Using Self Reported Income in a Collective Model: Within – Household Income Comparisons

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We propose a method of application of the collective model to the analysis of intra-household inequality using self reported income scales. The resources taken into account are labour, non-labour incomes and household production output. Starting with a collective model including household production under the assumption of marketable domestic goods, we look at the links between self-reported income and the theoretical results of the collective model. Members of households are assumed here to report an income level corresponding to their true income sharing. Using Russian data (Round V to VIII of the Russian Longitudinal Monitoring Survey), the model is estimated by the method of full information maximum likelihood (FIML). We first use the results obtained with couples who report the same level of income, interpreting this as an equal sharing of income. We then identify the sharing rule for the whole sample: we thus propose a new method for deriving, not only the derivatives, but the sharing rule itself.

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INTRODUCTION

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A very important issue in applications of the economics of the household to policy analysis is that of within-household welfare comparisons and, in particular, of intra-family inequality. The present article studies this issue in the framework of a collective model of household behaviour.

The purpose of the paper is methodological. We propose an application of the collective model to the analysis of intra-household inequality using self reported income scales. The collective model based on the sharing rule provides a theoretical framework to determine intra-household allocation of resources (Chiappori (1988, 1992, 1997), Apps and Rees (1997)). What we do here is to interpret intra-household equality as an equal distribution of full income between the (main two adult) members of the household. As usual, labour as well as non-labour income are included in household resources, but also the output of household production. When including the latter in full income, we follow recent models by Apps and Rees (1997), Chiappori (1997), or Solaz, Rapoport and Sofer (2003), (2005)). Such an approach better reflects the true consumption of leisure by both members of the household than more standard collective models. Also, the data we use (Russia Longitudinal Monitoring Survey, RLMS) allow us to do this.

Starting with a collective model including household production under the assumption of marketable domestic goods (Rapoport, Sofer and Solaz, 2003, 2005), we look at the links between self-reported income and the theoretical results of the collective model.

Then using the results obtained with couples who report the same level of income, interpreting this as an equal sharing of income, we derive the constant of the sharing rule for the whole sample: we thus propose a new method for deriving, not only the derivatives, but the sharing rule itself (cf. Browning, Chiappori and Lewbel, 2004).

Usually, the derivatives of the sharing rule are estimated using simultaneous labour supply equations for husband and wife (Browning and Chiappori (1988), Chiappori, Fortin and Lacroix, 2002). Adding household production leads to two simultaneous equation of full labour supply (including household work, Rapoport, Sofer and Solaz, 2005). We add a third equation estimating the probability of household members' discrepancy between their levels of income. The model thus can be formulated as an endogenous probit model: the probit equation comparing income levels of household members derives from the sharing rule, from which in turn leisure demands are derived. The model is estimated by the method of full information maximum likelihood (FIML).

Under the assumptions made, the estimation of leisure demands permits the recovering of the sharing rule derivatives. In a further stage, we recover in addition the constant of the sharing rule from the sample of households who give the same answer to the income ladder question.

In recent years a large number of empirical studies, aims at analysing self-reported income and poverty [Ferrer-i-Carbonell and Frijters (2004)]. While Ravallion and Lokshin (2001, 2002) argue that "the welfare inferences drawn from answers to subjective survey questions are clouded by concerns about measurement errors and how latent psychological factors influence observed respondent characteristics", subjective measure of income and poverty is used as a supplement to conventional socio-economic poverty measures. Though aware of the "clouds" mentioned above, we choose here to consider that the main reason why the two members of the family report different incomes in the survey might well be that they do get unequal incomes from household income sharing. As a matter of fact, and as predicted by non-unitary models (bargaining models as well as collective models), many households report distinct income value for husband and wife in the RLMS survey.

The paper is organized as following. Section 1 outlines the collective model of household labor supply with household production based upon Rapoport, Sofer, Solaz (2003, 2005). We then present its application to intra-household equality. Section 2 describes the data. Section 3 presents an econometric specification of the model and introduces the Maximum Likelihood Estimation methodology for its estimating. Section 4 presents the results. Finally, further steps are discussed in conclusions.

1. MODEL

In this section we derive conditions for an equal sharing of full income starting with a collective model including household production (Rapoport, Sofer, Solaz, 2003, 2005). These papers give a method for estimating the derivatives of the sharing rule under the assumption of marketable domestic goods. We extend the results to propose a method allowing an identification of the sharing rule itself.

1.1. The Collective Model with Household Production.

Consider two individuals *(i = f,m)*. Each has a utility function depending on leisure (assignable and observed), L_i, on the consumption of a Hicksian composite good (unobserved), C_i, with a normalized price of 1, and on a vector of domestic goods ***Y***.

Besides the market good, C_i, bought in the market, the household produces the vector of domestic goods, ***Y***. Let the production function of the k[th] domestic good[4] be

$$Y^k = g^k(t^k_f, t^k_m ; \mathbf{z}), \qquad k= 1, \ldots K,$$

where t^k_i, *(i=f,m)* is member *i*'s household work devoted to the production of domestic good *k,* and *z* is a vector of household characteristics. We assume that all goods are privately consumed.

Utility can be written: $u_i = u_i(L_i, C_i, Y_i; z)$, where $\mathbf{Y_i}$ is the vector of member's *i* consumption of domestic goods.

Let $t_i = \sum_k t_i^k$ *(i=f,m)* be the total time that household member i devotes to the production of domestic goods, and *T* the total time available, **z** is the an N-vector representing part of the individual heterogeneity in utility and in domestic production. Let **s** be an R-vector of distribution factors[5], *y* the household's non-labour income, and w_f, and w_m the wage rate of *f* et *m* respectively.

1.1.1. Household Maximisation Problem.

In the collective model with household production, the Pareto-efficient solution comes from program (P1):

$$\underset{L_f, C_f, Y_f, L_m, C_m, Y_m}{Max} \mu_f(.)U_f(L_f, C_f, Y_f, \ldots; \mathbf{z}) + \mu_m(.)U_m(L_m, C_m, Y_m, \ldots; \mathbf{z})$$

subject to (P1)

$$C_f + C_m + p.Y_f + p.Y_m + L_f w_f + L_m w_m \leq T w_f + T w_m + y + \Pi(w_f, w_m, \mathbf{p})$$

where $\mu_i = \mu_i(w_f, w_m, y, \mathbf{s}, \mathbf{z})$ are continuously differentiable weighting factors contained in [0, 1] such that $\mu_f + \mu_m = 1$. $\Pi(w_f, w_m, \mathbf{p})$ is the profit function from the household production. Assume from now on that domestic goods are marketable: they have market

[4] We assume that there is no joint production in the household production sector.
[5] Distribution factors are variables which influence the bargaining power of household members, but neither prices nor preferences, (cf Chiappori, Fortin, Lacroix, 2002)

substitutes and can be freely exchanged in the market. **p** is thus an exogenous price vector for domestic goods, the same for all households, and it can be considered as fixed in what follows. It will thus be omitted in the notations.

1.1.2. Decentralisation.

As in Apps and Rees (1997) and Chiappori (1997), the second theorem of welfare economics implies that the equilibrium corresponding to program (P1) can be decentralized and the solution can be obtained in two stages.

First, the household determines the optimal allocation of time of each member in domestic production, using the criterion of the maximization of profit or net value of domestic production. This imputed profit is added to the other income flows. In the second stage, consumption is decentralized by the appropriate choice of shares Φ_i ($i = f, m$) of total full income. Program (P1) is thus reformulated as (P2.1) and (P2.2):

$$\underset{t_f, t_m}{Max}\, \Pi = pY - w_f t_f - w_m t_m \qquad \text{(P2.1)}$$

$$\underset{C_i, L_i, Y_i}{Max}\, U_i(L_i, C_i, Y_i, ...; \mathbf{z}), \qquad i = f, m$$

subject to budget and time constraints: (P2.2)

$$C_i + pY_i + L_i w_i \leq \Phi_i$$

$$L_i + h_i + t_i = T,$$

where the sharing rule $\Phi_i(w_f, w_m, p, y; \mathbf{s}, \mathbf{c}, \mathbf{z})$ represents the part of full income allocated to member *i*, with:

$$\Phi = \Phi_{f+} \Phi_m = (w_f + w_m)T + y + \Pi$$

1.1.3. Sharing Rule.

Let h_i be member i's market labor supply, $H_i = h_i + t_i$ the *i*th member total labor supply including work in household production.

Extending Chiappori, Fortin, Lacroix (2002), Rapoport, Sofer Solaz (2003) show that identifying the sharing rule over full income Φ_i is equivalent to identifying a sharing rule over the sum of household's exogenous income and of household production profit:

$$\Phi_i = h_i w_i + t_i w_i + L w_i + \psi_i = T w_i + \psi_i, \qquad i = f, m \qquad (1.1)$$

with $\psi_f + \psi_m = y + \Pi$.

Denoting $\psi_f = \psi(w_f, w_m, y; \mathbf{s}, \mathbf{z})$ and $\psi_m = y + \Pi - \psi$, the budget constraints of program (P2.2) can be rewritten as:

$$C_f + pY_f \leq w_f H_f + \psi$$

$$C_m + pY_m \leq w_m H_m + y + \Pi - \psi$$

The price vector **p** being fixed is omitted from the endogenous functions of the model.

1.1.4. Demands for Leisure.

Resolving program (P3) below, which is a reformulation of the (P2), yields the Marshallian demands (3) and (4) for leisure. Noting $\boldsymbol{Y} = \boldsymbol{Y_f} + \boldsymbol{Y_m}$:

$$\underset{t_f, t_m}{Max}\, \Pi = pY - w_f t_f - w_m t_m \qquad \text{(P3.1)}$$

$$\underset{C_i, L_i, Y_i}{Max}\, U_i(L_i, C_i, Y_i, ...; \mathbf{z}), \qquad i = f, m$$

subject to: (P3.2)

$$C_f + pY_f \leq w_f H_f + \psi$$

$$C_m + pY_m \leq w_m H_m + y + \Pi - \psi$$

$$L_i + l_i + t_i = T,$$

$$L_f = L^f(w_f, \psi(w_f, w_m, y, \mathbf{s}, \mathbf{z}); \mathbf{z}) \qquad (1.2)$$

$$L_m = L^m(w_m, y + \Pi - \psi(w_f, w_m, y, \mathbf{s}, \mathbf{z}); \mathbf{z}) \qquad (1.3)$$

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1.2. Intra-household income comparisons.

1.2.1. Intra-household equality and the sharing rule.

Assuming intra household equality can be made in different ways. One can possibly assume, for example, that it means an equal bargaining power of the two household members, which would lead to choose as a social welfare optimum the maximum of the purely utilitarian social welfare function. Here, we are using data which give the answer to a subjective question about income. People have to subjectively situate their income on a 9-steps ladder. Making the usual assumption of no specific bias in the answers, we directly relate their answer to the subjective income question to the income they objectively get within the family. The assumption made here is that people's answers to this question give us information on the income share allocated to them within the household. Intra-household

equality will thus be defined below as equality in the sharing of full income, which in turn is measured as both husband and wife giving the same answer to the income question. More precisely, we shall assume that:

$\Phi_f > \Phi_m$, if the wife gives a strictly higher value to her income on the 9-steps ladder than her husband

$\Phi_f < \Phi_m$, if she gives a strictly lower value to her income on the 9-steps ladder than her husband

$\Phi_f = \Phi_m$, if husband an wife give the same answer to the income question.

The definitions of $\Phi_f = w_f T + \psi$ and $\Phi_m = w_m T + y - \psi$ imply the following system giving the intra-household equality criterion:

$$\begin{cases} \psi < \frac{1}{2}\left[(w_m - w_f)T + y + \Pi\right], & \text{if } \Phi_f < \Phi_m \\ \psi = \frac{1}{2}\left[(w_m - w_f)T + y + \Pi\right]. & \text{if } \Phi_f = \Phi_m \\ \psi > \frac{1}{2}\left[(w_m - w_f)T + y + \Pi\right], & \text{if } \Phi_f > \Phi_m \end{cases} \quad (1.4)$$

2. DATA

The data used in the econometric analysis come from the Russia Longitudinal Monitoring Survey (RLMS). This database has been jointly collected by Chapel Hill University (USA), the Russian Academy of Sciences and the Russian Institute of Nutrition.

The survey has two phases: during the first phase of the project (1992 - 1994), the RLMS collected four rounds (I – IV) of data on 5900 households on average; beginning in 1994 and ongoing, the RLMS has collected seven rounds (V - XII) of data in the second phase of the project. Since the RLMS switched collaborators in Russia for the second phase, the second phase data were drawn anew from the population. The second phase sample size is approximately 4000 households. The samples of the two phases are not comparable. The RLMS is a longitudinal study of populations of dwelling units, thus the data (set) has a repeated cross-section design which disadvantages a micro-level analysis of longitudinal change at the household or individual level. The exception is the potential to link households and individuals who remain in the original dwelling unit over time, but such a "panel" may be

vulnerable to selection bias when reasons for moving are correlated with the dependent variable of interest. This is not a problem for us, for we use the survey as cross-sectional data.

Two questionnaires are proposed to survey respondents: one of them is the household questionnaire, the other is the individual one. The first asks for information about household structure, expenditures, incomes, housing conditions, land use, etc. The second one questions on employment, labour income, educational level, economic conditions satisfaction, etc. The adult questionnaire for the rounds I – VIII (1992 – 1999) includes the section "Use of Time". This section contains the questions about amount of time used on the household occupations in the last 7 days preceding the interview. These occupations are working on the individual land plot, dacha, or garden plot, excluding farm plots or a personal subsidiary farm; looking for and purchasing food items; preparing food and washing dishes; cleaning the apartment; doing laundry, ironing linens, clothes; looking after the children; caring for any (other) children – either relatives or not – aged 12 or younger, who don't live with interviewee and caring for whom is not part of interviewee's job; looking after the father of more than 50 years old (going to the store, helping with cleaning, washing clothes, …); looking after the mother of more than 50 years old; helping relatives or acquaintances of more than 50 years old.

We use data from the rounds V– VIII (1994 – 1998) of phase II as we need The Use of Time questionnaire which allows including household production in the empirical analysis. The sample selected for the econometric analysis consists of couples where both partners are in the labour force and the household head is active. That is, men are between 16 and 59 years old and both partners work. The selection gives an unbalanced panel of 1480 households (household heads) or 2419 observations as some households are observed several times. After excluding households with missing values for needed variables we are left with 2103 observations for econometric estimations.

Table 1 shows sample means of variables used in the econometric analysis. In this table, the wage rates for each period are adjusted for inflation by converting them in dollars according to the exchange rate corresponding to the period.

Table 1 **Sample Means of Variables**

Variable	Women			Men		
	Round VIII Means	Round VII Means	Round VI Means	Round VIII Means	Round VII Means	Round VI Means
Market time per week (h_i), hrs	38.78 (15.38)	38.41 (14.68)	39.5 (12.23)	44.72 (17.25)	44.75 (16.84)	45.22 (12.99)
Domestic time per week (hh_i),	46.87 (29.8)	45 (30.7)	42.9 (30.4)	14.72 (16.47)	15.71 (19.36)	13.74 (17.52)

hrs						
Working time per week (H_i), hrs	85.66 (31.92)	83.23 (31.49)	82.36 (31.53)	59.39 (22.69)	60.43 (24.93)	58.95 (22.48)
Hourly wage (w_i), $	0.23 (0.43)	0.35 (4)	0.67 (1)	0.46 (3.28)	0.4 (0.74)	0.99 (2.58)
Total monthly income (Y)	18.24 (34.57)	18.51 (33)	53.28 (95.44)	25.89 (54.18)	28.81 (57.16)	77.36 (135.12)

Source: data base RLMS.
Exchange rates: 1997 (round VI): 5.1 rub. / 1$;
1998 (round VII): 21 rub. / 1$;
1999 (round VIII): 27 rub. / 1$.

3. ECONOMETRIC MODEL

In this section we first discuss household members' income comparisons as allowing an empirical analysis of intra-family inequality. Then we present the econometric model.

3.1. Self-reported income and its interpretation.

To measure individual income, we use the following Subjective Economic Ladder question asked in the RLMS: "Please imagine a 9-step ladder where on the bottom, the first step, stand the poorest people, and on the highest step, the ninth, stand the rich. On which step are you today?" We use the answers to this question to analyze the intra-family correlation in answers. In the present study we make he assumption that household members give the same answer to this question if they get the same share (the half) of household full income which includes monetary (market and domestic), as well as non monetary income.

For the descriptive statistics analysis we take all couples in which individuals responded to the above question. To analyze self-rated income, we aggregated the highest 6, 7, 8, and 9 ranks of the ladder into one due to a small number of respondents who considered themselves as richest. Table 2 summarizes responses to this question. The great majority of individuals feel poor: taking the poorest two rungs to be the subjectively poor, the subjective poverty rate rose from 19,12% in 1994 to 23,91% in 1998. Most individuals are concentrated on steps 3, 4 and 5.

Table 2. Income levels.

Economic Ladder Question 1- the poorest; 6 – the richest	Round5(1994) Number *(%)*	Round6(1995) Number *(%)*	Round7(1996) Number *(%)*	Round8(1998) Number *(%)*
1	109 *(6,01)*	145 *(9,13)*	72 *(6,26)*	102 *(8,13)*
2	238 *(13,11)*	184 *(11,58)*	147 *(12,78)*	198 *(15,78)*

3	471 *(25,95)*	350 *(22,03)*	266 *(23,13)*	333 *(26,53)*
4	462 *(25,45)*	403 *(25,36)*	291 *(25,30)*	309 *(24,62)*
5	404 *(22,26)*	386 *(24,29)*	280 *(24,35)*	243 *(19,36)*
6	131 *(7,22)*	121 *(7,61)*	94 *(8,17)*	70 *(5,58)*
Total (individuals)	1815 *(100)*	1589 *(100)*	1150 *(100)*	1255 *(100)*

Source: data base RLMS (rounds5-8).
Sample: couples (individuals who answer the question)

In this paper we are interested in income discrepancies within a given household. Table 3 looks at differences in the Economic Ladder answers of husband and wife. We selected married households' heads and compared their answer to that of their spouse. On average, in more than 50% of households men and women respond differently to the subjective question (cf. Table 3). Almost 18% of men feel one step poorer than their wives and 10% differ by more than 2 steps. On average, women report lower incomes than men in the same households: in 1998, more than 34% of households report a wife's lower income versus only 28% of husbands reporting being poorer. Our interpretation of the difference is that, as income sharing is the result of a bargaining process, income is not necessarily equally shared between husband and wife.

Table3. Within household discrepancies in self reported income

Wife score minus husband score	Round5(1994) Number *(%)*	Round6(1995) Number *(%)*	Round7(1996) Number *(%)*	Round8(1998) Number *(%)*
-2	87 *(10,82)*	61 *(9,38)*	53 *(11,35)*	60 *(11,83)*
-1	139 *(17,29)*	126 *(19,38)*	101 *(21,63)*	112 *(22,09)*
0	339 *(42,16)*	283 *(43,54)*	188 *(40,26)*	192 *(37,87)*
1	142 *(17,66)*	127 *(19,54)*	80 *(17,13)*	95 *(18,74)*
2	97 *(12,06)*	53 *(8,15)*	45 *(9,64)*	48 *(9,47)*
Total households	804 *(100)*	650 *(100)*	467 *(100)*	507 *(100)*

Source: data base RLMS (rounds5-8).
Sample: couples (husband and wife responses)
0- there is no difference between husband and wife responses. -1 – woman is situated one step lower than his spouse, -2 –woman is situated more than 2 steps lower than his spouse. 1- woman is situated one step higher than his spouse, 2 – woman is situated more than 2 steps higher than his spouse.

On the basis of these discrepancies we construct an index of intra household inequality for the empirical application. This index is equal to 0 if the within household response difference is negative (a wife reports being poorer than her husband), to 1 if there is no difference between husband and wife responses and to 2 if a wife reports being richer than her husband (the difference is positive).

3.2. Econometric specification of the model.

Adding household production leads to two simultaneous equations for full labour supply (including household work, Rapoport, Sofer and Solaz, 2005). We add a third equation estimating the probability of a household members' discrepancy between their levels of income. This equation is formulated as an endogenous ordered probit model (5): the ordered probit equation comparing income levels of household members derives from the sharing rule. In a second stage, we use the results obtained from the estimations above to draw the constant of the sharing rule, in addition to its derivatives. For this, we use the sample of households who give the same answer to the subjective ladder question, and for whom we assume that income is shared equally.

3.2.1. The Endogenous Ordered Probit Model.

Let I be an index function taking values 0, 1 or 2 depending on whether the difference observed between female and male levels of income is negative, zero or positive.

$$I = \begin{cases} 0, & \text{if } \Phi_f < \Phi_m \\ 1, & \text{if } \Phi_f = \Phi_m \\ 2, & \text{if } \Phi_f > \Phi_m \end{cases} \qquad (3.1)$$

Let ψ^* be a criterion function related with an unobservable sharing rule:

$$\psi^* = \boldsymbol{\gamma}'\mathbf{Z} + \varepsilon ,$$

where $\mathbf{Z}$ is a vector of household specific characteristics and distribution factors assumed to influence the sharing rule. In particular, it contains the wage rate difference $(w_m - w_f)$ and non-labour income *y*. Note that here (as well as in the data), the household exogenous income *y* can be individualized, which also implies that individual exogenous incomes can be used as distribution factors.

Then the index function is specified as

$$I = \begin{cases} 0, \text{ if } \psi^* \le \kappa_1 , \\ 1, \text{ if } \kappa_1 < \psi^* \le \kappa_2 , \\ 2, \text{ if } \psi^* > \kappa_2 , \end{cases} \qquad (3.2)$$

where k_1 and k_2 are unknown parameters to be estimated.

Recall that the sharing rule ψ depends on the domestic production profit Π which is endogenous as household production depends on the time devoted to household work. Thus, the system (3.2) should be completed by the equations describing household work. The resulting system (3.3) is the econometric representation of the theoretical model (1.4):

$$\begin{cases} \text{I} = 0, \text{ if } \psi^* \le \kappa_1, \\ \text{I} = 1, \text{ if } \kappa_1 < \psi^* \le \kappa_2, \\ \text{I} = 2, \text{ if } \psi^* > \kappa_2, \\ \\ t_f = \boldsymbol{\alpha}'_1 \mathbf{X}_1 + u_1 \\ t_m = \boldsymbol{\alpha}'_2 \mathbf{X}_2 + u_2 \end{cases} \tag{3.3}$$

where $\mathbf{X}_i$ are the vectors of individual i specific characteristics and household specific productivity factors. ε, u_1, u_2 are assumed to have a trivariate standard normal distribution with zero mean vector and covariance matrix $\boldsymbol{\Sigma}$:

$$\boldsymbol{\Sigma} = \begin{pmatrix} 1 & \rho_1 & \rho_2 \\ \rho_1 & 1 & \rho \\ \rho_2 & \rho & 1 \end{pmatrix}$$

with $\rho_i = cov\ (\varepsilon, u_i)$ and $\rho = cov\ (u_1, u_2)$.

3.2.2. Maximum likelihood estimation.

The model is estimated by the method of maximum likelihood (MLE). The method of estimation implements the full information ML procedure to simultaneously estimate *ordered* and continuous parts of the model in order to provide consistent standard errors.

The likelihood function for the system of equations (5.2-5.4) is:

$$L = \prod_{i:I=0} F\left((\kappa_1 - \boldsymbol{\gamma}_i' \mathbf{Z}_i) | u_1, u_2\right) \times$$
$$\times \prod_{i:I=1} \left[F\left((\kappa_2 - \boldsymbol{\gamma}_i' \mathbf{Z}_i) | u_1, u_2\right) - F\left((\kappa_1 - \boldsymbol{\gamma}_i' \mathbf{Z}_i) | u_1, u_2\right)\right] \times$$

$$\times \prod_{i:I=2} \left[1 - F\left((\kappa_2 - \boldsymbol{\gamma}_i' \mathbf{Z}_i) \middle| u_1, u_2\right)\right]$$

i notes the ith observation, $F\left(.\middle| u_1, u_2\right)$ is a conditional cumulative distribution function of ε on u_1, u_2.

Variable $\varepsilon | u_1, u_2$ follows a normal distribution. Denoting

$$\widetilde{\Sigma} = \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}$$

we find it's mean μ and variance σ^2 by (Green, 2000):

$$\mu = (\rho_1, \rho_2)\widetilde{\Sigma}^{-1}(u_1, u_2)' = \left[(\rho_1 u_1 + \rho_2 u_2) - \rho(\rho_1 u_2 + \rho_2 u_1)\right] / \left(1 - \rho^2\right)$$

$$\sigma^2 = 1 - (\rho_1, \rho_2)\widetilde{\Sigma}^{-1}(\rho_1, \rho_2)' = 1 - \left[\rho_1{}^2 + \rho_2{}^2 - 2\rho\rho_1\rho_2\right] / \left(1 - \rho^2\right)$$

Thus, the logarithmic likelihood function can be defined in terms of cumulative standard normal distribution as following:

$$\ln L = \sum_{i:I=0} \ln F_0\left(z_i^1\right) + \sum_{i:I=1} \ln\left(F_0\left(z_i^2\right) - F_0\left(z_i^1\right)\right) + \sum_{i:I=0} \ln\left(1 - F_0\left(z_i^2\right)\right)$$

with F_0 standing for the cumulative standard normal distribution function and $z_i^j = (k_j - \boldsymbol{\gamma}_i' \mathbf{Z}_i - \mu)/\sigma$, ($j$=1, 2).

3.2.3. Identification of the sharing rule : a new method

Distribution factor approach

According to Rapoport, Sofer, Solaz (2003), if the allocations of household member time between domestic work, market work and leisure are observable and there exists at least one observable distribution factor, the sharing rule can be recovered up to a constant. Applying the method of retrieving derivatives of the sharing rule proposed by the same authors to the case when the observable distribution factor is an individual non-labour income, we have:

$$\frac{\partial \psi}{\partial y_f} = \frac{D - 1}{D - C},$$

$$\frac{\partial \psi}{\partial y_m} = \frac{C(D-1)}{D-C},$$

$$\frac{\partial \psi}{\partial w_f} = -t_f + \frac{B(D-1)}{D-C}, \tag{3.5}$$

$$\frac{\partial \psi}{\partial w_m} = A\frac{D-1}{D-C},$$

where $A = \frac{L^f_{w_m}}{L^f_{y_f}}$, $B = \frac{L^m_{w_f}}{L^m_{y_f}}$, $C = \frac{L^f_{y_m}}{L^f_{y_f}}$, $D = \frac{L^m_{y_m}}{L^m_{y_f}}$.

The terms A, B, C, D can be calculated from the simultaneous estimation of total labour supply (market plus domestic work):

$$\begin{cases} H_f = \boldsymbol{\beta}'_1 \mathbf{Q} + v_1 \\ H_m = \boldsymbol{\beta}'_2 \mathbf{Q} + v_2 \end{cases} \tag{3.6}$$

where $\mathbf{Q} = (w_f, w_m, y_f, y_m, \mathbf{c}, \mathbf{z})$, is a vector which components are individuals' specific characteristics and household specific distribution factors. v_1, v_2 are distributed bivariate normally.

The next step is to identify the constant of the sharing rule in addition to its derivatives. To do this, assume that, as permitted here by the data, and in addition to conditions (3.5), there is an observable index of intra-household equality:

Let $\psi = \tilde{\psi}(w_f, w_m, y_f, y_m; \mathbf{c}, \mathbf{z}) + \psi_0$, where $\tilde{\psi}(w_f, w_m, y_f, y_m; \mathbf{c}, \mathbf{z})$ is the sharing rule defined up to a constant by the system (12) and ψ_0 is the constant to determine.

Then, assuming for the moment that Π is observable (which is not the case), ψ_0 can be retrieved from the observation of the sample of households who share full income equally.

For this sample, one gets:

$$\psi(\mathbf{s}) = \tilde{\psi}(w_f, w_m, y_f, y_m; \mathbf{c}, \mathbf{z}) + \psi_0 = \frac{1}{2}\left[(w_m - w_f)T + y + \Pi\right] \tag{3.7}$$

As $\tilde{\psi}(w_f, w_m, y_f, y_m; \mathbf{c}, \mathbf{z})$ is obtained from (3.6) and the term on the right of (3.7) is observed (by assumption), ψ_0 can easily be identified.

Under the assumptions:

1/ That income is shared equally within the sample of households who give the same answer to the subjective ladder question, and

2/ That profit from domestic production, Π is observable

Then, the constant of the sharing rule $\psi(\mathbf{s})$ can be identified.

As, unfortunately, Π can never be observed, using assumption 1/ above, what we do in addition is to assume that, empirically, the surplus from domestic production is negligible compared to the other sources of household income. This is equivalent to assuming that household production is evaluated at its market price, i.e. wages.

A *first* empirical justification for this is the very low values found for the correlations between domestic work and the sharing rule equations (ρ_1 and ρ_2 from equations (3.3) above). The correlation between man's domestic work and the index of intra household inequality is positive, very weak (0,004) and not significant (at 5% level). As for women, the correlation is also very low and not significant (at 5% level) but negative (-0,0103). As, for households where both members participate in the labor market, Π is the only channel in the theoretical model through which domestic work and the sharing rule could be correlated, this finding supports the assumption made.

Based on the sample of households who give the same answer to the subjective ladder question, the following procedure is carried out :

$\psi(\mathbf{s})$ can be approximated as

$$\psi(\mathbf{s}) = \psi_0 + \Delta\psi(\Delta\mathbf{s}), \tag{3.8}$$

where $\Delta\psi, \Delta\mathbf{s}$ are the variations of $\psi, \mathbf{s}$ respectively and $\Delta\psi$ can be defined by:

$$\Delta\psi(\Delta\mathbf{s}) = \mathbf{grad}(\psi(\mathbf{s})) \cdot \Delta\mathbf{s} \tag{3.9}$$

Note that $\mathbf{grad}(\psi(\mathbf{s}))$ is calculated according to (3.5). Then from (3.8) and (3.9) we have an expected value of the sharing rule constant:

$$E(\psi_0) = E(\psi - \mathbf{grad}(\psi(\mathbf{s})) \cdot \Delta\mathbf{s}) =$$

$$= E(\psi) - \mathbf{grad}(\psi(\mathbf{s}))E(\Delta\mathbf{s}) =$$

The derivatives of ψ can be identified as long as a significant distribution factor, or individualized non labor income, can be used, allowing to make the calculations according to (3.5) (Chiappori, Fortin Lacroix, 2002; Rapoport Sofer Solaz 2005).

Even when no significant distribution factor is found, a direct identification can nevertheless be obtained, based on the additional condition provided by the index of intra-household equality. The corresponding methodology is formulated as a two-stages 3SLS.

A Two-stages estimation approach

The total labour supply of household members are

$$\begin{cases} H_f = \alpha_1 + \beta_1 \Phi_f + \boldsymbol{\gamma}_1 \mathbf{X}_1 + e_1 \\ H_m = \alpha_2 + \beta_2 \Phi_m + \boldsymbol{\gamma}_2 \mathbf{X}_2 + e_2 \end{cases} \tag{3.10}$$

with

$$\begin{cases} \Phi_f = \boldsymbol{\delta}_1 \mathbf{X} + \lambda_1 \\ \Phi_m = \boldsymbol{\delta}_2 \mathbf{X} + \lambda_2 \end{cases}, \tag{3.11}$$

where $(\alpha_1, \alpha_2, \beta_1, \beta_2), \boldsymbol{\gamma}_1, \boldsymbol{\gamma}_2, \boldsymbol{\delta}_1, \boldsymbol{\delta}_2$ are the parameter vectors; $\mathbf{X}_1$ and $\mathbf{X}_2$ are the vectors of female and male individual characteristics respectively; the vector $\mathbf{X} = (w_f, w_m, y_f, y_m, \mathbf{c}, \mathbf{z})$; $e_1, e_2, \lambda_1, \lambda_2$ are the error terms assumed to have a joint normal distribution with zero means.

Using the sub-sample of households who are assumed to share full income equally, i.e. here the sub-sample of those couples who give the same answer to the subjective ladder question, one gets:

$$\Phi_f = \Phi_m = \frac{1}{2}\left[(w_m + w_f)T + y + \Pi\right]$$

Or, like previously, assuming Π to be negligible,

$$\Phi_f = \Phi_m = \frac{1}{2}\left[(w_m + w_f)T + y\right] \tag{3.12}$$

Thus, the system (3.10) can be estimated using the sub-sample. On this first stage the vectors of parameters $(\alpha_1, \alpha_2, \beta_1, \beta_2), \boldsymbol{\gamma}_1, \boldsymbol{\gamma}_2$ can be identified.

The vectors of parameters $\boldsymbol{\delta}_1, \boldsymbol{\delta}_2$ are identified on a second stage by estimating (3.14) using the whole sample:

$$\begin{cases} R_f = \boldsymbol{\delta}_1 \mathbf{X} + i_1 \\ R_m = \boldsymbol{\delta}_2 \mathbf{X} + i_2 \end{cases} \tag{3.13}$$

with

$$\begin{cases} R_f = (H_f - \alpha_1 - \boldsymbol{\gamma}_1 \mathbf{X}_1)/\beta_1 \\ R_m = (H_m - \alpha_2 - \boldsymbol{\gamma}_2 \mathbf{X}_2)/\beta_2 \end{cases} \tag{3.14}$$

and the error terms i_1, i_2 following a joint normal distribution with zero means:

$$\begin{cases} i_1 = e_1 + \lambda_1 / \beta_1 \\ i_2 = e_2 + \lambda_2 / \beta_2 \end{cases}$$

Due to a poor quality of non labour income, which cannot properly be individualized in the RLMS data, the latter strategy is followed in the empirical analysis. The method of estimation is 3SLS.

3.2.4. Results

Intra-household inequality analysis

On the first stage of this study we perform the ML estimation of simultaneous equations describing domestic labour supply of both woman and man along with the index of intra household inequality. The method of estimation implements the full information ML procedure to simultaneously estimate two continuous equations and one ordered probit equation in order to provide consistent standard errors. The dependent variables are the natural logarithm of man and woman's monthly domestic time in hours and the index of intra household inequality. All the independent variables are here assumed exogenous. We include the wages of both husband and wife, individual characteristics (age, age squared, and education), household characteristics (number of children, assets and durables possession) and type and region of settlement. The estimates are reported in TableA1 in Appendix.

Only a few variables significantly influence domestic labour supply but labour market variables are quite significant. In both equations the wage of household head (man) is an important determinant of domestic labour supply. But the effect of wages is not exactly the same for men and women: for both men and women, a higher wage decreases one's domestic work. But a higher male's wage increases his wife's domestic work, while a higher female's wage has no significant effect upon her husband's domestic work. Another significant variable in both equations is the number of children in the household: as expected, a higher number of children increases both spouses' domestic work. Variables that are not related to the labour market are not found important here. Possessing durables or an individual plot doesn't influence the duration of domestic work of either husband or wife. The same is true for type and regions of settlement. The exception is Ural for women's domestic labour supply (where they work less at home) and Moscow-St-Petersburg, where men work less at home.

In the ordered probit equation we included, some additional variables that, expectedly could influence the bargaining power of the spouses. These are: non labour incomes of

husband and wife, as well as the labour market status of both woman and man.[6] As mentioned above, we interpret the results as corresponding to the real sharing of full income. The results we obtain are those predicted by the theory: the wage difference is highly significant with a "right" sign. This index is equal to 0 if a wife reports being poorer than her husband, to 1 if there is no difference between husband and wife's responses and to 2 if a wife reports being richer than her husband. The difference is expressed in natural logarithm between man's and woman's wage. What we find is that, as expected, the greater the man's wage in comparison with his wife's, the smaller the probability of the woman's higher response. This conclusion is confirmed by a marginal effects analysis (cf. TableA1 in Annex). The marginal effects are almost the same in absolute value for the first and the third category of our dependent variable. So the result is symmetric for the opposite situation. Thus the wage ratio is found here to be a powerful determinant in the bargaining process. Other variables influencing the full income distribution among household members are age difference, marriage, number of persons of retirement age in the household and some region dummies. The age difference is constructed as woman's age minus man's age. The coefficient is negative and significant: the older the woman is relative to her husband, the less the probability of the woman's higher response. Interestingly the number of persons of retirement age in the household increases the probability of the wife to be richer. One interpretation could be that retired persons' monetary income is given in addition of the wife's income more often than of her husband's, thus increasing her non labor income. Also, retired persons' help in domestic work could increase more her full income than her husband's. To leave in Western or Eastern Siberia versus Centre increases the probability of a superior woman's response. It could be linked to economical and cultural differences among regions in Russia.

The correlation between domestic work and the sharing rule equations is low and not significant (see TableA1 in Annex for rho13 and rho23). This result strongly supports our assumption that the surplus from domestic production (profit Π from the theoretical model) is negligible compared to the other sources of household income. This is equivalent to assuming that household production is evaluated at its market price, i.e. wages.

[6] The fact of having one official regular job: Individuals having only one legally paid work in organizations, enterprises, or administrations. This category also includes entrepreneurs.

Unfortunately, non labour incomes are not significant in our results. It could be due to a poor quality of these variables in the RLMS data. Only salaries and pensions are really determined on the individual level[7].

Having a unique regular job doesn't influence the spouses bargaining power.

Our analysis shows that wage and age difference, the number of persons of retirement age in the household as well as the fact of living in Western or Eastern Siberia *are* important determinants of intra household inequality.

Sharing rule identification

The second part of the empirical study is a two-stage 3SLS estimation of the model described in (3.10) – (3.14), allowing the identification of the sharing rule. We first use the sub-sample of households who share full income equally. The dependent variables are the natural logarithm of man and woman's monthly total labor supply in hours. The explanatory variables used in the total labour supply estimation are the corresponding individual's full income calculated according to (3.12), individual characteristics (age, age squared, and education), household characteristics (number of children, assets and durables possession) and type and region of settlement. The explanatory variables of the sharing rule are the same as in the oprobit equation. The estimates are reported in TableA2 in Appendix.

The main results are the following.:

Total labour supply of both men and women are positively related with their corresponding full income.

Both wage rates have a positive impact on the woman's amount of (full) income. The man's wage rate positively influences both incomes and interestingly, the effect on his own share is almost twice as high as the effect on his partner's one. This finding shows once again that the effect of such a factor as the man's wage rate is not the same regarding the sharing of full income in the household. This result does support our initial assumption of an intra-household bargaining process.

The number of children has a positive impact on the woman's full income and a negative but insignificant one on the man's share. As children do not influence positively the woman's wage rate, this effect must appear through the bargaining process. Hence, and in

[7] To construct non labour income variables we took the reported total individual income and subtracted the calculated labour market income.R eported total individual income is the response to the following question: "Please try to remember, how much money in all did you personally receive in the last 30 days, counting wages, bonuses, profits, pensions, benefits, material help, incidental earnings, and other monetary receipts, including hard currency, but convert the currency into rubles?" It is well known, unfortunately, that such data are subject to high measurement errors.

contradiction with the assumption usually made that only market variables have an effect upon the bargaining power[8], we find that a higher number of children seems to increases the woman's bargaining power.

CONCLUDING REMARKS

We proposed an application of the collective model to the analysis of intra-household inequality using self reported income scales. The first results found in the paper support the assumptions made. The variables which are generally assumed to influence the spouses' bargaining power within the household are found to be good predictors of the difference in self reported income scales between husband and wife.

We also elaborated a new method of identification of the sharing rule: using the results obtained with couples who report the same level of income, interpreting this as an equal sharing of income, we identify the sharing rule for the whole sample. We find that the man's wage rate has a differentiated impact on the full income distribution. This finding supports the evidence of the bargaining process. Also, in contradiction with with the assumption usually made that only market variables have an effect upon the bargaining power[9], we find that a higher number of children seems to increases the woman's bargaining power.

[8] See Chiappori 1997, Rapoport, Sofer, Solaz, 2005
[9] See Chiappori 1997, Rapoport, Sofer, Solaz, 2005

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APPENDIX.

Table A1. ML estimation of woman and man's domestic labour supply and index of intra household inequality[a].

	Woman's supply	Man's supply	Index[a]	Marginal effects for ordered probit		
	Coefficient	Coefficient	Coefficient	dP(0)/dX3	dP(1)/dX3	dP(1)/dX3
Ln of man's monthly wage	0,061**	-0,054**	-			
Ln of woman's monthly wage	-0,084***	0,023	-			
Wage difference[b]	-	-	-0,094***	0,005636	-0,000195	-0,005441
Man's age	-	-0,022	-			
Man's age squared	-	0,023	-			
Woman's age	-0,013	-	-			
Woman's age squared	0,012	-	-			
Age difference[c]	-	-	-0,013**	0,000744	-0,000026	-0,000718
Woman has technical of higher education	0,009	-	-			
Man has technical of higher education	-	0,055	-			
Difference in levels of education	-	-	0,010	-0,000600	0,0000207	0,000580
Household non labour income	-	-	-0,00008	0,000002	0,000000	-0,000002
Number of children 0-7 years old	0,466***	0,463***	0,046	-0,002729	0,000094	0,002634
Number of children 7-18 years old	0,184***	0,165***	-0,003	0,000206	0,000000	-0,000199
Number of elderly males in the household	-0,095	0,008	0,105	-0,006250	0,000216	0,006034
Number of elderly females in the household	0,018	-0,133**	0,064	-0,003806	0,000132	0,003674
Ln of living space (sq. meters)	-0,008	-0,034	0,003	-0,000200	0,000000	0,000193
Automobile owned	0,041	-0,039	0,055	-0,003295	0,000114	0,003181
Washing machine owned	-0,018	0,027	-0,081	0,004856	-0,000168	-0,004688
Family is working on an individual plot	0,009	0,019	-0,061	0,003638	-0,000126	-0,003512
Rural	0,090	0,109	-0,033	0,001971	-0,000068	-0,001903
North Caucasian	-0,032	-0,008	0,073	-0,004342	0,000150	0,004192
Volga-Vaytski and Volga Basin	-0,040	-0,034	-0,002	0,000127	-0,000000	-0,000122
Moscow - St-Petersburg	-0,069	-0,178**	0,028	-0,001662	0,0000574	0,001604
Northern and North Western	-0,031	0,156*	0,151	-0,009002	0,0003111	0,008691
Ural	-0,159**	-0,089	0,123	-0,007382	0,0002551	0,007127
Western Siberia	-0,122	0,047	0,237**	-0,014184	0,0004901	0,013694
Eastern Siberia and Far Eastern	-0,091	-0,042	0,205**	-0,012278	0,0004242	0,011853
Round5	0,070	0,145**	0,143**	-0,008553	-0,0002955	0,008257
Round6	-0,022	0,007	0,104	-0,006203	0,0002143	0,005989
Round8	-0,110	-0,135*	0,049	-0,002917	0,0001008	0,002816
Constant	4,67***	4,252***	-			
Ancillary parameters						
c1			-0,515**			
c2			0,563**			
Rho13	-0,043					
Rho23	-0,014					
Rho12	0,359***					
Number of observations	2144					
Log likelihood	-7658,87					

* is significant at 10% level; ** is significant at 5% level; *** is significant at 1% level

[a] The dependent variable is index of intra household inequality: 0 – if a wife reports being poorer than her husband; 1 – there is no difference, 2 – if a wife reports being richer than her husband.

[b] Wage difference: the difference between ln of man's monthly real wage and ln of woman's real monthly wage.

[c] Age difference: the difference between woman's age and man's age

The reference categories are: Urban versus Rural, Central and Central Black-Earth for region, Round7 for round of observation.

Source: RLMS (round5-8)

Table A2. 3SLS estimation of woman's and man's full labour supply and sharing rule identification.

	Woman's full labour supply	Man's full labour supply	Woman's full income	Man's full income
	Coefficient	Coefficient	Coefficient	Coefficient
Individual full income (Φ_f=Φ_m)	**0,036***	**0,110*****		
Ln of man's monthly wage	-	-	**0,418***	**0,762*****
Ln of woman's monthly wage	-	-	**0,764*****	**-0,054**
Man's age	-	-0,017	0,126	0,052
Man's age squared	-	0,017	-0,143	-0,047
Woman's age	0,017	-	0,002	0,140
Woman's age squared	-0,018	-	0,038	-0,176
Woman has technical of higher education	0,013	-	-0,248	-0,084
Man has technical of higher education	-	0,019	-0,269	0,094
Household non labour income	-	-	0,000	0,000
Number of children 0-7 years old	0,176***	0,134***	1,323***	-0,178
Number of children 7-18 years old	0,098***	0,047**	-0,196	-0,063
Number of elderly persons in the household	-0,001	0,040	-0,441	-0,114
Ln of living space (sq. meters)	-0,026	-0,091*	-0,119	0,339
Automobile owned	0,018	0,078**	-0,080	-0,229
Washing machine owned	-0,018	-0,001	-0,889	-0,113
Family is working on an individual plot	0,006	0,036	0,641	-0,127
Rural	0,027	0,105**	1,265*	-0,343
North Caucasian	-0,010	-0,114*	-0,542	0,572
Volga-Vaytski and Volga Basin	0,025	-0,057	-0,104	0,656**
Moscow - St-Petersburg	-0,158***	-0,054	2,180***	0,087
Northern and North Western	-0,110**	-0,059	1,956**	0,736*
Ural	-0,081**	-0,127**	-0,045	0,435
Western Siberia	-0,099*	-0,119*	0,988	0,635*
Eastern Siberia and Far Eastern	-0,004	-0,012	-1,472	0,101
Round5	0,048	-0,053	-0,414	0,436
Round6	-0,038	-0,074	0,386	0,662**
Round8	-0,016	-0,078	-0,376	0,356
Constant	4,938***	4,813***	-2,127	-0,948
Number of observations	997		2419	

* is significant at 10% level; ** is significant at 5% level; *** is significant at 1% level

[a] The dependent variable is index of intra household inequality: 0 – if a wife reports being poorer than her husband; 1 – there is no difference, 2 – if a wife reports being richer than her husband.

The reference categories are: Urban versus Rural, Central and Central Black-Earth for region, Round7 for round of observation.

Source: RLMS (round5-8)