the review of income and wealth

Review of Income and Wealth
Series 64, Number 4, December 2018
DOI: 10.1111/roiw.12302

A RESTATEMENT OF EQUIVALENCE SCALES USING TIME AND MONETARY EXPENDITURES COMBINED WITH INDIVIDUAL PRICES

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In the classic equivalence scale estimations based on micro-econometric analysis, only the costs of market consumption are taken into account. We define the concept of full cost equivalence scales as integrating both monetary and the time use costs and measure it on matched French family budget and time use surveys. These data allow us to define full prices and to estimate equivalence scales conditional to possible substitution through prices. The results show higher full scales than the monetary for the preferred Independent of a Base specification. Relative to the cost of the second adult, the full child cost is also larger than the monetary for matching estimators and the Prais-Houthakker model. It shows households' capacity to substitute domestic production to market activities. In consequence the measures of income inequality diminish considerably using full income and full equivalence scales.

JEL Codes: D1, D13, J22

Keywords: cost of children, domestic production, equivalence scale, inequality, time allocation

1. Introduction

Arbitrary or normative equivalence scales are a basic policy maker tool in the implementation of taxation and welfare policies (see for instance Buhmann *et al.*, 1988). The general question which motivates equivalence scales estimation is the problem of standard of living comparisons between households having different socio-demographic characteristics: how much money is saved living together rather than separately? How is the situation of household changing if there is a modification of its demographic situation? What is the well-being (or poverty) status of families with respect to their socio-demographic and economic characteristics? Tentative answers to these questions in the literature ignore the parental time spent on child care and education in substitution of its other alternative use (market work, leisure, domestic production), despite the theoretical importance of Becker's allocation of time model. Apps and Rees (2002, see also Gronau and Hamermesh, 2006) suggests that limiting the analysis to the monetary aspects neglects the *key*

Note: This research was partially funded by ANR program MALDI.
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issue of the child cost. Similarly, Nelson (1993b) also notes that "the role of time in measurement of the standard of living has been neglected". Observing the time allocated to different forms of child care observed in time use surveys especially for young children, it can be reasonably supposed that the time "expenditure" value could be much larger than specific market expenditures on the child. For instance, in the French surveys we use in this paper, the ratio of time expenditure over full expenditure is about 65 percent for all types of activities.

We define the "full cost equivalence scale" and the full child cost" as the expression of the total, monetary and non-monetary, expenditure depending respectively on family structure or on the presence of a child. The child arrival in the household disturbs considerably the parents' time budget: market and domestic working times, leisure and even physiological time. The measurement of this global time redistribution cannot be limited to the simple accounting for activities specifically linked with child presence (caring, playing, reading…) which usually underestimate the time devoted to children like the overcharge in the general domestic works or the time shared simultaneously between children and parents. In this paper we propose a new method to estimate a *full cost equivalence scale* based on combined time and money expenditure. For this purpose we use the statistically matched files of the French INSEE Family Budget (2000) and Time Use (1999) surveys. This approach presents several opportunities both from the theoretical and empirical point of view.

First, the integration of monetary and non-monetary costs may help to identify the underlying real household's well-being status supposed to be constant between two compared households with different socio-demographic characteristics when estimating equivalence scales. In this sense it contributes to solve the crucial *identification problem* discussed by Pollak and Wales (1979) and Blundell and Lewbel (1991)[1].

Second, the usual methods of equivalence scales estimation do not take into account the price substitution effects caused by the presence of children as discussed by Barten (1964). According to Barten (1964), a change of the demographic structure of the family imparts a change in the structure of relative prices, public goods being less expensive for large families, while the reverse holds for private goods such as food. For instance one liter of milk is relatively more expensive for the family of three than for the family with one or two children. The differences between the full (monetary and non-monetary) prices can proceed from different households' opportunity costs or productivity (measured by the time taken by households to perform some activity). Thus, it may be possible to estimate the effects of differences in price based on matched time and money expenditure.

Third, these concepts may suffer less from measurement errors (like zero expenditures), and the enlarged income variable may be closer to a permanent income concept (if some substitution exists during the life-cycle between the two components of income).

Fourth, the information on time use is available at an individual (intra-household) level, so that a collective model of household behavior could be tested more easily than with monetary information aggregated by household.

[1]Blundell and Lewbel (1991) show that it is possible to obtain any cost of a child from a cross-section data in the frame of a theoretical model compatible with observed behavior.

Finally, full expenditure can be enlarged into household's full income and inequality and poverty indices based on full households' incomes. It will indicate how the substitution between domestic production and market activities allows households to optimize their well-being.

This article addresses four questions:

Is the cost of a child under evaluated when only monetary expenditure is considered?

Does the price substitution change the measure of child cost?

Is the difference between the full and monetary cost of a child due mainly to this price substitution effect or only due to the full child cost concept?

Does income inequality change when considering full expenditure instead of monetary one?

The article is organized as follows. Section 2 discusses the literature on the time cost of children. Section 3 presents the specification and identifying hypotheses corresponding to matching estimators, the Prais-Houthakker's model and the price dependent equivalent scales in the form of an Independent of a Base model (Lewbel, 1989). This model gives the opportunity to take into account the price substitution effect related to the family size. Section 4 describes the data sets and the econometric methods used to estimate the opportunity cost of time. Section 5 shows how these matched datasets allow defining full prices for all activities and Section 6 contains the results of the estimations for the French INSEE surveys. Section 7 compares inequality and poverty for full vs monetary households' incomes and section 8 contains a discussion of the empirical results and the conclusion.

2. Studies on the Time Cost of Children

The studies on time cost of children estimation are very rare as compared with the very rich literature on monetary costs evaluations. Among the most interesting, Ekert-Jaffé and Grossbard (2015) built an objective well-being indicator based on parents' personal time including physiological and leisure time and compare the time budgets between families with different number of children. The reduction in this parental time is interpreted as the utility loss due to the child care and education time or an increase in the domestic works induced by child presence. The parental time is regressed in a linear expenditure system with control variables such as parents' economic and social status and work participation. The results show that a couple spends in average 50 minutes per day of its time on their unique child aged 6–14. For younger children, 90 minutes increase of this time is observed and it is close to zero for teenagers aged more than 14.

Bittman and Goodin (1998) estimate a time equivalence scale on Time Use Surveys with the same methodology as used for the classic monetary scales. It is equivalent to an income scale in the sense that it regresses the total (market and not market) working time of adults on dummies controlling for the presence of children and other adults. The estimates show that children increase women's working time per week by 11 hours and by three hours for man. No other computation is made to evaluate the monetary cost of children. Bradbury (2004) proposes to estimate the *total child cost* using the Rothbarth's method which differentiates the goods

exclusively consumed by adults and children, the adult's good consumption being used as a household's well-being indicator. The Bradbury approach defines parents' personal and leisure time as an adult good. The relationship between this adult good, the family size and income is used to determine the total child cost. It is defined as the difference between the income levels required to have the same consumption of adults' good (leisure and personal time) in households with and without children. He obtains a total child cost which is much higher than the monetary cost and explains it by the fact that in his approach a child can have a higher impact on the parents' standard of living than an extra adult.

These studies do not consider the full cost associated to the family structure, nor the substitutions which may exist between monetary and non-monetary costs. This is the objective of our estimation of full cost expenditures using statistically matched files. Gardes *et al*. (2015) estimate such full equivalence scales on these matched data using the classic Prais-Houthakker model with matching based on the definition of 38 cells aggregated on both surveys according to the same households' characteristics. They obtain for grouped data a larger cost for a child on full expenditures compared to the monetary estimates.

The aim of this article is to estimate the adult and child cost using individual data and various specifications of the equivalence scales with a possible substitutability through prices related to the family demographic structure.

3. Specification

The estimation of equivalence scales is based on the comparison of total expenditures for households characterized by the same level of well-being but having different demographic characteristics. The first method used in the literature follows the Engel law in order to identify utility which is supposed to be identical for the two compared families. The changes in food budget share (in monetary terms) are used as an indicator of a household's standard of living. The food share should increase when a child arrives and this change is considered as a decrease in well-being. The estimation of the cost of children consists in regressing the food share on income (or total expenditure) and family size. The consumption function can be supposed to follow for instance the Working specification:

$$w_{if} = \alpha + \beta ln y + \gamma g(N) + Z\delta + \varepsilon \tag{1}$$

with $w_f = \frac{p_f x_f}{y}$ the budget share for food, with y the total household income, $g(N) = N$ *or* $log(N)$ with N the family size (or another function of the number of adults N_a and children N_c) and Z various socio-economic variables.

The equivalence scale (ES) for a couple with one child with respect to a childless couple is obtained in this case by the formula:

$$ES = e^{\frac{\gamma}{\beta}} \quad \text{for } g(N) = N \tag{2}$$

The underling hypotheses are that food is a necessity and that the budget share for food increases with the number of children resulting in a positive estimate of the cost

of children, based on a positive estimate for γ and a negative one for β (corresponding to an income elasticity smaller than one). Such a model affords on our dataset estimates of the equivalence scales for a child compared to the first adult: 0.51 (*s.e.=0.06*) for the monetary expenditures and 0.31 (*s.e.=0.11*) for full expenditures.

The identification of utility by means of the food budget share is highly disputable especially in developed countries. Moreover it produces a unique equivalence scale for all goods. Three other models are therefore used to estimate the full cost of a child: first, *matching estimators* between households without children to those with children allow comparing directly the expenditures made by both family types. This is the method applied by Hoa (1986) who grouped households just by income classes (identification for matching estimators being supplied by the relation supposed to hold between income classes or coordinates and the household's utility level). This simplistic matching method (see Table 3 column a) is compared to a matching by a vector of coordinates, using Abadie and Imbens (2006) methodology (Table 3, column b). Second, the classic *Prais-Houthakker*'s specification gives rise to a set of specific equivalence scales for all categories of expenditures. Third, the possibility of price substitution is considered in the estimation of an *Independent of a Base* model derived from Lewbel (1989), using Blackorby-Donaldson (1991) and Nelson (1993a) specifications.

For the Prais-Houthakker's specification[2], we use the identifying hypothesis which states that alcohol and tobacco expenditures are not related to the family size (i.e. alcohol and tobacco expenditures do not change between couples with and without children at the same level of well-being). Its main advantage is to allow the calculation of specific equivalence scales for all categories of expenditures composing the total budget. The total equivalence scale (for total expenditure) can be computed as a weighted average by the partial marginal income

[2]The scale coefficients are calculated in this model by estimating the following demand functions describing the changes in the family consumption as a function of its demographic structure at a fixed level of well-being: $\frac{p_i x_i}{m_i} = f_i\left(\frac{y}{m_0}\right)$ where m_0 is the total expenditure (income) scale and m_i the specific one for the item i. For the reference household (one adult without children) these scales are set to one. The demand functions are derived from the Almost Ideal specification. The equivalent expenditure on item i thus writes:

$$\frac{p_i\, x_i}{m_i} = a_i\, \frac{y}{m_0} log\left(\frac{y}{m_0}\right) + b_i\, \frac{y}{m_0}$$

Dividing by y and multiplying by m_i leads to the formulation in terms of budget shares. Adding socio-demographic variables Z and normally distributed error term vectors we obtain the following equation for all items i:

$$w_i = \frac{m_i}{m_0}\left[\alpha_i\, log\left(\frac{y}{m_0}\right) + b_i\right] + Z.\delta + \varepsilon.$$

Specific and total expenditures scales are supposed to be linear:

$$m_i = 1 + \alpha_i N_c + \beta_1 (N_a - 1) \text{ and } m_0 = 1 + \alpha_0 N_c + \beta_0 (N_a - 1)$$

where N_c is the number of persons aged less than 18 and N_a is the number of persons aged more than 18. In our estimations children are defined as being 18 or less years old rather than the usually used threshold of 16, because frequent cohabitation of young adults and also young adults under 18 are usually attached to the family fiscal unit.

propensities to consume (see Cramer, 1969 and Gardes *et al*., 2015) or by the average of partial ES for all goods and services (see Deaton-Muellbauer, 1980, p. 198, equation 2.7).

Note that both Engel's and Prais-Houthakker's approaches do not take into account the possible influence of prices over expenditure of families with different demographic structures. Models allowing for such price substitution have been rarely estimated because of the lack of price information in cross-sections. Our matched dataset gives such price information at the individual level as is shown in Section 5. In order to generalize the Engel identification of equivalence scales, Lewbel (1989) proposed an additively separable expenditure function (in logarithm):

$$C(u,p,Z)=c(u,p)c(p,Z) \tag{3}$$

where Z stands for family composition. This specification gives rise to an equivalence scale comparing households with demographic structures Z and Z′ which is independent from utility u:

$$ES(p,Z)=\frac{c(u,p)c(p,Z)}{c(u,p)c(p,Z')} \quad =\frac{c(p,Z)}{c(pZ')} \tag{4}$$

Blackorby and Donaldson (1991) used the following specification for this ratio:

$$ES(p,Z)=(N_c+1)^{\theta} \quad \prod_i p_i^{\gamma_i N_c} \tag{5}$$

with γ_i (summing to 0) proportional to the price elasticities of the equivalence scale.

Thus, a positive γ_i corresponds to an expenditure, the difference of which between large and small families increases with its price. The dependency of the equivalence scales on prices gives information on the substitution effects which characterize the family choices (a subject which could be also discussed in the Barten, 1964, specification). Incorporating (5) in a Pig-Log expenditure function:

$$\ln C(p,Z)=a(p)+b(p)u+\theta log(N_c+1)+N_c \quad \sum \gamma_i \ln p_i$$

with the usual price indexes of the Almost Ideal Demand System, gives directly (by deriving this logarithmic expenditure function over the logarithm of prices for i) the following demand system, in an Almost Ideal framework:

$$\begin{aligned} w_i=\alpha_i-\beta_i \ \alpha_0+\gamma_i N_c-\beta_i\theta\ln(N_c+1)+\sum_j\left[\left(\eta_{ij}-\beta_i \ \gamma_j\right)N_c\ln p_j\right] \\ +\beta_i\left\{\ln Y-\sum_j \alpha_j\ln p_j-\frac{1}{2}\sum_j\sum_k \eta_{jk}\ln p_j\ln p_k\right\}+u_i \end{aligned} \tag{6}$$

where $\eta_{ij}=\frac{1}{2}\left(\eta_{ji}+\eta_{ij}\right)$ with the usual additivity, homogeneity and symmetry constraints on parameters α_i, β_i, η_{ji}:

$$\sum_i \alpha_i = 1; \sum_i \beta_i = \sum_i \gamma_i = \sum_i \eta_{ij} = 0; \sum_j \eta_{ij} = 0 \text{ or all } i; \eta_{ij} = \eta_{ji}$$

The residual u_i is supposed to be i.i.d. across households. Note that all parameters of this system of equations are exactly or over-identified. Estimating the demand system (6) thus allows to test for the dependency of equivalences scales over prices, and to compare them to the usual scale (with no price substitution) corresponding to the estimation of equation (6) with all γ_i equal to 0.

This model identifies directly the child cost by the comparison of the expenditure of families with different number of children, and does not need to make any other identifying hypothesis. It can be slightly generalized to calculate both the child and the adult costs, writing the expenditure function:

$$\ln C(p, Z) = a(p) + b(p)u + \theta log(N^*) + N_c \sum_i \gamma_i \ln p_i \tag{7}$$

with N^* indicating the household's synthetic size: for instance $N^* = N_a + N_c$ (specification B1 in our estimations) or

$$N^* = m_0 = 1 + \alpha_0 N_c + \beta_0 (N_a - 1)$$

as in the Prais-Houthakker model (specification B2). This generalization of Nelson's specification allows considering the term $N^{*\theta}$ in the cost function as a measure of the household size used to compute the cost (or income) per unit of consumption:

$$\frac{C(u, Z)}{N^\theta}$$

The Independent of a Base assumption provides an identifying hypothesis for the calculation of equivalence scales (since it allows to compute it independently of the utility level). Tests of this assumption (i.e. tests of the dependency of the equivalence scale over utility or income) have been discussed by Biewen and Juhasz (2012) with the mixed evidence provided by estimations made either on consumption data, or on subjective answer on well-being or minimum income. Income dependency does not seem to be very pronounced. For instance Donaldson and Pendakur (2005, Section 5.1) obtain a positive test for income dependency but with equivalence scales for two parents with one child varying from 2.11 to 1.98 or 2.87 to 2.72 between top and bottom income 20th percentiles. However its pattern may differ across household types (increasing equivalence scales for multi-adult households without children, while they seem to decrease for couples with numerous children). As our main interest is to take into account price substitutions depending on the family structure, we choose to estimate an IB model which is much simpler than the generalized models proposed for instance by Donaldson and Pendakur (2005), in order to compare the results with the estimation of the Independent of a Base model on French data by Nelson (1993a)[3].

[3]Note that our measure of prices at the household level may minimize the income dependency of equivalence scales.

4. Data and Descriptive Statistics

We use a dataset which combines at the individual level the monetary and time expenditures into a common, unique good and services consumption structure by a statistical match of the information contained in two surveys: the Family Budget Survey (BDF, INSEE 2001, see Appendix 1 for description) and the Time Use Survey (EDT, INSEE, 1999, see Appendix 1 for description). This rather difficult exercise needs some arbitrary assumptions about the substitution between time use and monetary expenditures (see Gronau and Hammermesh, 2006 for a discussion). That is why the commodity consumption structure does not correspond exactly to what is very often used as a standard classification even if differences can be limited (see table A1 in Appendix II). The reason is that not all time use activities can have a clear work equivalent. This is particularly the case of the leisure time.

We define 8 types of activities or time use types compatible with the available data both from Family Budget Survey and Time Use Survey (see Appendix II, Table A2 for details) for instance for eating which combines *Eating and cooking time* (*Time Use Survey*) and *food consumption* (Family Budget Survey). Other activities correspond to housing, clothing, transport, education, health, leisure and various consumptions. As the needed information is present only in two separate data sources (Time Use Survey and Family Budget Survey) we need to combine them. The statistical matching between the surveys was done by two methods: in Gardes (2014), households are grouped in the two surveys into 38 cells defined by cross classifying the head's age and education level with the household's location. The average time for each activity, as it is computed on the Time Use Survey, is then affected to the corresponding cell in the Family Expenditures Survey. This matching has the advantage of suppressing all problems related to zero expenditures and measurement errors, but information is lost by aggregation. In this paper a second method regressing the times for each activity over a common set of socio-economic characteristics of households which are present in both surveys is used. The estimated coefficients are used to predict these times for each household in the Family Expenditure survey.

The main methodological issue of the aggregation of time use and monetary expenditures is the estimation of the monetary value of the time spent on different domestic activities. Several methods have been proposed, especially in the frame of national accounting of domestic production (Eurostat, 1999). Two approaches have been most frequently adopted—output or input method. The first one is based on the conventional value of domestic production and is close to the national accounts general methodology (Holloway et al. (2002), whereas the second one is based on evaluation of corresponding market alternative costs, more appropriate to microeconomic approaches. Thus the alternative costs of work at home can be obtained in two ways: (i) by multiplying the time spent on a given activity by the regional labor market price of work for the similar market activities or (ii) by multiplying domestic work time by the potential earnings (*opportunity costs*) which can be obtained by the given person on the labor market. The first solution is certainly more precise than the second, but needs detailed information on local market hourly wages for all equivalents of domestic production

activities, which are rarely available (see for example Havrylyshyn, 1976; Goldschmidt-Clermont, 1993).

Two methods have been used in this article to value the time spent on domestic activities. First, this value is simply the official minimum wage rate (SMIC) for this period in France, which is supposed to indicate the market wage for a low productive job. In the second method, when the time use is supposed to be perfectly exchangeable between market and non- market activities, the *opportunity cost* of non-market work is computed as the average actual net wage rates for all working individuals in the family, or by their expected hourly wage rate on the labor market for non-working individuals (estimated separately for men and woman using the two-step Heckman method). In the individually matched sample the total value of non-monetary activities can be obtained directly by adding men's and woman's contributions. Both evaluation methods are adjusted for income taxes and the estimated numbers of working days and hours. They give similar patterns of the equivalence scales estimates.

The definition of comparable good and time groups of expenditure is a difficult and sometimes arbitrary operation. However, comparing our classification with other similar approaches (Gronau and Hamermesh, 2006) we obtain similar patterns of what these authors call "relative goods/time intensity" defined as a "ratio of good to time inputs relative to total amount of goods and time allocated to commodity production". We report this figure in the last column of Table 1. For France, like for Israel and U.S. in the Gronau-Hamermesh paper, the goods–time intensity is relatively high for Dwelling, Health, Clothing and to a lesser extent for Transport. However, the Eating item differs considerably between France and these countries, being weakly good intensive in France (0.57) and highly good intensive in the U.S. and Israel (1.62, 1.82, respectively).

In our study we observe large differences in time and monetary budget shares (Table 1 and Table A2 in Appendix II). Time budget shares are much higher than their monetary equivalents for Eating, Leisure and Education while the commodity budget shares are significantly higher for Dwelling, Clothing, Health and Miscellaneous. These patterns vary only slightly when considering different family compositions. Families with children have relatively higher clothing, transport and leisure monetary budget shares than other families. On the other hand, time budget shares are diminishing with the number of children for leisure and increasing for education. Time to monetary expenditure ratios are globally decreasing with the number of children (see Table A2). This is especially the case of Eating, Education, Dwelling, Leisure and Clothing. The share of the time expenditure in the total expenditure (Table 2) is globally about 65 percent, varying among items and family composition. It is relatively stable for families with children (57–59 percent), very high for Leisure, Education and Eating (more than 75 percent) and very low for Health.

The descriptive analysis of monetary and full expenditures structures shows that the pattern of intensity of time over money is similar in France and in the two countries (the U.S. and Israel) studied by Gronau and Hammermesh. The difference between monetary and full budget shares also proves that the domestic production technology is, as expected, not the same for all consumption activities. This difference may depend on the characteristics of the household since economies of scale change

TABLE 1

MONETARY, TIME AND FULL EXPENDITURE PATTERNS: ALL HOUSEHOLDS

	Monetary budget shares	Time budget shares	Full expenditure budget shares	Yearly expenditure (euros)	Yearly time in hours	Yearly time value (euros)	Full expenditure (money+ time value) (euros)	Monetary exp.- time value ratio	Relative goods/time intensity
	1	2	3	4	5	6	7	8	9
Eating	0.15	0.26	0.22	4053	1858	12858	16911	0.32	0.57
Dwelling	0.33	0.13	0.20	8994	899	6221	15215	1.45	2.60
Clothing	0.06	0.03	0.04	1600	216	1495	3095	1.07	1.92
Leisure	0.16	0.37	0.30	4309	2661	18417	22726	0.23	0.42
Transport	0.14	0.10	0.12	3863	726	5024	8887	0.77	1.38
Education	0.001*	0.04	0.03	118	294	2036	2154	0.06	0.10*
Health	0.04	0.001**	0.02	1063	9	68	1131	15.6	28.06**
Miscealenous	0.13	0.07	0.09	3508	475	3287	6795	1.07	1.92
TOTAL	1	1	1	27509	7140	49409	76918	0,56	1

Source: Matched Family Budget Survey with Time Use Survey. 10,255 observations used in estimations.

Time is valued at minimum wage rate. Column 8 equals column 4 divided by column 6. Column 9 is column 8 divided by 0.56 (average monetary expenditure—time value ratio).

*These figures may be biased by state financed expenditures on education and health.

**These items may be badly reported especially as they are particularly difficult to separate from other activities.

TABLE 2
Share of Time Expenditure in Full Expenditure

	Couples no children	Couples 1 child	Couples 2 children	Couples 3 children	Total population
Eating	0.84	0.71	0.69	0.70	0.77
Dwelling	0.50	0.38	0.36	0.38	0.41
Clothing	0.61	0.37	0.39	0.41	0.49
Leisure	0.91	0.74	0.70	0.72	0.82
Transport	0.60	0.50	0.50	0.51	0.56
Education	1.00	0.94	0.91	0.90	0.96
Health	0.10	0.05	0.04	0.05	0.06
Miscealenous	0.54	0.42	0.42	0.44	0.48
TOTAL	0.73	0.58	0.57	0.59	0.65

Source: Matched Family Budget Survey with Time Use Survey. 10,255 observations used in estimations.

according to the family size and its level of being. In France, the difference principally applies to the comparison between childless households and households with one child, the composition of full expenditures remaining approximately the same for families with more than one child. Thus, the choice between a self-service economy (using durables and time for home production) and the market (buying directly goods and services on the market) may differ between different types of households.

5. Definition of Full Prices[4]

For monetary prices $\boldsymbol{p_i}$ and a quantity $\boldsymbol{x_i}$ of activity i, monetary expenditure writes: $\boldsymbol{p_i x_i}$. Suppose the opportunity cost for time is $\boldsymbol{\omega}$, the time-use expenditure for activity i is: $\boldsymbol{\omega t_i}$ where $\boldsymbol{t_i}$ is the necessary time for $\boldsymbol{x_i}$ units of activity. Suppose also that: (*i*) the monetary price $\boldsymbol{p_i}$ is the same for all households; and *(ii)* each unit of activity i necessitates a constant time use $\boldsymbol{\tau_i}$ (Becker domestic production technology). Under these hypotheses, full expenditure for the consumption of $\boldsymbol{x_i}$ units will be: $(\boldsymbol{p_i} + \boldsymbol{\omega\tau_i})\boldsymbol{x_i}$.

We define a proxy of the full price for the activity i by the ratio of full expenditures over their monetary component:

$$\boldsymbol{\pi_i} = \frac{(\boldsymbol{p_i} + \boldsymbol{\omega\tau_i})\boldsymbol{x_i}}{\boldsymbol{p_i x_i}} = \frac{\boldsymbol{p_i} + \boldsymbol{\omega\tau_i}}{\boldsymbol{p_i}} \tag{8}$$

These *full prices* can be considered rather as full (shadow) child and adult costs since they do not intervene on a market but concern household's internal decision process[5].

As the full expenditure depends on the opportunity cost of time as well as the full prices, a possible endogeneity can appear in the full demand equations. It

[4]See Gardes, 2014, for details.

[5]This definition is based on the calculus of full prices as the sum of the monetary price and the opportunity cost of time. It corresponds to the original Becker's model based on the assumption of a complementarity between monetary and time factors in the domestic production. The opposite hypothesis of a substitution between these factors allows defining another full price which does not differ empirically much from the first (see Gardes, 2016 for details).

is corrected by defining prices using the minimum wage as the opportunity costs while the full expenditure is defined on the household's net wage.

6. Results: A Comparison of Monetary and Full Child Cost Estimates Taking into Account The Price Substitution Effects

Tables 3 and 4 present the estimation of the income scale using three models: matching estimator, Prais-Houthakker model and Lewbel's Independent of a Base model which controls for price substitution effects (see Table A3 in Appendix 3). All estimations of the demand systems are made under additivity, homogeneity and symmetry constraints. In the estimation for full expenditures, the income coefficient has been calibrated by a weighted average of the corresponding estimates of the two components of the full expenditure. This is because the Almost Ideal Demand function cannot be supposed to hold for both, monetary and time components as well as for their sum (Gardes, 2014). The child costs are computed with price substitution effects linked to the number of children: for instance for specification A1 and household h we set:

$$ES(p_h, Z_h) = (N_c + 1)^{\vartheta} \prod_i p_{h_i}^{\gamma_i N_c} - 1 \tag{9}$$

where the individual prices are averaged for all households of a population of size n weighting each household by $\frac{1}{n}$, which gives an average equivalence scale:

$$\left\{ \prod_h (N_c + 1)^{\vartheta} \prod_i p_{hi}^{\gamma_{iN_c}} \right\}^{\frac{1}{n}} = (N_c + 1)^{\vartheta} \prod_i \left[\prod_h p_{h_i}^{\frac{1}{n}} \right]^{\gamma_{iN_c}} \tag{10}$$

Thus, *ES* depends on a geometric mean of individual prices. For models B1 and B2, *ES* is computed comparing populations of two adults without children and two adults with one child. Similar comparisons can be obtained for the adult cost comparing bachelors with couples. Three derived versions of that specification (10) are used in the estimations (see Table 4).

The first conclusion is that the time opportunity cost evaluation method by the household's net wage does not change the results considerably when compared with the minimum wage evaluation. Second, the specific scales coefficients for adults are, as expected, higher than those for children for monetary expenditures but not so different for full expenditures[6]. This result is also robust to the method used to value time cost. Third, the estimation of the Independent of a Base scale with price substitution effects shows clearly that the full cost of a child is higher than the monetary cost (the full cost of the second adult is also greater than the monetary estimate). The matching and Prais-Houthakker's estimators give similar estimates for the monetary and the full cost scales[7].

[6]Note however that in the Prais-Houthakker estimation, the ratio of the child cost over the second adult is greater for full expenditures. Nevertheless, regarding particular consumptions in the Prais-Houthakker model (Gardes, 2014), the ratio of the full child cost over the monetary averages 2.8 for all expenditures and is specially large for health and housing expenditures, smaller for clothing, leisure and other.

[7]Note however that Prais-Houthakker estimates of child cost measured of proportion of the second adult cost is greater using full expenditure.

TABLE 3

Full Cost Equivalence Scales without Price Substitution Effects: Matching Estimator and Prais-Houthakker Models

	Matching Estimator (a)		Matching estimator (b)		Prais-Houthakker	
	Adult	Child	Adult	Child	Adult	Child
Monetary ES	0.771	0.490	0.935	0.666	0.404	0.241
	(0.067)	*(0.020)*	*(0.012)*	*(0.012)*	*(0.033)*	*(0.040)*
Full Cost ES	0.474	0.395	0.974	0.504	0.307	0.241
(opportunity cost)	*(0.025)*	*(0.014)*	*(0.009)*	*(0.011)*	*(0.031)*	*(0.034)*
Full Cost ES	0.474	0.445	0.965	0.501	0.424	0.282
(minimum wage)	*(0.019)*	*(0.020)*	*(0.006)*	*(0.012)*	*(0.024)*	*(0.029)*

Source: Matched Family Budget Survey with Time Use Survey. 10,255 observations used in estimations.

Matching estimators: matching by (a) income class (Hoa method), or (b) by various coordinates (Abadie-Imbens method). Standard errors computed by delta method for (b).

Prais-Houthakker specification: Scale for consumption i: $m_i = 1 + \alpha_i * N_c + \beta_i * (N_a - 1)$, total scale: $m_0 = 1 + \alpha_0 * N_c + \beta_0 * (N_a - 1)$ with N_c the number of persons aged less than 18 and Na is the number of persons aged more than 18. Estimation in two steps, fixing the scale at the OECD level (adult cost 0.5, child cost 0.3) in the first step.

Thus, accounting for Barten's substitution between expenditures gives quite different patterns of the monetary child cost and seems to decrease both adult and child costs. Also, for the IB model, the ratio of the child cost over the cost associated with the second adult is much greater for the full cost estimates than for the monetary (1.06 vs. 0.46), which is similar to the result obtained with the two previous specifications without price substitution (0.72 vs. 0.60 for the Prais-Houthakker model). This implies that taking into account the time budget will have more impact on the relative child weight when compared with a supplementary adult because supplementary expenditures for children on private goods and services (compared to public goods such as housing) are larger than those which correspond to the second adult.

Equation (6) shows that the cost increases with the number of children as soon as $\sum_i \gamma_i \ln p_i > 0$. In our estimation (see Table A3), this expression is equal to 0.0101 in average, which means that increasing the number of children results by the substitution effect in a supplementary increase of the family cost by one per cent per child. This implies that the cost of children will be larger when taking into account this substitution effect in the IB specification compared to the Prais-Houthakker model.

The gamma coefficients in the IB model measure the price substitution related to the number of children. They are all significant for the various estimations of the model (A1, B1 and B2) and have the same signs and magnitudes as those of Nelson's estimation (1993a, Table 2, p. 56): for instance, the gamma coefficient for food is 0.018 (se=0.001) in Nelson's estimation, 0.0093 (0.00077) in our estimation for the specification A1 of Table 4 (Appendix II). It shows that the household's size increases the price substitution term for food. This may happen because large households have more incentive to take care of their expenditures on food as their share is greater compared to other expenditures characterized by

TABLE 4

Full Cost Equivalence Scales with Price Substitution Effects: Independent of a Base Model

	Adult Cost		Child Cost		
Specification	B1	B2	A1	B1	B2
Monetary ES	0.198	0.134	0.116	0.117	0.145
	(0.023)	*(0.017)*	*(0.081)*	*(0.084)*	*(0.059)*
Full Cost ES	0.693	0.435	0.574	0.399	0.523
(opportunity cost)	*(0.026)*	*(0.016)*	*(0.073)*	*(0.052)*	*(0.038)*
Full Cost ES	0.477	0.361	0.476	0.398	0.491
(minimum wage)	*(0.026)*	*(0.018)*	*(0.103)*	*(0.089)*	*(0.067)*

Source: Matched Family Budget Survey with Time Use Survey. 10,255, observations used in estimations.

Specification and population: A1: equation (6) with N=number of children, estimation on all households with two adults. B1: system (6) reduced from the first N* in $\theta \ln(N+1)$ equal to the household's size and the second (interaction term with prices)= number of children N_e; all households with one or two adults. B2: same specification with $\log N^* = \ln N_a^{\Theta_1} N_e^{\Theta_2}$, estimation on the whole population. Standard errors corrected for the presence of generated regressors by a bootstrap procedure (see for details Appendix II).

economies of scale (personal transport, durables, renting and heating). Note also that the price elasticity of the equivalence scale is γ_i which is positive whenever the time component of the full price $\omega\tau_i$ is large compared to the monetary component p_i. Therefore, the change in relative prices may have redistributive effects across households of different sizes according to the activities characterized by the higher relative prices. This effect cannot be estimated only through common price elasticities. In another sense, the estimation of price elasticities may be biased by these correlated effects due to the demographic structure of the family.

Summing up, it appears that children full costs are higher than those estimated in the traditional monetary way, either in absolute value or compared to the cost of an additional adult in the household.

7. Comparison of Households' Inequality and Poverty Rates Computed on Full and Monetary Incomes

When a household is supposed to be able to substitute domestic production to the purchase of the corresponding markets goods or services, the sum of its consumption and of the value of its domestic production measures its full income. In order to obtain a well-being measure, this full income must be divided by an equivalence scale estimated for full expenditures. Inequality measured for full income per unit of consumption may thus differ from inequality obtained using households' total monetary income because of the difference between the distributions of monetary and full income, and because of the larger adult and children full costs.

That definition of full income supposes that all fractions of time devoted to some activity by an adult of the household increases the household well-being by the corresponding monetary value indicated by the opportunity cost for time.

Thus, the choice of that opportunity cost is crucial. We define here the full income using the household's average net market wage, first because it measures the contribution to the social wealth by the household's market labor, second because the opportunity cost which can be estimated by a model of domestic production is shown to be correlated to this net market wage, with an elasticity of 0.85 (Gardes, 2014).

Results in Table 5 show that both effects—measuring full income instead of monetary income and taking into account the full cost of adults and children—diminish the inequality between households' income by 31 to 59 percent according to the indicator for total income and 22 to 45 percent for income per consumption unit. In particular, taking into account the family size by means of the full equivalence scale diminishes inequality by 10 to 20 percent, while no change appears when incomes are measured per capita.

Similarly, the poverty status of families as measured by different income and well-being indicators changes considerably when the full income replaces the monetary one (Table 6). The poverty rates are systematically much lower for full income whatever the equivalence scale used. Using monetary equivalence scale to the full disposable incomes diminishes the poverty rate indicator when compared with the results of the application of full income equivalence scale to these incomes. From the social policy point of view the most significant result is the shift of poverty rate from 15.2 percent for monetary income per UC to 6.9 percent for full income per UC.

Another interesting result appears when comparing the interactions between the monetary and full incomes poverty status. Among the 15.2 percent of the population classified as being poor for disposable monetary income per UC, only 4.6 percent remain poor in terms of full income per UC which shows that a lot of (monetary) poor households are able to escape poverty by means of domestic production.

Generally, it appears that the possibility to substitute domestic production for market labor allows poor households to improve their relative position in the income distribution, which reduces income inequality and poverty. Also, the economic size of large families, as it is measured by the full equivalence scale, diminishes their relative full income, which contributes to a further decrease of inequality.

Thus, crossing these two criteria (monetary and full income poverty) may help to better target a situation of hard poverty.

8. Concluding Remarks

The ratio between the child cost and the extra-adult cost is greater by 40 percent for full expenditures compared to the monetary. This ratio is particularly important, in the Prais-Houthakker estimates, for housing, health and transport—while it is smaller for clothing, leisure and other expenditures. This implies that a price change due to the time component (for instance through an increase of the opportunity cost for time along the life, or, along the business cycle, see Aguiar and Hurst, 2013 and Alpman and Gardes, 2015) has a larger impact on

TABLE 5
Inequality Indexes Compared for Monetary and Full Incomes

	Gini	Theil	Standard deviation of logs	Inter-Quartile range (log income)
Household's Disposable monetary income *no equivalence scale*	0.34402	0.20620	0.646	0.850
Household's Disposable full income *(no equivalence scale)*	0.27307	0.12116	0.469	0.593
Disposable monetary income *per capita equivalence scale*	0.33701	0.21031	0.595	0.757
Disposable full income *per capita equivalence scale*	0.27417	0.12597	0.511	0.667
Disposable monetary income *Prais Houthakker monetary* equivalence scale*	0.30945	0.17486	0.553	0.687
Disposable full income *Prais Hathakker full income** equivalence scale*	0.24030	0.09575	0.398	0.515

Source: Matched Family Budget Survey with Time Use Survey. 10,255 observations used in estimations.

*monetary Prais-Houthakker equivalence scale: 0.404, 0.241

**full Prais Houthakker equivalence scale: 0.307, 0.241

families with children. This is particularly the case of housing, health and transport expenditures. It may provoke a price substitution towards other expenditures.

The substitution between home production and monetary expenditures depends on the private or public nature of the activity. For a private one, both the monetary and the time components of the full cost increase with the household's size. However some economies of scale may exist for the time component only (for instance for eating) while for other activities, such as transportation, similar economies of scale may occur (the passenger being able to sleep while the conductor drives, with a constant monetary cost for two persons compared to one person). Therefore, we may observe a greater ratio of monetary over time cost for private activities, and therefore a substitution of domestic production to monetary expenditure[8]. Such a substitution diminishes the monetary cost and the monetary equivalence scale, while the full scale, which changes according to the variation of the full cost of the activity, may remain constant, increase or decrease, but to a less extent. On the contrary, for public goods such as housing, the monetary cost does not change with the family composition (at least for small variations) while the time component of the full cost increases (perhaps not proportionally to the family size). It should increase the ratio of the full cost over the monetary one. Thus, for both activity types, the substitution between monetary expenditure and domestic production caused by full price changes can explain our empirical finding that the full equivalence scale exceeds the monetary.

[8]Indeed, this substitution depends on the individual behavior of the family members: selfish adults can go on having their lunch at restaurant while they give carrots to eat to their children. In such a case, the ratio between monetary and time component decreases when the family size increases.

TABLE 6
Poverty Rates at 60% of Medium Income by Full and Monetary Income

Poverty rates ((%) 60% of median income)	Mean	Std Dev
Total monetary disposable income	22.9	0.42
Per capita monetary disposable income	17.4	0.38
per capita equivalence scale		
Per UC monetary disposable income	15.2	0.36
PH monetary scale*		
Total full disposable income	19.1	0.39
Per capita full disposable income	16.5	0.37
Per UC full disposable income	6.9	0.25
*PH** full income scale*		
Poverty rate by	4.6	0.21
monetary and full income poverty status		
PH scale*		

Source: Matched Family Budget Survey with Time Use Survey.
10,255 observations used in estimations.
*monetary Prais-Houthakker equivalence scale: 0.404, 0.241
**full Prais Houthakker equivalence scale: 0.307, 0.241

The fact that the difference between the full cost of a child and its monetary cost increases when taking into account price substitutions in an Independent of Base specification, shows that, generally, these substitutions are easier for the adult compared to children spending: expenditures for children decrease more the level of well-being in full prices terms than in monetary terms, because they cannot be substituted for cheaper expenditures. The explanation may be that, the time cannot be easily substituted between its different uses for children. The consequences in terms of public policies is for example the fact that the indirect taxation which applies only to the monetary component of the full prices would not be fully efficient to increase the well-being of families with children.

Heterogeneity between households may influence these results. For instance, low educated adults may be constrained on the labor market (having difficulties in finding a job which would be correlated with the value of their domestic production). In that case, they would increase their domestic activities beyond the level corresponding to their marginal productivity, thus their domestic production would be over-evaluated by the market wage, implying an over-evaluation of their full income. Therefore, low educated people would have a smaller monetary income, because of rationing on the labor market, and a higher full income than in a non-rationing situation. That would imply an under-evaluation of full income inequality compared to monetary measures[9].

This article presents two innovative methodological characteristics: first, it allows computing full prices at the individual level and thus takes into account price substitution effects *à la Barten* caused by the presence of children. Second, child costs and inequality indices are computed for full expenditures and compared to those corresponding to monetary expenditures.

Adding the time value of different domestic activities to the monetary expenditures results in an increase in the estimated child cost compared to an extra

[9]Argument suggested by Stéphane Gauthier.

adult cost. This result is particularly important for those households which can substitute between these two components of the full expenditure. This can be the case for example of wealthy households which are able to buy services in order to decrease the time component of their non-market activities. Therefore, official family scales may be under-estimated for those families. It may also have strong implications for the inside family monetary and time resources sharing rules. A second important result lies in the difference between estimates performed with or without price substitution, which shows the existence of such effects for households' choices: therefore, all estimations of equivalence scales made without concern of this substitution may be biased. This validates the spirit of Barten's methodological proposal. Finally, inequality indices decrease significantly when the value of domestic production is included in households' full income.

References

Abadie, A. and G. W. Imbens, "Large Sample Properties of Matching Estimators for Average Treatment Effects," *Econometrica*, 74, 235–57, 2006.

Aguiar, M. A and E. Hurst, "Time-use During the Great Recession," *American Economic Review*, 103.5, 1664–96, 2013.

Alpman A. and F. Gardes, "Time-Use during the Great Recession, a Comment," CES Working Paper, 2015.12, PSE, University Paris I Panthéon Sorbonne, 2015.

Apps, P. F. and R. Rees, "Household Production, Full Consumption and the Costs of Children," *Labour Economics*, 8, 621–648, 2002.

Barten, A. P., "Family Composition, Prices and Expenditures Patterns" in P. E. Hart, G. Mills, J. K. Whitaker (eds), *Econometric Analysis for National Economic Planning*. Butterworths, London, 1964.

Becker, G. S.,"A Theory of the Allocation of Time", *The Economic Journal*, 75, 493–517, 1965.

Biewen, M. and A. Juhasz, "Understanding Rising Inequality in Germany, 1999/2000–2005/06," *Review of Income and Wealth*, 58, 62–647, 2012

Bittman, M. and R. E, Goodin, "An Equivalence Scale for Time," *Social Policy Research Centre Discussion Paper*, 85, 1998.

Blackorby, C. and D. Donalson, "Adult Equivalence-Scales and Interpersonal Comparisons of Well-Being and Applied Welfare Economics," in Elster, J. and J. Romer (eds), *Interpersonal Comparison an Distributive Justice*, Cambridge University Press, 164–99, 1991.

Blundel, R. and A. Lewbel, "The Information Content of Equivalence Scales," *Journal of Econometrics*, 50, 49–68, 1991.

Bradbury, B., "The Price, Cost, Consumption and Value of Children," *Social Policy Research Centre, Discussion Paper*, 132, 2004

Buhmann, B., L. Rainwater, G. Schmaus, and T. M. Smeeding, "Equivalence Scales, Well-Being, Inequality, and Poverty: Sensitivity Estimates Across Ten Countries using the Luxembourg Income Study (LIS) database," *Review of Income and Wealth*, 34, 115–42, 1988.

Cramer, J. S., *Empirical Econometrics*, North Holland Amsterdam, 1969.

Deaton, A. and J. Muellbauer, "Economics and Consumer Behavior," Cambridge University Press, 1980.

Donaldson, D. and Pendakur K., "Equivalent Expenditure Functions and Expenditure-Dependent Equivalence Scales," *Journal of Public Economics*, 88,175–208, February 2005.

Ekert-Jaffé, O. and S. Grossbard, "Time Costs of Children as Parents Foregone Leisure," *Mathematical Population Studies*, 22, 80–100, 2015.

Eurostat Proposal for a Satellite Account of Household Production, Eurostat Working Papers, 9/1999/A4/11 p. 7, 1999.

Gardes, F., "Full Price Elasticities and the Opportunity Cost for Time," Working Paper, *Centre d'Economie de la Sorbonne*, 2014.14, 2014.

———, "The Estimation of Price Elasticities and the Value of Time in a Domestic Framework: An Application on French Micro-Data," under revision in *Annals of Economics and Statistics*, 2016.

Gardes F., I. Sayadi, and C. Starzec, "Les Échelles d'Équivalence Complètes: Une Estimation Intégrant les Dimensions Monétaire et Temporelle des Dépenses des Ménages," *Revue d'Economie Politique*, N°3, 317–474, 2015.

Goldschmidt-Clermont, L., "Monetary Valuation of Non-Market Productive Time, Methodological Considerations," *Review of Income and Wealth Series*, 39, 419–33, 1993.
Gronau, R. and D. S. Hamermesh, "Time Vs. Goods: The Value of Measuring Household Production Technologies," *Review of Income and Wealth*, 52, 1–16, 2006.
Havrylyshyn, O., "The Value of Household Services: A Survey of Empirical Estimates," *The Review of Income and Wealth*, 22, 102, 1976.
Hoa, T. V., "Measuring Equivalence Scales: a New System-Wide Approach," *Economics Letters*, 20, 95–9, 1986.
Holloway S.,S. Short, and S. Tamplin, "Household Satellite Account (experimental), Methodology, UK Office for National Statistics," www.statistics.gov.uk/hhsa/downloads. 2002.
INSEE Budgets de Famille (BDF), 2001, www.insee.fr/fr/ffc/docs_ffc/irsoc29.pdf
INSEE Emploi du Temps (EDT), 1999, in "Enquête Emploi Du Temps 1998–1999. Description des Activités Quotidiennes," Insee Résultats—Consommation Modes de Vie, n°101–,102, January 2000.
Lewbel, A, "Household Equivalence Scales and Welfare Comparisons," *Journal of Public Economy*, 39, 377—91, 1989.
Nelson, J. A., "Independent of a Base Equivalence Scales Estimation Using United States Micro-Level Data," *Annals of Statistics and Econometrics*, 29, 43–63, 1993a.
———, "Household Equivalence Scale: Theory versus Policy?," *Journal of Labor Economics*, 11, 471–93, 1993b.
Pollak, R. A., and T. Wales, "Welfare Comparisons and Equivalence Scales," *American Economic Review*, 69, 216–221, 1979.

Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web-site:

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