Is power more evenly balanced in poor households ?*

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October 25, 2007

Abstract

The structure of intra-household allocation is crucial to know whether a transfer from a rich household to a poor one translates into a transfer from a rich individual to a poor one. If rich households are more unequal than poor ones, then a progressive transfer among households reduces intra-household inequality, hence inequality among individuals. More specifically, if the part of the couple's expenditures devoted to goods jointly consumed decreases at the margin with the couple's income as well as the part of private expenditure devoted to the disadvantaged individual, then the Generalized Lorenz test is preserved when passing from the household to the individual level. This double concavity condition is non-parametrically tested on French data. Using three definitions of public expenditures and two ethical rules, the data do not reject the double concavity condition and support the thesis that for purposes of welfare comparisons across individuals, the structure of intra-household allocations can safely be ignored.

JEL Classification: D63, D13, C14. *Key Words*: Lorenz comparisons, intra-household inequality, sharing functions, non-parametric concavity test.

1 Introduction

As the success of the collective approach to household behavior shows, there is growing interest in making inequality or welfare comparisons between individuals. Nevertheless, the relevant data are

*We thank Jason Abrevaya and Wei Jiang, Jean-Yves Duclos, Marc Fleurbaey, Peter Lambert, Arthur Lewbel, Michel Le Breton, Federico Perali, Nathalie Picard, Nicolas Ruiz, the participants at CHILD International Workshop in Garda, CIRPEE 2004 Conference and 2005 ESEM and two anonymous referees for useful comments. INSEE data were made available through an agreement with IRESCO-Lasmas. Eugenio Peluso thanks the THEMA where he found a splendid environment during the preparation of a previous version of this paper. The usual caveat applies.

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generally collected at the household level, so welfare or inequality statements are usually assessed at this level. The question thus arises whether reducing inequality across households also reduces it across individuals. Obviously, if households share their resources equally, the answer is positive. However, if the bargaining power among household members is unbalanced, the answer is more complex. Suppose there is a *dominant* individual (husband or wife) who gets a larger share than under equal distribution. Conversely, *dominated* individuals are those who receive less. This intra-household inequality may neutralize the egalitarian effect among individuals of redistributive transfers from rich to poor households.

The basic intuition of a positive answer even in this case is quite simple: whether reducing inequality across households also reduces it between individuals depends solely on how the level of household income changes the balance of intra-household power. That is, if disadvantaged members have more bargaining power in lower income households, then transferring money to poor households does in fact benefit poor individuals. Peluso and Trannoy (2007) have specified this intuition when the family only consumes pure private goods. The private expenditure of the dominated person must be a concave function of household income whenever we are interested in comparing income distributions via the Generalized Lorenz (GL) test. To avoid misunderstanding, however, two qualifiers are needed. First, the requirement applies to the *marginal* expenditure of the disadvantaged individual, which is more demanding than a requirement bearing on the *average* share. Second, although the underlying intuition is clear enough, it may be misleading since it does *not* translate into the same kind of result for inequality comparisons of the Lorenz type. This paper inquires empirically whether disadvantaged members actually do have higher bargaining power in lower income households.

Our previous result, informative though it is, does not allow us to fully test the concavity restriction on real data, partly because that work neglected the presence of family public goods. It is widely acknowledged that living together involves joint consumption of goods and that the impact of economies of scale on individual well-being is quite large. We first extend our previous result by including public goods. We show that concavity of the part of expenditures devoted to public goods relative to household income is necessary to extend welfare judgments at the individual level. The richer the household, the lower must be the marginal propensity to consume public goods. This condition also becomes sufficient if joined with the concavity of the expenditure devoted to private goods of the *dominated* individual as a function of the budget dedicated to private goods in the household. In other words, the intra-household allocation is no longer an issue for the appraisal of welfare among individuals if the marginal share of income dedicated to private expenditure and to the consumption of the individual with the most power becomes increasingly important as the household gets richer.

These findings appear relevant from an empirical viewpoint since the double concavity condition may serve as a testable restriction in an econometric analysis. It is sufficient to check the sign of the second derivative of two functions. It is quite surprising that such simple conditions can be derived from a dominance approach, which is much more general than resorting to a single inequality index. As the empirical part of the paper shows, one can proceed to the double concavity test without a complete estimation of the intra-household "sharing rule" in the sense of the collective approach (see for instance, Chiappori (1988), Browning and Chiappori (1998), Donni (2003), or Browning, Chiappori and Lewbel (2003)).

Using the French Household Expenditure Survey, year 2000, we estimate non-parametrically the intra-family share of income devoted to public goods as well as the dominated individual's share of private consumption. The 'public' sharing function is estimated directly from a list of public goods. It is hard to define precisely which goods are public in household consumption, since externalities are so pervasive in everyday family life. To cope with this difficulty, three different definitions of public/private household consumption are used. The first is a restrictive view of joint consumption within a household, i.e. housing, heat, lighting and water. The second, somewhat broader, definition includes furniture and household services. An expanded definition also includes car-related expenditures and gasoline.

As consumption is observed at the household level, private or individual expenditure is unobserved. The private sharing function is recovered by an identification assumption. It is assumed that a single woman (or man) has the same taste for clothing as a woman (or man) in a couple. This kind of good has the advantage of permitting an easy assignment of expenditures to each member of a heterosexual couple. This assumption has been used in repeatedly studies designed to reconstruct "who gets what" within a couple. (Browning et al., 2003; Couprie, 2007; Laisney, 2002; Vermeulen, 2005). Here, the non-parametric concavity test proposed by Abrevaya and Jiang (2005) is implemented on both sharing functions.

Concavity of the public and the private sharing function are not rejected by the data. In other words, the French example provides a positive message regarding the preservation property of the GL test. At least for this country, welfare dominance statements that are verified at the household level deliver accurate information about the individual level as well.

The paper is structured as follows. In Section 2, the setup is presented with a statement of the theoretical result. The empirical strategy is described in Section 3. Section 4 describes the data, and empirical results are presented in Section 5. Extensions and possible developments are discussed in Section 6, which concludes. Proofs and additional material are collected in the Appendix.

2 The balance of intra-household power and the distribution of individual welfare

Before introducing normative statements about the impact of the balance of intra-household power on the distribution of individual welfare, let us set out our model of intra-household behavior.

2.1 The household model

The consumption pattern of couples is expressed in a reduced form, in that the preferences of members of the household remain in the background. The model is thus in tune with the empirical part, which is distinctly non-structural.

Three simplified features of the intra-household behavior are assumed. First, some goods are jointly consumed within the couple. Second, there are no externalities or domestic production. Third, the intra-household allocation of resources is biased in favour of one of the two members. This bias reflects unequal power between the two spouses.

Let Y_i be the total expenditure of a couple i. The *public sharing function* $g : \mathbb{R}_+ \to \mathbb{R}_+$ gives the expenditure for pure public goods within the couple. We assume g twice continuously differentiable, identical across households, with $g(0) = 0$, $g(Y_i) \leq Y_i$ and $g'(Y_i) \in [0, 1]$, $\forall Y_i \geq 0$. The remaining part of household income, $Y_i - g(Y_i)$ (henceforth denoted Y_i^*), is shared between private consumption of the *dominant* and the *dominated* individual. The dominated individual receives at most an amount equal to that of the dominant. The income $p_i = f_p(Y_i^*)$ received by the dominated individual in the household i is given by the *private sharing function* $f_p : \mathbb{R}_+ \to \mathbb{R}_+$.[1] It is assumed identical across households, twice continuously differentiable, non-decreasing, and such that $f_p(0) = 0$ and $f_p(x) \leq \frac{1}{2}x$, $\forall x \in \mathbb{R}_+$. The amount r_i of private expenditure devoted to the dominant individual is $r_i = f_r(Y_i^*) = Y_i^* - f_p(Y_i^*)$.

When joint consumption is not considered, a definition of *individualized* income naturally emerges as the part of the household budget devoted to each household member for her (or his) private expenditure. In the presence of joint consumption, no obvious definition emerges without additional assumptions. The following analysis resorts to a parametrized definition of *i*ndividualized income that makes the standard of living of members of a couple comparable with that of a single individual. We define the individualized income of each household member as the sum of his/her private expenditures and a part of the household expenditure on pure public goods.

[1] This is a reduced form for a distribution factor independent version of the collective model, one in which income pooling still holds (Browning, Chiappori, and Lechene 2004).

Definition 1 *Let $\alpha \in [\frac{1}{2}, 1]$. The individualized incomes in household i are given by the two functions $y_p^\alpha(.)$ and $y_r^\alpha(.)$ defined by*

$$y_{ip} = y_p^\alpha(Y_i) = \alpha g(Y_i) + f_p(Y_i^*) \text{ (dominated type)} \tag{1}$$

$$y_{ir} = y_r^\alpha(Y_i) = \alpha g(Y_i) + f_r(Y_i^*) \text{ (dominant type)} \tag{2}$$

The sum of the individualized incomes is equal to the couple's income only for $\alpha = 1/2$. In all other cases it is greater, meaning that living in couple creates economies of scale linked to joint consumption. This parametric definition offers a three-fold advantage: It does not require a structural model of individual behavior, it introduce flexibility in comparing the well-being of single and married individuals and it encompasses the various proposals made in the literature regarding the contribution of public goods to individual welfare (see Appendix A).

2.2 Welfare analysis: the double concavity condition

We take a population composed of n couples (indexed by $i = 1, ..., n$, with $n \geq 2$). Let $\mathbf{Y}^c$ designate a generic vector of couples' income, rearranged in an increasing way. Let $\mathbb{Y}_n$ be the feasible set of income distribution. Turning our attention to the $2n$ individuals living in couples, we designate by $\mathbf{y} \in \mathbb{R}_+^{2n}$ a generic vector of their *individualized* income, again rearranged in an increasing way.

The decision-maker starts from the premise that adults ought to be treated equally in allocating household resources. This principle is based on both empirical evidence and normative statement. Empirically, the two adults are supposed to be equally needy, which can be considered as a fair approximation of everyday life in a developed country for two healthy persons of the same age[2]. Normatively, the question of merit or reward within a couple should be neutralized. Differences in wage rates or hours of work can result in differences in consumption, but it is assumed here that the ethical observer believes that the intra-household allocation of resources ought not to be based on individual earnings. The factors that determine the bargaining power of individuals are simply not specified, as they are assumed to be ethically irrelevant[3]. To sum up, adults should be treated equally, and this also applies within couples.

To investigate the impact of intra-household allocation on welfare comparisons at *individual* level, at least two procedures are available. A very natural one is to adopt some inequality index to measure

[2] Of course, it can be mantained that the taller partner is entitled to a larger share in food expenditure. Actually, food counts far no more than 20% of the household budget in western countries, so a difference of 20% in calorie daily requirement justifies an extra 4% of the total budget in favour of the taller person, small enough that it can be safely neglected.

[3] This assumption is relaxed in the empirical part.

the *level* of inequality. For instance, Haddad and Kanbur (1990) find that when an additive inequality index is used, omitting intra-household inequality produces a serious downward bias in individual inequality. Lise and Seitz (2004) confirm this, showing that the underestimation is about 15% with the Gini index and 30% with the mean logarithmic deviation. This wide difference is the kind of result that we must be ready to accept when we are interested in trying to *measure* inequality, i.e., obtaining inequality comparisons that embody cardinal judgments.

The alternative route is the ordinal approach captured by the Lorenz criterion, which is less demanding but much more robust. The policy maker is satisfied if the social scientist can tell him whether inequality has increased or decreased. In this paper, we question whether or not Generalized Lorenz comparisons (Shorrocks 1983) are biased when intra-household inequality is ignored. The Generalized Lorenz test (GL) combines the size and the distribution dimensions in the evaluation of welfare. For a given population, it compares cumulative income for any cumulative percentage of households. This criterion will be used for comparing income distribution between households as well as between individuals. The GL test has an equivalence in terms of welfare comparisons: taking individual income distributions, $\mathbf{y} \succcurlyeq_{GL} \mathbf{y}'$ if and only if

$$\sum_{j=1}^{2n} u(y_j) \geq \sum_{j=1}^{2n} u(y_j'), \tag{3}$$

for the entire class of non-decreasing and concave utility functions u.

Typically, we want to know the conditions under which an increase in welfare at household level translates into the same ordinal statement at the individual level. If it does, we say that welfare dominance statements are *preserved* in moving from the household to the individual stage. We now establish the necessary and sufficient conditions for the GL preservation result.[4]

Proposition 1 *Let u, g and y_p^α be twice differentiable functions. The two following conditions are equivalent:*

i) The functions g and y_p^α are concave.

ii) For all $\mathbf{Y}^c, \mathbf{Y}^{c\prime} \in \mathbb{Y}_n$, $\mathbf{Y}^c \succcurlyeq_{GL} \mathbf{Y}^{c\prime} \Rightarrow \mathbf{y} \succcurlyeq_{GL} \mathbf{y}'$.

The concavity of the public sharing function and of the relation linking individual to household income ensure that welfare tests on households' income distributions also describe the pattern at the individual level. The intuition is clear enough. In order for an equality-enhancing transfer from rich to poor households not to be "undone" within the household, it must be the case that poor households are more egalitarian than rich. The former spend a lower marginal share on private goods

[4] See proof in Appendix B.

and the dispersion of individual incomes is reduced at the margin. It is important to notice that the concavity of the private sharing function is *not strictly* required for the Generalized Lorenz ranking to be preserved. However, if both sharing functions are concave, so is the individual income. Hence, we can express a simpler sufficient condition for the preservation of welfare test directly in terms of the public and private sharing functions.

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

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

This corollary[5] provides a testable restriction on individual choices that proves to be useful in our empirical analysis. If the part of the household budget devoted to public goods decreases at the margin as well as the dominated member's share in private goods, then any GL statement confirmed at the household level is automatically satisfied at the individual one as well. In other terms, if disadvantaged household members have more bargaining power in lower income households (i.e. a larger marginal share of private and public goods), then transferring money to poor households does necessarily imply a transfer to poor individuals.

3 Empirical Strategy

This section describes how we test for the concavity of the public and private sharing functions. The first empirical objective is to test whether poorer households generally spend a larger marginal share of their income on public goods than richer households. This refers to the question of the concavity of public expenditures with respect to total household expenditures. If this were the case, it would mean that the share of private consumption increases with income at the margin. In the presence of a balanced share of private consumption within the couple, the concavity of the public sharing function would aggravate intra-household inequality at the top of the household income distribution and attenuate it at the bottom. In this case, inequality between households and within households goes in the same direction.

However, we must make sure that the balance of power on private consumption does not move on the wrong way as household income increases. The second empirical objective is to test whether the intra-household share of private consumption depends on the amount of the households private

[5] Conversely, if both sharing functions are convex, then a more concentrated wealth distribution among couples would imply a more concentrated individual wealth distribution as well. An increase in wealth concentration means an increase in the cumulative top income.

consumption. In this second step, we test whether the expenditure of the dominated individual is concave with respect to household private expenditures. Private expenditures at the individual level are unobserved for couples in the data and have to be predicted. Taking clothes consumption as assignable[6], the identification mechanism relies on the inversion of single individuals' Engel curve of clothing consumption. The approach adopted here is innovative because it proposes a non-parametric prediction of the intra-household distribution of private consumption.

Practically, conditional means for each sharing function are derived before testing the concavity of this relation. The non-parametric test proposed by Abrevaya and Jiang (2005) requires the plot of the entire sample, corrected if necessary for endogeneity or partially linear effects. First the concavity test for the public sharing function is discussed, and then identification techniques for the private sharing function are detailed.

3.1 Testing the concavity of the public sharing function

With regard to the robustness of our empirical conclusion, we consider three different definitions of public expenditure and two ethical rules. Regarding the first robustness check, there is a broad consensus that housing is jointly consumed. Whether or not other consumption items should be so defined is more problematic: Should we include furniture, household services or even automobile costs? Of course, the public character of a good is a necessary condition, but one should also make sure that it is actually consumed jointly within the household. Since this requires observation of the everyday life of the couple, as a robustness check we use three different definitions (see Section 4).

The ethical perspective usually adopted is the standpoint of an ethical observer who holds that all adults are equal in their ability to convert income into individual welfare. This is tantamount to saying that all adults have the same needs, so we call this the "needs" perspective. We only need to check whether households at the top of the distribution show a higher share of public expenditure at the margin than those at the bottom. The unobserved heterogeneity component should be conditionally symmetric around zero, which requires us to control for endogeneity.

Another ethical standpoint, which we call the "merit" perspective, is also possible. Here, the ethical observer allows an unequal balance of power within a family in favour of the individual who contributes the most to household income. In this approach, a variable representing the inequality in individual incomes is included among the explanatory variables.

[6] We use "assignable" to designate a private good consumption observed on an individual basis.

3.1.1 Ethics: the needs rule

We recall that Y_i denotes the total expenditure of household i. Public expenditure is denoted G_i. In order to test the concavity of the link between G and Y, we need a cloud of points corrected for the endogeneity of Y, which stems from the fact that omitted variables simultaneously affect total household expenditure and public expenditure. In a non-parametric regression, endogeneity generates an ill-posed inverse problem (see e.g. Blundell and Powell, 2003). The non-parametric regression model is:

$$G_i = g_1(Y_i) + \varepsilon_i, \text{ where } E(\varepsilon_i|Y_i) \neq 0, \; i = 1, ..., n, \tag{4}$$

where g_1 denotes the link between total expenditure and public expenditure. Total household expenditure may be correlated with the error term. An augmented regression approach allows us, under some assumptions, to control for this endogeneity. Following Blundell, Browning and Crawford (2003), the error term is decomposed into two parts (in what follows the individual index is omitted):

$$\varepsilon = v\rho + u, \text{ with } E(u|Y) = 0, \tag{5}$$

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

$$Y = \zeta\pi + v, \text{ with } E(v|\zeta) = 0, \tag{6}$$

where π is a vector of parameters and ζ a matrix of instrumental variables correlated with Y (total gross household income, for example). As a consequence, equation (4) can be rewritten as the following regression:

$$G - v\rho = g_1(Y) + u \text{ with } E(u|Y) = 0. \tag{7}$$

Rewriting Equation (7) in terms of conditional expectancies, we get:

$$g_1(Y) = E(G|Y) - E(v|Y)\rho. \tag{8}$$

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

$$\widehat{m_g}(Y) = \frac{\sum_{i=1}^n K\left(\dfrac{Y_i - Y}{h}\right) G_i}{\sum_{i=1}^n K\left(\dfrac{Y_i - Y}{h}\right)}, \tag{9}$$

where K is a well-behaved quartic kernel function and n the sample size. The bandwidth, h, satisfies $h \to 0$ and $nh \to \infty$ as $n \to \infty$. It is asymptotically convergent and normally distributed (the asymptotic properties are surveyed in Pagan and Ullah (1999) for example).

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

$$\widehat{m_v}(Y) = \frac{\sum_{i=1}^{n} K\left(\frac{Y_i - Y}{h}\right)\widetilde{v_i}}{\sum_{i=1}^{n} K\left(\frac{Y_i - Y}{h}\right)}, \tag{10}$$

with $\widetilde{v_i}$ the empirical residual of the instrumental equation (6). Replacing conditional expectations with their estimations in equation (8), and replacing $g_1(Y)$ with its expression in equation (7), we have

$$G - \widehat{m_G}(Y) = (\widetilde{v} - \widehat{m_v}(Y))\,\rho + u. \tag{11}$$

The parameter $\widehat{\rho}$ follows from the OLS regression of equation (11). The null hypothesis of exogeneity can be tested by checking the statistical significance of the ρ parameter. Finally, the consistent estimator of function g_1 is an IV kernel estimator denoted $\widehat{g_1}$:

$$\widehat{g_1}(Y) = \widehat{m_G}(Y) - \widehat{m_v}(Y)\widehat{\rho}. \tag{12}$$

Practical aspects of the procedure are detailed in the result section; 95% confidence intervals corrected for endogeneity are calculated pointwise by bootstrap (case resampling).

3.1.2 Ethics: the merit rule

The second ethical rule requires an additional control including a variable for the intra-household inequality of exogenous individual incomes. Denoting by W_f and W_m the individual incomes of the woman and male respectively, a natural index of inequality of incomes within the couple would be the ratio of the maximum to the minimum incomes, i.e.:

$$I = \frac{\max\{W_f, W_m\}}{\min\{W_f, W_m\}}.$$

The inequality term, Z, is formulated as:

$$Z = \log\left(1 + \frac{1}{I}\right) \tag{13}$$

This variable takes values between 0 and $log2$ and is decreasing and convex with the index of inequality. This implies that the impact of intra-couple inequality on relative intra-household power diminishes as income rises. This variable is introduced in a linear portion of the model[7]. We use the following non-parametric regression model:

$$G = g_2(Y) + \gamma Z + \varepsilon, \text{ where } E(\varepsilon|Y) \neq 0, \; i = 1, ..., n, \tag{14}$$

[7] A fully non-parametric specification is not reasonnable, given the number of observations. The partially linear model is more restrictive but has a higher convergence rate (the parameter converges at a rate of $\sqrt{n}$).

Compared to the preceding case, if $E(Z/Y)$ is non linear and γ different from 0 then the sign of the slope of the relationship may be reversed between Y and G. Because Z and Y might be correlated, the estimation of g_2 and γ is not trivial. Moreover, the endogeneity problem still obtains.

Model (14) is an extension of the partially linear model estimator of Robinson (1988) to the case of endogenous variables. In what follows, the individual index is omitted. As previously, the error term is decomposed into two parts (Equation (5)), and we use the instrumental Equation (6). As a consequence, equation (8), in the semi-parametric case, becomes :

$$g_2(Y) = E(G|Y) - E(Z/Y)\gamma - E(v|Y)\rho. \tag{15}$$

After substituting g_2 from equation (14) and rearranging, we replace the conditional expectations with their non-parametric estimators to obtain the following linear regression:

$$G - \widehat{m_G}(Y) = \gamma(Z - \widehat{m_Z}(Y)) + \rho(v - \widehat{m_v}(Y)) + u. \tag{16}$$

Denoting the ordinary least squares estimates of the preceding equation by $\widehat{\gamma}$ and $\widehat{\rho}$, the estimator of g_2 is then given by:

$$\widehat{g_2}(Y) = \widehat{m_G}(Y) - \widehat{m_Z}(Y)\widehat{\gamma} - \widehat{m_v}(Y)\widehat{\rho}. \tag{17}$$

To summarize, the estimation procedure is the following:

Step 1: Estimate $E(G/Y)$ non-parametrically with a kernel estimator denoted $\widehat{m_G}$

Step 2: Estimate the instrumental equation $Y = \zeta\pi + v$ by OLS and evaluate the residual $\widetilde{v} = Y - \zeta\widehat{\pi}$.

Step 3: Regress the residual $\widetilde{v}$ non-parametrically on Y, and denote the estimation $\widehat{m_v}$

Step 4: Estimate $E(Z/Y)$ non-parametrically with a kernel estimator denoted $\widehat{m_Z}$

Step 5: Estimate γ and ρ by OLS using the following regression: $G - \widehat{m_G}(Y) = \gamma(Z - \widehat{m_Z}(Y)) + \rho(v - \widehat{m_v}(Y)) + u$

Step 6: Correct the estimation of $E(G/Y)$ for endogeneity and semi-parametric behavior to obtain a consistent estimator of g_2 : $\widehat{g_2}(Y) = \widehat{m_G}(Y) - \widehat{m_Z}(Y)\widehat{\gamma} - \widehat{m_v}(Y)\widehat{\rho}$.

3.1.3 The concavity test

Abrevaya and Jiang (2005) propose an efficient and general non-parametric test of concavity that may be used for both univariate and multivariate cases. The test requires very few assumptions and has a power of rejection comparable to Elison and Elison (2000). It was initially developed in a context where the explanatory variable is exogenous: $G = g(Y) + u$ where u is symmetric around 0. It is based on the entire cloud of points.

Generalization requires the correction of expenditure data using estimated parameter values: $G - \widehat{\rho}\widetilde{v} - \widehat{\gamma}Z$. The null hypothesis is the global concavity of the function $\widehat{g}(Y)$ against global alternatives (for the statistic U, see definition below) or local alternatives (for the statistic M). The distribution of the error term u should be symmetric conditional on Y, but neither homoscedasticity nor normality is required. The conditional symmetry was checked using the test proposed by Ahmad and Li (1997).

In the univariate case, the mechanism of the global concavity test (against global alternatives) consists in checking the validity of Jensen inequality for each possible 3-tuple of the sample. The simplex statistic is formulated as follows:

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

where n is the sample size and C_n^3 represents the number of 3-tuples in the sample. The variance of the statistic may be computed by bootstrap. Denoting by R the number of draws, we obtain:

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

where U_r denotes the U statistic for the r^{th} bootstrap sample. Denoting by 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

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

Under H_0, the standardized U statistics: $\widetilde{U_n} \mapsto N(0,1)$ when n becomes large enough. The bivariate version of the test ($U_n^0 = 0$ against $U_n^0 \neq 0$) allows testing the linearity of the g function against global concavity or convexity.

The global version of the test cannot reject the linearity of a function that is concave in the first half of the support and convex in the second. The *localized* version of the test has a greater power of rejection because it can detect local non-concavities, so it will be favoured in the empirical application. It requires the evaluation of the U_n statistic on the sample split into L sub-samples. The windows should be the same size and the width will optimally correspond to the optimal bandwidth of a second order kernel estimator. Denoting by $\widetilde{U_{n,l}}$ the standardized simplex statistic evaluated at the l^{th} location, M is the greatest 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 be evidence against concavity. The *localized 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 type I extreme-value distribution with $P(a(M-b) < k) = \exp(-\exp(-k))$, 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. The test (22) is univariate and rejection requires the M statistic to be above the critical value. If a linearity test were run, 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 is evidence against linearity. Under the linearity null hypothesis, $a(S-b)$ follows a type I extreme value distribution with $P(a(S-b) < k) = \exp(-2\exp(-k))$.

3.2 Testing the concavity of the private sharing function

The concavity test for the private sharing function follows the same principle as for the public sharing function. Abrevaya and Jiang's tests are used and three definitions of private expenditures and two different ethical rules ("needs" and "merit") are considered. However, one difficulty remains: the private expenditure of the dominated individual within the household is unknown, because it is not observed in the data. In this paper, the prediction of the sharing rule does not rely on parametric assumptions on preferences. Private individual expenditures are predicted by inverting the Engel curves estimated on single individuals for a good that is private and assignable: clothing. "Private expenditures" of single individuals are simply total expenditures less public expenditure according to the three definitions. This method resorts to an identification assumption: an identical clothing consumption pattern, for women and for men, across cohabitational status. In terms of preference restriction, this is equivalent to assuming both Hicksian separability between clothing and other goods and the identity of the individual sub-utilities from clothes consumption, regardless cohabitational status. The estimating procedure is precisely described hereafter.

3.2.1 Engel curves

First, Engel curve regression functions for clothes expenditures of singles are estimated semi-parametrically, keeping the relation between household private expenditures and clothes expenditures as general as possible. We denote by the subscript $j = sf, sm, f, m$ respectively a single female, a female living in a couple, a single male and a male living in a couple, their incomes are denoted Y_j.[8] The index i of the household is omitted. The Engel curve of clothing consumption of single females and single males can be written as

$$C_j = c_j(Y_j^*) + X_j\beta_j + \varepsilon_j, \text{ with } E(\varepsilon_j \mid Y_j^*) \neq 0, \; j = sf, sm \tag{24}$$

where C_j are clothes expenditures, c_j the Engel curve, and Y_j^* individual private expenditure (total expenditure less public expenditure), which are fully observed for single individuals. X_j is a vector of covariates introduced in the linear part of the model. Endogeneity of private expenditures is controlled for as in section 3.1.2.

According to marketing studies (see e.g. Jones and Hayes 2002), the demand for clothing is driven more by wants than needs, which implies that clothing is a normal good. In addition, the procedure requires c to be invertible (see 3.2.2). We ensure the monotonicity of the estimator $\widehat{c}$ by imposing a shape restriction on the kernel regression estimator (see Matzkin (1994) and Mukarjee and Stern (1994)). The monotonicity-constrained estimator, $\widehat{c}^{+}$, is an arithmetic mean of backward $\widehat{c}_1$ and upward $\widehat{c}_2$ estimators, the computation being straightforward:

$$\widehat{c}^{+}(Y^*) = \frac{\widehat{c}_1(Y^*) + \widehat{c}_2\left(Y^*\right)}{2}, \tag{25}$$

with:

$$\begin{cases} \widehat{c}_1\left(Y^*\right) = \max\limits_{Y^{*\prime} \leq Y^*} \widehat{c}\left(Y^{*\prime}\right) \\ \widehat{c}_2\left(Y^*\right) = \min\limits_{Y^{*\prime} \geq Y^*} \widehat{c}\left(Y^{*\prime}\right). \end{cases} \tag{26}$$

The validity of this restriction can be locally tested by checking whether the constrained estimation $\widehat{c}^{+}$ belongs to the 95% pointwise confidence interval of the unconstrained one.

Couples' clothing expenditures are estimated using the following unrestricted model; we get for women:

$$C_f = h_f(Y^*) + \frac{W_f - W_m}{W_f + W_m}\delta_f + X_f\beta_f + \varepsilon_f, \text{ with } E(\varepsilon_f \mid Y^*) \neq 0. \tag{27}$$

h_f captures the link between the clothing expenditure of each gender and the private expenditure of the household. It is termed the women's (or men's) *Household Engel curve for* clothing. This allows the clothing consumption of each gender to depend on the individual's relative contribution to household income. The inequality of the contribution enters more simply than for public goods, since in case of private goods we know who benefits by the consumption. Where the collective model of household behavior applies, and bargaining power depends on individual contributions to household income, we expect a positive sign for δ_f. In this case, the woman consumes more clothing if she earns

[8] For convenience, we adopt here a slightly different notation from the theoretical section.

more than half of the household's income, less otherwise. Naturally, this term is only introduced in the merit approach. An analogous men's household Engel curve for clothing is also estimated. Consistent estimators $\widehat{h_j}$, $\widehat{\delta_j}$ and $\widehat{\beta_j}$ are obtained for women and and men in couples.

3.2.2 Prediction of the private share of each member of the couple

In order to predict the individual private expenditure for each man and woman in a couple, it is assumed that the *Individual Engel curve* for clothing for single women (or men) does not change when they marry. For each gender, this identification assumption reads:

$$c_j(Y_j^*) = c_{sj}(Y_{sj}^*),\ j = f, m. \tag{28}$$

Under the *needs* approach, the private sharing function of the woman or man in a couple is described by some function f according to which:

$$Y_j^* = f_j(Y^*),\ j = f, m. \tag{29}$$

Finally, combining the *Individual Engel curve* with the private sharing function must give the *Household Engel curve,* that is

$$h_j(Y^*) = c_j(f_j(Y^*)),\ j = f, m. \tag{30}$$

Then, thanks to the identification assumption (28) and using (29) and (30) we can recover the unknown private expenditure of each partner by inverting the Engel curve of the singles

$$Y_j^* = c_{sj}^{-1}(h_j(Y^*)),\ j = f, m. \tag{31}$$

This is where the necessity of assuming monotonicity of the singles' Engel curve for clothing emerges. Using the Engel curve estimations (24) and (27), we get two predictions of the individual private expenditures for each couple, one for the woman, $\widehat{Y_f^*}$, and one for the man, $\widehat{Y_m^*}$:

$$\begin{cases} \widehat{Y_f^*} = \widehat{c}_{sf}^{+^{-1}}\left(\widehat{h}_f(Y)\right) \\ \widehat{Y_m^*} = \widehat{c}_{sm}^{+^{-1}}\left(\widehat{h}_m(Y)\right). \end{cases} \tag{32}$$

Of course a support condition has to be satisfied in order to make the inversion feasible. The estimate of clothing expenditure for the woman in a couple $\widehat{h}_f(Y)$ must belong to the support of predicted clothes expenditure for the sub-sample of single women, and likewise for men.

The prediction of the private expenditure of each member of the couple described in (31) is suited to the needs approach. For the merit approach, the prediction has to be adapted. The private sharing function of each member of the couple is described by some function f according to

$$Y_j^* = f_j(Y^*, \frac{W_j}{W_f + W_m}),\ j = f, m, \tag{33}$$

where the bargaining power of each partner is explicitly taken into account to predict individual private expenditures. Combining the *Individual Engel curve* with the private sharing function must coincide with the *Household Engel curve* augmented by the bargaining power term, that is,

$$h_j(Y^*) + \frac{W_j}{W_f + W_m}\delta_j = c_j(f_j(Y^*, \frac{W_j}{W_f + W_m})),\ j = f, m. \tag{34}$$

Then, thanks to the identification assumption (28), we can predict the unknown private expenditure of each partner by inverting the Engel curve of the singles

$$Y_j^* = c_{sj}^{-1}(h_j(Y^*) + \frac{W_j}{W_f + W_m}\delta_j),\ j = f, m. \tag{35}$$

An interpretation of the identification assumption (28) may be given in the case of Hicksian separability of preferences. The substitution effect of clothing demand may be influenced by the control variables X, whereas the income effect of clothes consumption transits via the Engel curve for single individuals and via the Engel curve and the sharing rule for individuals in a couple. In order to disentangle the impact of the bargaining power from the income effect, the same income effect is assumed across cohabitational status. Still, preferences for clothing are allowed to differ across marital status via the substitution effect.

Stability of preferences across cohabitational status has been used in a different context in the literature to identify the sharing rule (Browning et al., 2003; Couprie, 2007; Laisney, 2002; Vermeulen, 2005), but there is no doubt that it is a strong requirement. The existence of externalities in clothing consumption (one may care about one's spouse's appearance) is plausible, and it is also likely that the individual income effect on clothing preferences is altered by marriage or divorce. Another possibility is that the matching process may couple individuals who have specific preferences for clothes and thus can be related, directly or indirectly (through covariates) to the intra-household sharing rule. In all these cases, the prediction produced by the sharing rule would be biased. As a matter of fact, if we could observe the consumption behavior of the same individual before and after a change in marital status, we could test this assumption.

3.2.3 Simulation

To perform the concavity test, a cloud of points should be simulated using prediction errors for $\widehat{Y_f^*}$ and $\widehat{Y_m^*}$. A first method is to use observed prediction errors of the Engel curves for clothes for singles and couples. This is a cumbersome method that fails to guarantee the quality of the prediction. The alternative is to use the overidentification provided by (32). Prediction errors are observed at the household level:

$$e = Y^{*} - \left(\widehat{Y_f^*} + \widehat{Y_m^*}\right), \tag{36}$$

where e denotes the discrepancy between the observed total expenditure of the household and the sum of the predicted expenditures of the two partners. These errors are reimputed to one individual or the other according to a random variable α, which follows a uniform distribution between 0 and 1:

$$\widehat{e_f} = \alpha e \text{ and } \widehat{e_m} = (1-\alpha)e. \tag{37}$$

Simulations of the cloud of points are derived by bootstrap case resampling and using the presumed empirical distribution of these error terms. Finally, the private sharing function is the relation between the private expenditure of the *dominated* individual and the household's total private expenditures. The *dominated* individual's private expenditure is obtained by taking the minimum value of $\left\{\widehat{Y_f^*}, \widehat{Y_m^*}\right\}$ for each household. It is regressed on total household private expenditures Y^* by the procedure described at length for the public sharing function.

4 Data

The data come from the French household expenditure survey, the "Enquête budget des familles" (BDF), year 2000, collected by the French Statistical Institute, INSEE. Expenditure surveys are usually plagued by problems of differing purchase frequencies. To tackle this problem, two data collecting methods are used simultaneously . The survey households are interviewed to get information on monthly expenditures such as rent, electricity, and the like, expenditures during the last 2 months (clothing, fuel, etc.) and some expenditures during the last year (service charges). At the same time, the participating households record their expenditures for the last two weeks directly in a notebook. Misreporting due to faulty memory is minimized. INSEE also controls for seasonal effects to construct annual expenditures for each good category. As usual, data are collected at household level and we do not actually know for whom the good is bought within the household. Characteristics such as net income, savings and socio-demographic status are also collected. Incomes (salary, unemployment allowance) are detailed at the individual level. Some incomes such as the family allowance, which cannot be ascribed to an individual, are excluded from individual incomes (but not from household income)

$[INSERT\ TABLE 1]$

Table 1 gives the details of the sub-samples used in the empirical part. The first sub-sample contains 2,876 couples of all ages and serves to test the public sharing function. The second, third and fourth sub-samples are used to test the private sharing function under various specific assumptions. They are restricted to individuals aged less than 65 that consume a positive amount of assignable clothes. Couples and single households are strictly defined; they have no children and do not live with other adults. Only heterosexual couples, married or not, are considered.

In order to test the concavity of public expenditures, three lists of public goods have been compiled, from the most restrictive to the most extensive. The first definition, Public 1, is basic and comprises housing, water, heat and electricity. It represents around 30% of total household expenditures. At this stage, an important remark is necessary. To make the total consumption of renters and home owners comparable, economists have proposed that the net rental equivalence value or "net imputed rent" for homeowners should be added to any measure of consumption (see for instance Frick and Grabka 2002). This is the approach followed here, rents are imputed by INSEE based on specific characteristics of the house and market real estate prices. Rents are computed both for home owners and for social housing (for more precision, see Driant and Jacquot 2005). As a matter of comparison, the average housing expenditure nearly doubles when imputed rent is counted, from €3,216 to €7,140. This enormous difference is due to the fact that 70% of responding couples are homeowners. Naturally, total expenditure of the household also includes imputed rents. The second definition of public expenditure, Public 2, also includes furniture and housing services and rises on average to 36% of household expenditures. The third definition, Public 3, also includes car-related expenditures. This last definition of collective expenditures is very broad (especially for two-cars couples) and may be open to criticism. It accounts on average for 50% of household expenditures.

The good we treat as exclusive is men's and women's clothing, including shoes. Taking only households that consume assignable clothes and that are younger than 65 reduces the sample substantially, from 2,876 couples to 886. The couples selected for the private sharing function part tend to be wealthier and to spend a smaller share of the budget on housing and a higher share on clothes. In our view, the assumption of identity of clothing preferences across cohabitational status is more likely to hold for this specific sub-sample. Indeed the mean of women's clothing expenditure (€805) in the sub-sample is very close to the mean for single women (€856); the same holds for men (€783 and €855 respectively). The age selection is necessary because the share of the elderly is higher among single women than among single men or couples. Education levels do not differ much. Couples tend to be a little older and are more numerous than singles in the countryside, less numerous in big cities.

In practice, clothing is not always assignable to male or female consumption and the average amount of this unassignable expenditure is actually quite large for the subsample of couples (€651). It would have been arbitrary to consider this item as an individualized consumption, so we aggregated it with other goods. This specification is realistic because unassignable clothing is also an expenditure item for single individuals. It is true that single individuals tend to spend less than couples on unassignable clothes purchases. If this reflected a change in the way clothes consumption is classified into assignable categories according to the marital status, this would imply measurement errors linked to cohabitational status, and the results might been biased. Our thesis is that the difference in spending patterns is due to a difference in preferences for unassignable clothes, so unassignable clothes are simply considered like any other private expenditure.

5 Results

5.1 Public sharing function

Do poorer households generally spend a higher marginal share of their income on joint consumption? A concave shape of the public sharing function would mean that an income transfer from a rich to a poor household reduces inequalities within and between households. We now answer this question using our three different definitions of public expenditure and the two different ethical rules.

[INSERT FIGURE 1 AND 2]

Figure 1 displays the scatter diagram, the public sharing function estimated through kernel regression (thick line) and the pointwise 95% confidence interval estimated by bootstrap (thin lines) corresponding to the three definitions of the public sharing function for the ethical rule denoted "needs" (see eq. 4). Figure 2 provides the same information for the "merit" rule (eq. 14). The encapsulated tables give the estimation of the correction term for the endogeneity of total household expenditure, the ρ coefficient (see 5). In both cases, exogeneity of total household expenditure is strongly rejected. The instruments are total income and its square. When using the third definition of public good, the sign of the ρ coefficient changes. There is no straightforward explanation for this, because the correction depends on the conditional expectation of the residual of the instrumental regression on household expenditures, which has a general non-parametric shape.

The first ethical rule, "needs", considers that all individuals have the same capacity to transform income into welfare. This is explicitly coupled with a 50/50 ideal share of welfare within the family for the ethical observer. Practically, no control variable is taken into account in the conditional regression.

When looking at the curves in Figure 1, a slight convexity appears around €40,000 a year for Public 1 and above €50,000 a year for Public 2 and 3. The median household expenditures is around €24,000, the last quartile is around €33,000 and the last decile €45,000. Hence non-concavity appears for the top income deciles (€40,000=P85, €50,000=P94). For Public 3, a slight global convexity emerges in the income bracket [€10,000, €50,000].

The second ethical rule, "merit" (see Figure 2) controls for the inequality in individual incomes within the family to explain the public expenditure pattern. This rule holds that ideal sharing should be calculated in relation to individual contributions to household income. The inequality term (the Z variable, see eq. 13) is significantly negative for Public 1 and 2, which means that greater inequality is associated with higher public expenditure. The opposite is the case for the extended definition for public expenditure (including car-related expenditures). The magnitude of the effect of the intra-earnings inequality is modest. For the same household income, a couple with a single breadwinner will expend 8% more on housing than a couple where the two earners perform equally. When car-related expenditures are included, the situation is reversed, with collective goods expenditure decreasing by 5%. Intuitively, the signs of the intra-household inequality for the two first definitions, in which housing represents the bulk of public expenditure, seem unexpected. One presumes that intra-household inequality will have a negative impact on public expenditure because more equal households should contribute more to the public good. This result seems to clash with those of Phipps and Burton (1998), who find the Canadian housing data do not reject the income pooling assumption. Of course, we can imagine all sort of intra-household compensation mechanisms to explain a positive or negative effect of intra-household income inequality on the public/private expenditure pattern. But since we do not control for many other variables that may affect the housing decision, such as part-time work, we avoid overinterpreting the results. Anyway, the general shape of the public sharing curve does not differ greatly from the preceding figure: some possible convexity patterns appear for higher income households and for Public 3 a slight global convexity seems to prevail for the income bracket [€10,000, €50,000].

Th*e* statistical *localized global* concavity test is used to check whether this suspected local convexity significantly changes the global concavity pattern. Results are displayed in Table 2 and details of the concavity test are given in the Appendix C, Table A1.

[INSERT TABLE 2]

The test is first run on the entire sample. It is clear that the estimated sharing rule below €15,000 is concave, perhaps maybe due to censoring at zero. Since the censoring has not been taken into account in the estimation, this part of the curve is not used in a variant of the test where we only consider the reduced sample for the interval [€15,000 – €42,000]. Practically, we take a window width of €3,000, which is nearly optimal for second order kernel estimation. The U-statistic (see Section 4.1.3 for definition and Table A1 for the results) is calculated on each window. Each U-statistic represents the probability of that portion of the graph being convex (U>0), concave (U<0) or linear (U=0). The M-statistic presented in Table 2 is the maximum value of all the standardized U-statistics, whereas the S-statistic is the maximum absolute value of the M-statistics. The higher the M statistic the higher the probability of concavity being rejected, whereas a high S means that both convexity and concavity should be rejected against linearity. Whatever the definition of public expenditure and whatever the ethical rule, concavity is never rejected at usual level of confidence, not even linearity. These findings thus strongly support the concavity and even the linearity of public expenditure with respect to total household expenditure.

5.2 Private sharing

As explained in section 4.2, the private share of expenditures going to individuals belonging to couples is not observable in the data. It needs to be predicted before further analyzing the private sharing function.

5.2.1 Identification

Since the shape of the Engel curve for clothing does not change greatly with different definitions of public good, we only report the prediction using the median definition of public expenditure, Public 2.[9] To avoid outliers and measurement and prediction errors, the top and bottom 2% of clothing expenditures have been excluded.

INSERT FIGURES 3, 4 and TABLE 3

Figure 3 illustrates the Engel curves for single men and single women (3*a* and 3*b*). In Figures 3*c* and 3*d*, monotonicity is imposed, and the estimator appears inside the pointwise 95% confidence interval, which is calculated by bootstrap on the unconstrained estimator. As the constrained estimator is always comprised within the unconstrained confidence interval, monotonicity is not rejected pointwise. Figure 4 shows the Engel curves for expenditure of couples. The first two graphs (4*a* and 4*b*) present the kernel regression without controlling for the share of individual income in household income, the

[9] The same procedure was also applied using definitions 1 and 3 and the two ethical rules (controlling for individual incomes or not). Full estimation results are available from the authors upon request.

last two ($4c$ and $4d$) controlling for it. Partially linear effects of covariates and endogeneity results are presented in Table 3. The exogeneity of household private expenditures is rejected for couples but not for single individuals. The only covariate we ultimately retain in the partial linear effect model is the city size, which is the main explanatory variable for clothes expenditures. Age was significant for singles but not for couples. Moreover, age and age squared were not significant when considered jointly.

Finally, the effect of individual incomes is not statistically significant (this pattern is robust across different parametric specifications). This counter-intuitive result may be due to mis-specification or measurement errors on assignable clothes expenditures, but it does nevertheless doubt on the "merit" interpretation, which does not seem to be supported by the data. In any case, we present the results with and without controlling for this effect.

Figure 5

Details on the sharing rule prediction are presented in Figure 5. It shows the result of the inversion of the Engel curve for women (graph $5A$) and for men (graph $5B$) not controlling for individual incomes. These graphs display the predicted conditional expectation of individual private expenditures with respect to predicted household private expenditures. The predicted household private expenditures are the sum of predicted private expenditures for the two members. Then by construction, Figure $5B$ appears as the complement of Figure $5A$. Table 5 details some descriptive statistics of income variables, predicted shares, prediction errors (aggregated at the household level) and sub-sampling due to out-of-support observations.

On average, the woman tends to be dominated in low-income households, i.e. those below the median household private expenditures (€19,000 a year, definition 2). Above that amount they become dominant, but fall back below the share of 50% among the most affluent households (more than €35,000 a year in private expenditures, the top decile of the sub-sample). The share of the dominated individual averages €8,834, or 47% of the total budget. In other words, according to our estimates, French couples are quite close to perfectly egalitarian sharing of resources.

5.2.2 Test

Given the prediction errors, a cloud of points corrected for endogeneity is simulated in order to test the shape of the private sharing function. For all the scatter diagrams in Figures 6 and 7, the cloud is concentrated close to the regression curve. This may be because we do not observe real data on the private share and the simulation method.

[$INSERT\ FIGURES$ 6 AND 7]

As for the joint consumption, patterns are similar for both ethical rules but not for different definitions. If the general shape looks globally linear, it less so for definition 3, which shows a local convex pattern around €23,000 for the needs approach. A local convex pattern appears above €40,000 for the first (narrowest) definition and the "merit" rule. The graphs were based on a small cloud of points (3 times the sample), while the concavity test uses a larger cloud (20 times the sample).

[$INSERT\ TABLE$ 4]

Taking the predicted share of private expenditures of the dominated individual as given, we apply the same methodology as for the public sharing function to test the concavity of the private sharing function (see Table 4 and Table A2 for details in Appendix C). The *localized global* concavity test takes an optimal window width of €1,000. Since there may be substantial measurement errors for high income and some rejection of the symmetry for low incomes, the test is also run on a sub-sample going from percentile 10 to 90 of the private expenditures distribution[10]. For nearly all the definitions, the standardized M-statistic (which is the highest value of the U-statistics calculated on each window) is low. Concavity is never rejected for the "needs" rule. For the "merit" rule, i.e. controlling for inequality in individual incomes within the couple, concavity is only rejected once at the 5% level. It occurs for the merit rule and the median definition of private expenditures on the sub-sample P10-P90 but the P-value, 4,7%, is very close to 5%. In addition, linearity is never rejected whatever the sample.

Hence there is a quite clear evidence that the share of income of the dominated individual holds relatively stable along the private expenditure scale. Hence, if both private and public sharing function appears close to linear, intra-household inequality is nearly the same at all household income levels. These empirical findings therefore warrant extending welfare and inequality statements obtained at the household level to the individual level in the case of France. Indeed, if concavity is needed to preserve GL statements, inequality statements in terms of the Lorenz curve require linearity of both sharing functions (see Peluso and Trannoy (2007) for the reasoning in the case of pure private goods).

6 Concluding remarks

We have conducted an empirical test whether household level data can be considered sufficient to make welfare comparisons among individuals. This depends on how intra-household inequality is related to household income. The question is approached by distinguishing public from private goods in

[10] The value taken by percentiles P10, P90 depend on the chosen definition of private expenditures.

household consumption. In order for an equality-enhancing transfer from richer to poorer households to be immune to be "undone" within the household, poorer households must be more egalitarian (they spend a lower marginal share on private goods, and share the income devoted to private consumption more equally at the margin) than rich households. The key properties for Generalized Lorenz statements at the household level to be robust at the individual level are thus the concavity of the public and private sharing functions. If these two conditions are verified, then welfare statements at the individual level cannot conflict with those at the household level.

We find empirically that for French households this double concavity condition is not rejected. The global localized concavity test is, on the whole, accepted for the private sharing function. The public sharing function is linear over most of the support. This suggests that the share of resources allocated to the well-being of each partner does not vary significantly with household income. Hence, bargaining power within couples does not appear to be related to household income, so the structure of intra-household allocations can be ignored in welfare comparisons across individuals.

It goes without saying that our empirical findings call for testing the double concavity condition on other data sets. In particular, French couples seem to behave in a highly egalitarian way. It could be interesting to repeat this study on a population with a different culture or at a different level of development. In addition, our strategy for identifying individual expenditure within a couple is open to criticism on several grounds. What is needed is a data set that makes it possible to attribute more goods to each partner. Another direction for inquiry would be to focus on a restricted domain of household income distributions, i.e., only changes due to taxation or subsidies (see Peluso and Trannoy (2005) for a theoretical inquiry). In this case, to obtain preservation results, less restrictive conditions on sharing functions than concavity are required. Our own empirical findings offer support to the thesis that such conditions may be confirmed by the data.

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Appendix A: Individualized income and its definitions in the literature

The individualized income depends on the value of $\alpha \in [\frac{1}{2}, 1]$. We show that the two polar cases, $\alpha = \frac{1}{2}$ and $\alpha = 1$, correspond to particularly interesting definitions of the individualized income related to concepts proposed in the literature. The reasoning is illustrated by Figure 8. On the vertical axis, a Hicksian good z (with a unitary price) indicates the private consumption of one of the two spouses, say the wife. Let G be the quantity of public good, with price P ($\simeq 2$ in the figure).We suppose that the quantity G_0 of public good is chosen by the couple through a Lindhal equilibrium. The bundle (G_0, z_0) represents the consumption of thewife at this equilibrium. The slope of her indifference curve at (G_0, z_0) is her Lindhal price P_L. By definition $P_L \leq P$, and we get P when we sum the Lindhal prices of both individuals. Brennan's definition of individualized income (Brennan 1981) corresponds to the average of the Lindhal prices for the two individuals and is equal to $\frac{1}{2}PG_0 + z_0$. Hence, with $\alpha = 1/2$, we recover Brennan's measure.

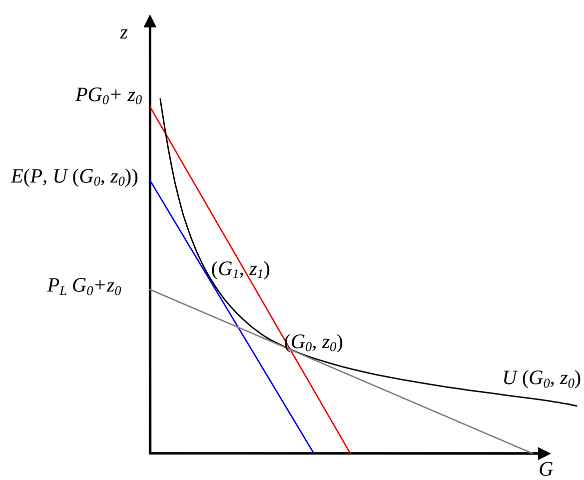


Figure 8: Definitions of individualized income

In order to interpret the other polar case, $\alpha = 1$, let us define $U(G, x)$ the utility function of a single woman, which may be different from that of a married woman. Then, using the expenditure function $E(P, U(.))$, we can define the individualized *equivalent income* $E(P, U(G_0, z_0))$, which is the income needed for a single person to achieve the same utility level offered by (G_0, z_0).[11] The individualized *equivalent income* $E(P, U(G_0, z_0))$ is in general lower than or equal to $PG_0 + z_0$; in fact, switching from 'married' to 'single' status entails a rise of the price of the public good from P_L to P. On top

[11] The figure is drawn in case where the single woman agrees with the preference of the wife.

of that, individual preferences may change in a non-specified way. The relevant point for our analysis is that as long as the preference of the single woman remains convex, she chooses a bundle that is at most as expensive as $PG_0 + z_0$. Formally, let $\mathbf{U}_s$ designate the class of the quasi-concave individual utility functions. Then, by the definition of the expenditure function, we state

Remark 1 $PG_0 + z_0 = Max(E(P, U(G_0, z_0))$, *for all* $U \in \mathbf{U}_s$.

As a result, the case of $\alpha = 1$ corresponds to an upper bound of the individualized equivalent income on the domain of quasi-concave utility functions. This polar case has the advantage of being based on a structural definition (the expenditure function) and also of accounting for our ignorance of the preferences of individuals, a suitable feature in a non-structural perspective.

Appendix B: Proof of Proposition 1

Without loss of generality, we consider the case $\alpha = 1$ and we skip the reference to α and (when possible) to i in the notation.

$i) \implies ii)$ Suppose that g and y_p are concave and consider $\mathbf{Y}^c, \mathbf{Y}^{c\prime} \in \mathbb{Y}_n$ such that $\mathbf{Y}^c \succcurlyeq_{GL} \mathbf{Y}^{c\prime}$. We prove that $\sum_{i=1}^n [u(y_{ip}) + u(y_{ir})] \geq \sum_{i=1}^n \left[u(y'_{ip}) + u(y'_{ir})\right]$ for all non-decreasing and concave u, which is equivalent to $\mathbf{y} \succcurlyeq_{GL} \mathbf{y}'$. For a given individual utility function u, let w_u be the function defined by $w_u(Y) = u(g(Y) + f_p(Y - g(Y))) + u(g(Y) + f_r(Y - g(Y)))$.

Step 1 We prove that, under assumptions, $w'_u(Y) \geq 0$ and $w''_u(Y) \leq 0$, $\forall Y \geq 0$.

$w'_u(Y) = u'(y_p)[g'(Y) + f'_p(Y^*)(1 - g'(Y))] + u'(y_r)[g'(Y) + f'_r(Y^*)(1 - g'(Y))]$. Since $0 \leq g'(Y) \leq 1$, this expression is non-negative. Using $y'_p(Y) = g'(Y) + f'_p(Y^*)(1 - g'(Y))$ and $y'_r(Y) = g'(Y) + f'_r(Y^*)(1 - g'(Y))$, we get

$$w''_u(Y) = u''(y_p)y'^2_p + u''(y_r)y'^2_r + u'(y_p)y''_p + u'(y_r)y''_r. \tag{38}$$

The first two terms are non-positive. For the last two terms, two situations have to be considered.

First case. Let us consider the part of the domain where $f''_p \geq 0$. In this case, given the assumptions, the third term is non-positive. Further,

$$u'(y_r)y''_r = u'(y_r)[f''_r(Y^*)Y^{*\prime 2} + g''(Y)f'_p(Y^*)].$$

This expression also is non-positive, proving $w''_u(Y) \leq 0$.

Second case $f''_p \leq 0$.

The two last terms of (38) are equal to

$$u'(y_p)[g''(Y) + f''_p(Y^*)Y^{*\prime 2} - g''(Y)f'_p(Y^*)] + u'(y_r)[g''(Y) + f''_r(Y^*)Y^{*\prime 2} - g''(Y)f'_r(Y^*)] \tag{39}$$

that is $u'(y_p)g''(Y)f'_r(Y^*) + u'(y_r)g''(Y)f'_p(Y^*) + f''_p(Y^*)Y^{*\prime 2}[u'(y_p) - u'(y_r)]$. Due to the concavity of u, this expression is non-positive and we conclude $w''_u(Y) \leq 0$.

Step 2

From $\mathbf{Y}^c \succcurlyeq_{GL} \mathbf{Y}^{c\prime}$, we get $\sum_{i=1}^n w_u(Y_i^c) \geq \sum_{i=1}^n w_u(Y_i^{c\prime})$ since w_u is increasing and concave 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 non-decreasing and concave u, which implies $\mathbf{y} \succcurlyeq_{GL} \mathbf{y}'$and the sufficiency part is proved.

$ii) \implies i)$ The proof is given by contradiction: we show that if for some $\bar{Y}$ the second derivative of g or y_p is strictly positive, then there exists a differentiable non-decreasing and concave utility function u such that the corresponding $w''_u(\bar{Y}) > 0$ and therefore $ii)$ is false. For concavity of g to be necessary, consider a rewriting of (38) and (39):

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

that is

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

It is clear that, if $g'' > 0$, then by adding a term ky to any non-decreasing and concave utility function u we obtain $\tilde{w}_u''(Y) > 0$ for all k sufficiently large.

Now as to the concavity of y_p, we start again from expression (38) and observe that, whenever $y_p''(\bar{Y}) > 0$, we obtain $w_u''(\bar{Y}) > 0$ by choosing an 'angle' utility function $u(y) = \min(y, z)$ with $y_p(\bar{Y}) < z < y_r(\bar{Y})$. Using standard approximation arguments, we can approximate $\min(y, z)$ by the twice continuously differentiable function $u_n(y) = \frac{1}{2}(y - z) - \frac{1}{2}[(x - z)^2 + \frac{1}{n^2}]^{\frac{1}{2}} + z$. Since u_n has limit $\min(y, z)$ as $n \to \infty$, we still obtain $w_{u_n}''(\bar{Y}) > 0$, for all sufficiently large n.

Finally, for both functions g and y_p, we end with a standard argument. Due to continuity assumptions, $w_{u_n}''(Y)$ is strictly positive in a neighborhood $N(\bar{Y})$. Let us consider the points a, b belonging to $N(\bar{Y})$ and define the income distributions $\mathbf{Y}^c$=$(Y_1, ... \, Y_n)$ and $\mathbf{Y}^{c\prime}$=$(Y_1', ... \, Y_n')$, such that $Y_1 = Y_2 = \frac{a+b}{2}$; $Y_1' = a, Y_2' = b$ and $Y_i = Y_i'$ for $i = 3, ..., n$. We have $\mathbf{Y}^c \succcurlyeq_{GL} \mathbf{Y}^{c\prime}$ and since w is convex in $N(\bar{Y})$, this

implies $\sum_{i=1}^n [u_n(y_{ip}) + u_n(y_{ir})] < \sum_{i=1}^n \left[u_n(y_{ip}') + u_n(y_{ir}')\right]$ by application of Jensen's inequality on the grand partial sums of household incomes. Thus, $\mathbf{y} \succcurlyeq_{GL} \mathbf{y}'$ is contradicted.

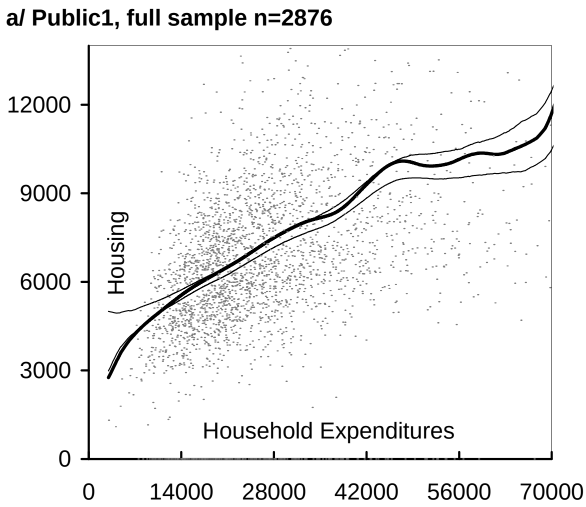
Appendix C: Complementary results about the concavity test

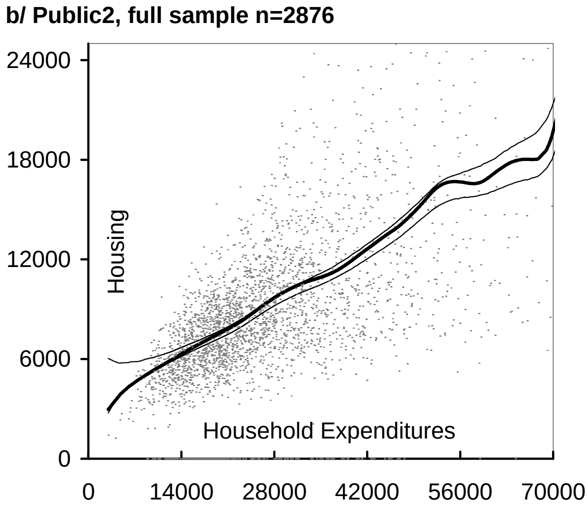
Table 1: Descriptive Statistics, French Expenditure Survey, year 2000

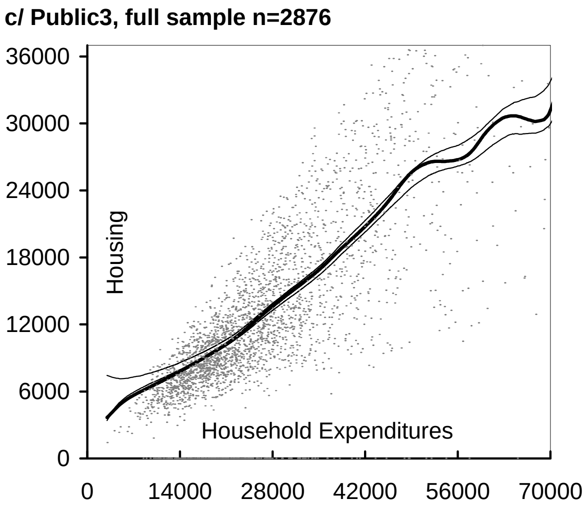
Variables	**All Couples**	**Couples**, consuming clothes and aged 65 or less	**Single women**, consuming clothes and aged 65 or less	**Single men** consuming clothes and aged 65 or less
	2876 obs.	**886**	**674**	**497**
Household before tax income (€/year)	29873.85	34570.40	16445.69	18681.39
	(19950.89)	(21792.89)	(9919.13)	(13287.72)
Female's individual income (€/year)	8661.79	11005.14		
	(8308.92)	(9071.78)		
Male's individual income (€/year)	17989.39	19946.34		
	(12967.32)	(16008.22)		
Household's total expenditures	27353.82	31758.95	17549.69	17728.17
(incl. imputations)	(14281.75)	(15487.12))	(9919.13)	(8487.49)
Public 1: Housing, water, electricity	7140.68	7331.53	5902.26	5388.97
	(2717.86)	(2745.38)	(2441.50)	(2342.36)
Public 2: Public1 + furnitures, HH services	9297.91	9859.14	7021.92	6272.23
	(4881.20)	(5084.55)	(3149.26)	(2924.33)
Public 3: Public2 + Car-related expenditures	13668.72	15879.38	9028.23	8918.23
	(8310.27)	(8723.92)	4944.64)(	(4939.84)
Women's clothes	435.59	804.56	855.95	
	(1559.80)	(799.11)	(931.50)	
Men's clothes	536.31	783.50		855.27
	(703.39)	(907.00)		(1151.92)
Unassignable clothes*	370.41	650.88	228.77	114.60
	(683.99)	(2039.35)	(540.34)	(570.19)
Age of household's head	58.40	45.70	42.04	39.31
	(16.26)	(13.95)	(14.90)	(12.21)
Education level (1 to 5)	2.84	3.20	3.44	3.24
	(1.31)	(1.37)	(1.48)	(1.56)
Home Ownership	0.70	0.58	0.36	0.32
	(0.46)	(0.49)	(0.48)	(0.12)
Big city	0.11	0.13	0.17	0.17
	(0.31)	(0.33)	(0.38)	(0.38)
Medium city	0.62	0.64	0.70	0.69
	(0.49)	(0.48)	(0.46)	(0.46)
Countryside	0.27	0.23	0.12	0.13
	(0.44)	(0.42)	(0.33)	(0.34)
Share of Public 1 (% of household expenditures)	29.54	25.53	36.56	34.60
	(11.33)	(9.42)	(13.12)	(13.57)
Share of Public 2 (% of household expenditures)	36.56	32.86	42.47	39.55
	(12.13)	(11.02)	(13.33)	(14.26)
Share of Public 3 (% of household expenditures)	50.22	48.71	52.01	52.73
	(12.99)	(12.96)	(13.14)	(14.28)
Assignable clothes	4.02	6.75	6.24	5.40
	(4.84)	(5.38)	(5.44)	(5.16)

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

Figure 1: Public sharing function, needs. (*)





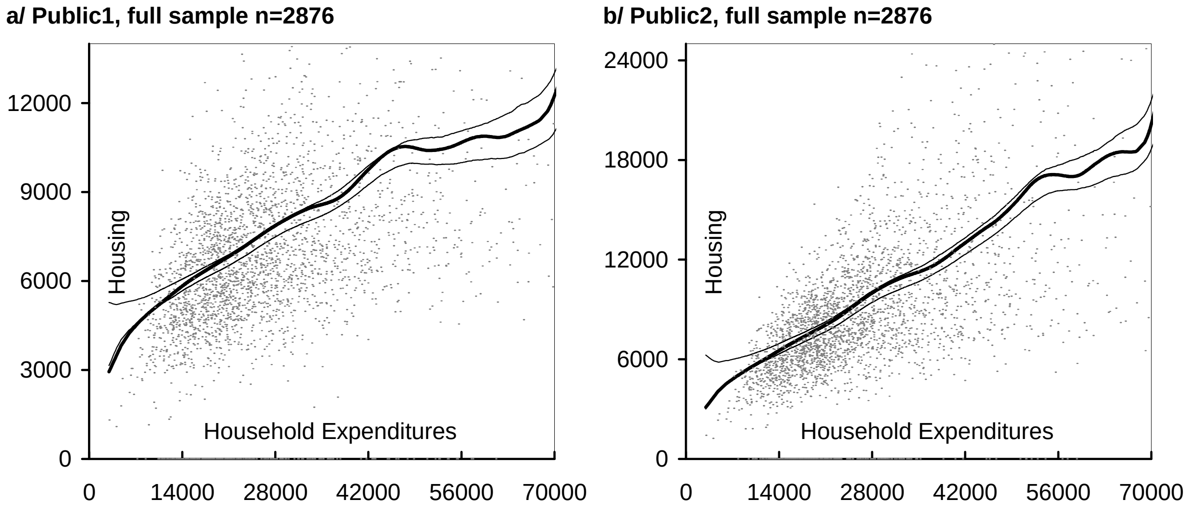


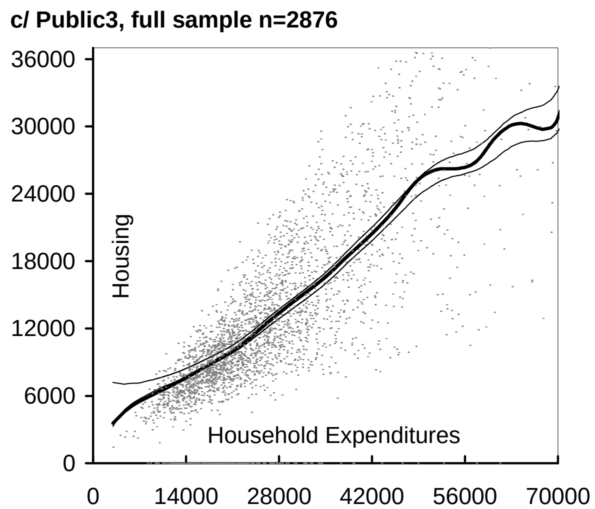
Endogeneity Correction Coefficient (ρ):

	Parameter	Std err.	T-stat
a	-0.044710	0.004368	-10.23464
b	-0.046593	0.007016	-6.641392
c	0.065165	0.008481	7.683934

(*) French couples, 2876 observations from 'Enquête Budget des Familles', year 2000. Kernel regressions and 95% pointwise confidence intervals. Instruments are household income and squared household income. Public 1 uses a minimalist definition of public consumption (housing and energy). Public 2 includes furnitures and household services. Public3 also includes car expenditures.

Figure 2: Public sharing function, merit (*)





Endogeneity Correction Coefficient (ρ)

	Parameter	Std err.	T-stat
a	-0.044710	0.004368	-10.23464
b	-0.046593	0.007016	-6.641392
c	0.065165	0.008481	7.683934

Effect of Inequality in individual incomes (γ)

	Parameter	Std err.	T-stat
a	-2536.082	429.1858	-5.90905
b	-3170.676	1511.035	-2.09835
c	1761.189	836.4001	2.10568

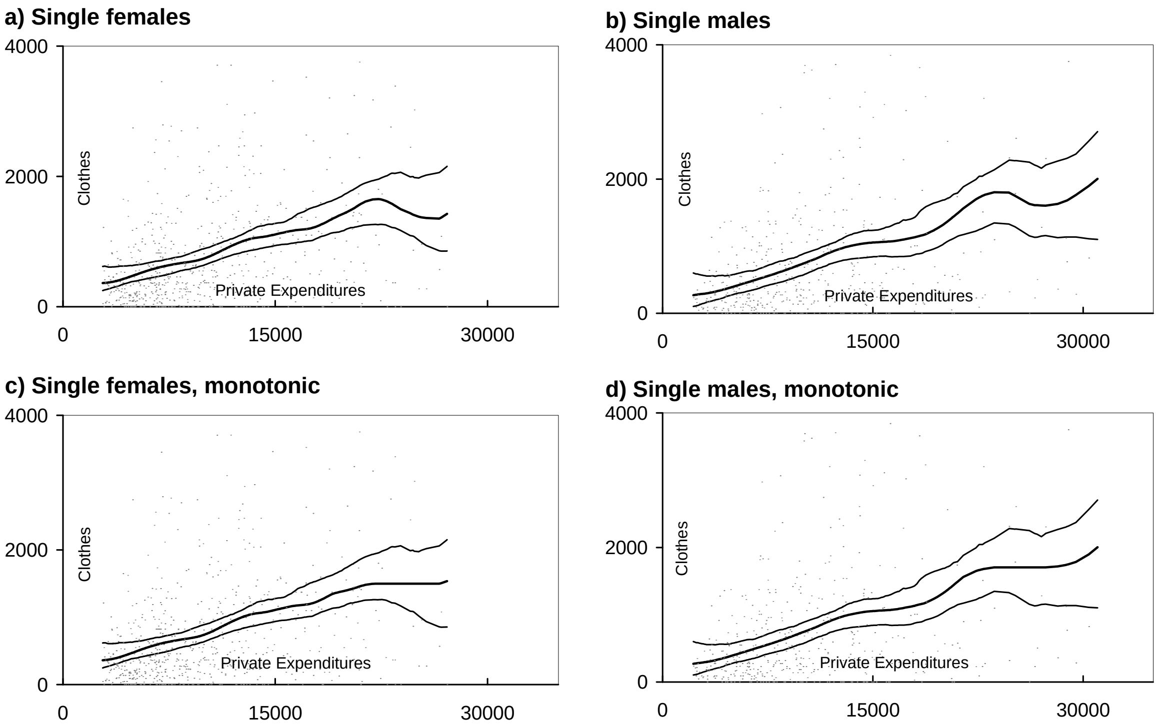
(*)see Figure 1. Partial linear kernel regressions. Inequality in individual incomes is measured by log(1+min{individual incomes}/max{individual incomes}).

Table 2: Localized Global concavity test of public expenditures *(*)*

	Needs				Merit			
Public 1	**M-stat**	**S-stat**	**P-value (concavity)**	**P-value (linearity)**	**M-stat**	**S-stat**	**P-value (concavity)**	**P-value (linearity)**
[0-70000+[	2.0488	2.1946	0.3789	0.4846	1.9838	2.4984	0.4287	0.2676
[15000-42000[	1.8835	1.8835	0.2998	0.5097	1.7799	1.7799	0.3606	0.5911
Public 2								
[0-70000+[	1.5608	2.4540	0.7986	0.2937	1.9853	1.9939	0.4275	0.6644
[15000-42000[	1.5608	1.5608	0.5145	0.7643	1.9853	1.9853	0.2481	0.4347
Public 3								
[0-70000+[	2.0819	2.0819	0.3551	0.5841	1.5141	1.9714	0.8346	0.6849
[15000-42000[	1.5760	1.5760	0.5028	0.7528	1.3080	1.5337	0.7154	0.7842

(*) Localized test based on a window width of 3000.

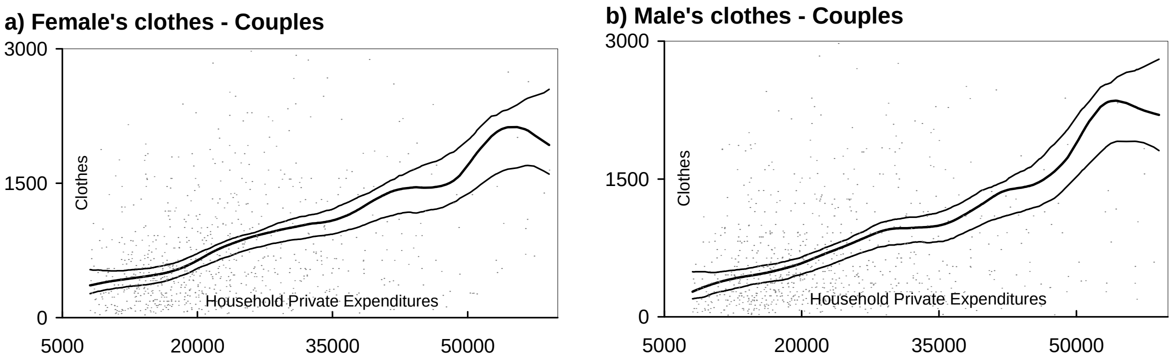
Figure 3: Engel curves for clothes expenditures, single individuals(*)



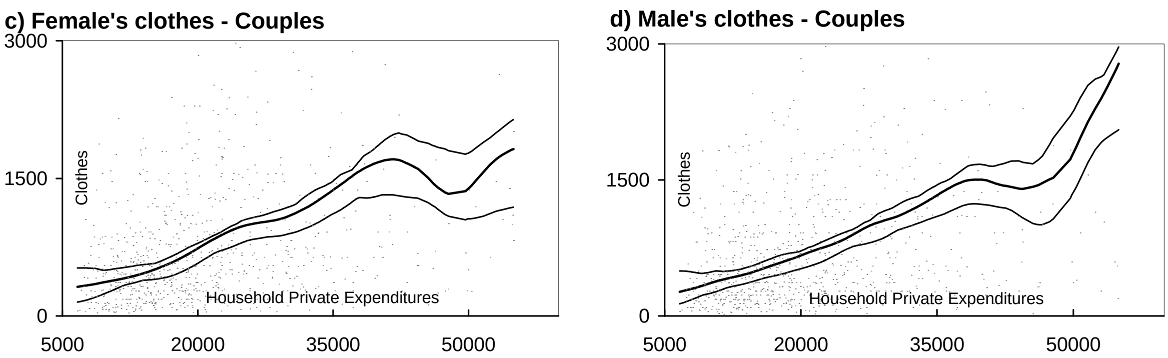
(*) Partial linear kernel regressions (city size). Instruments for private expenditures are total income and its squared value. 95% pointwise confidence band.

Figure 4: Engel curves for clothes expenditures, couples(*)

Without controlling for inequality in individual incomes



Controlling for inequality in individual incomes

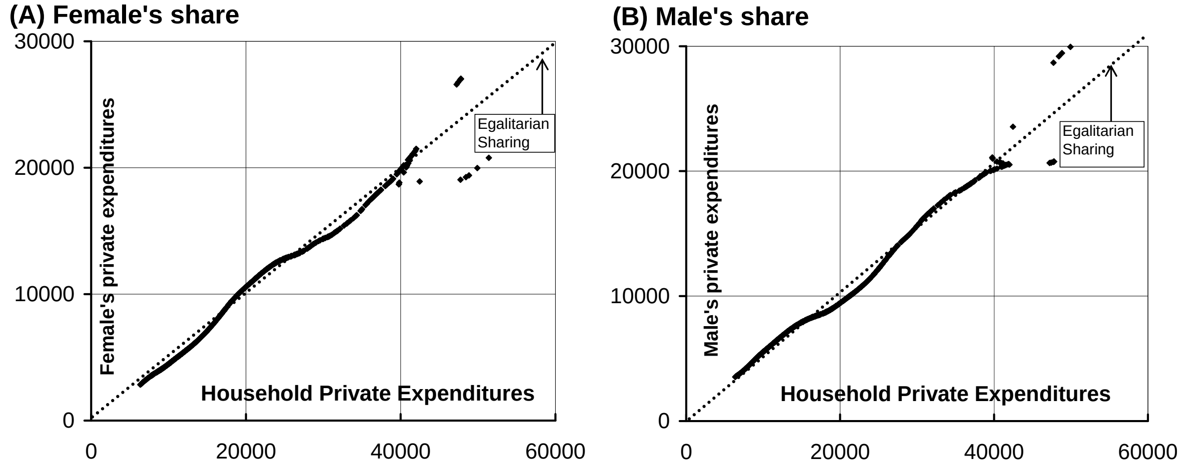


(*) see Figure 3.

Table 3: Single and couples Engel curves Partial Linear effect

Endogeneity correction term (ρ)	**Parameter**	**Std Error**	**T-stat**
Single Females (Figures 3a, 3c)	-0.000070	0.010639	-0.00658
Single males (Figures 3b, 3d)	-0.004880	0.011590	-0.42102
Without controlling for individual incomes			
Couples Females (Figure 4a)	-0.018614	0.003717	-5.00797
Couples Males (Figure 4b)	-0.017891	0.004159	-4.30190
Controling for individual incomes			
Couples Females (Figure 4c)	-0.019809	0.003844	-5.15374
Couples Males (Figure 4d)	-0.018695	0.004306	-4.34148
Big city			
Single Females (Figures 3a, 3c)	352.6543	90.52687	3.89558
Single males (Figures 3b, 3d)	401.5580	120.1803	3.34130
Without controlling for individual incomes			
Couples Females (Figure 3e)	248.9634	73.56489	3.38427
Couples Males (Figure 3f)	375.3277	82.31385	4.55971
Controling for individual incomes			
Couples Females (Figure 4c)	249.9099	73.65475	3.39299
Couples Males (Figure 4d)	373.9847	82.51472	4.53234
Share of individual income in HH income			
Couples Females (Figure 4c)	-24.54546	49.61205	-0.49475
Couples Males (Figure 4d)	-12.83123	55.57991	-0.23086

Figure 5: Prediction of spouses' private expenditures (*)

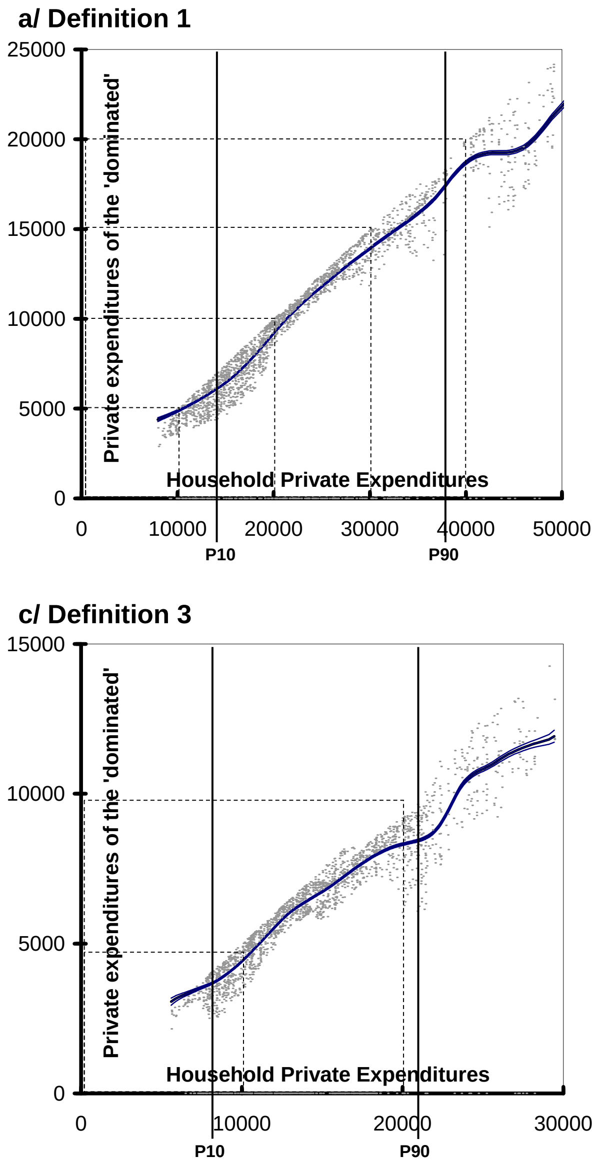


Predictions

	mean	stderr
Predicted Female Private Expenditures *(A)*	9179.60	4882.58
Predicted Male Private Expenditures *(B)*	9544.51	4722.69
Sum of Predicted Private Expenditures	18724.1	9510.67
HH Private Expenditures *(observed)*	20073.0	8114.20
Prediction Errors *(C)*	1348.91	2180.42
Private Expenditures of the dominated *(D)*	8833.93	4612.56
Number of observations	785	

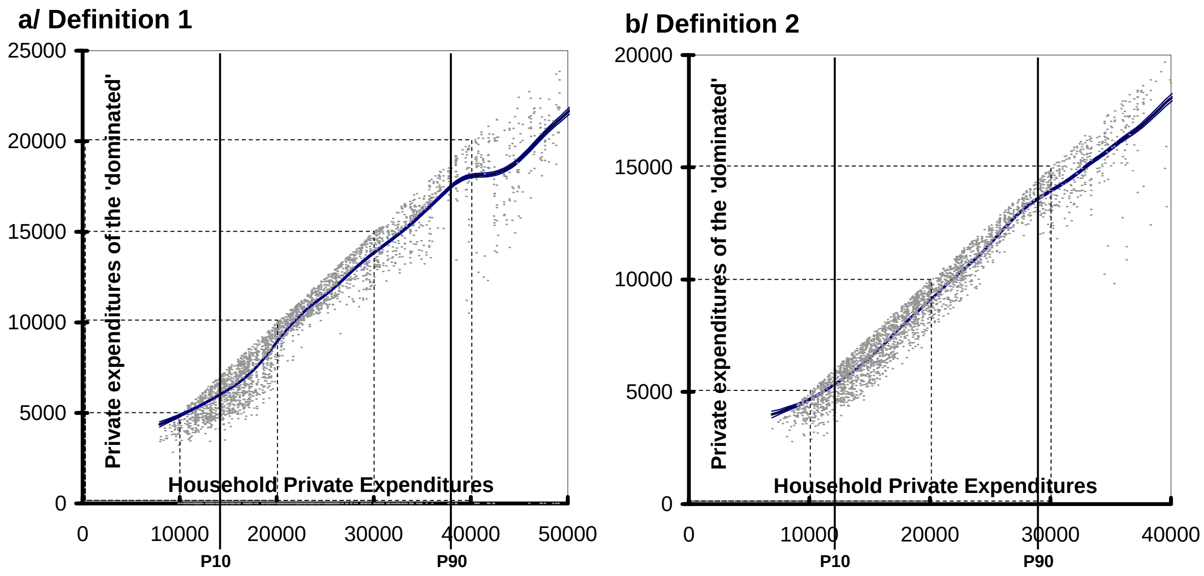
(*)(A) Inversion of Female's Engel curve of clothes expenditures. (B) Inversion of Male's Engel curve of clothes expenditures. (C) At the household level, prediction errors are the difference between observed private expenditures and predicted private expenditures. (D) At the individual level, private expenditures of the dominated are given by the minimum of predicted private expenditures for the female (A) and for the male (B).

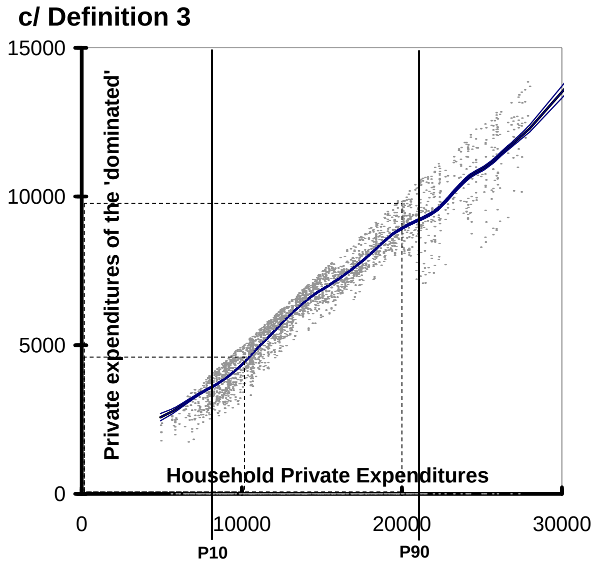
Figure 6: Private sharing function, needs(*)



(*) Smoothed unbiased conditional mean and cloud of simulated points derived using observed prediction errors *on household private expenditures*. Definition 1 is a maximalist definition of private consumption (total expenditures minus housing and energy). Definition 2 also excludes furniture and household services. Definition 3, the minimalist definition, also excludes car expenditures. P10 and P90 represents the first and last deciles of private expenditures.

Figure 7: Private sharing function, merit (*)





Effect of Inequality in individual incomes (γ)

	Parameter	Std err.	T-stat
a	-51.87462	76.20604	-0.680715
b	107.0113	59.00481	1.813603
c	-19.73361	41.47523	-0.475793

(*) See Figure 6. Partial linear kernel regression.

Table 4: Localized global concavity test of the private sharing function

	Needs				Merit			
Definition 1	**M-stat**	**S-stat**	**P-value (concavity)**	**P-value (linearity)**	**M-stat**	**S-stat**	**P-value (concavity)**	**P-value (linearity)**
Whole sample	1.9494	1.9494	0.7981	0.9592	2.3418	3.6009	0.3538	0.0273
Between P10 and P90	1.9494	1.9494	0.5176	0.7673	0.7238	3.6009	1.0000	0.0202
Definition 2								
Whole sample	2.2499	2.2499	0.4221	0.6660	2.9457	2.9457	0.0686	0.1325
Between P10 and P90	2.2499	2.2499	0.2044	0.4388	2.9457	2.9457	0.0470	0.0919
Definition 3								
Whole sample	1.8520	2.1709	0.7943	0.7346	2.1081	6.4056	0.3492	0.0001
Between P10 and P90	1.5495	1.8564	0.5571	0.5604	2.1081	6.4056	0.2222	0.0001

Appendix C, Table A1: Details of the global concavity test for public expenditures

Total		NEEDS						MERIT					
Expenditures		Public1		Public2		Public3		Public1		Public2		Public3	
Windows	N	U-stat	Stand-U	U-stat	Stand-U	U-stat	Stand-U	U-stat	Stand-U	U-stat	Stand-U	U-stat	Stand-U
[6000-9000[	28	-0.0855	-0,7381	-0.0971	-0,8725	-0.1026	-0,9773	-0.0830	-0,8439	-0.0928	-0,8873	-0.0702	-0,6139
[9000-12000[	113	-0.0944	-2,1946	-0.0953	-2,4540	-0.0844	-1,8871	-0.0927	-2,4984	-0.0927	-1,9939	-0.0869	-1,9714
[12000-15000[	248	0.0326	1,0407	0.0205	0,6423	-0.0057	-0,1760	0.0322	1,0397	0.0204	0,6039	-0.0055	-0,1788
[15000-18000[	338	-0.0245	-1,0701	-0.0110	-0,4549	-0.0355	-1,5096	-0.0240	-1,2105	-0.0100	-0,4334	-0.0356	-1,5337
[18000-21000[	389	-0.0097	-0,3962	0.0005	0,0205	0.0060	0,2862	-0.0091	-0,3911	0.0019	0,0926	0.0058	0,2536
[21000-24000[	317	0.0363	1,4706	0.0212	0,8887	0.0384	1,5760	0.0300	1,1869	0.0204	0,7616	0.0383	1,3080
[24000-27000[	278	0.0088	0,3087	0.0070	0,2733	0.0046	0,1677	0.0088	0,3470	0.0067	0,2352	0.0032	0,1052
[27000-30000[	250	0.0009	0,0289	0.0037	0,1378	-0.0036	-0,1316	0.0066	0,2226	0.0059	0,2008	-0.0048	-0,1565
[30000-33000[	194	-0.0087	-0,2423	0.0279	0,9345	0.0030	0,0886	-0.0108	-0,3083	0.0279	0,8253	0.0023	0,0634
[33000-36000[	143	0.0597	1,6090	0.0560	1,5608	-0.0370	-1,0277	0.0638	1,4890	0.0575	1,9853	-0.0403	-1,1564
[36000-39000[	108	0.0830	1,8835	0.0276	0,5958	0.0512	1,1367	0.0833	1,7799	0.0331	0,6971	0.0458	0,8412
[39000-42000[	98	0.0492	1,2441	0.0428	0,9973	-0.0178	-0,2956	0.0669	1,4212	0.0611	1,4607	-0.0092	-0,2085
[42000-45000[	77	0.0506	1,0337	0.0507	1,1724	0.0186	0,3507	0.0518	1,0754	0.0422	0,8957	0.0264	0,4532
[45000-48000[	73	-0.0093	-0,1661	-0.0781	-1,4389	0.0170	0,4099	-0.0063	-0,1047	-0.0766	-1,3554	0.0170	0,3859
[48000-51000[	40	0.0121	0,1443	0.0800	1,1208	-0.0545	-0,7295	0.0093	0,1063	0.0846	1,0903	-0.0543	-0,8523
[51000-54000[	48	-0.0027	-0,0442	0.0207	0,2621	-0.1162	-1,9868	-0.0027	-0,0340	0.0195	0,3627	-0.1244	-1,7573
[54000-57000[	29	0.1828	2,0488	0.0427	0,4983	-0.1237	-1,1836	0.1642	1,9838	0.0476	0,4519	-0.1275	-1,5810
[57000-60000[	24	0.0128	0,0933	-0.0138	-0,1005	0.1275	1,2098	0.0336	0,2422	-0.0385	-0,2618	0.1314	1,0453
[60000-63000[	11	0.1273	0,6410	0.1758	0,1921	0.3091	2,0819	0.1394	0,6307	0.1394	0,6055	0.2848	1,5141
H0: Global concavity		**M-stat**	**P-value**	**M-stat**	**P-value**	**M-stat**	**P-value**	**M-stat**	**P-value**	**M-stat**	**P-value**	**M-stat**	**P-value**
[0-70000+[	2872	2.0488	0.3789	1.5608	0.7986	2.0819	0.3551	1.9838	0.4287	1.9853	0.4275	1.5141	0.8364
[15000-42000[	2499	1.8835	0.2998	1.5608	0.5145	1.5760	0.5028	1.7799	0.3606	1.9853	0.2481	1.3080	0.7154

Appendix C, Table A2: Details of the global concavity test for the private sharing function (*)

Def1	Needs		Merit		Def2	Needs		Merit		Def3	Needs		Merit	
Wind.	**U-stat**	**Stand-U**	**U-stat**	**Stand-U**	**Wind.**	**U-stat**	**Stand-U**	**U-stat**	**Stand-U**	**Wind.**	**U-stat**	**Stand-U**	**U-stat**	**Stand-U**
[14-15[	0,0063	0,4976	-0,0272	-0,7975	[12-13[	0,0055	0,4403	0,0396	0,8792	[8-9[	-0,0100	-0,6613	0,0675	2,1081
[15-16[	0,0066	0,3965	-0,0654	-1,4470	[13-14[	0,0076	0,5246	0,0533	1,1801	[9-10[	-0,0061	-0,4536	-0,0979	-4,0515
[16-17[	-0,0045	-0,3097	-0,0239	-0,6105	[14-15[	-0,0090	-0,6957	0,0852	2,1601	[10-11[	0,0042	0,4308	0,0384	1,2250
[17-18[	-0,0066	-0,3279	-0,2443	-3,0021	[15-16[	0,0098	0,5481	-0,0089	-0,1883	[11-12[	-0,0141	-0,9724	-0,0788	-1,7341
[18-19[	-0,0176	-0,8916	0,0075	0,2150	[16-17[	0,0021	0,1222	0,1466	2,9457	[12-13[	-0,0088	-0,7928	-0,0938	-3,1800
[19-20[	-0,0112	-0,6294	-0,0173	-0,4413	[17-18[	-0,0050	-0,3882	-0,0652	-1,6116	[13-14[	-0,0270	-1,8564	0,0283	0,7389
[20-21[	0,0070	0,4460	-0,0534	-1,2816	[18-19[	0,0354	2,2499	0,0651	1,7273	[14-15[	0,0028	0,2859	-0,0049	-0,1284
[21-22[	-0,0016	-0,0810	-0,0550	-0,8868	[19-20[	0,0172	0,9626	-0,1206	-2,7586	[15-16[	0,0299	1,5495	-0,2491	-6,4056
[22-23[	-0,0164	-1,1263	0,0159	0,4027	[20-21[	0,0027	0,1530	-0,0703	-1,3324	[16-17[	0,0161	1,1355	-0,0389	-1,0767
[23-24[	-0,0102	-0,7484	0,0354	0,6912	[21-22[	-0,0133	-0,6882	-0,0301	-0,8217	[17-18[	0,0151	0,8520	-0,0511	-1,0379
[24-25[	-0,0066	-0,3140	0,0123	0,1903	[22-23[	-0,0021	-0,0876	0,0932	2,2790	[18-19[	-0,0065	-0,4402	-0,0471	-1,0258
[25-26[	0,0121	0,6724	-0,0033	-0,0453	[23-24[	0,0161	0,4598	-0,1724	-2,3618	[19-20[	0,0063	0,3267	0,0051	0,1710
[26-27[	0,0364	1,9494	-0,1416	-3,6009	[24-25[	0,0040	0,1184	-0,0182	-0,2967	[20-21[	-0,0169	-1,1751	-0,0700	-1,1782
[27-28[	-0,0344	-1,4734	-0,0771	-1,5390	[25-26[	-0,0162	-0,4860	0,0376	0,3882					
[28-29[	0,0041	0,1552	-0,0981	-1,7114	[26-27[	0,0970	1,9666	-0,0372	-0,5662					
[29-30[	0,0286	1,3493	-0,0578	-1,3307	[27-28[	0,0558	1,4891	0,0042	0,0714					
[30-31[	0,0259	1,1533	-0,0224	-0,3632	[28-29[	-0,0928	-1,0165	-0,0163	-0,2253					
[31-32[	-0,0060	-0,1791	-0,1813	-2,4097										
[32-33[	-0,0275	-0,8173	0,0067	0,0565										
[33-34[	-0,0480	-1,8219	0,0754	0,7238										
[34-35[	0,0125	0,5404	0,0241	0,2727										
[35-36[	-0,0129	-0,5548	-0,1557	-1,2525										
[36-37[	-0,0416	-1,2298	-0,1398	-0,7167										
[37-38[	-0,0132	-0,4815	0,0277	0,3003										

(*) Test based on a simulated cloud of 15000 points. Only percentiles 10 to 90 are presented in this table. Windows of private expenditures are expressed in 1000 of euros.