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From household to individual's welfare: does the Lorenz criteria still hold? Theory and Evidence from French Data

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Abstract - Consider an income distribution among households of the same size in which individuals, equally needy from the point of view of an ethical observer, are treated unfairly within the household. In the first part of the paper, we look for necessary and sufficient conditions under which the Generalized Lorenz test is preserved from household to individual level. We find that the concavity of the expenditures devoted to public goods relatively to household income is a necessary condition. This condition also becomes sufficient, if joined with the concavity of the expenditure devoted to private goods of the dominated individual. The results are extended to the case of heterogeneous populations, when more complex Lorenz comparisons are involved. In the second part of the paper, we propose a new method to identify the intra-family sharing rule. The double concavity condition is then non-parametrically tested on French households.

JEL Classification: D63, D13, C14

Keywords: Lorenz comparisons, intra-household inequality, concavity

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1 Introduction

Recent literature emphasizes the importance of omitting intra-household inequality in normative analysis. Haddad and Kanbur (1990) find that when an additive inequality index is used to measure the level of inequality inside a population, then a serious downward bias appears because intra-household inequality is omitted. Taking into account intra-household inequality in normative analysis would be straightforward if individual's welfare was directly observed. Unfortunately this is not the case as incomes and consumptions are generally collected at the household level, moreover economies of scales need to be controlled whien comparing households of different sizes.

In this paper, we question whether or not Lorenz-type comparisons are biased when ignoring the effect of intra-household inequality. If households (homogeneous in their composition) shared equally their resources, then it would be sufficient to resort to Lorenz dominance at the household level in order to compare inequality and welfare at the individual level. Peluso and Trannoy (2004) show that we may enlarge the validity of some very well known criteria of dominance of the Lorenz type beyond the strict case of pure equality between members of the household. Their starting point is that although individuals have the same needs from the point of view of an ethical observer, each household contains *dominant* individuals, advantaged in their private consumption with respect to *dominated* individuals. Under this assumption, Lorenz comparisons between households are meaningful to the analysis of inter-individual inequality if and only if the part of private expenditure devoted to the dominated individuals remains a constant share of the household income. This part must represent a concave function of household income whether we are interested in the comparisons brought by the Generalized Lorenz test (Shorrocks (1983)), which mixes both the size and the distribution dimensions in the appraisal of welfare.

These results, albeit interesting, do not fully allow us to test empirically the sensibility of the main assumptions. One important aspect has not been taken into account in the previous work: the presence of family public goods. It is well accepted that individuals living together generate public consumption of goods, altruism and externalities and the impact of these phenomena on the individual well-being cannot be dismissed. We assume here both intra-household public consumption of goods and a form of discrimination in each household. We adopt a non-structural model of the household, where the definition of *individual income* is justified by a large flexibility of individual preferences across different situations. This is consistent with our empirical analysis, based on some limited assumption on individual tastes. We find two necessary and sufficient conditions for the preservation of the Generalized Lorenz test at the individual level: the concavity of the part of expenditures devoted to public good relatively to household income, and the concavity of the individual income of the dominated individual. The richer the household is, the lesser the part devoted to public good must be. A sufficient condition is then proposed in terms of concavity of two sharing functions*:* a *public sharing function,* expressing the expenditure in public goods as a function of the household income, and a *private sharing function,* indicating the private expenditure of the disadvantaged individual as a function of the total sum devoted in private goods in the household. These assumptions mean that poorest households are the more egalitarian too. A testable interpretation could be that when a household becomes richer, the share of global income used for personal expenditures becomes more and more important, and the individual with the strongest bargaining power within the household takes the highest advantage.

A further extension encompasses the diversity of the population. The mentioned results concern a population homogeneous regarding the size and the composition of the households. It is difficult to maintain such an assumption in any empirical investigation, where the differences of individuals choice across family status often provide sources of identification. Here, to make things simple, but w.l.o.g, we consider populations composed of couples and singles. In this case, the appropriate criteria for welfare comparisons are a test pointed out by Bourguignon (1989) or the Sequential Generalized Lorenz test, proposed by Atkinson and Bourguignon (1987). The first criterion is based on the assumption that the marginal utility of an euro received by a couple is higher than the marginal utility of an euro received by a single individual. The Atkinson and Bourguignon test also assumes that this difference of marginal utility becomes less and less relevant when income increases. These assumptions may be translated in terms transfer principles: respectively, the social welfare is increased when a single makes a transfer of income in favor of a couple with less income, and the social welfare increases all the more as progressive transfers are performed among couples rather than among singles, others things being equal.

We exhibit conditions on intra-household distribution which convert the Bourguignon (1989) dominance criterion among homogeneous households into the Generalized Lorenz dominance at the level of individuals. We also show that it is impossible, in general, to produce a similar result for the Sequential Generalized dominance test, which consequently results unappealing when intra-househod discrimination is a relevant phenomenon.

These conditions may be served as testable restrictions in an econometric analysis. Using the French Household Expenditure Survey Data (FHES *Enquête Budget des Familles,* year 2000), we estimate non-parametrically the intra-family share of income devoted to public good as well as the share of the dominated individual. Our identification strategy is to assume that single individuals and members of couples of the same sex have the same taste just for an *assignable* good: here we consider clothes. A double concavity test is then implemented by checking the sign of the second derivatives of the sharing rule with respect to household's income. In this analysis, the effects of individual heterogeneity and difference in the wage rates on the sharing functions are not controlled. From a strict empirical viewpoint, this allows to maintain good small sample properties of the non-parametric estimator. In a normative economics perspective, there are two main justifications for this.

The first factors is related to needs. One may presume that different individuals may present different needs, which should be taken into account by the ethical observer. For example, if you are taller than your partner, you may have some claim for a higher share in food expenditures. In Western countries, food expenditures do no represent more than 20 % of the household budget, a difference of 20% in calorie need may vindicated a difference of 4% of the share in private expenditure, which admittedly belongs in the error margin. We conclude that our assumption of identical claim to the resources from a need perspective is a sensible assumption in a developed country like France.

The second justification is related to the notion of merit or talent. If a higher wage rate strictly reflects a higher marginal productivity of the individual, its effect on the intra-household sharing rule should not be controlled by the ethical observer. Different philosophical points of view have been defended regarding the pros and cons of claims on a bigger share of resources based on a higher talent. Here we suppose that the ethical observer does not support the view that the market wage rate has something to do with the intra-household distribution of resources.Based on that premise, we deduce that it is correct not to control in the estimation analysis of the sharing function for differences between the two partners in market wage rates.

In Section 2 we sketch the model and prove the results about the link between the welfare comparisons among homogeneous households and among individuals. In Section 3 we study the case with heterogeneous households. In Section 4 we present the empirical study. We discuss further extensions and possible developments in the concluding Section 5. Tables and proofs are collected in the Appendix.

2 The model and welfare analysis

2.1 Homogeneous households

We focus on a population composed of n couples (indexed by $i = 1, ..., n$, with $n \geq 2$) which differ in their income levels. Let $\mathbf{Y}^c$ designate a generic vector of couples' income, rearranged in an increasing way. The feasible set $\mathbb{Y}_n$ is

$$\mathbb{Y}_n = \left\{ \mathbf{Y}^c \in \mathbb{R}^n_+ \mid Y^c_1 \leq Y^c_2 ... \leq Y^c_n \right\}.$$

The welfare quasi-order in which we are interested is the Generalized Lorenz criterion (GL) *(Shorrocks (1983))*. For the sake of completeness, we recall it.

Definition 1 ***GL dominance***. *Given* $\mathbf{Y}^c, \mathbf{Y}^{c\prime} \in \mathbb{Y}_n$,

$\mathbf{Y}^c$ dominates $\mathbf{Y}^{c\prime}$ according to the Generalized Lorenz test, denoted by $\mathbf{Y}^c \succsim_{GL} \mathbf{Y}^{c\prime}$, if:

$$\frac{1}{n}\sum_{i=1}^{k} Y^c_i \geq \frac{1}{n}\sum_{i=1}^{k} Y^{c\prime}_i \quad for\ k = 1, .., n.$$

The idea that all *homogeneous agents* have same needs is translated, in the 'dominance approach' to inequality, by evaluating the well-being guaranteed by an income to any individual through the same utility function. The GL test has an interpretation in terms of welfare comparisons. An *individual* income distribution $\mathbf{y}$ dominates $\mathbf{y}'$ according to the GL test if and only if

$$\sum_{j=1}^{2n} u(y_j) \geq \sum_{j=1}^{2n} u(y'_j), \tag{1}$$

for all the class of non-decreasing and concave utility functions u. This standard result on welfare ranking is completed by a *principle of transfers*: $\mathbf{y} \succcurlyeq_{GL} \mathbf{y}'$ if and only if $\mathbf{y}$ can be obtained from $\mathbf{y}'$ by a finite sequence of *progressive transfers* (also named *Pigou-Dalton transfers*) or *increments*.[1]

2.2 The sharing functions approach

The household model adopted here may be seen as the representation of intra-household behavior formulated by an 'ethical observer', which takes into account two main features: some degree of cooperation among the members of the couple, and, at the same time, a kind of intra-household discrimination. We adopt a non-structural model: the expenditure patterns relevant for welfare analysis are expressed in a reduced form , and no utility functions are used to explain behavior.

The cooperative aspect is described by assuming a complete agreement in the couple on the expenditure for pure public goods. Let Y_i be the income of household i, we designate the *public sharing function* $g : \mathbb{R}_+ \to \mathbb{R}_+$ as the part of the household budget devoted to public goods. This allows to control for altruistic attitudes and positive externalities within the family. We assume that g is twice continuously differentiable, identical across households and respects the following properties: $g(0) = 0$, $g(Y_i) \leq Y_i$ and $g'(Y_i) \in [0, 1], \forall Y_i \geq 0$. We exclude the case where public consumption decreases with income and expenditures exceeding income. The remaining part of household income: $Y_i - g(Y_i)$ (henceforth denoted by $\tilde{Y}_i$)

[1] A *progressive tranfer* is an income transfer from a rich to a poor, its magnitude can at most reverse the initial positions. An *increment* is just a gift received by an individual. For a proof of the result cited above see Marshall and Olkin, (1979), C.6, p. 28 and A.9.a, p. 123.

is shared among the *dominant* and the *dominated* individual for their private consumption. The dominated individual receives at most an amount equal to that allowed to the dominant one. The amount $p_i = f_p(\tilde{Y}_i)$ received by the dominated individual in household i is defined here *private sharing function* and designated by $f_p : \mathbb{R}_+ \to \mathbb{R}_+$.[2] The function $f_p : \mathbb{R}_+ \to \mathbb{R}_+$ is assumed identical across households, twice continuously differentiable, non-decreasing, with $f_p(0) = 0$ and $f_p(x) \leq \frac{1}{2}x$, $\forall x \in \mathbb{R}_+$.

The amount r_i of private expenditure of the dominant type is $r_i = f_r(\tilde{Y}_i) = \tilde{Y}_i - f_p(\tilde{Y}_i)$.

Whether the normative analysis concerns households – and variations in saving and prices are omitted – one may equivalently consider income or consumption for welfare comparisons (see Deaton and Zaidi (2002)). Whether the analysis focuses on individuals, and public consumption is neglected, a simple definition of *individual* income naturally emerges as the part of the household budget devoted to each household member to her (or his) private expenditure. In the presence of public consumption, no obvious definition comes out without additional assumptions. In an abstract way, the 'real' *individual income* y_{ij} summarizes in the household i the contribution of expenditure for public and private goods to the evaluation (formulated by an ethical observer) of the well-being of individual j

$$\begin{aligned} u(y_{ip}) &= u(g(Y_i), f_p\left(\tilde{Y}_i\right)) \\ u(y_{ir}) &= u(g(Y_i), f_r\left(\tilde{Y}_i\right)). \end{aligned}$$

In the following, we denote y_{ij} the *individualized income* of an individual of type j living in the couple i. It corresponds to the amount of money necessary for an individual living single to buy exactly the same bundle of goods as if he was in a couple. Hence it is the sum of the public and the private sharing functions.

The *individual income* y_{ij} of the household member j living in the family i is

$$y_{ij} = \begin{cases} g(Y_i) + f_p\left(\tilde{Y}_i\right) & \text{if } j \text{ is a dominated type} \\ g(Y_i) + f_r(\tilde{Y}_i) & \text{if } j \text{ is a dominant type.} \end{cases} \tag{2}$$

[2] The sharing function approach presented here could be seen as the reduced form of a structural model of the household, in which the private consumption decision is taken *conditional* to a given level of public expenditrues (see for instance Chiappori, Blundell and Meghir (2002)).

A careful reader may notice that this definition of individual equivalent income does not take into account the eventual change in consumption behaviour that may occur for one individual accross different cohabitational status. For example, it is assumed that a divorced individual would continue to pay the same mortgage than if married. Hence the individual equivalent income, as defined here, may sometimes induce different utility levels for one individual accross different cohabitational status. Purely, it corresponds to the normative view of the ethical observer who does not anticipate the change in the consumption pattern accross marital status. A main advantage of this definition is that it does not require any structural modelisation of individual behaviour, which is usually not required in normative economics. Figure 1 describes the goods consumed by a household member: the vertical axe z indicates a Hicksian good (with unitary price) summarizing private consumption and G is the quantity of public good, with a market price p ($\simeq 2$ in the figure). We suppose that the couple follows an efficient scheme of contribution for the public good. More precisely, the quantity G_0 of public good is chosen through a Lindhal equilibrium. The bundle (G_0, z_0) then represents the consumption of an individual living in a couple at the equilibrium. The shape of his (her) indifference curve at (G_0, z_0) is the Lindhal price p_L of G for this person. By definition $p_L \leq p$ and if we sum the Lindhal prices of both individuals we get p. One one hand, we exclude here free riding as any other source of inefficiency. On the other hand, intra-household discrimination may affect Lindhal prices, in the sense that individual preferences *in the household* may be conditioned by social factors. In the simplified model presented here, the *individual income* (2) defined above corresponds to $pG_0 + z_0$,that is the income needed to a single individual in order to get the bundle (G_0, z_0) in his (her) opportunity set.

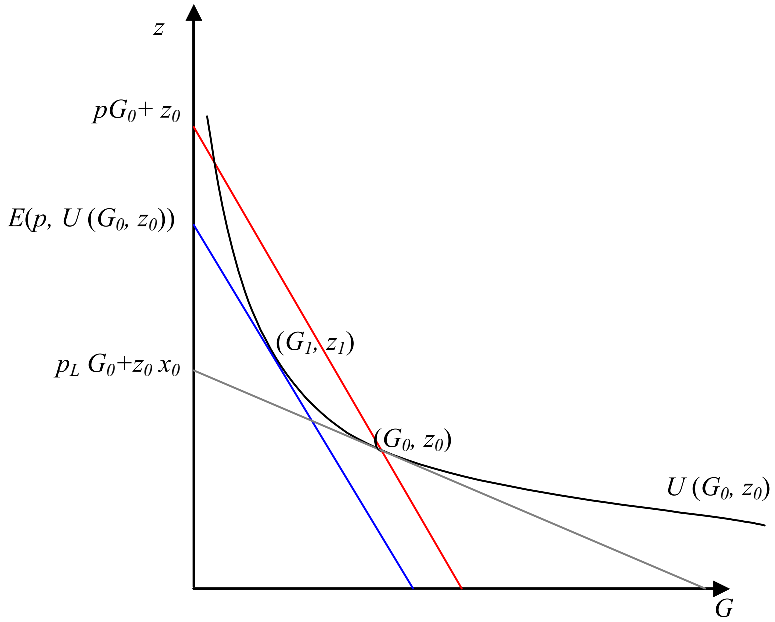

Figure 1: The definition of individualized income in a couple

Different definitions could be provided by introducing additional information about preferences. For instance, if we admit that individual preferences are invariant w.r.t. marital status,[3] we may define the *individual equivalent income* $E(p, U(G_0, z_0))$ as the income needed by a single to achieve the same utility level than if he was in a couple, which is reached in (G_0, z_0). As it appears in the figure 1, the *individual equivalent income* $E(p, U(G_0, z_0))$ is in general lower than *individual income* $pG_0 + z_0$. The definition of *individual equivalent income* approaches that of *individual income* (2) when a large flexibility of preferences is allowed. In order to clarify this point, observe that a different marital status generates two distinct effects. On one hand, individual preferences may change, in a non-specified way. On the other hand, to pass from the status of "married" to that of "single" entails a further effect on the price of the 'public' good, which rises from p_L to p. This price variation generates a substitution effect reducing the desired quantity of public good. If we do not pose any restriction on the domain of admissible preferences, the final result on the quantity of public

[3]Pollak (1991) designates the study of the choices of the same type of individual across different price-demographic situations as *situation comparisons*.

good of both effect is ambiguous. In the figure 2, we show two opposite cases.

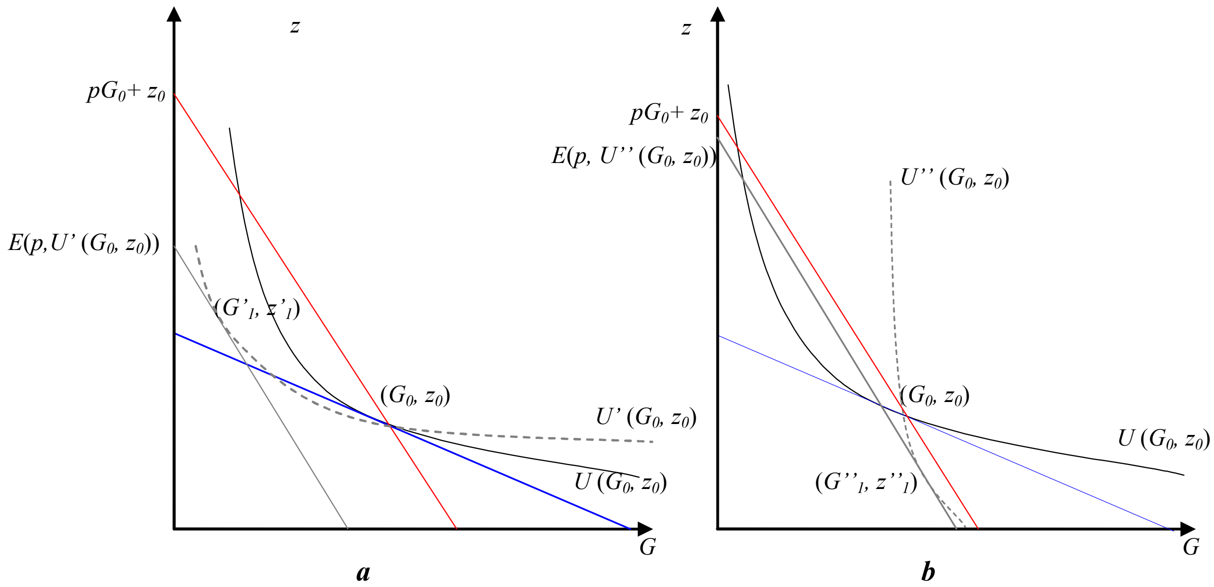

Figure 2: Heterogeneity of preferences across marital status

Single's preferences are represented by hatched indifferent curves passing through $(G_0, z_0))$, while the continuous indifference curves belong to an individual living in couple. In panel a), the change in preferences modifies the choice in the same direction as the substitution effect. In panel b), the change in preferences is in the opposite direction than the substitution effect, and its magnitude is so high that the substitution effect is more than compensated. The quantity of public good G_1'' chosen by a single in this case is higher than G_0.[4] g

The relevant point for our analysis is that for *any* quasi-convex preferences U_s, in order to achieve the utility level $U_s(G_0, z_0)$, the single chooses a bundle at most as expansive as (G_0, z_0). Formally, if we designate by $\mathbf{U}_s$ the class of the quasi-concave individual utility functions, the following remark holds.

Remark 1 $pG_0 + z_0 = Max(E(p, U_s(G_0, z_0)),$ *for all* $U_s \in \mathbf{U}_s$.

[4]The first situation means that the MRS of private to public goods is higher for individuals that live in a household. This is a plausible assumption, but not necessary in this paper. The case b) represents the opposite case, plausible for some kind of "public goods". For instance, if single individuals watch more TV than married men with their wives.

We can conclude that definition of *individual income (2)* naturally arises from the idea of *individual equivalent income,* whenever some sort of flexibility of tastes is allowed across marital status.

2.3 Welfare analysis: from couples to individuals

The preservation of the generalized Lorenz ranking means that an improvement in the distribution of household income distribution in the sense of the generalized Lorenz test generates a similar improvement in the distribution of individual incomes. The concavity of the sharing functions g and f_p guarantees that welfare and inequality tests performed on households' incomes distributions are informative about the pattern of welfare and inequality at the individual level. We first establish a necessary and sufficient condition

Theorem 1 *The two following conditions are equivalent:*

i) g and y_p are concave functions

ii) for all $\mathbf{Y}, \mathbf{Y}' \in \mathbb{Y}_n, \mathbf{Y} \succcurlyeq_{GL} \mathbf{Y}' \Rightarrow \mathbf{y} \succcurlyeq_{GL} \mathbf{y}'$.

Proof. $i) \implies ii)$ Suppose that g and y_p are non-decreasing and concave and consider $\mathbf{Y}, \mathbf{Y}' \in \mathbb{Y}_n$ such that $\mathbf{Y} \succcurlyeq_{GL} \mathbf{Y}'$. We prove that

$$\sum_{i=1}^{n} \left[u(y_{ip}) + u(y_{ir}) \right] \geq \sum_{i=1}^{n} \left[u(y'_{ip}) + u(y'_{ir}) \right],$$

for all u non-decreasing and concave, which is equivalent to $\mathbf{y} \succcurlyeq_{GL} \mathbf{y}'$. For a given individual utility function u, we denote w the sum of individual utilities in the household i, that is $w(Y_i) = u(y_{ip}) + u(y_{ir})$. We omit the index i and using the fact that all functions are twice differentiable, we prove an intermediate result.

Step 1 If g and y_p are concave functions, then $w'(Y) \geq 0$ and $w''(Y) \leq 0$, $\forall Y \geq 0$.[5]

$w'(Y) = u'(y_p)[g'(Y) + f'_p(\tilde{Y})(1 - g'(Y))] + u'(y_r)[g'(Y) + f'_r(\tilde{Y})(1 - g'(Y))]$. Since $0 \leq g'(Y) \leq 1$, it is easy to see that this expression is non-negative. From $y'_p(Y) = g'(Y) + f'_p(\tilde{Y})(1 - g'(Y))$ and $y'_r(Y) = g'(Y) + f'_r(\tilde{Y})(1 - g'(Y))$, we get

$$w''(Y) = u''(y_p)y_p'^2 + u''(y_r)y_r'^2 + u'(y_p)y''_p + u'(y_r)y''_r. \tag{3}$$

[5] See Peluso and Trannoy (2004) for a different proof in the non differentiable case without public goods.

The first two terms are non-positive. We then study $u'(y_p)y_p''(Y) + u'(y_r)y_r''$, that is

$$u'(y_p)[g''(Y) + f_p''(\tilde{Y})\tilde{Y}'^2 - g''(Y)f_p'(\tilde{Y})] + u'(y_r)[g''(Y) + f_r''(\tilde{Y})\tilde{Y}'^2 - g''(Y)f_r'(\tilde{Y})] \quad (4)$$

Two situations have to be considered.

First case. Consider the part of the domain where f_p'' is positive. Then $u'(y_p)y_p''(Y)$ is non-positive due to the assumption $y_p''(Y) \leq 0$. Moreover,

$$u'(y_r)y_r'' = u'(y_r)[f_r''(\tilde{Y})\tilde{Y}'^2 + g''(Y)f_p'(\tilde{Y})]$$

This expression is non-positive, proving the result.

Second case $f_p'' \leq 0$. Expression (4) gives:

$$u'(y_p)g''(Y)f_r'(\tilde{Y}) + u'(y_r)g''(Y)f_p'(\tilde{Y}) + u'(y_p)f_p''(\tilde{Y})\tilde{Y}'^2 + u'(y_r)f_r''(\tilde{Y})\tilde{Y}'^2.$$

The two first terms are non-positive, then we study the sign of

$$u'(y_p)f_p''(\tilde{Y})\tilde{Y}'^2 + u'(y_r)f_r''(\tilde{Y})\tilde{Y}'^2 = f_p''(\tilde{Y})\tilde{Y}'^2[u'(y_p) - u'(y_r)].$$

Due to the concavity of u,this expression is non-positive and we may conclude that $w''(Y) \leq 0$.

Step 2 From $\mathbf{Y} \succcurlyeq_{GL} \mathbf{Y}'$, we get $\sum_{i=1}^n w(Y_i) \geq \sum_{i=1}^n w(Y_i')$ and therefore

$$\sum_{i=1}^n [u(y_{ip}) + u(y_{ir})] \geq \sum_{i=1}^n \left[u(y_{ip}') + u(y_{ir}')\right].$$

The reasoning is valid for all u non-decreasing and concave and the sufficiency part is proved.

ii) $\implies$ *i)* Now we show that the concavity of g and y_p is necessary to get $w(Y_i) = u(y_{ip}) + u(y_{ir})$ concave *for all u non-decreasing and concave*, property that guarantees $\mathbf{Y} \succcurlyeq_{GL} \mathbf{Y}' \implies \sum_{i=1}^n [u(y_{ip}) + u(y_{ir})] \geq \sum_{i=1}^n \left[u(y_{ip}') + u(y_{ir}')\right]$ for all u non-decreasing and concave (the preservation of GL to individuals). The proof is given by contradiction: we show that if g or y_p are not concave, then there exists a non-decreasing and concave utility function such that $w''(Y_i) > 0$. Starting again from the expression (3), we first observe that, whenever $y_p'' > 0$, by choosing an angle utility function $u(y) = \min(ky, z)$ with a shape k such that $ky_p < z < ky_r$, we obtain $w''(Y) > 0$.

In order to prove the necessity of g concave, from (4) we get:

$$\begin{aligned} w''(Y) &= u''(y_p)y_p'^2 + u''(y_r)y_r'^2 + u'(y_p)g''(Y) + u'(y_p)[f_p''(\tilde{Y})\tilde{Y}'^2 - g''(Y)f_p'(\tilde{Y})] + \\ &\quad + u'(y_r)[g''(Y)f_p'(\tilde{Y}) - f_p''(\tilde{Y})\tilde{Y}'^2], \end{aligned}$$

that is

$$w''(Y) = u''(y_p)y_p'^2 + u''(y_r)y_r'^2 + u'(y_p)g''(Y) + [f_p''(\tilde{Y})\tilde{Y}'^2 - g''(Y)f_p'(\tilde{Y})][u'(y_p) - u'(y_r)].$$

It is clear that, if $g'' > 0$, by adding a term ky to any non-decreasing and concave utility function u, for a k sufficiently large it results $w''(Y) > 0$. ■

Whenever g *and* f_p are non-decreasing and concave, the same properties hold for y_p and we may express a sufficient condition in terms of the sharing functions.

Corollary 1 *If g and f_p are increasing and concave, then, for all* $\mathbf{Y}, \mathbf{Y}' \in \mathbb{Y}_n$

$$\mathbf{Y} \succcurlyeq_{GL} \mathbf{Y}' \Rightarrow \mathbf{y} \succcurlyeq_{GL} \mathbf{y}'.$$

The previous corollary provides restrictions on individual choices that are the basis of our empirical analysis.

3 Extension to a population of singles and couples

3.1 Heterogeneous households

The welfare analysis developed in the previous section is now extended to a population composed of n couples (always indexed by $i = 1, ..., n$, with $n \geq 2$) and m singles (indexed by $j = 1, ..., m$ with $n \geq 2$). Let $\mathbf{y}^s$ designate a generic income vector for single individuals, rearranged in an increasing way. Its feasible set $\mathbb{Y}_m$ is

$$\mathbb{Y}_m = \left\{ \mathbf{y}^s \in \mathbb{R}_+^m \mid y_1^s \leq y_2^s ... \leq y_m^s \right\}.$$

By denoting $\mathbf{Y} = (\mathbf{y}^s, \mathbf{Y}^c)$ a rearranged income vector of the overall population, we also define

$$\mathbb{Y} = \left\{ \mathbf{Y} \in \mathbb{R}_+^{m+n} \mid Y_1 \leq Y_2 ... \leq Y_{m+n} \right\}.$$

Given $\mathbf{Y} \in \mathbb{Y}_{n+m}$, the corresponding vector of *individual* incomes is denoted $\mathbf{y} = (\mathbf{y}^s, \mathbf{y}^c)$. To save notations, j will serve as an index for individuals as well. The set of feasible distributions of individual incomes is denoted by

$$\mathbb{Y}_{2n+m} = \left\{ \mathbf{y} \in \mathbb{R}_+^{2n+m} \mid y_1 \leq y_2 \leq .. \leq y_{2n+m} \right\}.$$

Observe that $\mathbf{y}$ contains the incomes of singles and the incomes of individuals living in a couple adjusted for public goods as defined in (2). We now strengthen the properties of g by introducing a further 'regularity' condition.

To investigate the inheritance of GL test from households to individuals is a pointless exercise whenever households have different needs, since the GL criterion becomes inappropriate for welfare comparisons. We then focus our attention on the dominance criteria proposed by Bourguignon (1989) and by Atkinson and Bourguignon (1987) (henceforth B and AB, respectively).

Assumption 1 *Let u^c and u be twice differentiable, non-decreasing and concave functions representing the utility of a couple and of an individual, respectively. We consider the following cases:*

$\bar{\mathbf{B}}$) $u^{c\prime}(z) - u'(z) \geq 0$ for all $z \geq 0$

$\overline{\mathbf{AB}}$) $u^{c\prime}(z) - u'(z) \geq 0$ and $u^{c\prime\prime}(z) - u''(z) \leq 0$, for all $z \geq 0$.

Under the assumption $\bar{\mathbf{B}}$, the difference between the utility functions of a couple and a single individual, for a given income, is a non-decreasing function. This difference becomes non-decreasing and concave under the assumption $\overline{\mathbf{AB}}$. The B and AB social dominance criteria are the following

Definition 2 *Given $\mathbf{Y}, \mathbf{Y}' \in \mathbb{Y}_{n+m}$,*

$\mathbf{Y}$ *dominates* $\mathbf{Y}'$ *according to the B (AB) criterion, denoted by* $\mathbf{Y} \succcurlyeq_B \mathbf{Y}'$ ($\mathbf{Y} \succcurlyeq_{AB} \mathbf{Y}'$), *iff*

$$\sum_{i=1}^{n} u^c(Y_i) + \sum_{j=1}^{m} u(y_j^s) \geq \sum_{i=1}^{n} u^c(Y_i') + \sum_{j=1}^{m} u(y_j^{s\prime}), \tag{5}$$

for all utility functions u^c and u satisfying the condition $\bar{\boldsymbol{B}}$ ($\overline{\mathbf{AB}}$).

The test associated to the AB dominance criterion is named sequential generalized Lorenz test and it is easy to implement: "take first the most deserving group, then add the next most deserving group and so on, until all groups are included, checking at each stage for GL dominance. If this obtains, one distribution can be recommended over the other" (Lambert (1993), p. 86). The Bourguignon criteria also is equivalent to an implementable algorithm, based on the Foster and Shorrocks' (1988) idea that the 'poverty gap' is always lower in the dominant distribution, whatever poverty limit that is chosen. Bourguignon criterion allows for different poverty limits among types of households, but imposing that the poverty limits are non-decreasing with needs.

It will be useful to recall the transfer criteria associated with these concepts of social dominance. Ebert (2000) clarified this topic: for an ethical observer that follows the B dominance criterion, the social welfare improves after *increments*, *progressive transfers within groups* and after *progressive transfer between groups*, that is any progressive transfers from a less deserving household to a needier one. If the normative criterion implemented by the decision maker is the AB one, then a further principle has to be added, the so called *principle of diminishing transfers between groups.* It is described by Ebert (2000) as follows: "A progressive transfer changing two given income levels within a subpopulation is relatively more desirable the needier the respective subpopulation".

3.2 Welfare analysis: from heterogeneous households to individuals

In this part of the paper we explore the possibility of the *conversion* of the welfare criteria for heterogeneous households into GL dominance among individuals. We show a positive result and a negative one. The dominance in the B sense among heterogeneous households implies GL dominance at individual level, but a similar result does not hold for the AB sequential test.

Corollary 2 *If g and y_p are concave, then for all* $\mathbf{Y}, \mathbf{Y}' \in \mathbb{Y}_{n+m}$

$$\mathbf{Y} \succcurlyeq_B \mathbf{Y}^{'} \implies \mathbf{y} \succcurlyeq_{GL} \mathbf{y}'.$$

Proof. We show that

$$[f_p \text{ and } y_p \text{ concave}] \implies \left[\text{not } \mathbf{y} \succcurlyeq_{GL} \mathbf{y} \implies \text{ not } \mathbf{Y} \succcurlyeq_B \mathbf{Y}'\right].$$

Suppose that $\mathbf{y} \succcurlyeq_{GL} \mathbf{y}'$ does not hold. Then there exists a non-decreasing and concave utility function $\tilde{u}$ such that:

$$\sum_{i=1}^{n} \tilde{u}(f_p(Y_i^c)) + \sum_{i=1}^{n} \tilde{u}(f_r(Y_i^c)) + \sum_{j=1}^{m} \tilde{u}(y_j^s) < \qquad (6)$$
$$\sum_{i=1}^{n} \tilde{u}(f_p(Y_i^{c\prime})) + \sum_{i=1}^{n} \tilde{u}(f_r(Y_i^{c\prime})) + \sum_{j=1}^{m} \tilde{u}(y_j^{s\prime})$$

which turns to be equivalent to: $\sum_{i=1}^{n} \tilde{u}^c(Y_i^c) + \sum_{j=1}^{m} \tilde{u}(y_j^s) < \sum_{i=1}^{n} \tilde{u}^c(Y_i^{c\prime}) + \sum_{j=1}^{m} \tilde{u}(x_j^s)$, where $\tilde{u}^c(Y_i^c) = \tilde{u}(f_p(Y_i^c)) + \tilde{u}(f_r(Y_i^c))$. If y_p and g are concave, by using differentiability and reasoning as in the proof of Theorem 1 we know that $\tilde{u}^c$ is non-decreasing and concave. Moreover, since $\tilde{u}^{c\prime}(Y) = \tilde{u}'(y_p)[g'(Y) + f_p'(\tilde{Y})(1 - g'(Y))] + \tilde{u}'(y_r)[g'(Y) + f_r'(\tilde{Y})(1 - g'(Y))]$, it is a weigthed mean of $\tilde{u}'(y_p)$ and $\tilde{u}'(y_r)$ and it is easy to see that $\tilde{u}^{c\prime}(Y) \geq \tilde{u}'(Y)\ \forall Y \geq 0$. Then $\tilde{u}^c$ may be interpreted as a non-decreasing and concave household utility function satisfying Assumption $\bar{\mathbf{B}}$. By comparing (5) and (6), we conclude that $\mathbf{Y} \succcurlyeq_B \mathbf{Y}'$ is negated.

This result is in line with the principle of progressive transfers among groups mentioned above, since a progressive transfer from a single to a couple generates a pair of progressive transfers among individuals. ■

A result similar to Proposition 2 cannot be guaranteed for the AB criterion, as we show in the following example, where we omit public goods and assume a 'very regular' sharing function.

Example 2 *Let us consider a first income distribution* $\mathbf{Y} = (\mathbf{Y}^c, \mathbf{y}^s)$, *such that* $\mathbf{Y}^c = (14, 16)$ *and* $\mathbf{y}^s = (10, 20)$ *and the income distribution* $\mathbf{Y}' = (\mathbf{Y}^{c\prime}, \mathbf{y}^{s\prime})$, *such that* $\mathbf{Y}^{c\prime} = (10, 20)$ *and* $\mathbf{y}^{s\prime} = (14, 16)$. *It is easy to check, using the sequential generalized Lorenz test, that* $\mathbf{Y} \succcurlyeq_{AB} \mathbf{Y}'$. *Assuming a perfectly egalitarian sharing function, we generate the individual income distributions* $\mathbf{y} = (7, 7, 8, 8, 10, 20)$ *and* $\mathbf{y}' = (5, 5, 10, 10, 14, 16)$. *These distributions are non-comparable by the GL criterion: even under the 'more regular' egalitarian sharing function, the AB criterion is not automatically converted into GL dominance at the level of individuals.*

The rationale behind this negative result can be explained in terms of principle of transfers. Let us consider the income distribution $\mathbf{Y}''$=$(\mathbf{Y}^{c\prime\prime}, \mathbf{y}^{s\prime\prime})$, such that $\mathbf{Y}^{c\prime\prime} = (10, 20)$ and $\mathbf{y}^{s\prime\prime} = (10, 20)$. The corresponding vector of individual incomes generated by the egalitarian sharing rule is, in this case, $\mathbf{y}'' = (5, 5, 10, 10, 10, 20)$. The distribution $\mathbf{Y}$ of the example above is obtained from $\mathbf{Y}''$ by performing a progressive transfer (of 4 units of income) *within group* at the level of the more deserving group (the couples). Similarly, $\mathbf{Y}'$ is obtained from $\mathbf{Y}''$ by performing the same progressive transfer among singles, that is among individuals belonging to the less deserving group. The *principle of diminishing transfers between groups* may operate, and we consistently register $\mathbf{Y} \succcurlyeq_{AB} \mathbf{Y}'$. Nevertheless, by reasoning in terms of individual income distributions, we observe that $\mathbf{y}$ is obtained from $\mathbf{y}''$ by a couple of progressive transfers (each of 2 income units) between relatively poor individuals, whereas $\mathbf{y}'$ is obtained from $\mathbf{y}''$ by a sole transfer of 4 income units in the high part of the income distribution. The problem arises since, in the social dominance setup, we cannot motivate that the first transfer is more welfare-improving than the second one by just referring to monotonicity and concavity of individual utility functions. The GL test appears as an inappropriate tool when the policy-maker is concerned for inequality among individuals.

4 Testing the "Double Concavity" condition

One stake of this paper is to determine whether or not the conditions of Corollaries 1 and 2 are attainable. If the household's public sharing function and private sharing function were concave, then intra-household inequality could be basically ignored to compare two income distributions. This is what is usually done up to now. In the opposite case, it would be necessary to identify individualized incomes before implementing any income distribution comparison.

This section presents a nonparametric test of the double concavity condition. The localized version of the test can detect local non-concavity. It requires a first step estimation of the conditional expectancy of the public sharing function and of the private sharing function. Household public expenditures are fully observed in the data, this is not the case for private expenditures. Hence the concavity test of the private sharing function requires some identification assumptions. Individualized incomes are recovered in the spirit of Chiappori (1988), Browning and Chiappori (1998), Donni (2003), or Browing, Chiappori and Lewbel (2003). However, the approach adopted here is innovative because it proposes a nonparametric prediction of the intra-household distribution of private consumption. Taking clothes consumption as an assignable good[6], the identification mechanism relies on the inversion of single individuals' Engel curve of clothes consumption. Because the prediction is non-parametric, a support condition needs to be taken into account, as well as the overidentifying restrictions implied by the observation of both spouses' behaviour. Finally, the endogeneity of total household expenditures has to be controlled.

The empirical part takes place in three steps. In a first sub-section, we present the nonparametric concavity test of the public sharing function. Then, sub-section 2 exposes the prediction of individuals' private expenditures and the assumptions required to achieve this prediction. Sub-section 3 presents the data and sub-section 4 shows the results.

4.1 Testing the concavity of the public sharing function

Abrevaya and Jiang (2005) propose an efficient and general nonparametric test of concavity which may be used in the univariate or multivariate case. The test requires very few assumptions and presents a power of rejection comparable to Elison and Elison (2000). The test was initially developed in a context where the explanative variable is exogenous, the generalization to the presence of endogeneity is straightforward. A fundamental assumption of symmetry of the error disturbance must be satisfied. We first present the public sharing function, then the concavity test.

[6]We use the term "assignable" to designate a private good consumption observed on an individual basis. Sometimes, clothes and shoes' expenditures cannot be assigned in the data in which case the consumption is included into "household's aggregate private consumption". Unassignable clothes consumption represents on average 1.5% of household's expenditures. "clothes expenditures" will always designate both clothes and shoes expenditures.

4.1.1 The public sharing function

We consider the following nonparametric regression model:

$$G_i = g(Y_i) + \varepsilon_i, \text{ where } E(\varepsilon_i|Y_i) \neq 0, \ i = 1, ..., n \tag{7}$$

The aim is to test the concavity between public household's consumption, denoted by G_i, with respect to household's total expenditures, denoted by Y_i. Hence the null hypothesis is the concavity of the function g. Total household expenditures, Y_i, may be correlated with the error term ε_i. This is due to the simultaneity of the saving and consumption decisions, or because household public consumption is related to the same unobserved heterogeneity variables than household's total expenditures. We may use total household gross income, denoted w_i, as an instrument. In the following, the individual index is omitted.

We decompose the error term into two parts:

$$\varepsilon = v\rho + u, \text{ with } E(u|Y) = 0 \tag{8}$$

where $v\rho$ is a correction term for the endogeneity, v being the residual of the following instrumental equation:

$$Y = w\delta + \nu \tag{9}$$

As a consequence, equation (7) can be rewritten as the following regression:

$$G - v\rho = g(Y) + u \text{ with } E(u|Y) = 0. \tag{10}$$

Provided the public expenditures term is corrected according to equation (9), this model satisfies the conditions of Abrevaya and Jiang (2005) test, i.e. the expectancy of the error term u conditionally on Y is null. Equation (10) can be rewritten in term of conditional expectancies, this explicitates the endogeneity bias[7]:

$$g(Y) = E(G|Y) - E(v|Y)\rho \tag{11}$$

[7] One may remark that the shape of the endogeneity bias is assumed linear with respect to household public expenditures. This shape is enough to induce a change in the global concavity property of the estimated g function. For example, if $\widehat{g_{exo}}(Y)$ appears slightly convex, and the endogeneity induce an overevaluation of the effect of Y on G. Then the consistent estimation $\widehat{g_{iv}}(Y)$ of the true $g(Y)$ function may be concave.

We denote $\widehat{g_{exo}}$ the Nadaraya-Watson kernel estimator of $E(G|Y)$:

$$\widehat{g_{exo}}(Y) = \frac{\sum_{i=1}^{n_j} K\left(\frac{Y_i - Y}{h}\right) G_i}{\sum_{i=1}^{n_j} K\left(\frac{Y_i - Y}{h}\right)}, \tag{12}$$

where K is a well-behaved quartic kernel function. The bandwidth, h, satisfies $h- > 0$ and $nh- > \infty$ as $n- > \infty$. It is asymptotically convergent and follows a normal distribution, which asymptotic properties are surveyed in Pagan and Ullah (1999) for example.

We denote $\widehat{v}$ the kernel regression estimator of $E(v|Y)$:

$$\widehat{v}(Y) = \frac{\sum_{i=1}^{n_j} K\left(\frac{Y_i - Y}{h}\right) \widetilde{v_i}}{\sum_{i=1}^{n_j} K\left(\frac{Y_i - Y}{h}\right)}, \tag{13}$$

with $\widetilde{v_i}$ the empirical residual of the instrumental equation (9). Substituting conditional expectancies by their estimations in equation (11), and replacing $g(Y)$ by its expression in equation (10), gives:

$$G - \widehat{g_{exo}}(Y) = (\widetilde{v} - \widehat{v}(Y))\,\rho + u. \tag{14}$$

The parameter $\widehat{\rho}$ follows from the OLS regression of equation (14). The null hypothesis of exogeneity can be tested by checking the significancy of the ρ parameter. Finally, the consistent estimator of function g is an IV kernel estimator denoted $\widehat{g_{iv}}$:

$$\widehat{g_{iv}}(Y) = \widehat{g_{exo}}(Y) - \widehat{v}(Y)\widehat{\rho}. \tag{15}$$

Further details about this estimator may be found in Blundell, Browning and Crawford (2003).

4.1.2 Concavity test

Theoretically, the concavity test should be applied on $\{G_i - \rho v_i, Y_i\}$. Practically, the concavity test is based on aggregated data $\{(\widehat{g_{iv}}(Y_i), Y_i) : i = 1, ..., n\}$. The test is consistent if the distribution of the error term u is symmetric conditional on Y. The distribution of the error term does not need to be homosckedastic, nor normally distributed. The symmetry property can be checked on the predicted $\widetilde{u_i}$ (see equation (10)):

$$\widetilde{u_i} = G_i - \rho\widetilde{v_i} - \widehat{g_{iv}}\left(Y_i\right) \tag{16}$$

We apply the nonparametric symmetry test proposed by Ahmad and Li (1997) on $\{\widetilde{u_i} : i = 1, ..., n\}$. Denoting f_u the density function of the error disturbance, the null hypothesis is $f_u(\widetilde{u}) = f_u(-\widetilde{u})$ and the test statistic is

$$I = \Sigma_{i=1}^{n}\Sigma_{j=1,j\neq i}^{n}\left[K\left(\frac{\widetilde{u}_i - \widetilde{u}_j}{h}\right) - K\left(\frac{\widetilde{u}_i + \widetilde{u}_j}{h}\right)\right] \cdot \left(\frac{1}{nh^{1/2}}\right). \tag{17}$$

Under the null, it follows a normal distribution with null expectancy and variance S:

$$\widehat{S} = n^{-1}\Sigma_{i=1}^{n}\widehat{f}_u(\widetilde{u}_i)\int K^2(\psi)d\psi.$$

In the univariate case, the mechanism of the concavity test is simple as it consists in checking the validity of Jensen inequality for each possible 3-tuple of the sample. In our case, the simplex statistics takes the following formulation:

$$U_n = \left(C_n^3\right)^{-1}\left[\text{\# of convex 3-tuples - \# of concave 3-tuples}\right], \tag{18}$$

where n is the sample size and C_n^3 represents the number of 3-tuples in the sample. A consistent bootstrap estimator of the variance, ζ, of this statistic is:

$$\widehat{\zeta} = R^{-1}\Sigma_{r=1}^{R}\left(U_r - U_n\right)^2, \tag{19}$$

where U_r denotes the proportion of convex 3-tuple in excess of concave 3-tuple, given a fix r^{th} observation. The r^{th} observation is randomly drawned from the original sample, R being the number of draws. We denote U_n^0 the true proportion of convex 3-tuples in excess of concave 3-tuples. The function g is globally linear if $U_n^0 = 0$, globally concave if $U_n^0 \leq 0$ and globally convex if $U_n^0 \geq 0$. The global version of the concavity test is directly based on the simplex statistic, it is a univariate test:

$$\begin{cases} H_0 : U_n^0 \leq 0, \; g \text{ is globally concave} \\ H_1 : U_n^0 \geq 0, \; g \text{ is globally convex} \end{cases} \tag{20}$$

Under H_0, $\widetilde{U_n} = \frac{n^{1/2}\left(U_n - U_n^0\right)}{3\widehat{\zeta}^{1/2}} - > N(0,1)$. The bivariate version of the test ($U_n^0 = 0$ against $U_n^0 \neq 0$) allows to test the linearity of the g function against global concavity or convexity alternatives.

The global version of the test cannot reject the linearity of a function which would be concave on a first half and convex on a second. The localized version of the test presents a higher power of rejection because it can detect local non-concavities. It requires the evaluation of the U_n statistic on the sample splitted into L sub-samples. Denoting $\widetilde{U_{n,l}}$ the standardized simplex statistic evaluated at the l^{th} location, M is the greater value taken by the standardized simplex statistic:

$$M = \max\{\widetilde{U_{n,l}} : l = 1, ..., L\}. \tag{21}$$

Intuitively, a larger value for M should give evidence against concavity. The global concavity test, consistent against all possible alternatives, is based on the M statistic:

$$\begin{cases} H_0 : g \text{ is globally concave} \\ H_1 : g \text{ is locally non-concave} \end{cases} \tag{22}$$

Under H_0, $a(M - b)$ follows a standard type I extreme value distribution, where $a = (2\ln(L))^{1/2}$, $b = (2\ln L)^{1/2} - \frac{\ln\ln L + \ln 4\pi}{2(2\ln L)^{1/2}}$. The variance of the statistic only depends on the number of locations L. It does not depend on the standard error of the localized simplex statistics. The test (22) is univariate, the rejection requires the M statistic to be greater than the critical value. In case a linearity test is implemented, we would need to calculate the statistic S which is defined as:

$$S = \max\{|U_{n,l}| : l = 1, ..., L\}. \tag{23}$$

Intuitively, a high value for S gives evidence against linearity. Further details may be found in Abrevaya and Jiang (2005), p.7.

4.2 Testing the concavity of the private sharing function

If the amount of public goods and the private expenditures of the *dominated* individual within the family is concave with respect to total household private expenditures, then intra-household inequality can be omitted when comparing two income distributions. Private expenditures of individuals living in a couple are not observed in the data and should be predicted. In this paper, the prediction cannot rely on parametric assumptions on preferences because it must keep the marginal utility of income unspecified. Hence we propose to predict individual private expenditures by inversing Engel curves of single individuals' clothes expenditures, after having assumed an identity of the clothes consumption pattern, for women and for men, accross cohabitational status. Technically, this is equivalent to assume both the Hicksian separability between clothes and other goods consumption and the identity of the individual sub-utilities coming from clothes consumption accross cohabitational status. Engel curves are estimated with a Nadaraya-Watson kernel estimator, controlling for endogeneity of private household expenditures. The numerical inversion requires a common support assumption. In the following we denote by the subscript $j = sf, cf, sm, cm$ respectively a single female, a female living in a couple, a single male and a male living in a couple. The indice i of the household is omitted.

4.2.1 Clothes consumption Engel curves for single females and males

Clothes have a specific property in our analysis: it is an assignable good. For single living individuals, the consumption of clothes of the opposite sex is extremely rare (see table (2)). For individuals living in a couple, we are able to guess that the man consumes the whole amount of male clothes expenditures of the family, whereas the woman consumes the whole amount of female clothes expenditures of the family.

The Engel curve of clothes consumption of single females can be written as:

$$c_j = f(y_j) + e_j, \text{ with } E(e_j \mid y_j) \neq 0 \text{ and } Var(e_f) = \sigma^2 I, \text{ for } j = sf, cf. \tag{24}$$

c is the vector of clothes expenditures, f is the Engel curve of females whereas y represents the vector of individual private expenditures[8] (which are fully observed for single individuals). It is equivalent to express the consumption in term of quantities or expenditures because

[8]'Private expenditures' for single individuals are simply total expenditures minus the expenditures which would be considered as public in our analysis if they were in a couple (e.g. accomodation).

the price of clothes is fix in our context. As for public expenditures, private expenditures could be endogenous to the clothes consumption process because of the simultaneity of the consumption decisions, or because both variables are linked to the same unobserved heterogeneity variables. This is why, generally $E(e_j|y_j) \neq 0$. We adopt the same method to control for the endogeneity of y_j than in section 3.1.1. We take w, the household gross income, as an instrument orthogonal to the error disturbance $E(e_j|w_j)$. Denoting v_j the residual of the instrumental equation (see equation 9), we may have the following augmented regression model:

$$c_j = f(y_j) + v_j\rho + \varepsilon_j \text{ with } E(\varepsilon_j|y_j) = 0 \tag{25}$$

The Nadaraya-Watson IV regression estimator is detailled in section 3.1.1, it is denoted $\widehat{f}(y_j)$ and converges in probability to the true function f when $h- > 0$ and $nh- > \infty$ as $n- > \infty$. In order to be inversible, the f function should be monotonic. We ensure the monotonicity of $\widehat{g}$ by imposing a shape-restriction on the Kernel regression estimator (see Matzkin (1994) and Mukarjee and Stern (1994)). The monotonicity-constrained estimator, $\widehat{f}_c$ is an arithmetic average of a backward $\widehat{f}_1$ and an upward $\widehat{f}_2$ estimators, its computation has the advantage to be straightforward:

$$\widehat{f}_c(y) = \frac{\widehat{f}_1(y) + \widehat{f}_2(y)}{2}, \tag{26}$$

with:

$$\begin{cases} \widehat{f}_1(y_j) = \max\limits_{y'_j \leq y_j} \widehat{f}^j(y'_j) \\ \widehat{f}_2(y_j) = \min\limits_{y'_j \geq y_j} \widehat{f}^j(y'_j) \end{cases}. \tag{27}$$

The validity of this restriction can be locally tested by checking if the constrained estimation $\widehat{f}_c$ belongs to the 5% confidence intervall of the unconstrained one. The same approach is adopted for single males.

4.2.2 Prediction of individuals living in a couple' private expenditures

We suppose that the same econometric model (equation (24)) explains clothes expenditures across marital status. This assumption requires that *preferences for clothes* do not change when getting married. There is no doubt that this is a strong requirement. If we can deplore the eventual presence of externalities of clothes consumption (one could care about his or her spouse appearance), it is also likely that individual preferences for clothes, with respect to other goods, change when getting married or when getting divorced. Another possibility is that the marriage market selects individuals who present different preferences for clothes and thus can be directly or indirectly (through covariates) related to the intra-household sharing rule. In all these cases, the prediction of the sharing rule can be biased. However, the identity of preferences accross cohabitationnal status is a standard assumption to identify the intra-household sharing rule (e.g. Browning et al., 2003, Couprie, 2002; Laisney, 2002; Vermeulen, 2005). In these papers, parametric assumptions on preferences generally allow a very delimited change in preferences because of the change of cohabitational status. In our nonparametric approach, clothes expenditures should follow exactly the same pattern accross cohabitational status.

We first illustrate the prediction of female's private expenditures. Individual private expenditures of women living in a couple, y_{cf}, is simulated using $\widehat{f}$ and the distribution of the error term for singles, denoted $\widehat{\psi}$. Let us denote $\widetilde{e_{cf}}$ a residual drawn from $\widehat{\psi}$. In principle, y_{cf} is given by the following expression:

$$y_{cf}(e_{cf}) = f^{-1}\left(c_{cf} - e_{cf}\right), \tag{28}$$

where the true Engel curve f may be replaced by the predicted one, $\widehat{f}$, and the true error term, e_{cf}, may be replaced by $\widetilde{e_{cf}}$. In practice, we cannot predict outside the support of the predicted $\widehat{f}$. Let us denote the support of predicted clothes expenditures $[\underline{c}, \overline{c}]$ for the subsample of single women, namely, $\underline{c} = \min \widehat{f}(y_j)$. More precisely if the non random clothes expenditure satisfies

$$c_{cf} - \widetilde{e_{cf}} \in [\underline{c}, \overline{c}], \tag{29}$$

and if $\widehat{f}$ is monotonic, then the individual private expenditure is given by

$$y_{cf}(\widetilde{e_{cf}}) = \widehat{f}^{-1}(c_{cf} - \widetilde{e_{cf}}). \tag{30}$$

It may be the case that the residual $\widetilde{e_{cf}}$ is such that the support condition (29) is not satisfied. Then in this case, we cannot predict the individual private expenditure. To overcome this problem, we draw several residuals for each observation. The resulting distribution is called the distribution of replicate. Doing it uncarefully may introduce a disturbance between the genuine distribution and the replicate one. In order to prevent this shortcoming, the number of residuals drawn is in due proportion to the fraction of non random clothes expenditure out of the support condition (see equation (29)). A Kolmogorov-Smirnov test permits to check that the probability density function of $\widetilde{e_{cf}}$ is not significantly different than $\widehat{\psi}$. In this case, the support condition is neutral on our prediction.

Applying the same method on males, we simulate private individual expenditures of males living in a couple, $y_{cm}(\widetilde{e_{cm}})$. The quality of the prediction can be checked by looking at the adequation between the sum of the predicted private expeditures of spouses to the household's observed private expenditures: $y_{cf}(\widetilde{e_{cf}}) + y_{cm}(\widetilde{e_{cm}}) \approx \widetilde{Y}$. Male's prediction gives an over-identification restriction to the model, the ratio of women expenditures is predicted by averaging over both predictions.

4.2.3 Concavity test

The private sharing function is the relation between private expenditures of the *dominated* individual and household private expenditures. The *dominated* individual is obtained by taking, for each household, the minimum value of $\{y_{cf}(\widetilde{e_{cf}}), y_{cm}(\widetilde{e_{cm}})\}$. It is then regressed on total household private expenditures, $\widetilde{Y}$. The concavity test follows Abrevaya and Jiang (2005), details are given in section 3.1.2.

4.3 Data

We use the French family expenditure survey namely *enquête budget des familles*, year 2000 for the implementation of the test. This kind of data usually presents problems due to the different purchase frequencies of goods. To prevent this problem, two data collecting methods are simultaneously used. The first one is a direct interview of the household, which aims at collecting last household's expenditures such as rent, electricity, childcare, etc., expenditures during the last 2 months (clothes, fuel, etc.) and some expenditures during the last year (service charges). Expenditures for the last two weeks are directly recorded by individuals themselves on a small book. With this method, misreporting due to remembering is minimized. On the counterpart, INSEE needs to control for seasonality in the expenditures in order to construct annual expenditures for each good category. As usual, data are collected at the household's level and we do not explicitly know who is the main beneficiary of each consumption within the household. Apart from expenditures, net incomes, savings and socio-demographic characteristics are also collected.

$[INSERTTABLE1]$

Table 1 shows the sub-sampling selection process. Households containing more than two adults without children, excluding elderly, were excluded from the analysis. This selection rule ensures that the identification assumptions are plausible.[9] The selection tends to select households with a lower income but with a slightly higher share of clothes consumption. Finally, as usual, we withdraw from the sample individuals who do not consume a positive amount of assignable clothes. This selection rule implies that households with a higher taste for clothes or with a higher income are selected. The neutrality of this selection rule on the analysis is assumed even if it could potentially be related to the household's decision-making process. One good point is that the average household's income is nearly the same between column 2 and 3. As shown in Table 1, individual characteristics slightly differ when selecting the sub-sample. In particular, the educational level tends to be higher, this could potentially affect (probably reduce) within household inequality.

The sample size appears small for a nonparametric analysis (461 observations for single men, 569 for single women and 764 couples). For consistency purposes (with the theoretical section), the analysis will not control further for the heterogeneity in clothes' consumption taste. Hence, nonparametric regressions will be univariate and this ensures an acceptable

[9] The identity of preferences for clothes accross cohabitationnal status is more likely to hold on this specific sub-sample.

convergence rate even with this sample size.

$[INSERT\ TABLE2]$

Table 2 shows descriptive statistics of the sub-sample. Overhall, clothes consumption represents a relatively small share of household's expenditures (around 5%). As the share is low, results could be sensitive to the presence of small clothes consumption measurement errors. Nevertheless, clothes constitutes the only assignable good disposable in the data, Browning et al. (1994) identified the intra-household sharing rule with clothes' demand functions. The variation of shares between singles and couples gives an indication of the degree of publicness or economies of scales implied by the specific good category consumption. Indeed, expenditures related to the accommodation represent a much lower share of the budget for couples than for singles, this probably reveals the public nature of the house. On the contrary, the other goods do not show a decreasing share when looking at couples instead of singles. This is the case for clothes expenditures which we can suspect to be mainly private as the share does not change much between singles and couples (forgetting about heterogeneity in preferences and income). This exploratory analysis leads us to choose a quite restrictive definition of public expenditures which are defined as the expenditures related to the accommodation (rent, heating, energy for the house).

4.4 Results

4.4.1 Intra-household sharing rule

$[INSERT\ FIGURE2]$

Figures 2a and 2b represent the Engel curve estimation of clothes consumption of single women and single men. The conditional moment is estimated with a Nadaraya–Watson quadratic kernel, controlling for endogeneity and constrained to monotonicity (see equation (26)). Total household gross income is very significant as an instrument both for women and for men, the t-statistic equals respectively 49,4 and 35,3 for them. The exogeneity of household private expenditures was clearly rejected in the data with a p-value lower than

0.001 for both Engel curves. Monotonicity can be tested by checking if the constrained-estimator (the Engel curve) lies between the confidence band which corresponds to the unconstrained model. This is equivalent to a point by point testing of the monotonicity. Globally, both the constrained curves and the unconstrained ones (see figures A1 and A2 in appendix) are very similar and monotonicity is never rejected. Outliers were removed from these estimations. This reduces the sample size of the predicted clothes expenditrues for singles by approximately 10% but does not affect the final result of the monotonicity and of the concavity test.[10]

$[INSERT\ TABLE 3\ AND\ 4]$

Table 3 and 4 show the results of the prediction of the private sharing function for individuals living in a couple. We should precise that it is the first time a nonparametric prediction of the intra-household share of welfare is proposed in the literature. The prediction of female's private expenditures is obtained by inversing single female's Engel curve of clothes consumption using observed assignable clothes consumption of women in-a-couple. For males, the mechanism is the same but standard error appears greater than the mean which could reveal some prediction error, probably due to the strong identifying assumptions we used. Despite this, we are quite confident in the predictions because all our indicators go in the good direction. First, summing both male and female's predictions, we obtain predicted household private expenditures, 23000 on average, which appears not so far from observed ones (25000). Second, the neutrality of the support condition seems to hold. This neutrality can be checked by comparing the distributions of the predicted error disturbance for single individuals with the one used in the simulation for individuals living in a couple. An illustration is given in appendix, table A3. A formal Kolmogorov-Smirnov test can be used to check if both distributions are statistically different. Results indicate that the nul hypothesis of identical distributions is not rejected, with p-value equals to 0.563 for females and 0.239

[10] This selection improves the quality of the graphs but does not affect the relationship between the private sharing function and household private expenditures, which remains linear. Keeping the outliers would lead to a strong over-prediction of the average household income and would induce a non-neutrality of the support condition.

for males.

Finally, we can reconstitute female's share of household's private expenditures. It represents on average 54% of household total private expenditures. Looking at the quantiles of this ratio, we remark that it is quite symmetrical and rarely falls below 20%. This ratio reveals the presence of intra-household inequality which appears, with these data, most of the time in defavor of males. This result is close to the parametric prediction obtained by Browning, Chiappori and Lewbel (2003) on consumption data. What we are interested in now is: how does the intra-household inequality change with household's income?

4.4.2 Is the double concavity condition valid?

$[INSERTFIGURE3$ and $4]$

We are looking at the concavity of the public and the private sharing functions. Figures 3 and 4 present data on the public and the private sharing function for couples, they also show a conditional mean kernel estimation controlling for endogeneity of the explanative variable. In both cases, exogeneity is rejected with p-values equals to 0.0077 for the public sharing function and 0.0138 for the private sharing function. First, one should remark that the monotonicity of the conditionnal mean is not rejected in both cases. The estimation lies in the unconstrained confidence band (see figures A.4 and 4). Second, the private sharing function looks linear whereas the public sharng function tends to present, at first sight, a convex part in the middle of the graph. Then we can turn to Abrevaya and Jiang (2005) formal concavity test.

$[INSERT\ TABLE5]$

Table 5a presents the concavity test for the public sharing function and table 5b presents the test for the private sharing function. Data are split between 6 or 7 sub-samples in order to eventually detect the presence of local non-convexities. Each line presents the result of the global concavity test on the split sample, whereas the last lines of each table present the localized global concavity test. The first column gives the U-statistic which represents the proportion of convex 3-tuple in excess of concave ones, the columns in the middle present standard-errors, p-values for the local test. The last two columns aims at checking that the conditions of validity of the test are satisfied.

We start with table 5a. The local test rejects concavity for households with incomes lower than 21000 and for households with incomes between 35000 and 42000. As a consequence, the global test realized on the full sample rejects global concavity of the public sharing function. If we select only households from the center of the income distribution, i.e. households with expenditures between 14000 and 35000, the global concavity is not rejected. Looking at the symmetry condition necessary for the test to be valid, we can notice that symmetry is strongly rejected for very low incomes. This is probably due to the censoring of the data, this could explain the rejection of concavity for low income households. But the p-value of the symmetry test for households spending between 35000 and 42000 euros per year appear equal to 0.02 which rejects symmetry of the error disturbance distribution at the 5% threshold but not at the 1% threshold. Hence we can be confident in the rejection result of the concavity test for these households.

For the private sharing function (table 5b), the sample was split into 6 parts. The result of each local concavity test is clear. Local concavity is not rejected, except probably for the [28000-35000[window which shows a p-value of 0.024. Local linearity is never rejected, the lowest p-value equals 0.055. The error disturbance is clearly symmetric, the symmetry statistics is always below 1.25 in absolute value. Hence the global test concludes in favor of the linearity of the private sharing function. This means that the intra-household level of income does not change, on average, the balance of bargaining power within the family.

5 Concluding remarks

Our aim was to look if welfare comparisons made at the household level could be translated on an individual basis. For this reason, in the first part of the paper we find necessary and sufficient conditions on intra-household behavior that guarantees the preservation of the GL criterion and the conversion of Bourguignon's and A&B test. The key-properties we find are the convavity of the public and private sharing functions. It is not difficult to show that

Corollary 1 and 2 still hold under more general notions of individual income: for instance, applying to the function g in Definition (2) a linear or concave transformation, different for each individual. In this way, we could implement differences in individual consumption of public goods in our model. Another possible extension of our theoretical analysis could take into account the preservation of welfare quasi-orders for populations with a different number of households of each size (see, among others, Jenkinks and Lambert (1993)) or focus on poverty.

The main result of the empirical part is that the double concavity condition is rejected for the whole income distribution but can be considered as valid in the middle of the income distribution, excluding highest and lowest incomes. This rejection is due to a local convexity pattern in the public sharing function and could be due to measurement errors in the extreme of the income distribution. After having predicted the share of private expenditures going to the female within the family (54% on average), we conclude on these data that intra-household inequality is a relevant problem when implementing welfare comparison, notally for a policy maker which deals with poverty analysis. On one hand, this result should be taken carefully as the prediction relies on strong identifying assumptions. In fact, further research should focus on relaxing them and propose a better control of the economies of scales within families. On the other hand, focusing on a restricted domain of household income distributions, i.e. considering only particular changes due to taxation or subsidies, (see Peluso and Trannoy (2005)) it is possible to find less restrictive conditions on sharing functions that could be consistent with the empirical evidence provided here.

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Table 1: Sub-sample selection

	All families (couples or singles)	**Without children, excluding elderly**	**Consuming assignable Clothes**
Number of observations	9962	2750	1794
Number of single men	1114	688	461
Number of single women	2281	711	569
Number of couples	6567	1351	764
Household's share of clothes expenditures			
- women	0.0197 (0.0331)	0.0219 (0.0359)	0.0302 (0.0401)
- men	0.0155 (0.0299)	0.0181 (0.0288)	0.0259 (0.0376)
- children	0.0094 (0.0250)	0.0002 (0.0031)	0.0003 (0.0038)
- unassignable*	0.0122 (0.0316)	0.0127 (0.0362)	0.0135 (0.0357)
Household's total expenditures (in euros/year)	24769.1 (16632.8)	22041.5 (14703.0)	22446.1 (14696.0)
Household before tax income (in euros/year)	28717.8 (21263.1)	25349,5 (18859.8)	25316.2 (19601.5)
Age of household's head	50.98 (16.74)	41.45 (12.55)	39.76 (12.51)
Education level (1 to 5)	2.88 (1.39)	3.23 (1.44)	3.39 (1.45)
Household has a child	0.31 (0.46)		

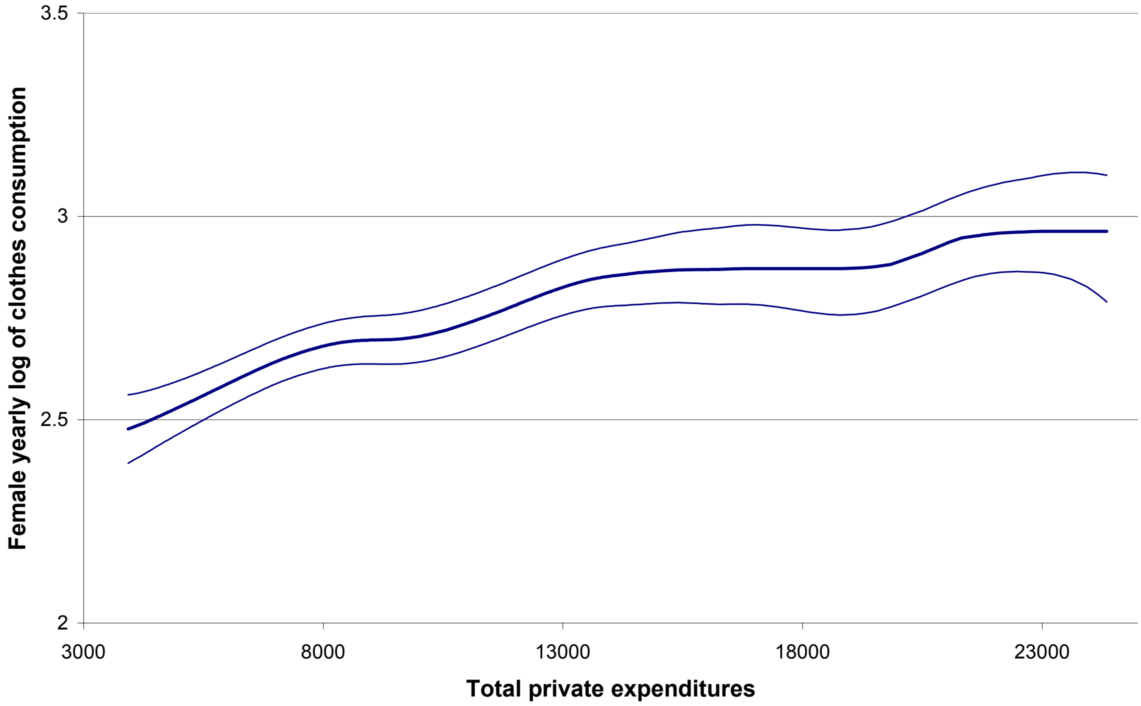
** In the following, this category will be included in other private expenditures.*

Table 2: Descriptive statistics of the sub-sample

	Single men	Single women	Couples
A/ Shares of household annual expenditures (in %)			
Accommodation and energy (**Public**)	24.51	26.61	16.61
Furnitures for the house	3.11	3.50	4.70
Small furnitures for the house	5.10	4.82	5.81
Car buying	3.22	3.28	6.67
Gasoline and car-related expenditures	12.38	9.18	11.22
Leisure	13.89	12.52	11.35
Health and body	3.81	8.77	8.06
Food at home	11.03	13.18	14.69
Vices	4.41	2.59	3.18
Clothes	5.47	5.82	5.49
Other expenditures (bank, transfers…)	13.07	9.73	12.22
B/ Income and expenditures (in euros/year)			
Before tax income	18647.5 (13124.9)	16658.5 (10313.7)	35788.0 (22962.6)
Total Expenditures	16373.3 (8809.4)	16016.8 (8217.4)	30898.8 (16906.1)
Women' clothes expenditures	2.7050 (39.7841)	892.23 (966.31)	815.09 (812.49)
Men' clothes expenditures	892.83 (1181.86)	7.963 (96.053)	821.68 (941.80)
C/ Covariates			
Age of household's head	37.50 (10.84)	38.19 (12.99)	42.30 (12.64)
Education level (1 to 5)	3.29 (1.55)	3.59 (1.47)	3.29 (1.36)
Number of observations	**461**	**569**	**764**

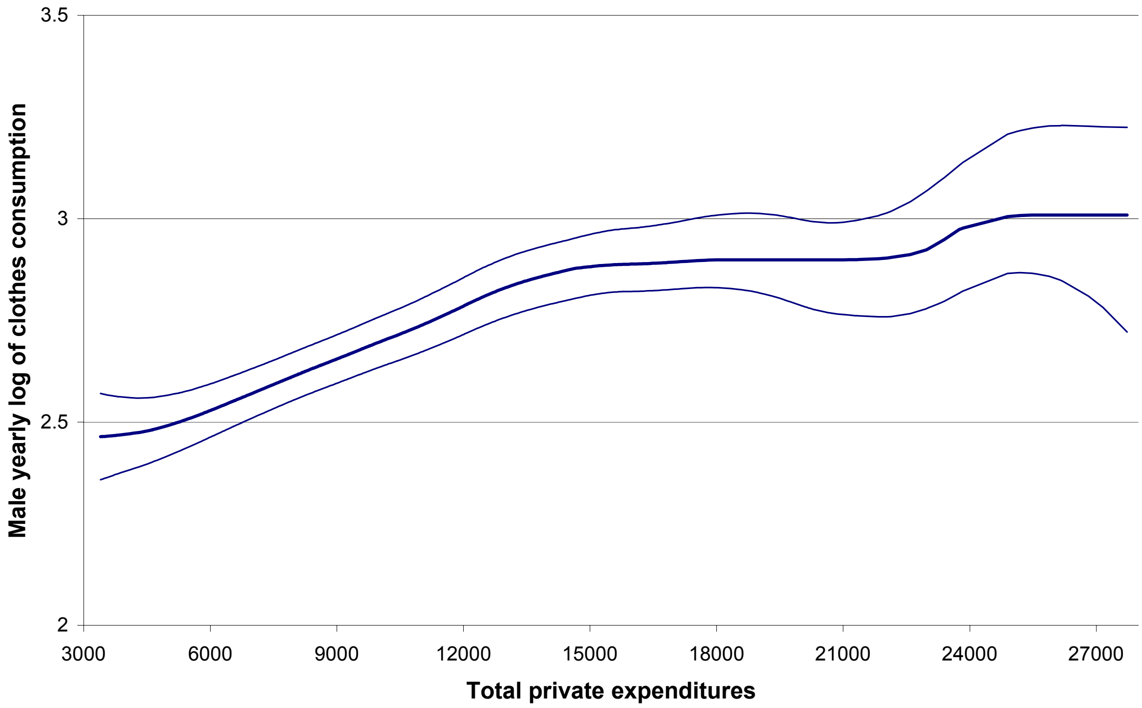
Figure 1: Clothes consumption Engel Curves estimates for single individuals

Figure 1.a: Single women



** Monotonicity-constrained regression. The 5% confidence band corresponds to unconstrained estimates.*

Figure 1.b: Single men



** Monotonicity-constrained regression. The 5% confidence band corresponds to unconstrained estimates.*

Table 3: Private sharing function prediction results for couples

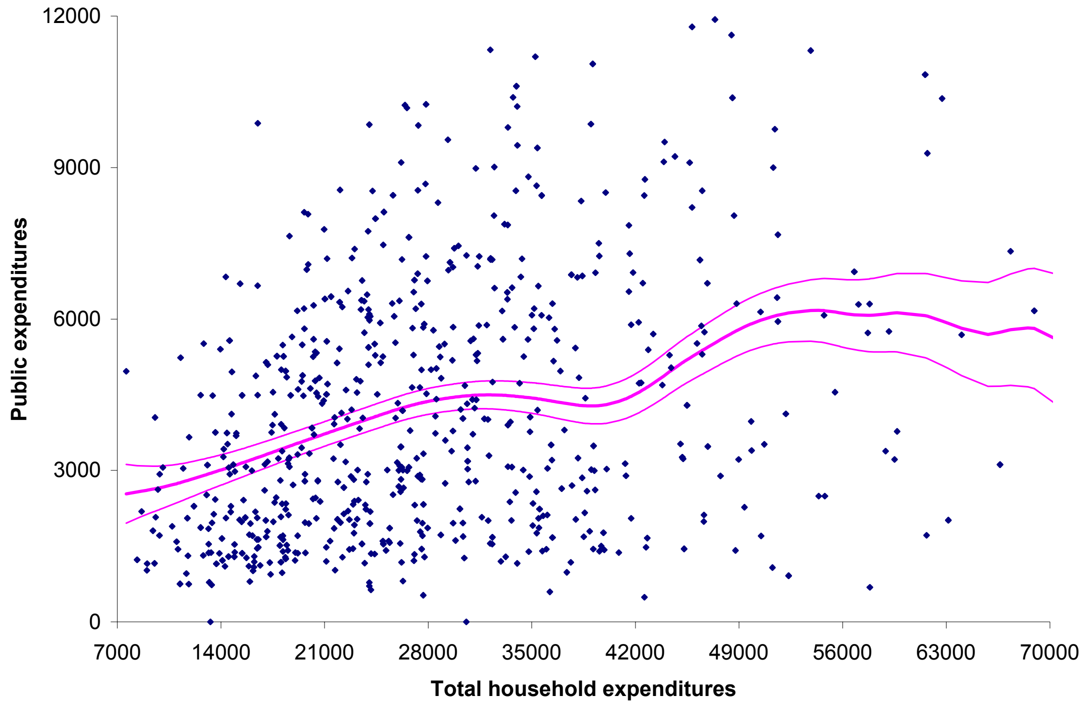
	Mean	Standard error	Median
Female Private expenditures *(A)*	10932.9	5585.1	10280.4
Male Private expenditures *(B)*	13141.8	15363.5	10838.1
Household's Private expenditures *(C)*	23022.0	8426.8	21448.8
Female's ratio of household's private expenditures *(D)*	0.5469	0.2363	0.5324
Private expenditures of the dominated *(E)*	13701.15	8377.3	12151.5

(A) Inversion of Female's Engel curve of clothes expenditures; *(B)* Inversion of Male's Engel curve of clothes expenditures; *(C)* Sum (A+B); *(D)* 0.5(A+Private expenditures-B)/Private expenditures; *(E)* (A) if (D)<0.5 and (B) if not.

Table 4: Quantiles of female's sharing rule

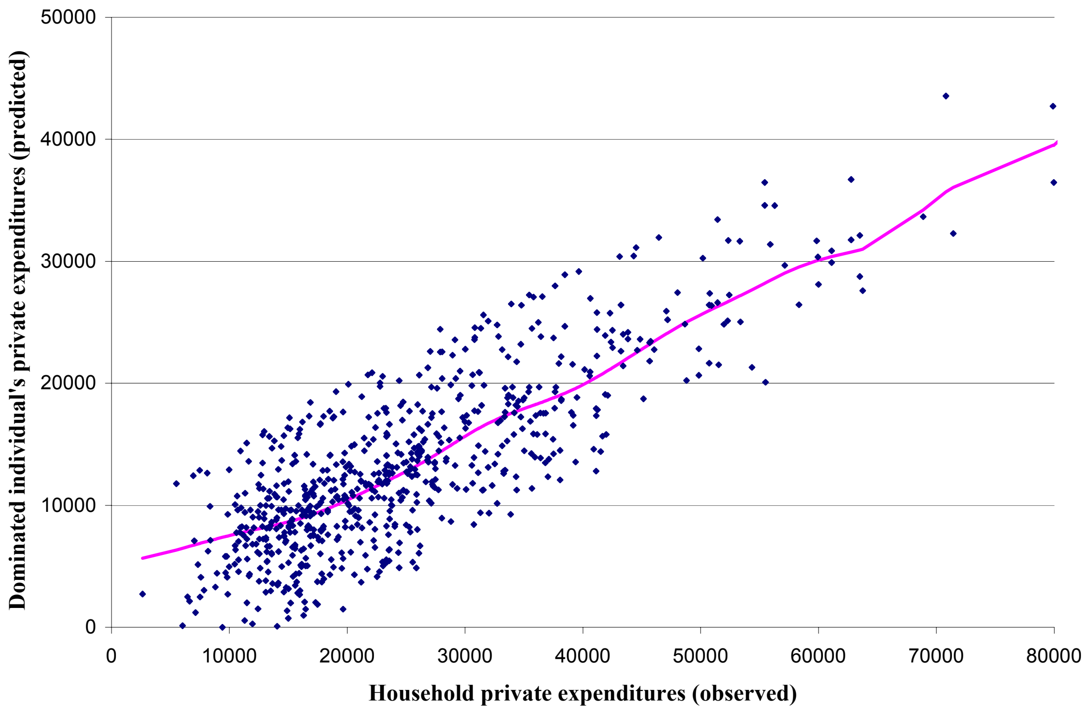
Q_5	Q_{10}	Q_{25}	Q_{40}	Q_{50}	Q_{60}	Q_{75}	Q_{90}	Q_{95}
0.2090	0.2898	0.4222	0.4962	0.5324	0.5675	0.6541	0.7969	0.9498

Figure 2: Engel curve for couples' public expenditures*



* *Instrumental variables Quadratic Kernel estimation*

Figure 3: Private sharing function



* *Instrumental variables Quadratic Kernel estimation.*

Table 5: Double concavity test (*)

Table 5a: Public Sharing Function

Total household expenditures	Number of obs.	U-stat *(a)*	Standard error (ζ)	$\widetilde{U}$ -stat *(b)*	p-value (concavity)	p-value (linearity)	Symmetry Statictic *(c)*	p-value (symmetry)
[7607-14000[	54	0.8444	0.1430	14.461	0.000	0.000	7.2676	0.000
[14000-21000[	175	0.1962	0.4367	1.9816	0.024	0.047	1.7005	0.089
[21000-28000[	194	-0.9424	0.0555	-78.812	1.000	0.000	0.6910	0.490
[28000-35000[	125	-0.9930	0.0076	-484.31	1.000	0.000	-0.1882	0.851
[35000-42000[	87	0.7331	0.2419	9.4227	0.000	0.000	2.2872	0.022
[42000-70000[	109	-0.8988	0.0654	-47.819	1.000	0.000	0.3023	0.762
[70000-126971]	20	-0.0737	0.3379	-0.3250	0.627	0.745	-1.1397	0.254
Global localized test			M-Stat *(d)*	S-Stat *(e)*				
All sample	764		14.461	484.31	0.000	0.000		
[14000-35000[	494		1.9816	484.31	0.120	0.000		

Table 5b: Private Sharing Function

Private household expenditures	Number of obs.	U-stat *(a)*	Standard error (ζ)	$\widetilde{U}$ -stat *(b)*	p-value (concavity)	p-value (linearity)	Symmetry Statictic *(c)*	p-value (symmetry)
[2642-14000[	117	-0.0026	0.1434	-0.0651	0.526	0.948	0.3516	0.725
[14000-21000[	211	0.0039	0.1417	0.1331	0.447	0.894	-0.0253	0.980
[21000-28000[	169	0.0631	0.1423	1.9200	0.027	0.055	0.2728	0.785
[28000-35000[	91	0.0394	0.1783	0.7031	0.241	0.482	0.1279	0.898
[35000-42000[	65	0.0228	0.1439	0.4266	0.335	0.670	1.2489	0.212
[42000-114233]	74	0.0749	0.1487	1.4442	0.074	0.149	0.3177	0.751
Global localized test			M-Stat *(d)*	S-Stat *(e)*				
All sample	727		1.9200	1.9200	0.181	0.330		

(*) Abrevaya and Jiang (2005). The details of the statistics and their distribution are in section 3.1.2. (a) Proportion of convex 3-tuples in excess of concave ones. (b) Standardized U-statistic, follows a N(0,1) under the nul: linearity or concavity. (c) Standardized I-statistic, follows a N(0,1) under the nul: symmetry of the error disturbance. (d) Maximum value of the standardized U-stat. (e) Maximum absolute value of the standardized U-stat.

APPENDIX

Figure A.1 Female's Engel curves of clothes consumption (unconstrained estimation)

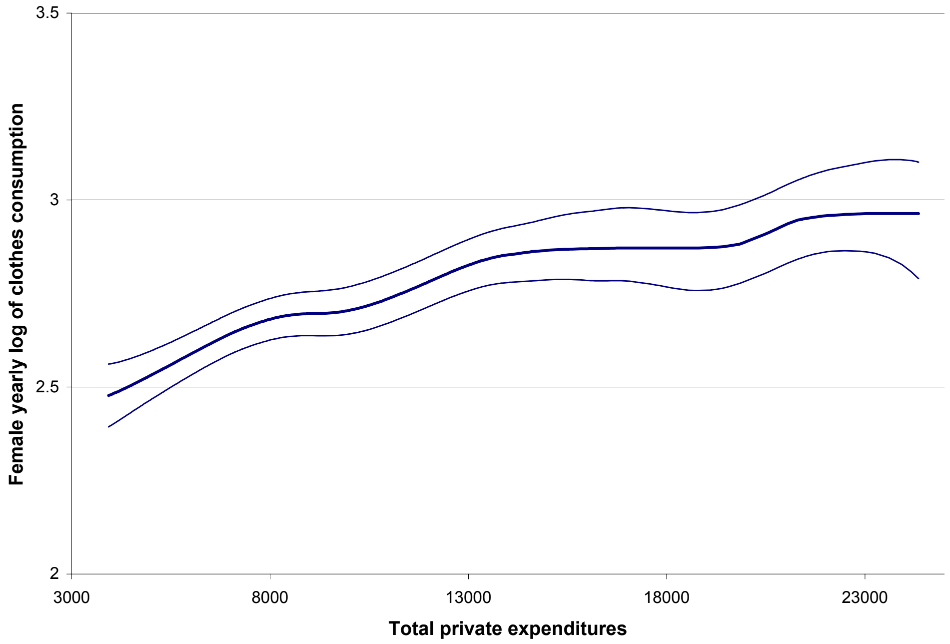


Figure A.2 Male's Engel curves of clothes consumption (unconstrained estimation)

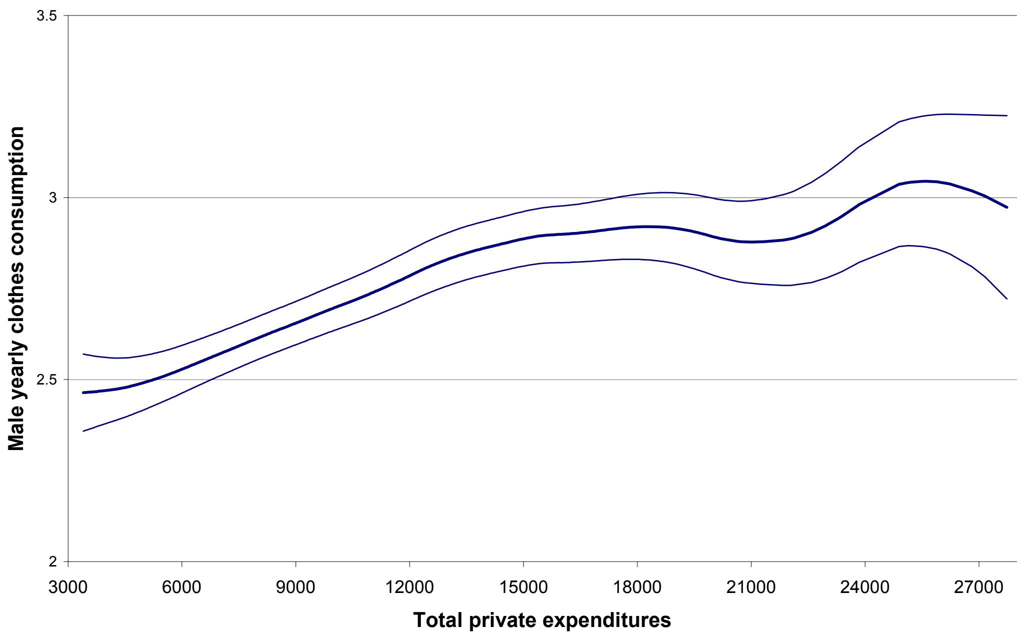


Figure A.3 Cumulative distribution functions of the error disturbances before and after the support condition

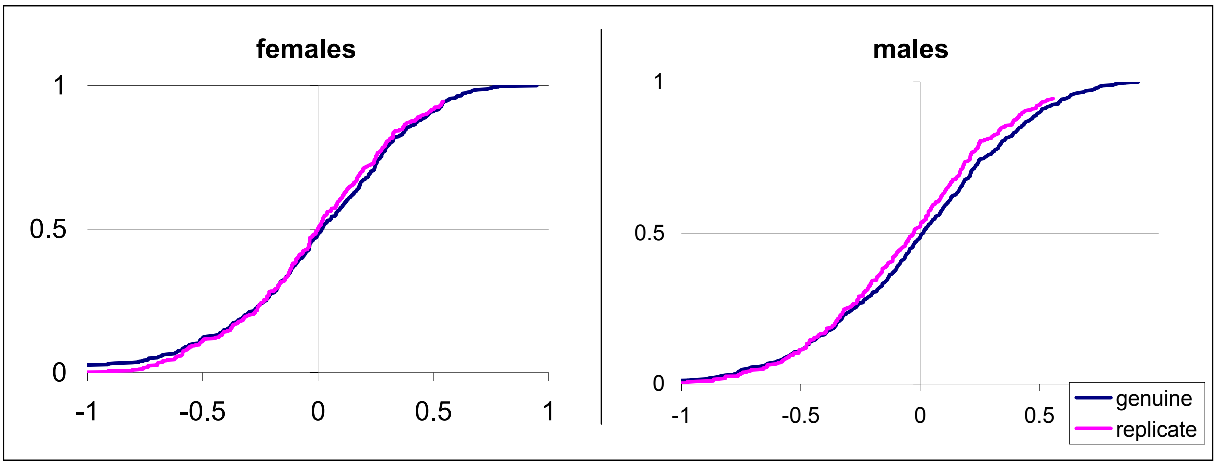
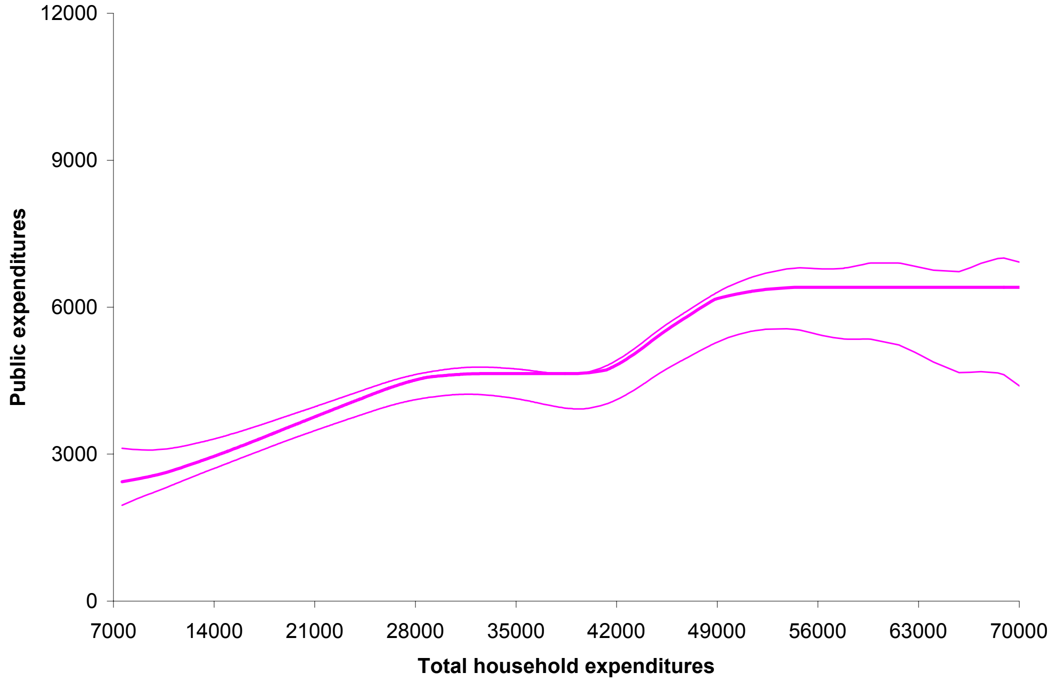


Figure A.4 Public sharing function (monotonicity-constrained estimation)



** Monotonicity-constrained regression. The 5% confidence band corresponds to unconstrained estimates.*