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Is power more evenly balanced in poor households ?*

Hélène Couprie†, Eugenio Peluso‡and Alain Trannoy§

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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, two conditions have to be satisfied for extending Generalized Lorenz judgments from household level to individual one. The fraction of the couple's expenditures devoted to goods jointly consumed should decrease at the margin with the couple's income as well as the part of private expenditure devoted to the disadvantaged individual. This double concavity condition is non-parametrically tested on the French Household Expenditure Survey (2000). It is not rejected by the data and support the view that power is more evenly distributed in poor households.

JEL Classification: D63, D13, C14.

Key Words: Lorenz comparisons, intra-household inequality, sharing functions, non-parametric concavity test.

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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 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 formalized 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 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 et al., 2006a).

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 the 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 repeatedly used in studies designed to reconstruct "who gets what" within a couple. (Browning et al., 2006a; Couprie, 2007; Laisney, 2002; Vermeulen, 2006). 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 Generalized Lorenz 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 home 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 D_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 $p_i = f_p(D_i)$ 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 $r_i = f_r(D_i) = D_i - f_p(D_i)$.

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

[1] This is a reduced form for a distribution factor independent version of the collective model, one in which income pooling still holds (see Browning et al, 2006b).

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.

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*

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

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

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 distributions. 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

[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.

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 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 (2007) 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 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 Generalized Lorenz 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 Generalized Lorenz 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 $\mathbf{Y}^c, \mathbf{Y}^{c\prime} \in \mathbb{Y}_n$, $\mathbf{Y}^c \succcurlyeq_{GL} \mathbf{Y}^{c\prime} \Rightarrow \mathbf{y} \succcurlyeq_{GL} \mathbf{y}'$.

[3] This assumption is relaxed in the empirical part where we introduce wage rates as controls for the different bargaining power in the household.

[4] See proof in Appendix B.

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 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 Generalized Lorenz 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 the concavity test for the public and private sharing functions is implemented on a cross-sectional family expenditures survey. 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, this 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

[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.

between households and within households go 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.

Hence, the second empirical objective is to test whether the intra-household share of private consumption depends on the amount of households private expenditures. In this second step, we test whether the expenditure of the 'dominated' individual is concave with respect to household private expenditures, the 'dominated' being the individual who benefits from the lowest intra-household share of private expenditures. Private expenditures at the individual level are unobserved for couples in the data and have to be predicted. This is also true for the identity of the 'dominated' individual within each household. We propose to predict private expenditures at the individual level for couples by using the observed behaviour and private expenditures of single individuals. Taking clothes consumption as assignable[6], the identification mechanism relies on the inversion of single individuals' Engel curve of clothing consumption.

The prediction method is strongly inspired by parametric methods which allow the identification of the intra-household share of private expenditures under collective rationality, caring preferences and adequate control of returns to scale in consumption within the family (see Browning et al., 1994, Couprie, 2007, Lise and Seitz, 2007). These identification methods, and their drawbacks, are well-known in the collective model literature. Identification conditions in our concern, assignability case with fixed prices, are detailed in Bourguignon et al. (2009). They rely on two major assumptions. The first one is the separability between public and private good consumption in individual preferences. The second one is the 'caring' preferences assumption which considers that the partner's clothes consumption only impacts one's own preferences via the partner's sub-utility function. As a consequence, intra-household externalities of clothes consumption are not allowed, which means that one could not get a direct utility gain, or loss, from his partner's clothes consumption. Both assumptions, which are of widespread use and which, as far as we know, have never been relaxed in the fixed price context, are problematic. Donni (2009) developped a public/private good separability test in the varying prices context which leads to a rejection of the separability. The validity of the 'caring' assumption can be checked using the Bourguignon et al. (2009) test. Both assumptions can be simultaneously checked by testing for the validity of an overidentifying restriction which imposes that the predicted shares add-up to observed household private expenditures using the Browning et al. (1994) specification. A companion paper (Couprie, 2009) shows that the test proposed by Bourguignon et al. (2009) is not valid in our case because no evidence of distribution factors[7] existence can be found. It also shows

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

[7] These *distribution factors* are variables affecting the balance of bargaining power within the household without

that the overidentifying restriction test does not pass the 5% threshold, but is accepted at the 10% one, on our data. It then illustrates that a voluntary non-linear but coherent parametrization such as in Browning et al. (1994) could lead to a too high proportion of women among the dominated individual in the family. Finally, a bit more flexible parametrization for demand functions such as a quadratic one would not allow the derivation of a statistical test that both predicted shares add-up to household private expenditures. Given all this information, the potential advantages of a parametric approach compared to a non-parametric one are lost.

The approach adopted here is semi-parametric and allows fully flexible shapes for the Engel curves. The prediction of the intra-household distribution of private consumption is obtained without any reference to a structural model for preferences. This allows the obtention of a flexible relationship between the share of the 'dominated' individual and household private expenditures. For each couple, two predictions for the private sharing rule are obtained: one for the female and one for the male. Both should add up to observed household private expenditures. If this is not the case, inspecting the prediction errors could be viewed as a way to checking the validity of the identification assumptions. As a substitute for a formal overidentification test on parameters estimates, the magnitude of the prediction errors at the household level and their dependency to household private expenditures are carefully analysed. We then apply a non-parametric concavity test which allows testing the nul hypothesis of global concavity *against any local alternatives*. Practically, the global concavity is tested at the conditional mean for each sharing function, controlling in the partially linear part for any relevant effect such as taste or bargaining power shifting effects. Bargaining power variables are anonymised for the public and the private sharing rule since what matters is not the identity of the rich and the poor in the household but the disparity of wages among spouses. 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. In the following, we first discuss the concavity test for the public sharing function, then identification issues for the private sharing function are detailed.

3.1 Testing the concavity of the public sharing function

Three different definitions of public expenditures are considered. 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

impacting preferences. They were used is Chiappori et al. (2002) as a way of improving the identification of the sharing rule.

consumed jointly within the household. Since this requires observation of the everyday life of the couple, our robustness check consists in using a varying range of public good expenditures which are more carefully described in Section 4.

We recall that Y_i denotes the total expenditure of household i. Public expenditure is denoted G_i, relevant controls for observed heterogeneity in taste or bargaining powers are introduced in a linear part[8] of the model where Z_i denotes the vector of covariates. The semi-parametric regression model reads:

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

In order to test the concavity of the g 'public sharing' function, we need to control for the potential endogeneity of Y. There are reasons to believe that some variables omitted from the model could simultaneously affect total household expenditure and public expenditure. This argument is quite standard in household demand analysis. In this regression, endogeneity generates an ill-posed inverse problem (see e.g. Blundell and Powell, 2003). Moreover, because Z and Y might be correlated, the estimation of g and the vector of parameters γ is not trivial. Robinson (1988) semi-parametric estimator should be extended to the case of endogenous variables. We chose to be parsimonious in the way the endogeneity of Y is controlled by simply using a control in the partially linear part of the model. This augmented regression approach follows 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:

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

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

$$g(Y) = E(G|Y) - E(Z \mid Y)\gamma - E(v|Y)\rho. \tag{8}$$

[8] A fully non-parametric specification would not represent a parcimonious choice, given the loss of convergence rate it would imply, the number of observations and the final interest of the analysis which is the g relation.

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

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

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.

Similarly, $\widehat{m_v}$ designates the Kernel regression estimator of $E\left(v|Y\right)$:

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

with $\widetilde{v_i}$ the empirical residual of the instrumental equation (6). Following the same principles, $\widehat{m_Z}$ refers to the kernel regression estimator of $E(Z|Y)$. In the presence of several covariates, it is a vector of the same dimension as Z. Replacing conditional expectations with their non-parametric estimators in equation (8), replacing $g(Y)$ with its expression in equation (7) and rearranging, we obtain the following linear regression:

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

Finally, denoting the ordinary least squares estimates of the preceding equation by $\widehat{\gamma}$ and $\widehat{\rho}$[9], the consistent estimator of function g is an IV kernel estimator denoted $\widehat{g}$ given by:

$$\widehat{g}\left(Y\right) = \widehat{m_G}(Y) - \widehat{m_Z}(Y)\widehat{\gamma} - \widehat{m_v}(Y)\widehat{\rho}. \tag{12}$$

To summarize, the estimation procedure consists in six steps:

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 kernel estimation $\widehat{m_v}$

Step 4: Estimate $E(Z/Y)$ into $\widehat{m_Z}$, this requires a number of non-parametric regression corresponding to the number of Z covariates.

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

[9]The null hypothesis of exogeneity can be tested by checking the statistical significance of the ρ parameter. Practical aspects of the procedure are detailed in the result section; 95% confidence intervals corrected for endogeneity are calculated pointwise by bootstrap (case resampling).

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

The concavity test is described in Appendix C.

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. Three different definitions of private expenditures are used as a robustness check. However, one difficulty remains: the private expenditure of the dominated individual within the household is not observed in the data. In this section, we detail how we predict the sharing rule by inverting the Engel curves estimated on single individuals for a good that is private and assignable: clothing. This method resorts to an identification assumption: an identical clothing consumption pattern, for women and for men, across cohabitational status. We detail in the following the estimation method and discuss the identification assumption.

The starting point is the Engel curve regression functions for clothes expenditures of individuals. 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.[10] The index i of the household is omitted. The Engel curve of clothing consumption can be written as

$$C_j = c_j(D_j) + X_j\beta_j + \varepsilon_j, \text{ with } E(\varepsilon_j \mid D_j) \neq 0, \ j = sf, sm, f, m \tag{13}$$

where C_j are clothes expenditures, c_j is the Engel curve, and D_j is individual private expenditure (total expenditure minus housing (public) expenditure). X_j is a vector of covariates introduced in the linear part of the model which capture the heterogeneity of preferences on clothes demand, such as occupation, city size and age. The clothing expenditures for the female and male living in couple is supposed to obey to the same model but in their case, D_j, the individual private expenditure of each couple member is not observed in the data. In general, D_j is related to private expenditure of the couple D (total expenditure minus public expenditure) by some sharing function f_j:

$$D_j = f_j(D, S) \tag{14}$$

where the effect of covariates on the bargaining power of each partner is explicitly taken into account through the variables S. These variables can be distribution factors, or also include taste shifting covariates X_f and X_m. For couples only, substituting (14) into (13) leads to:

$$C_j = c_j\left(f_j\left(D, S\right)\right) + X_j\beta_j + e_j, \text{ with } E(e_j \mid D_j) \neq 0, \ j = f, m \tag{15}$$

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

Then, we resort to the following identification assumption:

$$\begin{cases} c_j(.) = c_{sj}(.) \\ \beta_j = \beta_{sj} \quad \text{for } j = f, m \end{cases} \tag{16}$$

that is, identity of the Engel curves and of the effect of taste shifter covariate through marital status. There is no doubt that this assumption (16), as well as the specification of couples' clothes consumption (equ. 13) have a structural meaning. If we were in a parametric context, we would be very close to Browning et al. (1994) identification assumptions, which require public and private good separability as well as 'caring' preferences in a collective rationality context. The authors discuss extensively in their paper the validity of these hypothesis, which may be affected by externalities in clothing (one may care not only about one's spouse sub-utility function but also about one's spouse's appearance driven by clothes consumption). Moreover, it is also likely that the individual income effect on clothing preferences is altered by marriage or divorce. The marriage market may also match 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. Despite these critics, stability of preferences across cohabitational status has been used in various contexts in the collective models literature and can hardly be avoided (Browning et al., 2006a; Couprie, 2007; Laisney, 2002; Vermeulen, 2005). There is no doubt that in the cross-sectional assignable case with fixed prices it is a strong requirement. This is the reason why we pay attention to the robustness of the result, regarding the sharing rule prediction, but also regarding the concavity test result. We will compare the prediction obtained non-parametrically and parametrically and also check that the concavity test result is not affected by prediction errors which can be observed at the household level.

Regarding the identification assumption (16), it seems reasonable to maintain a different shape for the endogeneity effect across marital status:

$$E\left(e_j/D_j\right) \neq E\left(\varepsilon_{sj}/D_{sj}\right), j = f, m.$$

This is because for couples, the e error term should also include a disturbance term specific to the match (and the sharing) and not only one that is specific to individual demand for clothes. The endogeneity of household private expenditures could transit via both match specific and individual effects so it cannot be inferred from single individual data. Solving eq. (15) with respect to f_j drives:

$$f_j\left(D, S\right) = c_j^{-1}\left(C_j - X_j\beta_j - e_j\right). \tag{17}$$

A prediction of the sharing rule for male and female in the couple can then be obtained by using observed C_j on couples data, by substituting c_j, β_j by their estimations obtained on single data, and

by replacing e_j with its prediction obtained from a preliminary estimation of clothes consumption at the household level on couple data. This preliminary estimation is assumed to have a semi-parametric shape where S covariates enter in a partially linear part and total household expenditures enter in an unrestricted way and represent an Engel curve of clothes consumption at the household level. In this semi-parametric regression and the one achieved on single individuals from eq. (13), endogeneity of private expenditures is controlled for as in section 3.1.

Of course, in order to have a valid $\widehat{c_j^{-1}}$, a monotonicity and support condition have to be satisfied. Engel curves obtained on singles should be monotonic. Moreover, the estimate of clothing expenditure for the woman in a couple must belong to the support of predicted clothes expenditure for the sub-sample of single women, and likewise for men. 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:

$$\widehat{c}^{+}(D) = \frac{\widehat{c}_1(D) + \widehat{c}_2(D)}{2}, \tag{18}$$

with:

$$\begin{cases} \widehat{c}_1(D) = \max\limits_{D' \leq D} \widehat{c}(D') \\ \widehat{c}_2(D) = \min\limits_{D' \geq D} \widehat{c}(D'). \end{cases} \tag{19}$$

The validity of this restriction can be locally tested by checking whether the constrained estimation $\widehat{c}^{+}$ belongs to the 95% point-wise confidence interval of the unconstrained one. The validity of the support condition will be checked observation per observation.

We then get two predictions of the individual private expenditures for each couple, one for the woman, $\widehat{D_f} = \widehat{f}_f(D,S)$, and one for the man, $\widehat{D_m} = \widehat{f_m}(D,S)$. The dominated individual can be easily identified for each household by choosing the one who obtains the minimum predicted individual private expenditures. The private sharing function, which is the share of the dominated, follows in a straightforward way: $\min\{\widehat{D_f}, \widehat{D_m}\}$. After that, as for the public sharing function, the concavity of this share with respect to household private expenditures can be checked, controlling for taste and bargaining shifting variables. Instead of imposing by simulation methods that both predictions should sum up to observed household private expenditures, the concavity is directly checked with respect to predicted household private expenditures. Then, for robustness purpose we check that prediction errors at the household level do not depend on observed household private expenditures.

One further remark about the robustness of the method follows. In principle, it would be good to introduce a correlation term between the residuals of the two sharing functions, since presumably

they are interconnected at least through unobserved heterogeneity. However, estimating simultaneous estimation in a semi-parametric setting is difficult in itself and the reader is bound to notice that the estimation method is already quite complex as it contains many intermediate steps. A joint estimation in a parametric setting of the public sharing function and the Engel curve for clothes in couples (Couprie 2009), with a possible correlation between the residuals of clothes and public expenditures equations, tends to reject the relevance of a joint system estimation approach on our data[11].

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 collection methods are used simultaneously. The 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).

< TABLE 1>

Table 1 illustrates the sub-sampling process. As usual, there is a trade-off between the size of the sample and the need to control for different sources of heterogeneity across households. The analysis is restricted to couples or single individuals, households containing other adults are removed. Households

[11] More precisely, a first stage simultaneous estimation in a parametric setting (Couprie 2009) indicates that there is no efficiency gain, on these data, from using a joint public-private consumption system, whereas there could be some by using a joint female-male clothes consumption system. Regarding this last kind of correlation, we can refer to Blundell, Browning and Crawford (2003) p.216: the simultaneous modelling of a demand system does not bring any efficiency gain provided the same bandwidth and kernel are used to estimate the Engel curves. This is the case in our estimation.

with children are usually not considered. This is because it would be harder to justify and define a split between public and private consumption expenditures in this case. In addition to that, children, even small, could impact the decision process via their own preferences. The age selection is necessary because the share of the elderly is higher among single women than among single men or couples. With the age lower than 65, this brings us to 3,323 observations. In the data, individuals also report non-assignable clothes such as presents. Restricting to households who report a positive expenditure in assignable clothes further downsizes the sample by more than one third. The last two selection rules are quite costly in terms of data but are necessary as we do not explicitly model family labour supply decisions. Selecting households in which every member works restrains the sample size by one third. Finally we only keep households with full-time earners. It is indeed very likely that consumption and labour supply behaviour are not separable (Browning and Meghir, 1991). This remark makes even more sense in the case of clothes expenditures, where the separability between labour and clothes consumption is essential to adequately identify the Engel curves and the sharing rule. One could argue that clothes consumption is related to the labor market status because employees need to obey a dressing code when working in some jobs. Moreover, consuming clothes is also a time-consuming activity and we could suspect that controlling for the hours of work in the right hand side of the clothes consumption equation would not solve the potential endogeneity problem of working time. Last but not least, by considering dual full-time earners, the economic bargaining power of each partner in the couple can be captured by the wage rates. They largely reflect the education level and so depend on past decisions. They can then be safely introduced as explanative variables of public and private sharing rules. In addition, reducing the sample size tends to improve the quality of the fit to the data for the specification proposed.[12]

Table 2 shows descriptive statistics corresponding to the resulting sub-sample.

< TABLE 2 >

The definitions of public good

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 22% 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

[12] In any case, the sensitivity of the result to greater sub-samples has been analyzed in an earlier version of this paper (see Couprie et al. 2007).

rent" for homeowners should be added to any measure of consumption (see for instance Frick and Grabka, 2003). 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 a detailed discussion, 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 30% of household expenditures. The third definition, Public 3, also includes car-related expenditures and accounts on average for 48% of household expenditures. This last definition of collective expenditures is very broad (especially for two-car couples) and may be open to criticism. For this reason, we favour the first and above all the second definition in the presentation of the results.

Clothing

The good we treat as exclusive is men's and women's clothing, including shoes. 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 (€860) in the sub-sample is close to the mean for single women (€923); the same holds for men (€901 and €989 respectively). 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 (€863). It would have been arbitrary to consider this item as an individualized consumption, so we aggregated it with other goods. This treatment does not introduce bias across cohabitational status because unassigned clothing is also an expenditure item for single individuals. It is true that single individuals tend to spend less than couples on unassigned 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 be biased. Our thesis is that the difference in spending patterns is due to a difference in preferences for unassigned clothes, so unassigned clothes are simply considered like any other private expenditure.

Definition of the covariates

The covariates are the same for both sharing rules. Following previous non structural studies of

the private sharing rule such as Browning and Bonke (2006), two sets of variables are distinguished.

The first one characterizes the household or individual background. Among the variables which the significance has been tested, one finds the region of residence in three classes (the Mediterranean region, the Paris region, the remaining areas), the city size in three classes, (Paris agglomeration, cities of more than 100 000 inhabitants, the remaining), the level of education (the education of each spouse is defined in terms of years of non compulsory schooling) and the age. A bunch of variables intend to catch the influence of the social background. The Browning and Bonke study (2006) suggests that it matters to distinguish whether the mother of the husband has been a housewife or not. Such a dummy variable has been created. In addition, the husband or wife father in three categories (worker, farmer + independant, the remaining) completes the description of the initial background.

The second set of variables tries to capture the bargaining power in the household and compare the spouses according to some items. Individual income variables, which are widely recognized as playing a role in the sharing rule, are introduced in the analysis in the simplest possible way. To avoid any endogeneity due to hours of work on clothes consumption or intra-household sharing decision, wage rates are considered instead of observed individual income. We expect the own wage rate to impact positively her (his) consumption of clothes. For the private sharing rule, one might note that the dominated individual could be a woman or a man, this is the reason why bargaining variables are introduced anonymously (minimum and maximum of the household wage rates) as for the public sharing rule. In that case, a positive effect of the minimum wage rate would suggest that the household tries to compensate intra-household wage rate inequality by increasing the share of public expenditures. The welfare of the dominated individual would increase in this way.

We test the significativity of a very large set of variables in a preliminary parametric approach (Couprie 2009) and only a very few proved to be significant. In the semi-parametric approach, we only keep those which are either significant in the parametric estimation or very important in themselves such as the distribution factors.

5 Results

5.1 Public sharing function

Do poorer households generally spend a higher marginal share of their income on joint consumption? We now answer this question using our three definitions of public expenditure.

< FIGURE 1 >

Figure 1 displays the scatter diagram, the public sharing function estimated through kernel regression (thick line[13]) and the pointwise 95% confidence interval estimated by bootstrap (thin lines) corresponding to the three definitions of the public sharing function, controlling for the partial linear effects of age, city size, region and anonymous bargaining variables. The encapsulated tables give the estimation of the correction term for the endogeneity of total household expenditure, the ρ coefficient (see equation 5) as well as covariates effects. In all three cases, exogeneity of total household expenditure is rejected (only weakly rejected in the third case) with a different sign for the endogeneity correction. 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. As in the parametric parallel analysis (Couprie 2009), age and age squared are jointly but not individually significant. This is the reason why we kept these variables. The anonymous effect of wage rates never appears significant in any of these three specifications. Even if one presumes that intra-household inequality will have a negative impact on public expenditure because more equal households should spend more on public goods, our results are comforted by those of Phipps and Burton (1998), who find the Canadian housing data do not reject the income pooling assumption.

The shape of the public sharing function looks overall linear in the three specifications. However, some variations, especially for rich households could be noticed. They could be attributed to the small number of points for these income levels. A formal statistical test presented in Table 3 allows to check this visual impression and if these pertubations matter. As explained in Appendix C, the concavity test checks the global concavity against any local deviation from concavity. It requires separating the sample into windows of the same width as for a non parametric regression. U-statistics computation for each window and their p-values are presented in the table, they allow to test the local concavity against local convexity alternatives. Each U-statistic represents the probability of that portion of the graph to be convex (U>0), concave (U<0) or linear (U=0). Even at the local level, it is never rejected, except for the interval [50000, 59000[for the third definition. Then the last two lines present the M and S-statistics. The M-statistic is the maximum value of all standardized U-statistics. It allows to test global concavity against any local deviation. The S-statistic is the maximum absolute value of the M-statistics. It allows testing for global linearity against any local alternative. Concavity or linearity are never rejected. This is also true when the sub-sample is restricted to the 10 to 90th percentiles (see Appendix D TAB D1).[14]These findings thus strongly support the concavity (and even the linearity)

[13]One should note that these lines are shifted upward compared with the plots of observed public expenditures, simply because the g estimation functions do not include the effect of the covariates of the partial linear part.

[14]This concavity result is also obtained on the wider sample of 2876 couples (see Table 1 in a previous version Couprie

of public expenditure with respect to total household expenditures.

< TABLE 3 >

5.2 Private sharing

As explained in section 3.2, the private share of expenditures which go to spouses is not observable in the data. It needs to be predicted before further analyzing the private sharing function.

5.2.1 Prediction of individual private expenditures

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.[15] To avoid outliers and measurement and prediction errors, the top and bottom 2% of clothing expenditures have been excluded.

Figure 2 illustrates the Engel curves for single men and single women, imposing or not monotonicity. The constrained estimator is always contained within the unconstrained confidence interval, which suggests that monotonicity is not rejected pointwise. The confidence interval is computed by bootstrap.

< FIGURE 2 >

Figure 3 shows the Engel curves for expenditures of couples (which is the one that allows predicting the e in equation 17).

< FIGURE 3 >

Partially linear effects of covariates and endogeneity results are also presented in Figures 2 and 3. The exogeneity of household private expenditures is rejected for couples as well as for single individuals. Despite extensive research, very few covariates impact clothes expenditures: age and city size are strongly significant on single behaviour. In this case, age and age squared were not significant when considered jointly in the previous parametric exploration on the data.

et al., 2007) and parametrically (see Couprie 2009).

[15] The same procedure was also applied using definitions 1 and 3. The results of concavity tests are given in Table 6 and intermediate results can be obtained upon request.

Finally, the effect of wage rates is not statistically significant (this pattern is also robust across different parametric specifications). This counter-intuitive result may be due to mispecification or measurement errors on assignable clothes expenditures, but it does nevertheless cast some doubt on the real impact of distribution factors for this dataset.

< TABLE 4 >

The details on the sharing rule prediction are presented in Table 4 which shows that the prediction process works quite well for definitions 1 and 2 as very few observations are lost due to support conditions. For definition 3, 20% of the sample is lost and the method does not seem to run very well. The estimated average female share of household private expenditures is approximately 47% which is in line with intuition and other results in the literature for developed countries. For instance, Browning and Bonke (2006) find around 50% for Denmark, Couprie (2007) 47% for UK and Browning Chiappori and Lewbel (2006) between 50% and 55% on Canadian data. Summing up the predicted shares of female and male, one could obtain a prediction error at the household level which suggests an underestimation when using definition 1 and overestimation with the other two definitions. The best specification is obtained with definition 2 for which the discrepancy between estimated and observed data is about 1% on average. When compared with parametric predictions obtained on the same data (see Table 8B Couprie 2009), we find the same average share for the females. Moreover, it turns out that the non-parametric approach tends to perform better than the parametric one for definitions 1 and 2[16], with, for example for definition 2, an average prediction error of -665 euros per household parametrically and 274 euros per household non-parametrically. The dispersion of the prediction errors tends to be quite high, but still, the non-parametric prediction method lowers the standard error by approximately 20%. On average, women tends to be more often the dominated individual in the household (61 to 68% of the cases which are comparable to the figures obtained in the parametric estimation for the first two definitions). For each household, the share of the dominated individual is predicted.

5.2.2 Test

Figure 4 presents the sharing function regression, and its partial linear effects. It is surprising to notice that all covariates are strongly significant. This maybe due to the fact that the cloud of point is quite

[16] It remains worse than the method from Browning and al. (1994). We recall that this last method cannot be used in our case as it restricts the shape of the sharing rule and presents other drawbacks (see introduction of section 3).

narrow. Further parametric and non-parametric exploration suggests that the prediction error (at the household level) tends to be correlated to covariates, especially to age and wage rate variables, but not to the size of the city. These correlations could bias the observed partial linear effects that we will not try to comment here.

< FIGURE 4 >

We must make sure, at least, that the shape of the private sharing function is not affected by these prediction errors. In order to do that, we perform a non-parametric linearity test of the prediction errors with respect to household total expenditures in Appendix D, Table D2. Linearity is never rejected. Then we can turn to the concavity test for the private sharing function in Table 5.

< Table 5 >

As for the public sharing function, the concavity of the private sharing function is never rejected. One should note that this result is also obtained on a wider sample including non-working or part-time working individuals and excluding the impact of wage rate variables (see Couprie et al. 2007). It is also obtained on a sub-sample restricted to percentiles 10 to 90th (See Appendix D, Table D3).

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 household consumption. In order for an equality-enhancing transfer from richer to poorer households to be immune to being "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 both sharing rules. In addition, they are linear over most of the support. This suggests that in France the share of resources allocated to the well-being of each partner does not vary significantly with household income. Hence, at least on this

dataset, the bargaining power within couples does not appear to change with household income, so the structure of intra-household allocations can be ignored in welfare comparisons across individuals. In addition, contrary to Lundberg et al. (1997), most of our parametric and semi-parametric results do not lead to a clear rejection of the income pooling on our data set.

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 the bottom part of the income distribution and poverty analysis: the preservation conditions established in this paper could be easily accommodated, as shown by Peluso and Trannoy (2009).

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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 A1. 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.

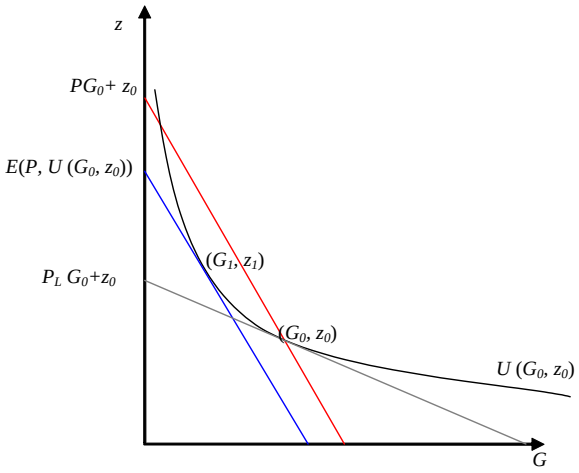


Figure A1: Definitions of individualized income

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).[17] 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

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

from 'married' to 'single' status entails a rise of the price of the public good from P_L to P. On top 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) $\Longrightarrow$ *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 $w_u(Y) = u(g(Y) + f_p\left(Y - g(Y)\right)) + u(g(Y) + f_r(Y - g(Y)))$.

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

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

$$w''_u(Y) = u''(y_p)y'^2_p + u''(y_r)y'^2_r + u'(y_p)y''_p + u'(y_r)y''_r. \tag{20}$$

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,

$$u'(y_r)y''_r = u'(y_r)[f''_r(D)D'^2 + g''(Y)f'_p(D)].$$

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

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

The two last terms of (20) are equal to

$$u'(y_p)[g''(Y) + f''_p(D)D'^2 - g''(Y)f'_p(D)] + u'(y_r)[g''(Y) + f''_r(D)D'^2 - g''(Y)f'_r(D)] \tag{21}$$

that is $u'(y_p)g''(Y)f'_r(D) + u'(y_r)g''(Y)f'_p(D) + f''_p(D)D'^2[u'(y_p) - u'(y_r)]$. 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) $\Longrightarrow$ *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 (20) and (21):

$$\begin{aligned} w''_u(Y) \;=\; & u''(y_p)y'^2_p + u''(y_r)y'^2_r + u'(y_p)g''(Y) + u'(y_p)[f''_p(D)D'^2 - g''(Y)f'_p(D)] + \\ & + u'(y_r)[g''(Y)f'_p(D) - f''_p(D)D'^2], \end{aligned}$$

that is

$$w''_u(Y) = u''(y_p)y'^2_p + u''(y_r)y'^2_r + u'(y_p)g''(Y) + [f''_p(D)D'^2 - g''(Y)f'_p(D)][u'(y_p) - u'(y_r)].$$

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 (20) 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: 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:

$$U_n = \left(C_n^3\right)^{-1} [\#\text{ of convex 3-tuples - }\#\text{ of concave 3-tuples}], \tag{22}$$

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:

$$\widehat{\chi} = R^{-1}\Sigma_{r=1}^{R}(U_r - U_n)^2, \tag{23}$$

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

$$\begin{cases} H_0 : U_n^0 \leq 0,\ g \text{ is globally concave} \\ H_1 : U_n^0 \geq 0,\ g \text{ is globally convex.} \end{cases} \tag{24}$$

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

$$M = \max\{\widetilde{U_{n,l}} : l = 1, ..., L\}. \tag{25}$$

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

$$\begin{cases} H_0 : g \text{ is globally concave} \\ H_1 : g \text{ is locally non-concave.} \end{cases} \tag{26}$$

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 (26) 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

$$S = \max\{|U_{n,l}| : l = 1, ..., L\}. \tag{27}$$

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 $P(a(S-b) < k) = \exp(-2\exp(-k))$.

Appendix D: Complementary results of the empirical analysis

TAB D1: Non parametric concavity test of the public sharing function - P10 to P90 (*)

Household Expenditures Windows	N	Public1 stat	p-value	Public2 stat	p-value	Public3 Stat	p-value
[18000-25000[	90	0,0831	0,0678	0,0891	0,0411	0,0364	0,2217
[25000-32000[	95	0,0123	0,3835	-0,0251	0,7079	-0,0688	0,9161
[32000-39000[	55	-0,0567	0,7841	-0,0079	0,5419	-0,0587	0,8311
[39000-46000[	36	0,0350	0,3414	0,0429	0,3117	-0,1062	0,9110
[46000-53000[	23	0,1067	0,1582	0,0073	0,4726	0,0344	0,3850
Global localized concavity test	299	1,4920	0,3177	1,7377	0,2181	0;7665	0,7547

(*) *See caption of TAB 3.*

TAB D2: Linearity test for the prediction errors when regressed on total household private expenditures (*)

Household Private expenditures Windows	N	Private1 Stat	p-value	Windows	N	Private2 stat	p-value	Windows	N	Private3 stat	p-value
[7000-16000[	89	0,0248	0,6514	[4000-11000[	24	-0,0148	0,8877	[5000-13000[	86	-0,1067	0,0735
[16000-25000[	129	0,0297	0,4992	[11000-18000[	118	0,0340	0,4305	[13000-21000[	91	-0,0284	0,6042
[25000-34000[	44	0,1009	0,1606	[18000-25000[	99	0,0555	0,3007	[21000-29000[	47	0,0452	0,6481
[34000-43000[	53	0,0045	0,9361	[25000-32000[	29	0,0991	0,3207	[29000-37000[	23	-0,0175	0,8666
[43000-52000[	10	0,3167	0,0959	[32000-39000[	31	0,0238	0,7807	[37000-44000[	39	0,0469	0,4798
[52000-60000[	18	0,0490	0,7071	[39000-46000[	43	0,0137	0,8676				
				[46000-53000[	5	-0,2000	0,5250				
Global localized linearity test	343	1,6652	0,4773		349	1,0349	0,9237		286	1,7895	0,3614

(*) *See caption of TAB 3.*

TAB D3: Non parametric concavity test of the private sharing function when restricted to percentiles 10 to 90 of private expenditures (*)

Household Private expenditures Windows	N	Private1 Stat	p-value	Windows	N	Private2 stat	p-value	Windows	N	Private3 stat	p-value
[9000-18000[	77	-0,0399	0,7631	[9000-16000[	85	0,0241	0,3157	[7000-14000[	98	-0,0018	0,5222
[18000-25000[	118	0,0002	0,4985	[16000-23000[	118	-0,0272	0,7391	[14000-21000[	71	0,0337	0,2055
[27000-34000[	39	-0,0312	0,6781	[23000-30000[	41	-0,0317	0,6389	[21000-28000[	41	-0,0154	0,6167
[36000-45000[	34	0,1056	0,1173	[30000-37000[	23	0,1158	0,1838				
Global localized concavity test	268	1,1888	0,4111		267	0,9008	0,5789		210	0,6170	0,6211

(*) *See caption of TAB 3.*

Tables and Figures

TAB 1: Subsampling

Original sample size **10305 household observations**	**Number of households**	**Couples**	**Single females**	**Single males**
Single headed households or couples	9962	6567	2283	1112
Without children or any other adult member	5517	2876	1645	996
Less than 65 years old	3323	1697	877	749
Consuming assignable good (clothes)	2056	886	674	496
Employment episode in the year for every member of the HH	1329	495	462	372
Not in part-time (weekly hours>30 or annual hours>1500)	1021	373	355	316

French Family Expenditure Survey, year 2000

TAB 2 : Descriptive statistics of the subsample

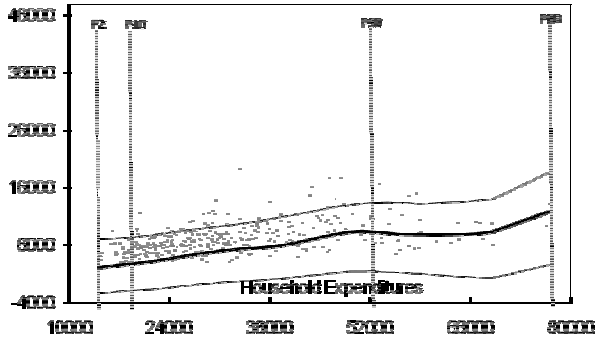
VARIABLES	**COUPLES**		**SINGLE FEMALES**	**SINGLE MALES**
Household before tax income (€/year)	38425		19965	22457
	(19701)		(9960)	(13353)
Household's total expenditures incl. imputations (€/year)	33373		19205	19490
	(16584)		(8004)	(8332)
Public 1: Housing, water, electricity (€/year)	7328		6117	5858
	(2601)		(2470)	(2433)
Public 2: Public1, furnitures, HH services (€/year)	10156		7249	6909
	(5952)		(3046)	(3116)
Public 3: Public2, Car-related expenditures (€/year)	16144		9715	10155
	(8917)		(4965)	(5320)
Assignable clothes (€/year)	1762.18		947.54	993.44
	(1582.4)		(928.7)	(1337.7)
Unassignable clothes (€/year)	863.86		250.32	115.72
	(2713.55)		(534.83)	(346.31)
Big city	0.18		0.23	0.22
	(0.39)		(0.42)	(0.42)
Married Couple	0.53			
	(0.50)			
	FEMALES	MALES		
Wage rate (€/hour)	8.29	9.59	9.04	9.58
	(5.50)	(4.70)	(4.15)	(4.66)
Women's or Men's clothes expenditures (€/year)	860.33	901.85	939.68	989.49
	(810.49)	(991.25)	(923.57)	(1338.1)
Age	36.4	38. 4	39.7	38.3
	(12.1)	(11.9)	(11.7)	(9.9)
Number of non compulsory schooling years	2. 4	2.1	2.6	2.4
	(2.3)	(2.4)	(2.5)	(2.6)
Born in France	0.95	0.95	0.92	0.92
	(0.21)	(0.23)	(0.28)	(0.28)

Standard deviations in brackets.

FIG 1: Public sharing function, couples [(*)]

Definition 1

Engel curve, household public expenditures

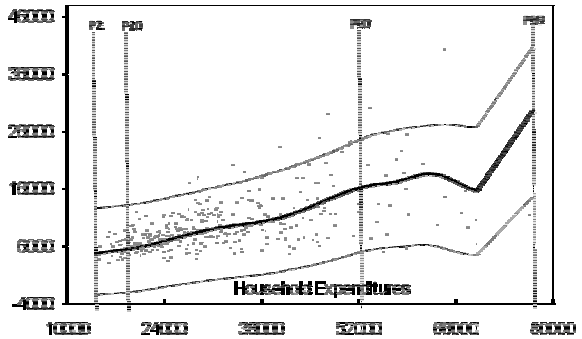


Partial Linear effects

	Parameter		Std.err
Endogeneity	-0.1064	***	0.0319
Age female	-31.5425		125.039
Age female ^{2}	80.3927		156.190
Age male	130.256		132.719
Age male ^{2}	-158.173		166.964
Big City	1442.79	***	376.015
Paris Region	-83.0672		288.497
Maximum wage in HH	9.0866		22.2907
Minimum wage in HH	-55.0192		66.5758

Definition 2

Engel curve, household public expenditures

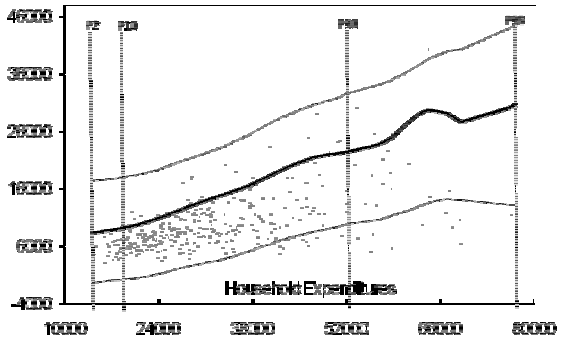


Partial Linear effects

	Parameter		Std.err
Endogeneity	-0.1309	**	0.0590
Age female	285.620		223.2126
Age female ^{2}	-337.885		278.9192
Age male	-297.048		237.4978
Age male ^{2}	408.720		298.9447
Big City	1718.16	**	681.3516
Paris Region	-420.308		523.7006
Maximum wage in HH	36.0302		39.6534
Minimum wage in HH	-81.0046		126.8137

Definition 3

Engel curve, household public expenditures



Partial Linear effects

	Parameter		Std.err
Endogeneity	0.1177	*	0.0722
Age female	42.0802		283.112
Age female ^{2}	1.7357		353.646
Age male	66.2241		300.501
Age male ^{2}	-136.070		378.040
Big City	-312.997		851.373
Paris Region	-198.341		653.213
Maximum wage in HH	26.474		50.4706
Minimum wage in HH	-112.267		150.741

[(*)] Partial linear kernel regressions. Definition 1 is a minimalist definition of public consumption (housing and energy). Definition 2 includes furnitures and household services. Definition 3 includes car-related expenditures. Household expenditures instrumented using income and squared household income. The cloud of points corresponds to observed public expenditures, not corrected for partial linear effects. 95% pointwise confidence band.

TAB 3: Non parametric concavity test of the public sharing function [(*)]

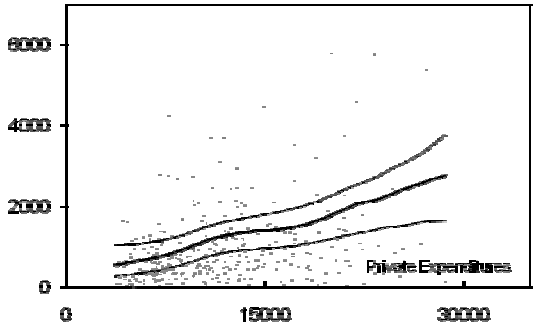
Household Expenditures Windows	N	Public1 stat	p-value	Public2 stat	p-value	Public3 stat	p-value
[14000-23000[	89	-0,0080	0,5682	-0,0143	0,6213	0,0240	0,3182
[23000-32000[	126	-0,0101	0,6046	-0,0375	0,8591	-0,0459	0,8673
[32000-41000[	65	-0,0295	0,6980	-0,0105	0,5703	-0,0437	0,7945
[41000-50000[	42	0,0059	0,4676	0,0270	0,3513	0,0448	0,2661
[50000-59000[	25	0,0191	0,4176	0,0652	0,3110	0,2035	0,0209
[59000-68000[	8	0,1786	0,2167	-0,1071	0,7053	0,2143	0,2107
[68000-77000[	4	-0,5000	0,9457	0,5000	0,0897	-0,5000	0,9457
Global localized concavity test (M)	359	0,7833	0,8791	1,3423	0,5041	0,3819	0,7472
Global localized linearity test (S)	359	1,6049	0,5664	1,3423	0,7541	1,0763	0,6257

[(*)] Test proposed by Abrevaya and Jiang (2005). Bootstrap standard errors computed using 1999 iterations. Test result robust to change in starting values or initialization of the random number generator.

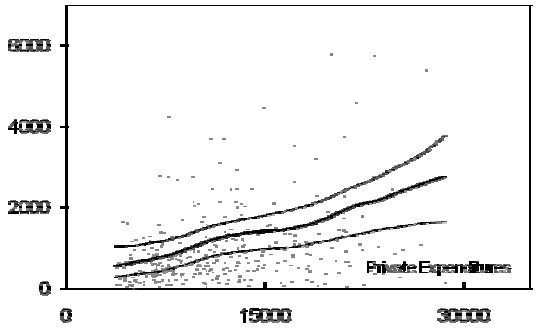
FIG 2: Clothes consumption Engel curves, single individuals(*)

Single Females

Engel curve



Engel curve, contrained to monotonicity

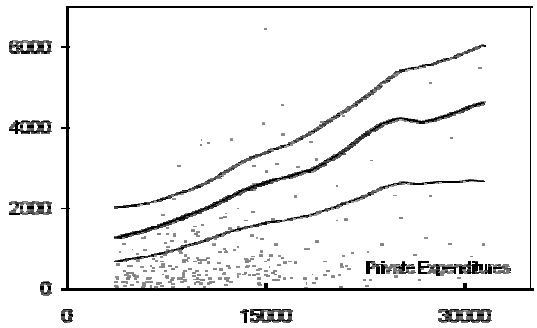


Partial Linear effects

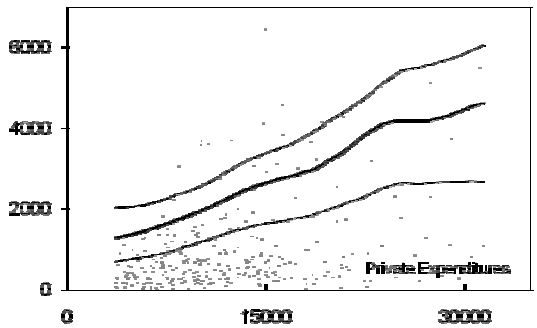
	Parameter		Std.err
Endogeneity	-0.0437	**	0.0173
Age	-8.1759	**	4.0773
Big City	365.0610	***	110.5991

Single Males

Engel curve



Engel curve, contrained to monotonicity



Partial Linear effects

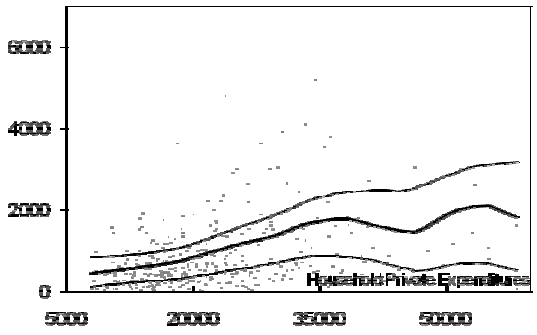
	Parameter		Std.err
Endogeneity	-0.0891	***	0.0245
Age	-35.7335	***	8.3914
Big City	362.4745	**	157.3359

(*) Partial linear kernel regressions rectricted to percentiles 2 to 98 of private expenditures. Intermediate definition of private expenditures is used. Instruments for private expenditures are total income and its squared value. Clouds of points are not corrected for partial linear effects. 95% pointwise confidence band.

FIG 3: Clothes consumption Engel curves, couples (*)

Females

Engel curve

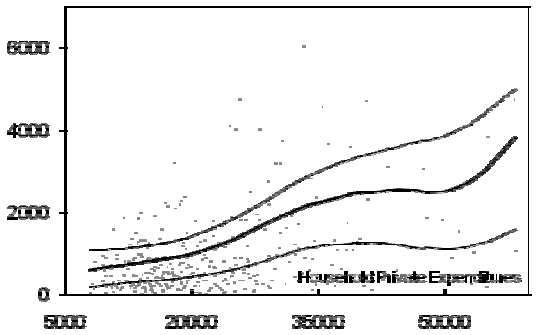


Partial Linear effects

	Parameter		Std.err
Endogeneity	-0.0247	**	0.0112
Age female	8.9974		9.7304
Age male	-11.7098		9.9149
Female wage	-6.3925		7.6574
Male wage	-1.2951		13.7835
Big City	382.7709	***	103.582

Males

Engel curve



Partial Linear effects

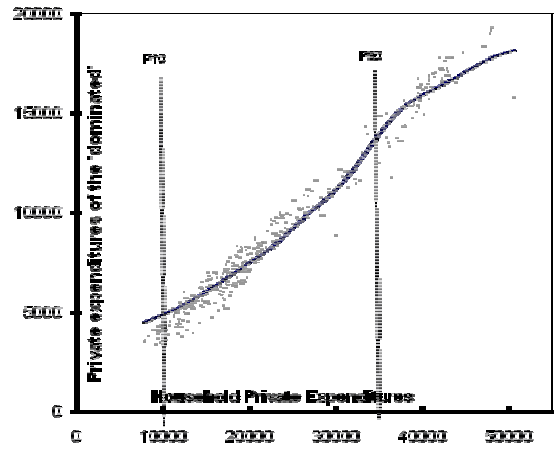
	Parameter		Std.err
Endogeneity	-0.0398	***	0.0130
Age female	7.4386		11.3558
Age male	-12.7278		11.5712
Female wage	-8.4591		8.9365
Male wage	-15.175		16.0860
Big City	369.4947	***	120.885

(*) *See caption of FIG 2.*

TAB 4: Female sharing rule prediction results

	DEF 1	DEF 2	DEF3
Predicted female private expenditures	11997.5	10961.8	9323.4
	(6382.3)	(5315.8)	(4818.4)
Predicted male private expenditures	13067.4	11837.8	11064.5
	(6278.2)	(5345.5)	(5715.1)
HH predicted private – observed	-494.43	274.49	2964.6
	(4068.4)	(4267.8)	(5647.5)
Predicted share of female private expenditures	0.4752	0.4801	0.4608
	(0.0541)	(0.0561)	(0.0696)
Private expenditures of the `dominated'	11597.3	10472.0	8953.5
	(6263.4)	(5235.6)	(4809.0)
The 'dominated' individual is the female	0.6472	0.6103	0.6818
	(0.4785)	(0.4884)	(0.4666)
Observations lost due to support condition	4%	3%	20%

FIG 4: Private sharing function (Definition 2) [(*)]



Partially linear effects

Share of the `dominated'	Parameter		Std.err
Endogeneity	0.1158	***	0.0191
Age female	41.1139	***	10.944
Age male	-40.7876	***	10.832
Max wage	74.0982	***	14.448
Min wage	107.251	***	22.663
Big City	42.9854		106.98

[(*)] *See caption of FIG 2.*

TAB 5: Non parametric concavity test of the private sharing function (*)

Household Private expenditures		**Private1**				**Private2**				**Private3**	
Windows	**N**	**Stat**	**p-value**	**Windows**	**N**	**stat**	**p-value**	**Windows**	**N**	**stat**	**p-value**
[7000-16000[	89	-0,0176	0,6298	[4000-11000[	24	0,1057	0,1864	[5000-13000[	86	0,0278	0,2807
[16000-25000[	129	0,0365	0,1680	[11000-18000[	118	0,0090	0,4154	[13000-21000[	91	0,0225	0,3391
[25000-34000[	44	-0,0089	0,5411	[18000-25000[	99	-0,0445	0,8364	[21000-29000[	47	-0,0353	0,6712
[34000-43000[	53	-0,0322	0,6704	[25000-32000[	29	-0,0969	0,8535	[29000-37000[	23	0,0491	0,3041
[43000-52000[	10	0,1667	0,2093	[32000-39000[	31	-0,0138	0,5588	[37000-44000[	39	-0,0938	0,9012
[52000-60000[	18	-0,0956	0,7489	[39000-46000[	43	0,0291	0,3628				
				[46000-53000[	5	0,4000	0,1093				
Global localized concavity test (M)	343	0,9619	0,7072		349	1,2302	0,5832		286	0,5807	0,8593
Global localized linearity test (S)	343	0,9619	0,9142		349	1,2302	0,8262		286	1,2886	0,6676

(*) See caption of TAB