$\frac{\partial w_1}{\partial d \partial \ln p_1} = a_4$
$\frac{\partial w_1}{\partial \ln p_1 \partial d} = -\beta_1 \delta_1$	$\frac{\partial w_1}{\partial \ln p_1 \partial d} = a_4.$

Equating the corresponding elements of the Jacobian and Hessian matrices and solving we have

$$\beta_1 = a_5,$$

$$\rho = \frac{a_2}{a_5},$$

$$\delta_1 = \frac{a_4}{a_5},$$

where the parameters of the equivalence scales in the structural form are function of the parameters identified in the reduced form, and hence the former are identifiable as well.

Differentiating twice the second demand equation w_2 we obtain the following relationships

Structural Form	**Reduced Form**
$\frac{\partial w_2}{\partial d \partial \ln p_2} = -\beta_2 \delta_2$	$\frac{\partial w_2}{\partial d \partial \ln p_2} = b_4$
$\frac{\partial w_2}{\partial \ln p_2 \partial d} = -\beta_2 \delta_2$	$\frac{\partial w_2}{\partial \ln p_2 \partial d} = b_4,$

from which we derive the following identifying conditions:

$$\beta_2 = b_5,$$
$$\rho = \frac{b_2}{b_5},$$
$$\delta_2 = \frac{b_4}{b_5}.$$

The overidentifying condition of the parameter associated with the equivalence scale is:

$$\rho = \frac{a_2}{a_5} = \frac{b_2}{b_5}. \square$$

Remark 1. Note that $\rho = a_2 / a_5 = a_2 / \beta_1 = b_2 / \beta_2$. It follows that the estimation of the parameter associated with the equivalence scale is inversely proportional to the dimension of the income parameter. It is therefore important to verify during the econometric execution the effects related to the choice of the price level and of the deflating term ln$a(p)$ on the dimension of the parameter associated with income, and, as a consequence, on equivalence scales. This effect is similar to the one documented by Pashardes (1993) in relation to the distortion generated on the parameters associated with the use of the Stone index in substitution of the term ln$a(p)$ which introduces non linearities in the parameters of the estimation. The problem is exacerbated in the quadratic specification because the deflating effect of the term ln$a(p)$ can exert a strong scaling effect on the level of the income parameter.

Remark 2. The identification proof shows that the demand system is estimable both in the structural and in the reduced form by estimating in the first stage the reduced form and imposing in a second stage the parameters of the structure applying the derived restrictions. This estimation technique is known as Minimum Distance Estimation (MDE).[3]

Remark 3. Note that if the translating term describes Gorman fixed costs $P^T(p,d)$ includes the same variables related to household composition r present also in the term $B(r)$, that is, if it is specified as $P^T(p,d,r)$, then the parameter associated with the variable r is not identifiable. The proof of this assertion follows step by step the demonstration line offered in Proposition 1 and is not therefore reproposed here.

[3] For an application see Blundell, Pashardes, and Weber (1993), Chiappori, Fortin, and Lacroix (2002), Perali (2003), and Menon and Perali (2008).

As underlined in Remark 1, the demonstration shows the importance of the dimension of the income parameter in the determination of the size of the equivalence scale. It is therefore critical to verify that the estimation of the parameter associated with income is stable and not biased, for example, by endogeneity problems of the income variable or specification problems of the price aggregator term $\ln a(p)$ when it acts as income deflator.

5. Data Description

The estimation of the complete demand system uses the household budgets collected by the Italian National Statistical Institute (ISTAT) in 2002. The sample, after excluding the observations with household head older than 65 corresponding to 30.75 percent of the entire sample, is composed of 19,045 observations. The households with head more than 65 years old have been excluded because they present an expenditure behavior significantly different from the expenditure style of the younger households.

The composition of expenditures include the expenditure flows and exclude expenditures on durable goods and expenditures on house rentals. The purchase of durable goods is not frequent, though durables are used everyday like the other goods. The quantity and the value of the daily use of durable goods is subject to often large measurement error. The inclusion of durables therefore may introduce a significant distortion in the estimated parameters. The choice of excluding housing rents is based on the fact that the imputation of the rent values for owned houses could introduce significant distortions in the composition of expenditure for housing especially if one considers that 72.4 percent of the sample lives in a owned house. As a consequence of this choice, the estimated demand system is conditional upon the decisions made about the consumption of durable goods and housing. The conditioning has been modeled including dichotomic variables for the presence of a owned house.

The equivalence scale describes the differences in the cost of living associated with the different socio-economic characteristics of the households and with the related different levels of necessities. For this reason, and in line with the definition of the cost of maintaining a child, the aggregation of the expenditure items in groups is made up only of the necessity components (Phipps 1998) with the exception of the residual category *other* goods. For example, the group of food items does not include the expenditure for food-away-from home, and clothing does not include expenditures for furs and other luxury goods. The non necessary components have been included in the category “other goods.” This aggregation permits computing absolute equivalence scales corresponding to the difference between the cost of living of a comparison and a reference household expressed in terms of the expenses for all necessary goods. Expenditures for necessities do not vary significantly as the level of income increases.

The following table describes the components of each expenditure group. Interestingly, a similar reclassification of the basket of goods based on a basic needs approach has been adopted by ISTAT (2009) for the measurement of absolute poverty.

Good categories included in the analysis	*Goods excluded because not necessities and included in the category "other goods"*	*Goods excluded because durables*
Food	Food away from home	
Basic housing expenditures	Gardeners, majordomos	Repairs, refurbishing, expenditures for second houses, purchase of technologies
Basic clothing expenditures	Furs	
Basic transport and communication expenditures	Air tickets, taxi and house removals, taxi	Purchases of autos, cycles, motocycles, telephones
Basic education, recreation and health (dentist and medicines) expenditures	Travelling abroad	Purchases of boats, autos, eye-glasses, prothesis
Other goods and luxury goods		silverware, radio, computers, cameras

A limitation of the ISTAT household budgets is the absence of information about quantities consumed by each household. If quantities and expenditures were known, then it would be possible to derive the associated household specific prices as unit values. This information is fundamental for demand studies having the objective of estimating welfare and utility levels necessary to derive cost functions for the estimation of equivalence scales. It has been therefore necessary to estimate the unit values with an alternative procedure described in Atella, Menon, and Perali (2003) and Hoderlein and Mihaleva (2008). This technique impute to the ISTAT monthly price indices, published at the province level, the variability of unit values which incorporates the spatial differences in prices and the objective and subjective differences in the goods quality as they can be deduced from the household socio-economic characteristics.

The set of demographic characteristics D is divided in two subsets $D = \{r, d\}$. The subset r includes the household characteristics for the estimation of equivalence scales: $r_i = \{r_1$ (number of children less of 5 years old), r_2 (number of children of age between 6 and 13), r_3 (number of adolescents of age between 14 and 18), r_4 (number of adults beyond the couple members), r_5 (*single*)$\}$, with associated parameter vector $\rho_i = (\rho_1, ..., \rho_I)$ with i=1, …, 5. The complement subset d includes the demographic variables, $d_s=\{d_1$ (=1 if resident in the north), d_2 (= 1 if resident in the south or islands), d_3 (age of the household), d_4 (= 1 if the household head is a dependent worker), d_5 (level of instruction of the household head classified as low, average or high), d_6 (= 1if the household lives in rural areas), d_7 (= 1 if the wife is employed), d_8 (= 1 if the house is owned)$\}$ with associated vector of demographic parameters $\delta_i=(\delta_1, ..., \delta_s)$ for s = 1, ..., 8. The reference household is a household living in the Centre of Italy, which is the region excluded from the estimation, for which all variables of the r

and *d* subset take the value of 0. Thanks to this construction and to the chosen functional form, the value of the cost sub-function $m(p,r^0,d^0)$ in equation (5) is equal to 1 and the property of independence of equivalence scale from the chosen reference household is maintained.

The budget shares for male, female and children clothing, for education, and health are censored in a non negligible size. The proportion of zero outcomes is the following: male clothing 56%, female clothing 53%, children clothing 43%, non assignable clothing 48%, education and recreation 16%, health 49%. The realization of zero expenditures is in part explained by the short duration of the *recall* period of the survey design and in part by the budget constraint (Pudney 1990). The choice of the recall period for the expenditure of semi-durable goods is one of the most important problems encountered by a researcher when designing an expenditure survey (Grosh and Glewwe 2000). An excessively long recall period can lead to underestimation of the effective expenditure. Considering that the zero generating process is of different nature for each expenditure category, the specification of bivariate models, in alternative to Tobit models, which are appropriate only in the cases where the consumption participation decision and the choice about how much to consume is determined by the same set of covariates, as it should be the case when the decision not to consume is a corner solution of the classical consumer problem, has been studied *ad hoc* for each censored expenditure category (Blundell and Meghir 1987). Total expenditure computed from the imputed expenditures of the censored goods corrects in part also the measurement error often responsible for the endogeneity of total expenditure. Despite the correction for those measurement errors stemming from the lack of continuity in purchases, the endogeneity problem of total expenditure persists. According to the results of the Hausman-Wu test, total expenditure is endogenous with respect to all budget shares but for housing. Total expenditure has been corrected using the technique shown in Mroz (1987).

Table I.1 in Appendix reports the definition of the variables used in the econometric analysis along with their mean, standard deviation and minimum and maximum values. The subsequent descriptive tables illustrate the consumption habits of Italian households, expressed in terms of aggregate goods, as the household typology, income, family size and macro region vary.

Table I.2 in Appendix shows the different consumption habits of Italian household types. As it is reasonable to expect, the comparison between consumption patterns reveals very different life-styles. For example it is interesting to note the differences between young and old couples without children. While the young couple without children presents a food share lower than the food share of the couple with children, the elderly couple devotes to food more money than the couple with children. This lack of monotonicity in the increase of the food share as family size gets lager is an apparent contradiction of the second Engel law which shows how, at same level of household income, a large household has a higher food budget share (Perali 2008). Further, the elderly childless couple reports the lowest transportation and communication share with respect to all other household types. Because of these differences in consumption patterns, it is very important to control for the "life-style" effects both in the specification of the econometric model and in the derivation of household equivalence scale which should be independent of the choice of both the reference household and its life-style. If we consider the food share a reliable indicator of welfare, we can plausibly observe that the mono-parental households are relatively poorer. On the other hand, those who live alone and the couples without young children are the household types with higher budget shares on luxury goods.

Table I.3 in Appendix shows the variation of the consumption shares by quintile of total expenditure. The first row related to the food share is in line with the first Engel law. Household expenditure, on the other hand, weighs relatively more in the budget of the less affluent families. Expenditures for transportation and communication, for clothing, and education, recreation and health do not vary significantly as the level of income changes. This evidence is not surprising if we consider that the selected expenditures are those related to necessary goods with the exception of the "Other Good" category, which includes luxury goods, which increases sensibly as income increases.

Table I.4 in Appendix describes the variation in consumption shares associated with household size and the macro-region of residence. The level of the food share for the North, Centre and South of Italy is in line with the second Engel law with the exception of the transition from the childless couple to the couple with one child because of the effect related to the different life-style of the young and elder childless couplet previously shown. Looking at the table moving from the North to the Centre and the South of Italy we see that the level of the shares increases in line with the first Engel law, because the income levels decrease with the latitude. In the North, housing expenditures are relatively higher because of the heating. Similar considerations can be extended for the other goods. The presence of one or more children changes significantly both the household organization and the consumption pattern.

The horizontal difference across levels of shares varies as the number of children varies and expresses a rough measure of household scale economies. These are present, as it is reasonable to expect, especially for housing and clothing expenditures. However, the effect is modest. This is not surprising because only 3.7 percent of the sampled households has more than two children.

The evidences reported in Tables I.2 - I.4 show the importance of conducting an estimation conditioning both for differences in life styles σ and for the presence of scale economies η. The possibilities to control the estimates of equivalence scales also for the rule governing the intra-household allocation of resources ϕ requires a dedicated study, but is in principle estimable.

6. Estimation Method and Results

The adopted estimation technique is maximum likelihood. The share omitted to avoid singularity of the variance-covariance matrix is the other goods share. The demand system has been estimated with the restrictions of homogeneity and symmetry as maintained hypotheses and the conditions guaranteeing the econometric identification of the equivalence scales as shown in Section 4.

The joint estimation of the complete demand system comprising six goods "food, housing, clothing, transportation and communication, education, recreation and health, and other goods," which exhaust total expenditure, has been carried out using the quadratic specification of income transformed with the translating demographic modification corresponding to relationship (4).

Table 1 reports the estimated parameters. They are in general significantly different from zero. The statistical significance of the demographic parameters in most equations is an evidence in favor of the importance of controlling for differing life-styles and scale economies when measuring equivalence scales. The parameters associated with both the linear and quadratic income terms are stable. Considering the attention lent to guaranteeing the exogeneity of incomes and to the specification of the $\ln a(p)$ price aggregator, the income parameters are not expected to be biased. As stressed in Remark 1, these estimation features are crucial for a robust estimate of the equivalence scale.

The observation that the parameters associated with the quadratic term are all statistically significantly different from zero supports the fact that the Engel space underlying the demand system has rank three.

The parameters associated with the equivalence scale, presented in the last row of Table 1, are also significantly different from zero. As described in equation (6), equivalence scales correspond to the exponents of the parameters.

Tables 2 and 3 describe the matrix of compensated price elasticities and expenditure elasticities and the matrix of the marginal impacts of demographic variables computed at the data means respectively. The own compensated price elasticities along the diagonal have the expected sign. The demand system, therefore, satisfies the regularity conditions at the data means. The Slutsky matrix is negative semi-definite. It is then possible to integrate the demand system and recover the cost function uniquely. The estimates can therefore be properly used to operate inter-household comparisons because they comply with the requirements of welfare theory.

Note that income elasticities are less than one for all goods, in line with their nature of necessary goods, with the exception of the good "transportation and communication" and the "other goods" category which presents an expenditure elasticity larger than one. This effect is not surprising especially for the residual category "other goods" because this expenditure aggregate is composed mainly by less necessary goods.

The relative equivalence scales are presented in Table 4. The presence of a child less than six years old induces a maintenance cost increase of 19.4% with respect to the cost of living of a childless couple.[4] With reference to an adult equivalent, that is the equally weighted member of a couple, the child less than six years old costs 38.7%. The cost of maintaining a child of age between 6 and 13 years old increases the costs of a childless couple by 16.3% which corresponds to 32.6% of the cost of an adult equivalent. An adolescent costs 35.8% of an adult equivalent, while an extra adult, who can also be a child more than 18 years old living in the household of origin, costs 13.3% of the cost of an adult equivalent. For example, with respect to a 6 members household composed by a married couple, three children distributed uniformly across the three age classes and an extra adult, would give a household equivalence scale of 3.2 adult equivalents. The effective household size is almost halved. The difference between the real and effective family size measures the economies of scale that the comparison household obtains with respect to a household composed by 6 adult equivalents.

The household composed by a single person has a cost of almost 80% with respect to the cost of a childless couple due mainly to the impossibility of sharing the fixed costs associated with the expenditure for the house including rents and other household public goods. With respect to an equivalent adult, the person living alone bears a cost of living of about 60% more.[5]

The cost of a child can be expressed in monetary terms using the concept of absolute equivalence scale corresponding to the difference between the cost of living of the comparison household, for example a couple with a child, and the cost of living of a reference childless couple. If we consider an average monthly expenditure of a childless couple of the sample for necessary goods including house rent of about 1300 €,[6] the cost of maintaining a child in absolute terms for the age classes defined in the study corresponds to {0-5,6-14,15-18}={252 €, 212 €, 233 €}.

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[4] It is worth remarking that equivalence scales can be translated in terms of equivalent adults evaluating each single component of the couple as equal to 1, not 0.5. This is equivalent to multiply the scales by 2. This normalization in equivalent adults makes the scales comparable to the household dimension and is therefore possible to put side by side per-capita and equivalent incomes. For example, suppose that we are interested in comparing two households with the same income of 60 units and same household size of 6. If we do not have further information about the composition of the two households, then both households enjoy the same welfare level of 60 units. Suppose now that we know that family A is composed by a couple with 4 children with a household equivalence scale of 4 and household B is composed by a couple, an extra adult, and 3 children with an equivalence scale of 5. The more the number of equivalent adults is less than 6, the greater economies of scale are. Therefore each member belonging to household A enjoys the same welfare level of a reference household composed by a single adult of 15 units, while household B enjoys a level of welfare per equivalent adult of 12 units. Note that the per capita income of the two households would be 10 units. In utility terms, the welfare of family A corresponds to 90 units for the 6 members, while the welfare level of household B is 72 units. Alternatively, household B to reach the same welfare level of household A should enjoy 75 units of welfare.

[5] In separate calculations, available upon request from the authors, we also estimate Engel equivalence scales. The equivalence scales presented here are less than Engel scales as dictated by the theory. Such coherence, which predicts that the theoretical scale be less than the upper limit represented by the Engel scale, is maintained for the different age classes. This degree of conformity with the theory can be considered acceptable because the test is empirical and is basically intended to control that the estimates are reliable under an economic point of view.

[6] Considering that the expenditure for necessary goods in the sample used in this study does not vary significantly as income, the macro-region, and different life cycles vary, the choice of a single level of expenditure on which to base the derivation of absolute equivalence scales is justified and is in line with the concept of independence of the base income chosen to implement inter-household comparisons. The data show that household with double-earners have expenditures for necessary goods greater by about 15%. This difference can reasonably be attributed to differences in the quality of necessity goods. This evidence can in part explain why also the cost of maintaining the child can grow as income increases (Donaldson and Pendakur 2004).

Table 5 proposes an international comparison of equivalence scales. The problem that is found when comparing households translates also the comparison across societies or across the same society at different time periods. However, if equivalence scales are effectively measuring differences in needs, it is then plausible that differences in the estimates of the relative cost of maintaining a child in different societies vary within a relatively small range independently from the method used and the peculiarities of the survey data used for the estimation.[7] In other words, it is unlikely to find a society where a child costs as much as an adult.

In general, the comparison across equivalence scales is complicated by the fact that the equivalence scales are not reported in terms of the same reference household. In some cases, the household chosen as the basis for comparison is the childless couple, in other cases the person living as a single. The comparison requires a change in basis as it is traditionally done in cost of living indexes (Atella, Caiumi, and Perali 2001).

According to the classification proposed by Buhman *et al.* (1988), the household equivalence scales can be divided into scales based on the empirical data of household expenditure surveys and scales based on experts' opinions about specific physiological needs or socio-cultural necessities. The household scales derived from microdata can be further divided into subjective scales, based upon the individuals' perceptions about the minimum income necessary to enjoy the same level of utility of a reference family (Kapteyn and van Praag 1976, van Praag 1991, van Praag and Warnaar 1997, Koulovatianos, Scrhöder, and Schmidt 2005), and objective scales based on consumption data. In line with the classification by Banks and Johnson (1993), the scales based on demand analysis can be further distinguished as a) scales based on basic necessities, b) scales which approximate the exact measure of welfare, such as the Rothbarth and Engel scales, and c) scales based on the estimation of a complete demand system which are reported in Table 6 because comparable to the indexes estimated in the present study.

The comparison presented in Table 6 refers only to the cost of maintaining a child because the studies estimating also the cost of the characteristics "living alone," or "being an elder," or other household characteristics are not as frequent. In the construction of the table, we assumed that three hypothetical children are spaced according to the following age profile (<5,5-10,>10). When the cost of the child is not directly estimated in the examined studies, then the cost of the child is computed as the average of the cost of the first, second and third child.

The list of estimated equivalence scales, which is not exhaustive, shows that the interval of variation for the cost of a child is [0.19, 0.69] with respect to the cost of an adult equivalent corresponding to the member of a childless couple. The comparison of the equivalence scales reported

7 Equivalence scales based on a complete preference structure are in general base independent by construction. This property, which maintains the cost of a child constant along the income distribution of a society, also reduces the variability of the scales across countries and time because it is less sensible to changes in income distribution.

in Table 6 shows further that the equivalence scales estimated for the Italian case are comparable both across countries and different periods. The Italian scale is slightly higher than the average of the set of estimates based on a complete demand system. We can therefore maintain that the estimates of the Italian case are coherent with the other international estimates related to the cost of maintaining children.

7. Conclusions

This research estimates the cost of maintaining a child for different age classes, the cost of the characteristic “being single” or “being an adult member” of a household in order to make the income levels of households of different composition comparable. The estimated scales are derived using a method consistent with economic theory, analogous to the real cost of living index, based on a complete quadratic demand system plausibly modified to include demographic characteristics and consistent with an extended theory of household equivalence scales.

This paper contributes to the existing literature on equivalence scales under 2 point of views:

a) clarifies important issues related to the econometric identification of equivalence scales and the estimation procedure to guarantee robust estimates;
b) it separates differences in needs, described by a generalized income scale, and differences in life styles/household technologies, as captured by demographic translating (fixed costs).

The cost of maintaining a child less than 6 years old increases the cost of a couple without children by 19.4% and corresponds to 38.7% of the cost of an adult equivalent. The cost of maintaining a child with age between 6 and 13 and of an adolescent correspond to 32.6% and 35.8% of the cost of an adult equivalent respectively. An extra adult costs 13.3% with respect to an adult equivalent, while the cost of a *single* is larger than 60% with respect to a childless couple.

It is important to recognize that the estimated equivalence scales are a household concept which refer to the welfare of the family and not to the individual welfare of the household members. Implicitly, equivalence scales assume that household resources are shared equally among each household member. The situations where resources are not equally distributed are in fact frequent. We can think at cases in which one or both parents are not altruist, or extreme cases where one or both parents are addicted to the consumption of alcohol or drugs. To overcome this often unrealistic assumption, many economists are moving their attention to the estimation of individual demand systems derived from member specific welfare functions within a collective framework (Arias *et al.* 2003, Borelli and Perali 2003, Browning, Chiappori, and Lewbel 2008, Chiappori, Fortin, and Lacroix 2002, Menon and Perali 2008, Menon, Perali, and Piccoli 2008). This extension may represent an important progress because it may allow to estimate equivalence scales accounting for the intra-household allocation rules and would make not only inter-household but also inter-personal comparisons admissible (Lewbel 2003).

As Sen (1983) remarked, moving from inter-household to inter-personal comparisons, implies abandoning the assumption implicit in traditional equivalence scales of a “glued together” or “despotic” family where the parents’ indifference maps are considered as representative of each member’s preferences or a family where all members enjoy the same level of welfare. To accomplish this task, a more articulate welfare function would be necessary in order to describe the collection of unequal levels of welfare of each household member generated by a “mini” social choice problem.

The knowledge of the rule governing the allocation of resources between adults and children (Bourguignon 1999, Arias *et al.* 2003) permits answering Browning’s (1992) expenditure question and estimating the (full) cost of raising a child, given by the value of the amount of material and time resources invested on children, which is not directly observable. This information which depends on income, however, is fundamental to explain fertility choices (Lazear and Michael 1988, Menon and Perali 2006) and shall not be confused with the cost of maintaining a child which is more plausibly independent of income. The specification of the demand system used in this study has the potential to include aspects related to both the publicness of household goods, with a Barten type transformation of prices into individual specific shadow prices, and the sharing rule for a collective specification of the demand system. This is next in our research agenda.

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Table 1. Estimated Parameters of the QAIDS Model with $\tilde{P}^{T}=B(r)P^{T}(p,d)$

	Food	**Housing**	**Transport &commun.**	**Clothing**	**Educ-recreation-health**
Intercept	2.6494	-0.0287	-1.1740	0.1165	0.0629
	0.0495	*0.0442*	*0.0583*	*0.0266*	*0.0222*
Lnp(Food)	-1.0396	0.1451	0.6543	-0.0062	0.0114
	0.0408	*0.0206*	*0.0287*	*0.0118*	*0.0098*
Lnp(Housing)		-0.0398	-0.0481	-0.0374	-0.0209
		0.0062	0.0125	0.0019	0.0015
Lnp(transp&commun.)			-0.5554	-0.0079	-0.0060
			0.0337	*0.0078*	*0.0065*
Lnp(clothing)				0.0601	-0.0054
				0.0013	*0.0012*
Lnp(educ&recreation&health)					0.0197
					0.0015
Lnx	-0.4915	0.0764	0.3291	0.0143	0.0152
	0.0127	*0.0118*	*0.0155*	*0.0072*	*0.0059*
(Lnx)2	0.0230	-0.0081	-0.0193	-0.0022	-0.0013
	0.0008	*0.0008*	*0.0010*	*0.0005*	*0.0004*
			Commodity Specific Demographic Function		
R1	-0.0210	0.0130	-0.0158	-0.0020	0.0062
	0.0018	*0.0011*	*0.0016*	*0.0006*	*0.0006*
R3	0.0155	-0.0152	0.0019	0.0117	-0.0112
	0.0019	*0.0011*	*0.0017*	*0.0007*	*0.0006*
Rural	0.0126	-0.0062	0.0061	-0.0013	-0.0005
	0.0017	*0.0011*	*0.0016*	*0.0006*	*0.0006*
Age Household Head	0.0237	0.0100	-0.0016	-0.0094	-0.0017
	0.0010	*0.0006*	*0.0009*	*0.0003*	*0.0003*
Education Household Head	-0.0128	0.0038	-0.0026	0.0036	0.0039
	0.0010	*0.0007*	*0.0010*	*0.0004*	*0.0004*
Ts	-0.0056	0.0031	-0.0013	0.0047	0.0013
	0.0014	*0.0009*	*0.0013*	*0.0005*	*0.0005*
L_indj	-0.0097	-0.0022	-0.0010	0.0009	0.0002
	0.0017	*0.0011*	*0.0016*	*0.0006*	*0.0006*
Ownership	0.0021	0.0033	0.0014	-0.0021	-0.0045
	0.0015	*0.0009*	*0.0014*	*0.0005*	*0.0005*
	Nch05	Nch613	Nch1418	Adults_ ag	Single
	0.1770	0.1512	0.1647	0.0642	-0.2263
	0.0087	*0.0063*	*0.0078*	*0.0049*	*0.0119*
Mean of log-likelihood		-3.3245			

Note: Standard errors are in italic.

Table 2. Elasticities of the QAIDS model with $\tilde{P}^{T}=B(r)P^{T}(p,d)$

	Compensated Price Elasticities						Income Elasticity
	Food	Housing	Transport& communication	Clothing	Education Recreation Health	Other Goods	
Food	-1.223	0.263	0.514	0.034	0.063	0.349	0.488
Housing	0.656	-0.998	0.429	-0.155	-0.035	0.103	0.662
Transport&communication	0.785	0.263	-1.748	0.122	0.149	0.430	1.243
Clothing	0.106	-0.194	0.248	-0.273	0.054	0.060	0.813
Education, recreation and health	0.192	-0.043	0.300	0.054	-0.695	0.192	0.965
Other goods	0.625	0.074	0.505	0.034	0.112	-1.351	2.004
			Budget share means				
Estimated	0.307	0.123	0.201	0.099	0.100	0.171	
Observed	0.304	0.123	0.202	0.099	0.100	0.173	

Table 3. Marginal Impacts of Demographic Variables

Shares	**North**	**South**	**Rural**	**Age class of Houserhold Head**	**Education Level**	**Wife Working Condition**	**Head Independent Worker**	**House Owned**
Food	-0.071	0.052	0.043	0.080	-0.043	-0.018	-0.033	0.007
Housing	0.104	-0.122	-0.049	0.083	0.030	0.026	-0.019	0.026
Transport&communication	-0.078	0.009	0.030	-0.010	-0.013	-0.007	-0.004	0.007
Clothing	-0.021	0.119	-0.013	-0.094	0.037	0.048	0.009	-0.022
Education, recreation and health	0.062	-0.112	-0.004	-0.017	0.039	0.013	0.002	-0.045
Other goods	0.119	-0.018	-0.066	-0.129	0.026	-0.013	0.072	-0.001

Table 4. Relative Equivalence Scales – Base = Childless Couple

	Base	
	Childless couple =1 Adult equivalent = 0.5	Childless couple =2 Adult equivalent = 1
Child 0-5		
	1.194	2.387
s.e.	*0.010*	
t stat*	*18.646*	
Child 6 - 13		
	1.163	2.326
s.e.	*0.007*	
t stat*	*22.274*	
Child 14 -18		
	1.179	2.358
s.e.	*0.009*	
t stat*	*19.468*	
Additional Adult		
	1.066	2.133
s.e.	*0.005*	
t stat*	*12.690*	
Single		
	0.797	1.595
s.e.	*0.009*	
t stat*	*21.340*	

Note: * - tests the hypothesis that the scale is statistically significantly different from 1.

Table 5. International Comparison of the Cost of Maintaining a Child

Author (survey year)	Household Types				Cost of a Child <18	Comments
		I	II	III		
Consumption Scales derived from Complete Demand Systems						
McClements - U.K. (1972)		0.34	0.42	0.44	0.40*	Quasi-utility
Blundell, Lewbel - U.K. (1970-84)		0.18	0.29	0.65	0.37*	AIDS
Ferreira *et al.* - U.S. (1987)		0.26	0.17	0.13	0.19*	Endogenous Children - AIDS
Ray - U.K. (1968-79)		0.42	0.42	0.42	0.42	Extended AIDS
Ray e Lancaster - AUS (1984-88/89)		0.23	0.23	0.24	0.23	Extended AIDS
Phipps - CAN (1978, 82, 86 & 92)		0.31	0.25	0.21	0.26*	Translog
Merz *et al.* - U.S. (1986)		0.43	0.24	0.03	0.23	Extended Linear Exp. System
Merz, Faik - GER (1983)		0.34	0.21	0.13	0.23*	Extended Linear Exp. System
Menon, Perali - IT. (This study)		0.39	0.33	0.36	0.36	QAIDS
Subjective Scales						
van Praag *et al.* - NE (1982)		0.25	0.17	0.15	0.19	
Koulovatianos *et al.*- GER (1999)		0.22	0.20	0.20	0.21	
Expert Scales						
OCSE		0.5	0.5	0.5	0.5	
Scale of International Experts [χ]		0.45	0.39	0.34	0.39	

Note: a) The temporal distance between a child and the next corresponds to a hypothetic age profile: (<5, 5-10, >10), b) the cost of maintaining a less than 18 years old child, signed with an asterisk, is the mean of the cost of the characteristic "first, second, and third" child, c) Merz *et al.* (1994).

Appendix: Data

Table I.1. Descriptive Statistics of the Italian Sample, ISTAT - 2002; N. of Observations 19,045

VARIABLE	DEFINITION	Mean	STD. DEV.	MIN.	MAX.
	Demographic Characteristics				
Sex_cf	= 1 if head is male	0.816		0	1
Age_cf	Head age	47.671	10.5498	19	65
Fsize	Family size	3.032	1.2688	1	10
Nch018	N. of children 0-18	0.687	0.9042	0	7
Nch05	N. of children 0-5	0.176	0.4464	0	3
Nch613	N. of children 6-13	0.302	0.5957	0	4
Nch1418	N. of children 14-18	0.210	0.4734	0	4
Adults_ag	No. of additional adults[a)]	0.574	0.8450	0	7
Single	= 1 if single	0.146		0	1
Tj	= 1 if head employed	0.658		0	1
Ts	= 1 if wife employed	0.416		0	1
l_dips	= 1 if wife dependent worker	0.358		0	1
l_indj	= 1 if head independent worker	0.177		0	1
Ownership	= 1 if house is owned	0.724		0	1
Edu_cl	Head education[b)]	0.456	0.6579	0	2
Age_cl	Head age classes[c)]	1.424	0.7340	0	2
Rural	= 1 if living in rural areas	0.164		0	1
R1	= 1 if living in the north	0.446		0	1
R2	= 1 if living in the center	0.187		0	1
R3	= 1 if living in the south	0.366		0	1
	Budget Shares, Prices and Total Expenditure				
Wfood	Food	0.304	0.1159	0.001	0.745
Whouse	Housing	0.123	0.0612	0.005	0.588
Wtrasporti	Transport and communicaiton	0.202	0.0918	0.002	0.759
Wcloth	Clothing	0.099	0.0367	0.004	0.535
Weduricr	Eudcation and recreation	0.100	0.0309	0.000	0.407
Wother	Other goods	0.173	0.1297	0.001	0.855
Lnfood	Food price, in log.	6.292	0.3458	4.700	7.192
Lnhouse	Housing Price, in log.	5.208	0.4175	3.708	6.079
Lntrasporti	Transp. and Communic. price, in log.	5.505	0.5870	3.555	6.594
Lncloth	Clothing price, in log.	5.000	0.9477	2.223	6.378
Lneduricr	Education and recreation price, in log.	5.246	0.7669	2.547	6.555
Lnother	Price of other goods, in log.	5.295	0.8633	3.073	6.850
x	Total expenditure in euro	1706.026	933.3131	151.205	10771.550
lnx	Log of total expenditure	7.308	0.5243	5.019	9.285

Note: [a)] the additional adult is the dependent person more than 18 years. The second member of a couple has not been considered as an additional adult. [b)] = 0 if head has a primary school degree; = 1 if secondary school; = 2 if high school or college degree. [c)] = 0 if age head <=35 years; = 1 if between 36 and 45 years; = 2 if > 46 years old.

Table I.2. Consumption Share per Household Type

Expenditure categories	Single < 65 years	Childless Couple <45	Childless Couple >45 and <65	Couple with young children	Couple with older children	Single parental	Multi nuclear	Total
Food	0.29	0.248	0.323	0.283	0.303	0.314	0.312	0.304
Housing	0.143	0.116	0.133	0.117	0.113	0.13	0.117	0.123
Transport and Communication	0.2	0.212	0.187	0.19	0.197	0.2	0.211	0.202
Clothing	0.069	0.104	0.089	0.129	0.114	0.094	0.1	0.099
Health, education, ricreation	0.096	0.1	0.095	0.101	0.108	0.097	0.099	0.1
Other goods	0.202	0.22	0.172	0.179	0.164	0.165	0.161	0.173
Frequency	*2653*	*1021*	*1503*	*1496*	*3229*	*1861*	*7014*	*19045*

Note: the single parent household is the household without partner and/or with other adults and/or children; the multinuclear household is formed by a couple with other adults and/or children of which at least one is an over eighteen.

Table I.3. Consumption Share per Expenditure Quintiles

Expenditure Categories	Expenditure Quintiles				
	I	**II**	**III**	**IV**	**V**
Food	0.353	0.339	0.323	0.3	0.254
Clothing	0.159	0.138	0.124	0.114	0.1
Transport and Communication	0.202	0.202	0.199	0.204	0.199
Clothing	0.109	0.112	0.112	0.106	0.091
Health, Education and Ricreation	0.084	0.098	0.106	0.106	0.097
Other goods	0.093	0.11	0.135	0.17	0.259

Table I.4. Consumption Shares by Number of Children and Macro Region

Macro Regions		Number of Children				
		0	**1**	**2**	**3**	Total
North	Food	0.268	0.268	0.271	0.288	0.27
	Housing	0.135	0.13	0.122	0.118	0.129
	Transport and communication	0.191	0.198	0.199	0.187	0.196
	Clothing	0.089	0.101	0.101	0.098	0.098
	Health, Education and Ricreation	0.105	0.106	0.111	0.116	0.108
	Other goods	0.211	0.196	0.195	0.193	0.2
	Total Expenditure	*1460*	*2167*	*1523*	*247*	*5397*
Centre	Food	0.299	0.286	0.298	0.306	0.293
	Housing	0.121	0.115	0.111	0.112	0.115
	Transport and communication	0.2	0.21	0.216	0.207	0.21
	Clothing	0.09	0.105	0.102	0.102	0.101
	Health, Education and Ricreation	0.097	0.103	0.105	0.111	0.103
	Other goods	0.193	0.18	0.168	0.162	0.178
	Total Expenditure	*466*	*862*	*726*	*88*	*2142*
South and Island	Food	0.349	0.34	0.338	0.362	0.343
	Housing	0.116	0.111	0.106	0.107	0.109
	Transport and communication	0.203	0.209	0.201	0.197	0.203
	Clothing	0.107	0.119	0.117	0.108	0.115
	Health, Education and Ricreation	0.081	0.087	0.097	0.102	0.092
	Other goods	0.145	0.134	0.14	0.122	0.137
	Total Expenditure	*744*	*1369*	*1971*	*528*	*4612*
Total	Food	0.296	0.294	0.307	0.335	0.302
	Housing	0.127	0.121	0.113	0.111	0.119
	Transport and communication	0.196	0.204	0.203	0.195	0.201
	Clothing	0.094	0.107	0.109	0.105	0.105
	Health, Education and Ricreation	0.097	0.1	0.104	0.107	0.101
	Other goods	0.19	0.174	0.165	0.147	0.172
	Total Expenditure	*2670*	*4398*	*4220*	*863*	*12151*