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# Household Sharing and Commitment: Evidence from Panel Data on Individual Expenditures and Time Use

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# Household Sharing and Commitment: Evidence from Panel Data on Individual Expenditures and Time Use\*

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## Abstract

In this paper, we analyze the nature of intra-household allocations and commitment using unique panel data on individual-specific within-household consumption expenditures and on time used for leisure, market production and home production. Specifically we estimate a dynamic collective model of the household in which husbands and wives care about private consumption, private leisure, and a public good produced in the home with time and market purchased inputs. We find that the household weight on the wife is strongly related to her relative market productivity in the cross-section. Additionally, within households the weight on the wife is related to unpredicted changes in relative wages, but the effect is about half as strong, and only statistically significant for large changes. Our results are consistent with limited commitment within the household: small shocks are fully insured while large shocks provoke a renegotiation.

KEYWORDS: Intra-household allocations, dynamic collective model, limited commitment.

JEL CLASSIFICATION: D12, D13, J22.

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# 1 Introduction

There are substantial benefits to individuals from living in couples. Individuals gain from sharing public goods within the household, and can take advantage of specialization resulting in comparative advantage in home or market production. Individuals in a household can pool income risk, sharing in each other's gains and insuring one another in the case of poor health or job loss. It is natural to think that individuals care about the wellbeing of their spouse. At the same time they are very likely to have distinct preferences for the share of household resources devoted to the public (non-rival) good relative to own private consumption and leisure. The final allocation will necessarily depend on each individual's weight, or bargaining power, in household decision making.

A popular approach to modeling the allocations that result from the intra-household decision making process is the collective model of the household, originally proposed by [Chiappori \(1988, 1992\)](#) and [Apps and Rees \(1988\)](#). This is a static model of intra-household allocations. The key assumption of the collective model is that households arrive at Pareto efficient allocations, while the exact intra-household bargaining process is left unspecified. An important result, which is very useful for empirical analysis, is that by observing an assignable good (for example leisure or private consumption), it is possible to identify how the share of total household resources allocated to the husband and wife differs by differences in individual bargain power.

There are now a substantial number of cross-sectional empirical studies demonstrating, in a wide variety of contexts, that allocations within households are related to the source of income and other factors such as the sex ratio and divorce legislation.<sup>1</sup> Recently, [Attanasio and Lechene \(2013\)](#) provide compelling experimental evidence rejecting a unitary model of the household in favor of the collective model. They use the exogenous variation in the wife's share of household income induced by a cash transfer program in Mexico (PROGRESSA). In the households that were randomly treated, the wives received cash transfers

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<sup>1</sup>A non exhaustive list includes [Thomas \(1990\)](#); [Browning, Bourguignon, Chiappori, and Lechene \(1994\)](#); [Lundberg, Pollak, and Wales \(1997\)](#); [Chiappori, Fortin, and Lacroix \(2002\)](#); [Blundell, Chiappori, Magnac, and Meghir \(2007\)](#); [Lise and Seitz \(2011\)](#); [Browning and Gortz \(2012\)](#); [Cherchye, De Rock, and Vermeulen \(2012\)](#).

amounting to between 25 and 33 percent of total household expenditures. This resulted in a huge change in the share of household income contributed by the wife. [Attanasio and Lechene \(2013\)](#) show that the expenditure patterns of households cannot be rationalized by a unitary model, but are fully consistent with the collective model. In addition, they implement the test of the collective model proposed by [Bourguignon, Browning, and Chiappori \(2009\)](#) and find evidence in support of the collective model, in particular that the resulting expenditures are Pareto efficient.

The results presented in [Attanasio and Lechene \(2013\)](#) provide strong support for the idea that, within a period, households are able to attain Pareto efficient allocations. The bargaining process within the household, whatever exact form it may take, does not result in wasted current period resources. At the same time, the fact that within-period allocations depend on the relative source of *current* income (husband or wife) suggests that members of the household lack sufficient commitment to provide full insurance to each other. Such a lack of commitment precludes household members from attaining *ex ante* efficient allocations. Indeed, if we take the cross sectional evidence at face value, we would infer that households do a poor job pooling risk since at the very moment when a member needs insurance, his or her bargaining position is weakened.

In an important paper, [Mazzocco \(2007\)](#) highlights the substantial issues raised by the the degree of commitment when modeling the intertemporal behavior of households. He characterizes the dynamics of collective household behavior with and without commitment. He shows that the full commitment version is nested within the limited commitment model, which provides a test for full commitment (*ex ante* efficiency), but cannot distinguish between no commitment (a series of static interactions) and limited commitment (limited only by participation constraints). The empirical implementation of the test is based on pseudo panel data constructed from the US Consumer Expenditure Survey. The data used does not allow one to measure individual private consumption and does not contain a panel dimension. As a result it is not possible to distinguish continuous re-bargaining from re-bargaining when one of the spouses has a binding participation constraint. The implementation also requires sufficient separability to justify ignoring public goods, home production and leisure.

The degree to which household members can commit to future allocations, and as a result realize the benefits of risk sharing, likely depends on the institutions governing contractual arrangements between spouses. [Voena \(2013\)](#) studies the effect of changes in divorce laws across the US states (from mutual consent to unilateral), combined with different rules as to how assets are allocated at divorce (title based or equal division), on the savings and labor supply behavior of households. She finds that the observed responses of household asset accumulation and the labor supply response of the wife support a model of limited commitment in households.

The main contribution of this paper is to separately estimate how the Pareto weight in the household problem varies across households at the time of marriage and how it responds to news over time for a given household. We are able to separate the two channels using a unique data set from Japan. In this data we have a panel of households, observed for up to 15 years. In each year we have information on the private consumption expenditures of the wife, the private consumption expenditures of the husband, and expenditures for the household. In addition, we have information on the number of hours each member spends on market work, home work, and leisure.<sup>2</sup>

The dynamic model of the household we work with is general, including a role for private consumption, public consumption, and time used for leisure, market production and home production.<sup>3</sup> The model captures all of the gains to marriage discussed above: sharing a public good, specialization in market or home production, risk sharing, and caring. We find that 1) differences between wives and husbands at the time of marriage in expected wages over the life cycle strongly influences the household Pareto weight in the cross section; 2) small and moderate deviations from the forecast relative wages are fully insured within the

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<sup>2</sup>Recently, [Cherchye, De Rock, and Vermeulen \(2012\)](#) use Dutch data on the allocation of private and public consumption expenditure and individual time use to fully identify and estimate a household sharing rule. The data they use is from a single cross section, and as a result they are identifying how allocations relate to differences in relative wages across households, and not necessarily how allocations would change within a household resulting from unanticipated income shocks. [Browning and Gortz \(2012\)](#) also use a collective model to interpret similar cross sectional data, but without considering home production.

<sup>3</sup>The importance of distinguishing leisure from home production is noted clearly by, for example, [Becker \(1965\)](#); [Apps and Rees \(1996\)](#). The issues of dealing with public goods (children) in a collective model are clarified by [Blundell, Chiappori, and Meghir \(2005\)](#).

household; 3) large deviations trigger a move in the Pareto weight. These results are fully consistent with a model of the household in which *ex post* incentive compatibility limits the extent of insurance the household can provide its members. Furthermore, our estimates suggest that husbands and wives have similar preferences for expenditures on public goods. The implication is that if we are interested in how changing the relative wage of a woman affects her material wellbeing in the household, we will arrive at different answers if we use cross-sectional variation than if we use within-household time variation. At the same time, if we are instead interested in how such a change might affect the wellbeing of children, the answer is likely to be the same in both cases, since the share of total expenditures on public goods is essentially unresponsive to changing the Pareto weight.

The remainder of the paper is organized as follows. In Section 2 we present the dynamic household model and derive the equations that will form the basis of estimation. In Section 3 we discuss the data set and present summary statistics as well as the general patterns in the raw data. In Section 4 we present the estimation procedure in detail. We present the estimation results and analysis in Section 5 and the conclusions in Section 6.

## 2 A dynamic model of household decision making

Consider a household  $i$ , comprising two decision makers  $A$  and  $B$ . Household member  $j \in \{A, B\}$  in period  $t$  cares about his or her own private consumption ( $c_{ijt}$ ), private leisure ( $\ell_{ijt}$ ), and a household public good ( $q_{it}$ ).<sup>4</sup> The household public good is produced using a combination of market purchased goods ( $g_{it}$ ) and time spent by the partners in home production ( $h_{ijt}$ ). Household members  $A$  and  $B$  have distinct utility functions  $u^A(\cdot)$  and  $u^B(\cdot)$ . We assume that children are not decision makers in the household but that they consume the public good. The relative extent to which members  $A$  and  $B$  care about the children is captured

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<sup>4</sup>This setting is equivalent to a model in which individuals also care about the wellbeing of their spouse (see [Browning, Chiappori, and Lechene \(2006\)](#) and [Appendix A.1](#) for a presentation of such a model, which produces identical estimating equations).



by their preferences for the public good, and the sensitivity of these preference to the presences of children. We assume that utility is additively separable over time, with discount factor  $\delta$ . The weight the household puts on the utility of member  $A$  in period  $t$  is given by  $\mu_t$ . The household is assumed to maximize the expected, discounted, weighted sum of the partners' period utilities:

$$U_{i0}^H = \mathbb{E}_0 \sum_{t=0}^T \delta^t \left( \mu_{it} u^A(c_{iAt}, \ell_{iAt}, q_{it}; x_{1iAt}, x_{2iAt}) + u^B(c_{iBt}, \ell_{iBt}, q_{it}; x_{1iBt}, x_{2iBt}) \right),$$

subject to a constant returns to scale home production function:

$$q_{it} = q(g_{it}, h_{iAt}, h_{iBt}; x_{3it});$$

the per-period time constraint:

$$\ell_{ijt} + h_{ijt} + m_{ijt} = 1, \quad j \in \{A, B\},$$

the period-by-period budget constraint:

$$\begin{aligned} c_{iAt} + c_{iBt} + g_{it} + w_{iAt}(\ell_{iAt} + h_{iAt}) + w_{iBt}(\ell_{iBt} + h_{iBt}) \\ = w_{iAt} + w_{iBt} + (1 + r_t) a_{it} - a_{i,t+1} \equiv y_{it}, \end{aligned}$$

where  $y_{it}$  denotes period  $t$  full income, the non-negativity constraints:

$$c_{ijt}, g_{ijt}, \ell_{ijt}, h_{ijt}, m_{ijt} \geq 0,$$

and the stochastic process for wages, described by a first-order autoregressive process in logs with individual-specific growth ( $\omega_{0i}^j$ ) and gender-specific persistence ( $\omega_1^j$ ):

$$\log w_{ijt} = \omega_{0i}^j + \omega_1^j \log w_{ij,t-1} + \varepsilon_{ijt}, \quad \mathbb{E}[\varepsilon_{ijt}] = 0.$$

The observables  $x_{1ijt}$ ,  $x_{2ijt}$  and  $x_{3jt}$  are individual and household characteristics, including the presence of children, that affect intra-temporal preferences, inter-temporal preferences and home productivity respectively.

## 2.1 The distinction between full and limited commitment

Following [Mazzocco \(2007\)](#), we can fully characterize commitment in terms of the Pareto weight  $\mu_{it}$ . The distinction between full and limited commitment within the household boils down to whether the Pareto weight is fixed at time zero, or is revised during the marriage with the revelation of new information. If households are able to fully commit at the time of marriage, then all household decisions are efficient in the sense that they are always on the *ex ante* Pareto frontier. In this case the only thing that matters for determining the Pareto weight is the relative decision power at the time of marriage. In other words the Pareto weight is only a function of information available at the time of marriage (including the forecastable components  $z_{i0} \equiv \{\mathbb{E}_0 z_{it}\}_{t=0}^T$ ):

$$\mu_{it} = \mu(z_{i0}) \quad \forall t.$$

The vector  $z_{it}$  contains all the relevant variables that influence the relative power in the household. This may include total resources available to the household (in terms of initial financial and human wealth) as well as variables that capture bargaining power of the household members, but do not shift preferences, the home production technology, or the budget set (termed extra-environmental parameters by [McElroy \(1990\)](#) or distribution factors by [Browning, Bourguignon, Chiappori, and Lechene \(1994\)](#)). Note that with full commitment all variation in the Pareto weight is cross-sectional.

With limited commitment (or no commitment), the Pareto weight may change as information is revealed through period  $t$ . In this case the Pareto weight depends both on the date zero forecastable components  $z_{i0}$  and the realized deviations from this forecast  $z_{i1t} \equiv z_{it} - \mathbb{E}_0 z_{it}$ :

$$\mu_{it} = \mu(z_{i0}, z_{i1t}).$$

We explicitly allow  $z_{i0}$  and  $z_{i1t}$  to have independent effects on the Pareto weight.

In the absence of full commitment there are two alternatives for how the Pareto weight may be updated with new information. It could be that the dynamics of household allocations are well represented by a sequence of repeated

static problems, in which case the Pareto weight would update period by period. Alternatively, it may be that renegotiation takes place only when the participation constraint of one of the household members is binding; the member would be better off single than married given the current allocation, but both members would be better by renegotiating and remaining married. In the second case the Pareto weight only moves with  $z_{i1t}$  when the new information indicates a binding participation constraint. As a result, the Pareto weight may remain constant in the face of small realized deviations and only change in response to large deviations that are indicative of a binding participation constraint.<sup>5</sup>

The limited commitment case nests the full commitment case, which in turn nests the case in which the Pareto weight does not depend on any of the factors in  $z$ :

$$\mu_{it} = \mu_i \quad \forall t,$$

generally called a unitary model of the household.<sup>6</sup>

## 2.2 Parametrization of preferences, technology and heterogeneity

For estimation it is necessary to parametrize the utility and home production functions.<sup>7</sup> We consider the following CES specification for the flow utility func-

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<sup>5</sup>Mazzocco (2007) adopts the approach developed by Marcet and Marimon (2011) and shows that the Pareto weight will remain constant unless the participation constraint binds. For example, the Pareto weight will increase whenever  $z_{i1t}$  reveals new information such that  $\mathbb{E}_\tau \sum_{t=0}^{T-\tau} \delta^t \mu_{it} u^A(c_{iAt}, \ell_{iAt}, q_{it}; x_{1iAt}, x_{2iAt}) < \underline{u}^A(z_{i1t})$ , where  $\underline{u}^A(z_{i1t})$  is the value of being single for member  $A$ . In this case the Pareto weight is updated to satisfy member  $A$ 's participation constraint. The reduced form of this process is that the Pareto weight is updated whenever  $z_{i1t}$  is "large enough".

<sup>6</sup>See Browning, Chiappori, and Lechene (2006) for a discussion of the extent to which it is possible to distinguish a static collective model from a unitary model with arbitrary preference heterogeneity.

<sup>7</sup>For the purposes of estimating the Pareto weight we can relax the functional form assumptions for utility and home production. We include such a specification as a robustness check.

tion (in order to reduce notational clutter we suppress the household index  $i$ ):

$$\begin{aligned} u^A(c_{At}, \ell_{At}, q_t; x_{1At}, x_{2At}) &= \frac{\zeta_t}{1 - \sigma} \left( \alpha_{1t} c_{At}^\phi + \alpha_{2t} \ell_{At}^\phi + (1 - \alpha_{1t} - \alpha_{2t}) q_t^\phi \right)^{\frac{1-\sigma}{\phi}} \\ u^B(c_{Bt}, \ell_{Bt}, q_t; x_{1Bt}, x_{2Bt}) &= \frac{\xi_t}{1 - \varsigma} \left( \beta_{1t} c_{Bt}^\varphi + \beta_{2t} \ell_{Bt}^\varphi + (1 - \beta_{1t} - \beta_{2t}) q_t^\varphi \right)^{\frac{1-\varsigma}{\varphi}}, \end{aligned}$$

and the following constant returns to scale specification for the home production function:

$$q(h_{At}, h_{Bt}, g_t; x_{3t}) = (\pi_t h_{At}^\gamma + (1 - \pi_t) h_{Bt}^\gamma)^{\frac{\rho}{\gamma}} g_t^{1-\rho}.$$

Preferences are heterogeneous between and within households and non-separable among private consumption, leisure, and public consumption. The intra- and inter-temporal substitution parameters  $\{\phi, \varphi, \sigma, \varsigma\}$  differ by gender, and the share parameters  $\{\alpha_{1t}, \alpha_{2t}, \beta_{1t}, \beta_{2t}\}$  and the inter-temporal preference parameters  $\{\zeta_t, \xi_t\}$  vary with individual and household observable characteristics  $\{x_{1At}, x_{2At}, x_{1Bt}, x_{2Bt}\}$ . The technology for home production is constant returns to scale in  $\{g_t, h_{At}, h_{Bt}\}$ . The share parameter  $\pi_t$  varies with the individual and household characteristics  $x_{3t}$ .

### 2.2.1 Heterogeneity

We parametrize heterogeneity in preferences and productivity in terms of observable characteristics of the two household members  $\{x_{1jt}, x_{2jt}, x_{3t}\}$ . The Pareto weight is parametrized in terms of observable distribution factors  $\{z_0, z_{1t}\}$ .

**Preference heterogeneity** Theory requires that  $\alpha_{1t} \geq 0$ ,  $\alpha_{2t} \geq 0$ ,  $\alpha_{1t} + \alpha_{2t} \leq 1$ ,  $\beta_{1t} \geq 0$ ,  $\beta_{2t} \geq 0$ ,  $\beta_{1t} + \beta_{2t} \leq 1$ ,  $\zeta_t \geq 0$ , and  $\xi_t \geq 0$ . We respect these restrictions and model preference heterogeneity using the specifications:

$$\begin{aligned} \alpha_{kt} &= \frac{\exp(\alpha'_k x_{1At})}{1 + \exp(\alpha'_1 x_{1At}) + \exp(\alpha'_2 x_{1At})} \quad \text{for } k = 1, 2, & \zeta_t &= \exp(\zeta' x_{2At}), \\ \beta_{kt} &= \frac{\exp(\beta'_k x_{1Bt})}{1 + \exp(\beta'_1 x_{1Bt}) + \exp(\beta'_2 x_{1Bt})} \quad \text{for } k = 1, 2, & \xi_t &= \exp(\xi' x_{2Bt}), \end{aligned}$$

where  $x_{1jt}$  is a vector of observables for household member  $j$  at time  $t$  that affect intra-temporal preferences and  $x_{2jt}$  is a vector of observables for household mem-

ber  $j$  at time  $t$  that affects inter-temporal preferences. Specifically  $x_{1jt}$  contains a constant, age, education and the number of children, and  $x_{2jt}$  contains household size. Within-period allocations are determined by  $\{\alpha_{1t}\alpha_{2t}, \beta_{1t}, \beta_{2t}, \phi, \varphi\}$ , while the allocation of resources across periods is governed by  $\{\zeta_t, \xi_t, \sigma, \varsigma\}$ .

**Home production heterogeneity** Theory requires that  $0 \leq \pi_t \leq 1$ ,  $0 \leq \rho \leq 1$ , and  $\gamma \leq 1$ . We impose this requirement and model productivity shifters by the specification:

$$\pi_t = \frac{\exp(\pi'x_{3t})}{1 + \exp(\pi'x_{3t})} \text{ and } \rho = \frac{\exp(\rho_0)}{1 + \exp(\rho_0)},$$

where  $x_{3t}$  is a vector of observables pertaining to productivity at home of the two members of the household in period  $t$ . Specifically  $x_{3t}$  contains a constant and the number of children under the age of seven.

**The Pareto weight** To facilitate interpretation we specify the weight on member A's utility as

$$\mu_t = \exp(\mu'_0 z_0) \exp(\mu'_1 z_{1t}) \geq 0,$$

where  $z_0 \equiv \{\mathbb{E}_0 z_t\}_{t=0}^T$  is the time zero expectation of the series  $z_t$  and  $z_{1t} \equiv z_t - \mathbb{E}_0 z_t$  is the realized deviation from this time zero expectation. Information known or forecast at the start of marriage fixes the cross-sectional weight, while information revealed at time  $t$  potentially shifts the weight around. Breaking the distribution factors into the forecastable component at date zero and the date  $t$  forecast error allows us to distinguish between full commitment and limited commitment.

Let  $\omega_{0j}$  denote the individual-specific growth rate for wages, and  $\nu_0$  denote the growth rate for the total household resources. Additionally, denote by  $\text{ed}_j$  years of education for individual  $j$ ;  $\text{xp}_{j0}$  years of experience at the time of marriage for individual  $j$ ;  $\text{sr}_j$  the sex ratio (number of men relative to women) in the prefecture where individual  $j$  grew up;  $y_j^P$  the income of individual  $j$ 's parents; and  $\text{occ}_j^P$  the

social status of the father's occupation. The time zero component of  $z$  contains

$$\left\{ \omega_{0A} - \omega_{0B}, \nu_0, \log \left( \frac{\text{ed}_A}{\text{ed}_B} \right), \log \left( \frac{\text{xp}_{A0}}{\text{xp}_{B0}} \right), \log \left( (\text{sr}_A)^{\frac{1}{2}} (\text{sr}_B)^{\frac{1}{2}} \right), \log \left( \frac{y_A^P}{y_B^P} \right), \log \left( \frac{\text{occ}_A^P}{\text{occ}_B^P} \right) \right\}$$

while the second component contains the date  $t$  values of

$$\left\{ \log \left( \frac{w_{At}}{w_{Bt}} \right) - \mathbb{E}_0 \left[ \log \left( \frac{w_{At}}{w_{Bt}} \right) \right], \log y_t - \mathbb{E}_0 \log y_t \right\}_{t=0}^T.$$

## 2.3 Optimality conditions

We will base our estimating equations on the optimality conditions that characterize the intra- and inter-temporal allocations of the household.

### 2.3.1 Intra-temporal first-order conditions

**Home production technology** The first-order conditions for the optimal choice of home production inputs  $\{g_t, h_{At}, h_{Bt}\}$  imply, with the current functional forms, the following marginal rate of transformation equations:

$$\left( \frac{\pi_t}{1 - \pi_t} \right) \left( \frac{h_{At}}{h_{Bt}} \right)^{\gamma-1} = \frac{w_{At}}{w_{Bt}}, \quad (1)$$

$$\pi_t \left( \frac{\rho}{1 - \rho} \right) \left( \frac{h_{At}^{\gamma-1}}{H_t} \right) g_t = w_{At}, \quad (2)$$

$$(1 - \pi_t) \left( \frac{\rho}{1 - \rho} \right) \left( \frac{h_{Bt}^{\gamma-1}}{H_t} \right) g_t = w_{Bt}, \quad (3)$$

where we define  $H_t = \pi_t h_{At}^\gamma + (1 - \pi_t) h_{Bt}^\gamma$ .

**Private consumption and leisure** The first-order conditions for the optimal within-period allocation of private consumption and leisure  $\{c_{At}, \ell_{At}, c_{Bt}, \ell_{Bt}\}$  im-

ply the marginal rate of substitution conditions:

$$\frac{\alpha_{1t}}{\alpha_{2t}} \left( \frac{c_{At}}{\ell_{At}} \right)^{\phi-1} = \frac{1}{w_{At}}, \quad (4)$$

$$\frac{\beta_{1t}}{\beta_{2t}} \left( \frac{c_{Bt}}{\ell_{Bt}} \right)^{\varphi-1} = \frac{1}{w_{Bt}}, \quad (5)$$

$$\frac{\mu_t \zeta_t A_t^{\frac{1-\sigma-\phi}{\phi}} \alpha_{2t} \ell_{At}^{\phi-1}}{\xi_t B_t^{\frac{1-\varsigma-\varphi}{\varphi}} \beta_{2t} \ell_{Bt}^{\varphi-1}} = \frac{w_{At}}{w_{Bt}}, \quad (6)$$

$$\frac{\mu_t \zeta_t A_t^{\frac{1-\sigma-\phi}{\phi}} \alpha_{1t} c_{At}^{\phi-1}}{\xi_t B_t^{\frac{1-\varsigma-\varphi}{\varphi}} \beta_{1t} c_{Bt}^{\varphi-1}} = 1, \quad (7)$$

where we define  $A_t = \alpha_{1t} c_{At}^{\phi} + \alpha_{2t} \ell_{At}^{\phi} + (1 - \alpha_{1t} - \alpha_{2t}) q_t^{\phi}$  and  $B_t = \beta_{1t} c_{Bt}^{\varphi} + \beta_{2t} \ell_{Bt}^{\varphi} + (1 - \beta_{1t} - \beta_{2t}) q_t^{\varphi}$ .

**Public consumption** In addition, we have four conditions relating the optimal choice of home production inputs to the optimal within-period allocation of private consumption and leisure:

$$\mu_t \zeta_t A_t^{\frac{1-\sigma-\phi}{\phi}} \alpha_{2t} \ell_{At}^{\phi-1} = \pi_t \rho h_{At}^{\gamma-1} H_t^{\frac{\rho-\gamma}{\gamma}} g_t^{1-\rho} D_t, \quad (8)$$

$$\mu_t \zeta_t A_t^{\frac{1-\sigma-\phi}{\phi}} \alpha_{1t} c_{At}^{\phi-1} = (1 - \rho) g_t^{-\rho} H_t^{\frac{\rho}{\gamma}} D_t, \quad (9)$$

$$\xi_t B_t^{\frac{1-\varsigma-\varphi}{\varphi}} \beta_{2t} \ell_{Bt}^{\varphi-1} = (1 - \pi_t) \rho h_{Bt}^{\gamma-1} H_t^{\frac{\rho-\gamma}{\gamma}} g_t^{1-\rho} D_t, \quad (10)$$

$$\xi_t B_t^{\frac{1-\varsigma-\varphi}{\varphi}} \beta_{1t} c_{Bt}^{\varphi-1} = (1 - \rho) g_t^{-\rho} H_t^{\frac{\rho}{\gamma}} D_t, \quad (11)$$

where we define the household's marginal value of public consumption by

$$D_t = \mu_t \zeta_t A_t^{\frac{1-\sigma-\phi}{\phi}} (1 - \alpha_{1t} - \alpha_{2t}) q_t^{\phi-1} + \xi_t B_t^{\frac{1-\varsigma-\varphi}{\varphi}} (1 - \beta_{1t} - \beta_{2t}) q_t^{\varphi-1}.$$

### 2.3.2 Inter-temporal allocations

Finally, we can use the individual-specific Euler equations for the inter-temporal allocation of individual private consumption:

$$\mathbb{E}_{t-1} \left[ \frac{\mu_t}{\mu_{t-1}} \frac{\zeta_t}{\zeta_{t-1}} \frac{\alpha_{1t}}{\alpha_{1,t-1}} \left( \frac{A_t}{A_{t-1}} \right)^{\frac{1-\sigma-\phi}{\phi}} \left( \frac{c_{At}}{c_{A,t-1}} \right)^{\phi-1} R_t \delta \right] = 1 \quad (12)$$

$$\mathbb{E}_{t-1} \left[ \frac{\xi_t}{\xi_{t-1}} \frac{\beta_{1t}}{\beta_{1,t-1}} \left( \frac{B_t}{B_{t-1}} \right)^{\frac{1-\varsigma-\varphi}{\varphi}} \left( \frac{c_{Bt}}{c_{B,t-1}} \right)^{\varphi-1} R_t \delta \right] = 1. \quad (13)$$

### 3 Data

Estimation requires using panel data with detailed information on expenditures for private and public goods and on time used for market work, home production, and leisure. A unique data set that satisfies this requirement is the Japanese Panel Survey of Consumption (JPSC).

#### 3.1 Description of JPSC data

We use the JPSC data covering the period from 1993 to 2007. The JPSC data include three cohorts: cohort 1 comprising 1,500 women aged 24 to 34 in 1993, cohort 2 comprising 500 women aged 24 to 27 in 1997, and cohort 3 comprising 836 women aged 24 to 29 in 2003. In addition to rich data on demographics, education, wages and labor supply, the JPSC has a consumption expenditure module and a time use module. We keep married women and their husbands for whom we observe, for both spouses, (i) their demographic characteristics, such as current age, age at marriage, and education; (ii) their expenditures and time use for at least two consecutive years; and (iii) their wages for at least three consecutive years. We exclude those who were divorced during the sample period. The sample used in the analysis includes 781 households (8,312 household-year observations).

The JPSC asks the following question about the components of household expenditures<sup>8</sup>:

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<sup>8</sup>The expenditure items listed are Foods (including eating-out/food-dispensing); House rent, land rent and home repairs (excluding housing loans); Utilities (light, fuel, water and sewerage); Furniture and housekeeping equipments (include bedclothing); Clothing and shoes; Healthcare (including nutritious drinks, health foods); Transportation (including the purchase of an automobile, fuel, or commuter pass); Communication (Postal fees, telephone, the Internet, etc.);



Please write down your household expenditure in September this year. (Including not only cash purchases, but also purchases with the credit loan(s), or those charged to your bank/post office account. (If there was no expenditure corresponding to the items below, put “0” for each answer.)

Importantly for our purposes, the JPSC also asks for the breakdown of total household expenditures into the following five categories: 1) Expenses for all of your family, 2) Expenses for you, 3) Expenses for your husband, 4) Expenses for your child(ren), 5) Expenses for the other(s).

We treat categories 1, 4 and 5 as expenditures on household public goods  $g$ , category 2 as private consumption of the wife  $c_A$ , and category 3 as the private consumption of the husband  $c_B$ .

The JPSC also has relatively detailed information on the time use of individuals. Specifically it asks the following question (answered for the wife and the husband):

How many hours do you or does your husband spend in total per workday and day off (if you don’t work, answer about your husband’s day off.) for each of 6 activities listed below? (Enter the time in hour and decade of minutes.) If you or your husband has two or more activities in the same period of time, choose the most important of them: 1) For attending school or workplace; 2) For work; 3) For schoolwork (studies); 4) For housekeeping and child care; 5) For hobby, leisure, social intercourse, etc; 6) For other activities such as sleeping, meals, taking a bath, etc.

We categorize activities 1, 2, and 3 as market hours  $m_j$ , activity 4 as home hours  $h_j$ , and activities 5 and 6 as leisure hours  $\ell_j$ .<sup>9</sup>

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Education (school fees, private tutoring schools for entrance exams or supplementary lessons, textbooks, reference books, etc.); Culture and entertainment (including lessons except for those for entrance exams or supplementary tutoring, or durable goods for culture and entertainment); Social expenses; Pocket money for you, your husband, your child(ren) and allowance for your child(ren); Allowance or pocket money for your and your husband’s parent(s); Other expenses.

<sup>9</sup>Hours spent on schoolwork is negligible for the sample of married couples we use in estimation.

Table 1: Summary Statistics, JPSC

	Wife		Husband		Household	
	Mean	SD	Mean	SD	Mean	SD
Expenditure (percent of household total)	34,305 (6.3%)	59,199	77,834 (15.0%)	65,618	420,657 (78.7%)	23,541
Time use, hours per week (share of own time)						
Market work	30.1h	20.3	60.9h	14.2		
- including commuting	(17.9%)		(36.3%)			
Home production	44.0h	24.6	7.4h	9.1		
- including child care	(26.2%)		(4.4%)			
Leisure	93.8h	19.7	99.6h	15.4		
- including sleep	(55.9%)		(59.3%)			
Observables						
Age	35.2	5.4	37.8	6.4		
Education (years)	13.1	1.5	13.4	2.2		
Wage	889	565	1638	582		
Children aged 0–6					0.68	0.83
Children aged 7–17					0.95	0.99

*Note:* All monetary values are in 2005 Japanese Yen.

### 3.2 Summary statistics

Basic demographic characteristics of the households are presented in the bottom panel of Table 1. On average the women in our sample are 35.2 years old, with husbands who are, on average, 2.6 years older. The average number of years of education is quite similar between men and women at 13.4 and 13.1 years respectively. The average number of children under the age of seven is 0.68, while the average number of children between the ages of seven and 15 is 0.95.

In the top panel of Table 1 we present the average expenditures (and shares) on private consumption of the wife, private consumption of the husband, and consumption for the household (expenditures for the family, children and others). On average 21.3 percent of expenditures are reported as private expenditures for either the wife or the husband, leaving 78.7 percent of household expenditures as public on average. There is a substantial difference between the average share of expenditures devoted to the private consumption of the wife, 6.3 percent, and husband, 15 percent.

There are also notable differences in the average share of time spent by women and men on market work and home production. Women spend 17.9 percent of their time on market work and 26.2 percent on home production. The corresponding shares for men in the sample are 36.3 and 4.4. There appears to be substantial specialization. We include commuting in the hours of market work and child care in home production. In terms of leisure, there is much less difference, with women spending on average 55.9 percent of their time and men 59.3 percent of their time on hobbies, recreation, entertainment, sleep, meals, and personal care.

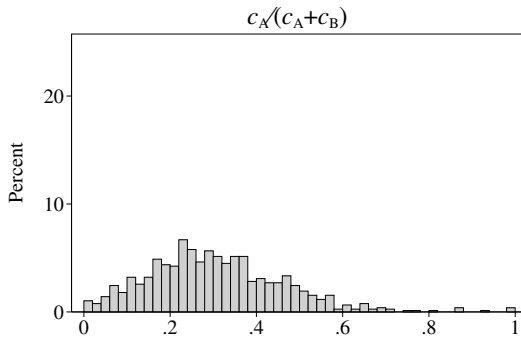
In a similar data set for Dutch households, [Cherchye, De Rock, and Vermeulen \(2012\)](#) report that average public expenditures is 79.3 percent, nearly identical to our Japanese households, but private expenditure is much more equal at 10 percent for wives and 10.7 percent for the husband. The patterns for leisure are also similar for Dutch and Japanese men, both spending 59.3 percent of their time on these activities. Dutch women spend 61.3 percent of their time on leisure activities compared to 55.9 for Japanese women. There are also gender differences in the allocation between market and home hours for the Dutch, although they are not quite as stark as in Japan: Dutch women spend 21.5 percent of their time on home production compared to 26.2 spent by Japanese women. Dutch men spend 12.3 percent of their time on home production, substantially more than the 4.4 percent spent by Japanese men. Much of these differences are likely due to differences in relative wages, the ratio of average wages of women to men (in the sample of couples) is 0.92 for the Dutch and 0.54 for the Japanese.<sup>10</sup>

### 3.3 Expenditure, time-use, and wage shares

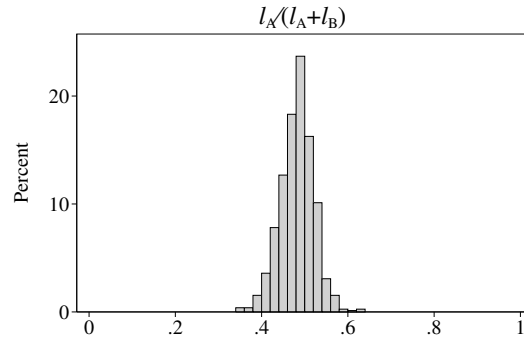
In [Figure 1](#) we plot the distributions of the wife’s wage share along with her share in each of the allocations and the share of expenditures devoted to public goods. Specifically, we plot the histograms of  $\frac{c^A}{c^A+c^B}$ ,  $\frac{\ell^A}{\ell^A+\ell^B}$ ,  $\frac{h^A}{h^A+h^B}$ ,  $\frac{m^A}{m^A+m^B}$ ,  $\frac{g}{c^A+c^B+g}$ , and  $\frac{w^A}{w^A+w^B}$ , where  $A$  represents the wife and  $B$  the husband in each household. For the figure, we take an average of the shares over the sample period within each

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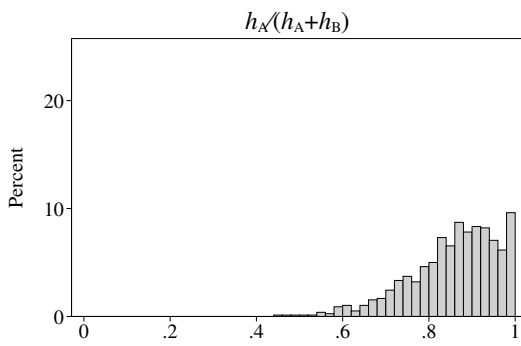
<sup>10</sup>Also see [Burda, Hamermesh, and Weil \(2008\)](#) for time use by gender in Germany, Italy, Netherlands and the US.



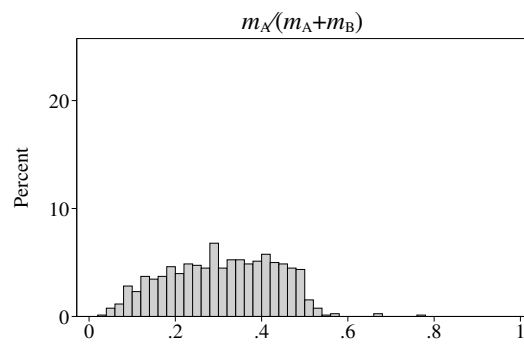
(a) Private consumption



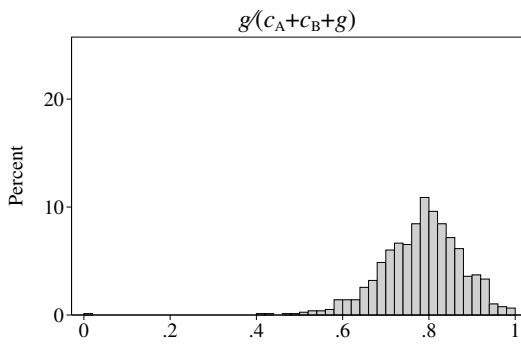
(b) Leisure hours



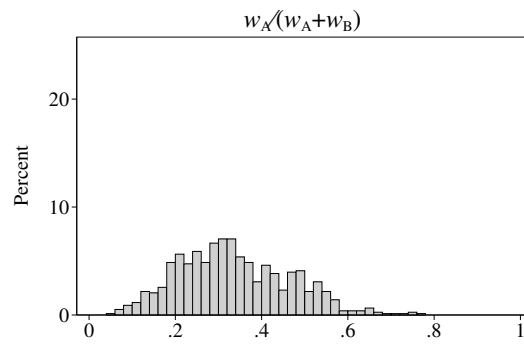
(c) Home hours



(d) Market hours



(e) Public expenditures



(f) Wages

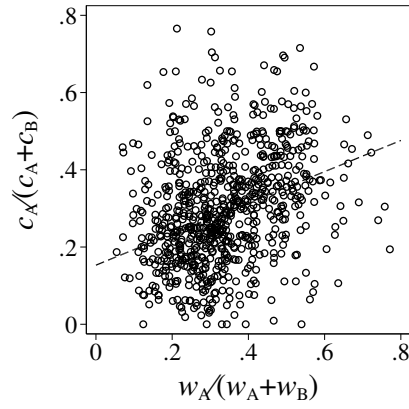
Figure 1: Distributions across households of allocation shares

household. Individual wages are imputed (see section 4.1 for details). There is substantial dispersion in the wife’s wage share across households in our sample. The mode is below 0.3, indicating that in most households the wife has a market wage less than half of her husband. In the majority of households the wife’s share of private consumption is also below half, although there is substantial dispersion across households. Looking at leisure, the average share is much closer to one half, and there is much less dispersion, with the female leisure share in all households lying between one third and two thirds. Looking at the share of home hours and market hours, we see that the share of home hours by the wife is above half in all households, and the share of market hours is below one half in almost all households. Finally, we see that the share of expenditures for the household is centered around 0.79, with almost all households allocating more than half of the budget to public expenditures.

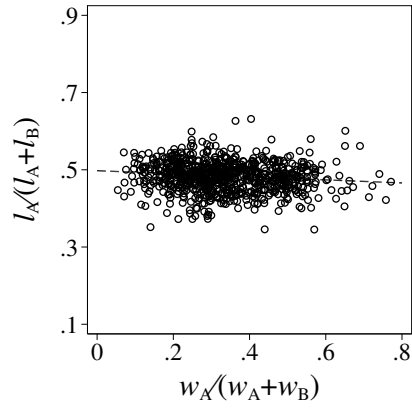
In Figure 2 we present scatter plots of each of the shares against the wage share, along with a line of the slope from a univariate median regression. In the raw data, there is a clear positive relationship between consumption and wage shares. The relationship between leisure and wage shares is nearly flat, while it is clearly negative for the share of home hours and positive for market hours. The share of expenditures allocated to household public goods is also mildly negative. While we cannot conclude much directly from these figures, the patterns will be very informative for estimating the parameters of the Pareto weight and the degree of complementarity between consumption and leisure. For example, these patterns are certainly inconsistent with a unitary model with separability between private consumption and leisure, which would imply no relationship between the wage share and the consumption share and a negative relationship between wage share and leisure share.

## 4 Estimation

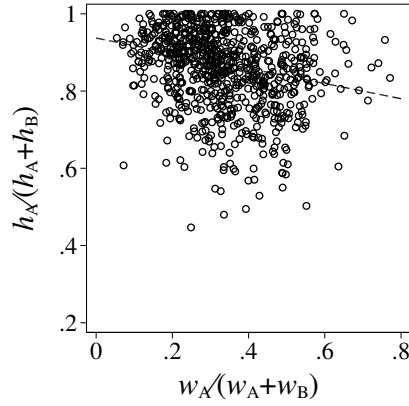
We estimate the model parameters by nonlinear generalized method of moments (GMM). The estimating equations (15) to (27) (see Appendix A.2) are formed by taking logs of equations (1) to (13) which characterize optimal household allocations. We impute individual wages and the household full income from a



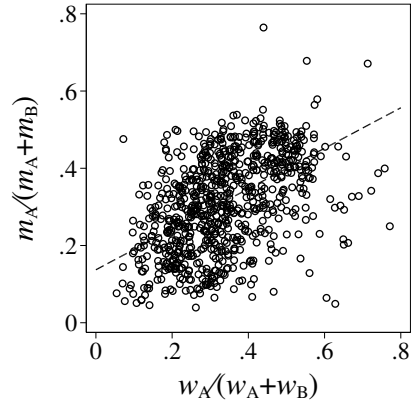
(a) Private consumption



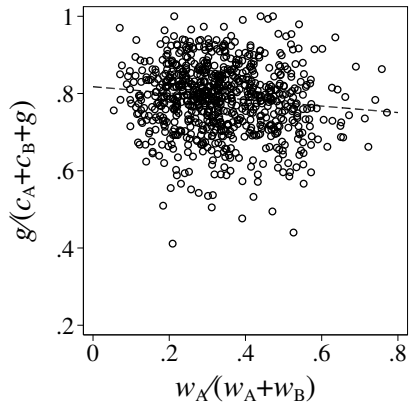
(b) Leisure hours



(c) Home hours



(d) Market hours



(e) Public expenditure

Figure 2: Allocation shares versus wage shares

first-order autoregressive process of individual wages and the household full income with individual and household fixed effects. We assume an interior solution for private consumption, public consumption, leisure and home hours (but not market hours) and treat observations of zero for either private consumption or home hours as the result of infrequency of purchases. The details of the estimation are described below.

## 4.1 Wage process

We assume that the wages of member  $j$  in household  $i$  evolve as a first-order autoregressive process with individual fixed effects:

$$\log w_{jit} = \omega_{0i}^j + \omega_1^j \log w_{ji,t-1} + \omega_2^j \lambda_{jit}^w + \epsilon_{jit}^w, \quad j \in \{A, B\},$$

where  $\lambda_{jit}$  is the inverse Mills ratio that accounts for missing wages in year  $t$  (Heckman, 1979). We first estimate  $\widehat{\lambda}_{jit}$  from a Probit model in which the dependent variable is an indicator for whether individual wages are observed for a given year, and explanatory variables are the number of children under the age of seven, the number of children aged seven to 17, and own and spousal age and education. We then estimate the wage process using the method proposed by Anderson and Hsiao (1981), in which we use the log wages lagged twice as an instrument in the instrumental variable regression of the first-differenced equation. We use the imputed wages (one period ahead forecasts) instead of the actual wages in estimating equations to account for measurement error.

Using the estimated coefficients  $\{\widehat{\omega}_{0i}^j, \widehat{\omega}_1^j, \widehat{\omega}_2^j\}$ , we can calculate the trajectory of wages as

$$\mathbb{E}_0 [\log w_{jit}] = \widehat{\omega}_{0i}^j \sum_{\tau=1}^t (\widehat{\omega}_1^j)^{\tau-1} + (\widehat{\omega}_1^j)^t \log w_{ji0} + \widehat{\omega}_2^j \sum_{\tau=1}^t (\widehat{\omega}_1^j)^{\tau-1} \widehat{\lambda}_{ji,t-\tau+1}^w$$

for a given value of  $\log w_{ji0}$ . Since we do not directly observe wages at the time of marriage for most of the couples, we calculate it as

$$\log w_{ji0} = \varpi_0^j + \varpi_1^j \text{xp}_{ji0} + \varpi_2^j \text{xp}_{ji0}^2 + \varpi_3^j d_{ji}^{ed} + \varpi_4^j d_{ji}^{edf} + \varpi_5^j d_{ji}^{edm} + \varpi_6^j d_{ji}^{rg} + \varpi_7^j \widehat{\lambda}_{ji0}^w,$$

where  $xp_{jit} = \text{age}_{jit} - \text{ed}_{ji} - 6$ , and  $xp_{ji0}$  is the years of potential experience at the time of marriage. The coefficients  $\varpi$ 's are obtained by the linear regression of log wages on experience, experience squared, dummies for own, father's, and mother's education, dummies for prefectures of birth, and the inverse Mills ratio.

We also estimate a first-order autoregressive process for the log full income ( $y_{it}$ ) with household fixed effects to obtain its permanent component.

$$\log y_{it} = \nu_{0i} + \nu_1 \log y_{i,t-1} + \nu_3 \text{age}_{it} + \nu_2 \lambda_{it}^y + \epsilon_{it}^y,$$

where we include the age of husband to control for persistency and preference changes. We then calculate the trajectory of income as

$$\begin{aligned} \mathbb{E}_0 [\log y_{it}] = & \widehat{\nu}_{0i} \sum_{\tau=1}^t (\widehat{\nu}_1)^{\tau-1} + (\widehat{\nu}_1)^t \log y_{i0} \\ & + \widehat{\nu}_2 \sum_{\tau=1}^t (\widehat{\nu}_1)^{\tau-1} \text{age}_{i,t-\tau+1} + \widehat{\nu}_3 \sum_{\tau=1}^t (\widehat{\nu}_1)^{\tau-1} \widehat{\lambda}_{i,t-\tau+1}^y \end{aligned}$$

for a given value of  $\log y_{i0}$ , which can be predicted from own and spousal experience, experience squared, dummies for own, father's, and mother's education, dummies for prefectures of birth, and the inverse Mills ratio.

We use the relative skill endowment  $\widehat{\omega}_{0i}^A - \widehat{\omega}_{0i}^B$  and the household resource endowment  $\widehat{\nu}_{0i}$  as elements of  $z_0$  and the deviation of the imputed wages and income from the trajectory  $\left( \widehat{\log w_{Ait}} - \widehat{\log w_{Bit}} \right) - \mathbb{E}_0 [\log w_{Ait} - \log w_{Bit}]$  and  $\widehat{\log y_{it}} - \mathbb{E}_0 [\log y_{it}]$  as elements of  $z_{1t}$ .

We also examine other distribution factors in  $z_0$ : (1) the log of the geometric mean of male and female sex ratios in their birth years and prefectures; (2) the log differential between wife's parental income and husband's parental income. We use the predicted log income from the linear regression of log annual parental income on time invariant characteristics including dummies for father's and mother's education and father's and mother's birth years; and (3) the log differential between wife's father's occupational prestige and husband's father's occupational prestige. We use predicted log occupational prestige from the linear regression of log occupational prestige on time-invariant characteristics including



dummies for father’s education and father’s birth years. Occupational prestige is measured using the [Treiman \(1977\)](#) scale.

## 4.2 Infrequency

We construct variables for consumption and hours from the data on expenditure in the last month before the survey (September) and time use in a typical week. Because of infrequency, these variables occasionally take a value of zero for some individuals. To account for this, we include in each estimating equation the inverse Mills ratio estimated from a Probit model in which the dependent variable is an indicator of whether consumption and hours are greater than zero, and explanatory variables are own and spousal age and education, the number of children under the age of seven, and the number of children aged seven to 17.

## 4.3 GMM

We estimate the entire system of equations (15)–(27) by two-step GMM. Consumption and hours and the real interest rate are treated as endogenous variables, while preference and productivity shifters and imputed wages and income are treated as exogenous variables. We use the logs of consumption and hours lagged one year as the instruments for the logs of consumption and hours in the intra-temporal conditions from equation (15) to (25) and the log of the interest rate lagged one year and the logs of consumption and hours lagged two years as the instruments for the log of interest rate and the change in the logs of consumption and hours, respectively, in the inter-temporal conditions from equations (26) and (27). Since the set of endogenous and exogenous variables differs across estimating equations, the set of instrumental variables differs across estimating equations.

## 4.4 Identification of the location of the Pareto weight

It is not possible to identify the mean of the Pareto weight separately from preference heterogeneity. Looking at estimating equations (20) to (27), we find that in all cases  $\mu_t$  appears either in log difference form, or together with  $\zeta_t$ . We

can always find a value for the constant in  $\zeta_t$  that will rationalize any value for the constant in  $\mu_t$ . To make a meaningful distinction between sharing/bargaining and preferences, we assume that  $\mu_t$  is equal to one at the mean of full income when the husband and wife have equal wages, education, and experience. In other words, if we observe a household in which the husband and wife have equal wages, education, and experience, but different private consumption and leisure, we will attribute this difference to preference heterogeneity, not bargaining power.<sup>11</sup>

## 5 Results

### 5.1 Parameter estimates

We present the baseline parameter estimates in column 1 of Table 2. The estimates for preference and technology shifters are evaluated at the sample mean of the data. We present the details of the underlying coefficient estimates in Table 4 in the Appendix A.2.

**Home production** The estimates indicate mild complementarity between the home hours of the wife and husband. The elasticity of substitution,  $1/(1 - \gamma)$  is equal to 2.3. Additionally, the estimate of  $\pi$  indicates that women are only moderately more productive at home than men (at the mean observables). Indeed, we cannot reject the null hypothesis of equally efficient home hours. Taken together, the point estimates indicate that absent any differences in market productivity, wives would supply 1.11 hours of home production for every 1 hour supplied by their husband (and we cannot reject equality). Relative market productivity, rather than relative productivity at home, explains the large differences in hours of home production within Japanese households.

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<sup>11</sup>Cherchye, De Rock, and Vermeulen (2012) attain identification of the location of the sharing rule by assuming no preference heterogeneity.

Table 2: GMM estimation

	(1)	(2)	(3)	(4)	(5)
Home production					
$\gamma$	0.565 (0.083)	0.568 (0.083)	0.563 (0.083)	0.564 (0.083)	0.550 (0.084)
$\pi$ (at sample mean)	0.556 (0.049)	0.552 (0.048)	0.556 (0.049)	0.557 (0.049)	0.560 (0.047)
$\rho$	0.083 (0.005)	0.083 (0.005)	0.082 (0.005)	0.083 (0.005)	0.081 (0.005)
Preferences					
$\theta$ (at sample mean)	0.489 (0.063)	0.489 (0.061)	0.473 (0.057)	0.481 (0.060)	0.468 (0.062)
$\vartheta$ (at sample mean)	0.494 (0.073)	0.494 (0.072)	0.456 (0.071)	0.482 (0.071)	0.469 (0.067)
$\phi$	0.285 (0.050)	0.289 (0.048)	0.294 (0.046)	0.292 (0.048)	0.294 (0.046)
$\varphi$	0.309 (0.082)	0.310 (0.082)	0.341 (0.078)	0.321 (0.080)	0.296 (0.073)
$\sigma$	-0.514 (0.147)	-0.489 (0.147)	-0.551 (0.144)	-0.530 (0.144)	-0.791 (0.196)
$\varsigma$	-0.507 (0.154)	-0.492 (0.158)	-0.555 (0.154)	-0.522 (0.149)	-0.739 (0.186)
$\alpha_1$ (at sample mean)	0.359 (0.060)	0.364 (0.059)	0.368 (0.055)	0.363 (0.058)	0.324 (0.060)
$\alpha_2$ (at sample mean)	0.264 (0.035)	0.260 (0.034)	0.264 (0.035)	0.261 (0.035)	0.238 (0.028)
$\beta_1$ (at sample mean)	0.289 (0.044)	0.291 (0.044)	0.304 (0.044)	0.292 (0.043)	0.281 (0.041)
$\beta_2$ (at sample mean)	0.238 (0.031)	0.238 (0.030)	0.226 (0.029)	0.236 (0.030)	0.255 (0.032)
$\zeta$ (at sample mean)	0.673 (0.090)	0.680 (0.089)	0.690 (0.086)	0.681 (0.088)	0.660 (0.091)
$\xi$ (at sample mean)	0.674 (0.107)	0.681 (0.105)	0.701 (0.105)	0.682 (0.105)	0.656 (0.107)
Pareto weight					
$\mu$ (at sample mean)	0.614 (0.073)	0.648 (0.082)	0.615 (0.073)	0.614 (0.074)	0.614 (0.072)
$\mu_{01}$ : $\omega_{0A} - \omega_{0B}$	0.626 (0.076)	0.627 (0.077)	0.624 (0.074)	0.625 (0.075)	0.625 (0.073)
$\mu_{02}$ : $\nu_0$	-0.025 (0.028)	-0.025 (0.028)	-0.024 (0.030)	-0.025 (0.028)	-0.042 (0.026)
$\mu_{03}$ : $\log(\text{ed}_A/\text{ed}_B)$	-0.213 (0.124)	-0.215 (0.124)	-0.228 (0.124)	-0.214 (0.125)	-0.199 (0.137)
$\mu_{04}$ : $\log(\text{exp}_A/\text{exp}_B)$	-0.061 (0.025)	-0.064 (0.025)	-0.056 (0.025)	-0.061 (0.026)	-0.056 (0.028)
$\mu_{05}$ : $\frac{1}{2} \log(\text{sr}_{ASTB})$		1.167 (1.062)			
$\mu_{06}$ : $\log(y_A^P/y_B^P)$			0.025 (0.033)		
$\mu_{07}$ : $\log(y_A^P + y_B^P)$			-0.024 (0.012)		
$\mu_{08}$ : $\log(\text{occ}_A^P/\text{occ}_B^P)$					
$\mu_{11}$ : $z_{1t}$	0.260 (0.066)	0.266 (0.065)	0.259 (0.064)	0.262 (0.064)	
$\mu_{12}$ : $z_{2t}$	0.017 (0.012)	0.016 (0.012)	0.018 (0.017)	0.016 (0.011)	
$\mu_{13}$ : $z_{1t} \times \mathbf{1}\{q_1 < z_{1t} < q_3\}$				0.015 (0.073)	0.018 (0.234)
$\mu_{14}$ : $z_{1t} \times \mathbf{1}\{z_{1t} \leq q_1 \cup z_{1t} \geq q_3\}$					0.254 (0.064)

Notes: Here  $z_{1t} \equiv [\log(w_{At}/w_{Bt}) - \mathbb{E}_0 \log(w_{At}/w_{Bt})]$  is the deviation in the realized log relative wage from the time zero prediction and  $z_{2t} = \log y_t - \mathbb{E}_0 [\log y_t]$  is the deviation in realized log full income from time zero prediction.  $q_1$  and  $q_3$  are the first and third quartile of the distribution of  $z_1$  and  $\mathbf{1}\{\cdot\}$  is an indicator function that takes a value of 1 when the argument is true. Standard errors in parentheses are computed by block bootstrap with 100 replications.

**Preferences** A convenient way to summarize the estimated inter-temporal preferences is by calculating the coefficient of relative risk aversion:

$$\theta \equiv -c_{At} \frac{u_{cc,t}^A}{u_{c,t}^A} = - \left[ (1 - \sigma - \phi) A_t^{-1} \alpha_{1t} c_{At}^\phi + (\phi - 1) \right]$$

$$\vartheta \equiv -c_{Bt} \frac{u_{cc,t}^B}{u_{c,t}^B} = - \left[ (1 - \varsigma - \varphi) B_t^{-1} \beta_{1t} c_{Bt}^\varphi + (\varphi - 1) \right].$$

The point estimates, at the mean of observables, are 0.489 and 0.494 for wives and husbands respectively. Our estimates indicate that husbands and wives view variations in consumption similarly. The estimates are positive, but below one for all individuals in our sample. Note that positive relative risk aversion also implies that utility is increasing and strictly concave, which holds for all individuals in our sample.

Interestingly, the estimates of intra-temporal preferences are quite different for husbands and wives. Evaluated at the mean of observables, the weights on private consumption, leisure and public consumption are 0.36, 0.26 and 0.38 for wives and 0.29, 0.24 and 0.47 for husbands. While our estimates indicate that in the average household husbands put more weight on the public good than their wives, this changes with the number of children present in the household. In Table 3 we present the mean preference weights for wives and husbands as we change the number of children from zero to 3. The weight on household public expenditure of the husband is relatively insensitive to the number of children, falling from 0.48 to 0.45 as we move from zero to three children. In contrast, the estimated weight for the wife rises from 0.28 without children to 0.56 when three children are present. Both the husband and wife put a weight of 0.46 in the presence of two children.

**Pareto weight** Evaluated at the mean of the data, the estimate of the Pareto weight is 0.61. There is substantial variation across households ranging between 0.25 and 1.38; however, there are very few households with estimated weights at or above one (see Figure 3(a)). Relative productivity growth has a strong effect on the Pareto weight. A ten percent difference in relative growth rates of market productivity at marriage results in a six percent difference in the Pareto

Table 3: How preferences vary with the number of children

	Number of Children			
	0	1	2	3
$\alpha_1$	0.420	0.367	0.309	0.249
$\alpha_2$	0.301	0.266	0.228	0.188
$\alpha_3$	0.280	0.367	0.463	0.563
$\beta_1$	0.273	0.278	0.282	0.287
$\beta_2$	0.249	0.252	0.256	0.259
$\beta_3$	0.478	0.470	0.462	0.454

weight. The effect of increasing full income at the time of marriage is negative, but small and not statistically different from zero. Similarly, differences in relative education do not result in statistically significant differences in the Pareto weight, while relative experience at marriage is estimated to have a small negative effect, with a 10 percent increase in experience resulting in only a 0.6 percent reduction in  $\mu_0$  (over that already captured by the permanent component of relative wages).

We also introduce three additional distribution factors that are external to the household, the geometric mean of the cohort sex ratios in the year and prefecture where the husband and wife were born; the relative incomes of the parents of the couple; the sum of the parental income of the parents; and finally the relative occupational prestige of their fathers' jobs. None of these variables has a statistically significant effect on the estimated Pareto weight (see columns 2–4 of Table 2).

Based on these estimates, we can reject the strong (distribution factor free) version of the unitary model in favor of the collective household model.<sup>12</sup> Next we turn to the estimates that are informative on the degree of commitment within the household.

We find that innovations to the relative wage during marriage (the deviation of the realized log relative wage in period  $t$  from the time zero predicted log relative

<sup>12</sup>We have also estimated a robust version of the Pareto weight that uses only four of the 13 equations that define the full system. In this case we approximate the log of the marginal utility of consumption and leisure by a polynomial expansion. The robust estimates are less precise, but none of the conclusions differ from the estimates based on the full system and the parametric specification for utility and home production. We provide details of the estimating equations and the results are presented in Appendix A.3.

wage) also has a positive effect on the Pareto weight, but it is less than half the size as the effect in the cross section. A ten percent increase in the realized relative productivity (relative to predicted) results in a 2.6 percent increase in the Pareto weight. The effect of innovations to full income is estimated to be small and not statistically different from zero.

The fact that innovations to the relative wage are estimated to have an effect on the Pareto weight is evidence against full commitment, consistent with the evidence in [Mazzocco \(2007\)](#). Notably, changes in relative wages within households have a substantially smaller effect on relative allocations than differences in relative wages across households. Additionally, the variation in the innovations to relative wages during marriage is substantially smaller than the heterogeneity across households at the time of marriage. To obtain a sense of the relative importance of the initial setting of the Pareto weight and the revisions we plot the time-constant and time-varying components of the weight in [Figure 3](#). Recall that our parametrization of the weight is multiplicative

$$\mu_t = \mu_0(z_0)\mu_1(z_{1t})$$

so we can interpret the left hand panel as the weight established at marriage and the right hand panel as proportional shifters of the weight over time. The main source of dispersion in the Pareto weight comes at the time of marriage. Recall that the mean is 0.61 and the range across households is 0.25 to 1.38. Looking at the revisions over time, we see that on average these are positive (revisions favor the wife on average) but not large. The total range of estimated revisions to the weight are between 0.91 and 1.08, with almost all revisions contained to the interval 0.95 to 1.05. While the non-zero estimates of the effect of realized deviations in relative wages clearly reject the null hypothesis of full commitment, the effect of the revisions is small relative to initial conditions at marriage. Our estimates indicate that it is extremely unlikely that the Pareto weight would be revised up or down by more than five percent over the duration of a marriage.

To provide some evidence on the nature of renegotiation during marriage, we re-estimate the model allowing the sensitivity of the Pareto weight to depend on the size of the innovation to relative wages. We interact the innovation with

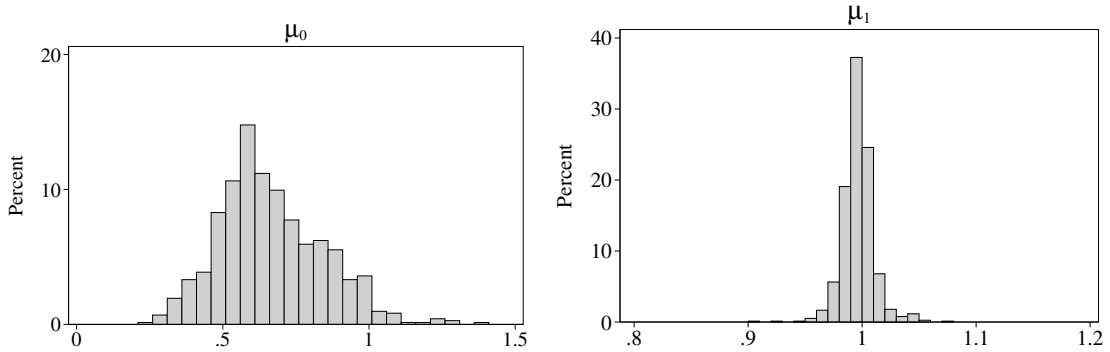


Figure 3: Distributions of  $\mu_0(z_0)$  and  $\mu_1(z_{1,t})$

an indicator of whether the change is large or small. Specifically, we include an indicator variable for whether the innovation is in the bottom or top quartile of changes (i.e. whether the relative wage falls a lot or rises a lot) or whether the innovation is within one quartile of the mean. The estimates are presented in column 5 of Table 2. For innovations in the tails, the effect on the Pareto weight remains at 0.25 (with the same precision), while for small to moderate innovations the magnitude of the effect is not statistically different from zero. These results are consistent with a model in which the household provides insurance against small innovations to wages, but renegotiates when faced with innovations that are large enough that the participation constraint of either the husband or wife binds.

In summary, we find that 1) relative wages affect relative allocations in the cross-section; 2) innovations to relative wages within households lead to changes in relative allocations during marriage; 3) the effect of innovations over time within marriages is much smaller than the effect of differences between household at marriage; 4) within marriage, husbands and wives are insured against small innovations to wages, but re-bargain in the face of large innovations, which is consistent with a model of limited commitment where renegotiation within marriage occurs only when the participation constraint of one of the spouses is binding.

## 5.2 The effect of relative wages on relative allocations,

To illustrate the difference across households when looking at permanent differences in relative wages and unpredicted changes in relative wages within households, we plot the wife's share of consumption, leisure hours, market hours, home hours, the share of total expenditures on public goods, and the Pareto weight as we vary the wife's wage at the time of marriage (looking across households) and unpredicted changes in the wife's wage during marriage (within households). In the first case we vary  $\omega_{iA}$ , which changes both the wage at marriage and the expected wage profile. In the second case we vary the deviation in realized wage ratios from time zero predictions of the wage ratios. In both cases, when we change the wife's wage we adjust non-labor income (adjusting savings or borrowing) to hold full income constant.

We plot the model predicted allocations in Figure 4. We fix the parameters at our preferred point estimates (Table 2, column 5). Our reference household has the mean wage share, 0.35, and an expenditure share on public goods of 80 percent. The solid line traces out the allocation shares as we vary the wife's wage at time of marriage, holding all else constant. We vary the wage to trace out wage shares between 0.15 and 0.55, which correspond to the first and 99th percentiles of the cross-sectional data. The dashed line traces out the allocation shares as we vary the unpredicted (at time of marriage) component of the wife's wage, tracing out shares between 0.27 and 0.43, again corresponding to the first and 99th percentiles of the within household unpredicted changes in the wage share.

There are several striking differences when we look across households compared to within households. While in both cases the wife's share of market hours is increasing in the wage share (panel (c)), the increase is steeper within than between households. The reason for the difference is that there is a stronger income effect for the wife when looking across rather than within households, due to the increase in total resources associated with an increased Pareto weight. This difference has strong implications for how consumption and leisure allocations change with wage shares.

Looking across households, the wife's private consumption share is strictly



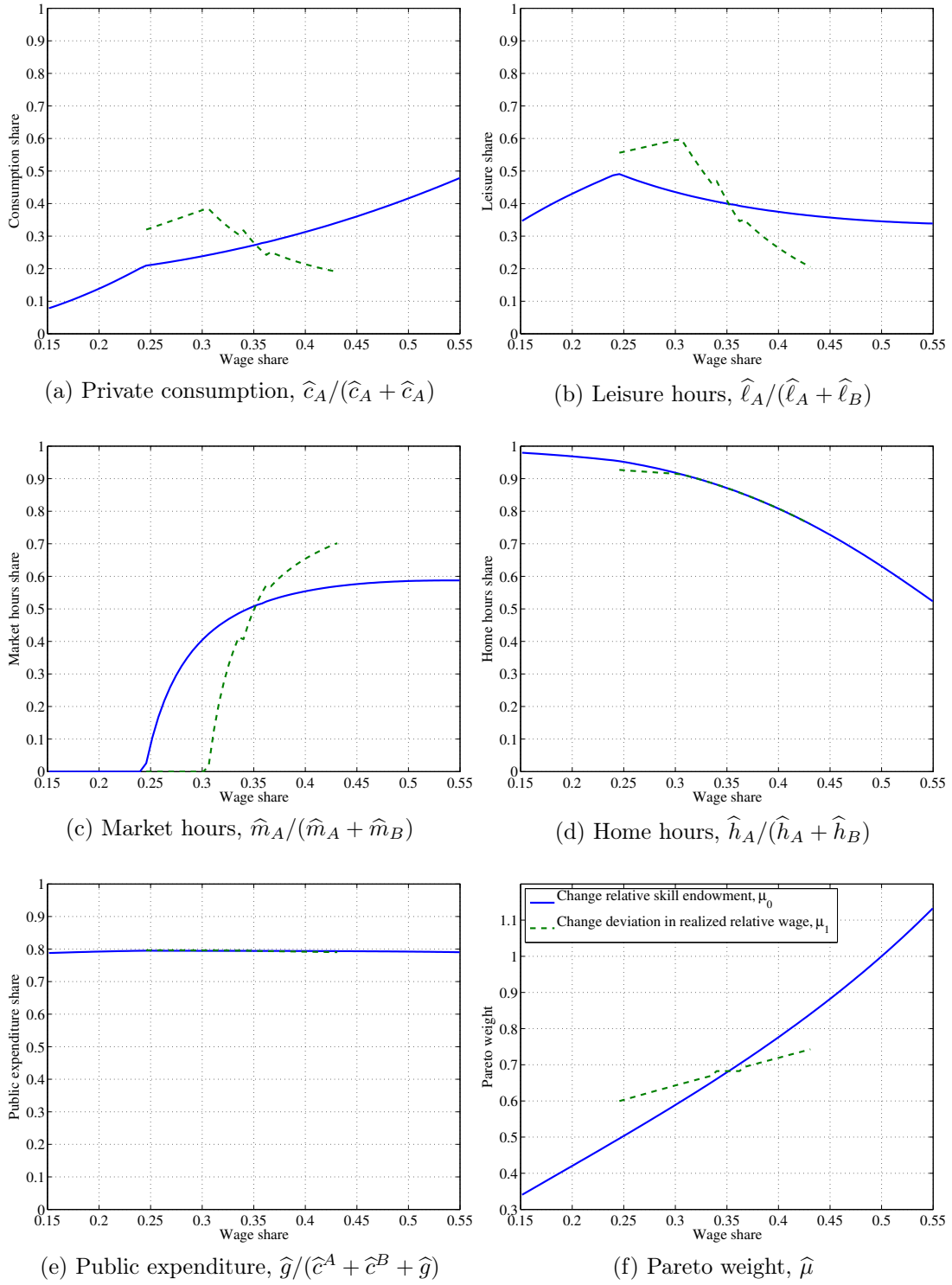


Figure 4: Predicted allocation shares versus wage shares

increasing with her wage share. The increase is, however, muted to some extent at the point she begins to supply positive hours to the market. The reason is that consumption and leisure are complements (according to our estimates), and working positive hours in the market means reducing leisure and the consumption that is complementary to it. When we look at the effect of an unpredicted change in the wife's wage within a household, the income effect is lower (the Pareto weight is less sensitive to these changes). As a result, market hours increase more, leisure declines more, and in this case consumption also declines as the income effect is not strong enough to offset the effect of reducing the amount of complementary leisure.

The share of total expenditure used as an input into producing the public good is only mildly responsive to the change in wage share, both across and within households, declining very slightly to reflect the fact that we estimate that wives put a slightly lower weight on public goods. The optimal mix of inputs in home production does not depend on the Pareto weight, except indirectly through the effect on whether or not the wife supplies positive market hours.

There are two very interesting remarks to be made here. The first is that if we are interested in how changing the relative wage of a woman affects her material wellbeing in the household, we will arrive at different answers if we use cross-sectional variation than if we use within-household variation over time. At the same time, if we are instead interested in how such a change is likely to affect the wellbeing of children, the answer is likely to be the same in both cases. According to our estimates, the share of total expenditures devoted to producing the public good is essentially invariant to the wage share (due to similar enough preferences). At the same time, the share of time devoted to home production by the wife and husband does depend on the wage share, but this is due to the effect of the relative price of time, not which spouse's preferences have more weight (except indirectly when one of the spouses does not supply hours in the market).

## 6 Conclusion

We find that relative wages have a strong impact on the wife's weight in household decision making at the time of marriage. We also find that, during mar-

riage, unpredicted deviations in the relative wage impact on this weight, but the magnitude is substantially smaller, and is only statistically significant for large realizations. These results are consistent with a model of household behavior in which husbands and wives remain committed to allocations agreed at the time of marriage, and only renegotiate in the face of binding participation constraints. Interestingly, the share of total consumption expenditure allocated to the public good is essentially invariant to the wage share. The mix of husband and wife's hours in home production is affected by the wage share only through relative prices, and not directly through the household weight on the wife's utility.

It is worth noting that our estimates are obtained under the assumption that both market and home productivity are exogenous. In a model where wages depend on market participation (learning by doing) we would expect substantial inefficiencies to arise within the household if participation in market work lead not only to increased income, but also an increased share of household resources by shifting the Pareto weight. These, and other related issues are the subject of our further research.

## A Technical Appendix

### A.1 Caring Preferences

In general, individuals will care not only about their own private consumption ( $c$ ) and leisure ( $\ell$ ) and a household public good ( $q$ ), but also the wellbeing of their partner. Specifically,

$$u_t^j = u^j(c_{it}, \ell_{it}, q_t, u_t^k; x_{it}), \quad j \neq k \in \{A, B\}.$$

With caring preferences the household is maximizing

$$U_0^H = \mathbb{E}_0 \sum_{t=0}^T \delta^t (\tilde{\mu}_t u^A(c_{At}, \ell_{At}, q_t, u_t^B; x_{At}) + u^B(c_{Bt}, \ell_{Bt}, q_t, u_t^A; x_{Bt})), \quad (14)$$

subject to the same budget and time constraints presented in Section 2. The distinction between power and caring is actually not very meaningful. The effect of person  $A$  caring strongly for the welfare of person  $B$  and the effect of person  $A$  having low power relative to person  $B$  will be the same; consumption and leisure will tend to reflect person  $B$ 's preferences. Indeed, we could alternatively call caring preferences deferential preferences (Pollak, 2003). This is easy to see in the following simple example from Browning, Chiappori, and Lechene (2006). Suppose that caring takes the following special form

$$u_t^j = u_t^j(c_{jt}, \ell_{jt}, q_t; x_{jt}) + \tau_j u_t^k(c_{kt}, \ell_{kt}, q_t; x_{kt}), \quad j \neq k \in \{A, B\},$$

where  $\tau_j \in (0, 1)$ . Then we can rewrite equation (14) as

$$U_0^H = \mathbb{E}_0 \sum_{t=0}^T \delta^t (\mu_t u^A(c_{At}, \ell_{At}, q_t; x_{At}) + u^B(c_{Bt}, \ell_{Bt}, q_t; x_{Bt})),$$

where

$$\mu_t = \frac{\tilde{\mu}_t + \tau_B}{1 + \tau_A \tilde{\mu}_t}.$$

Caring puts some limits on how far from one the effective Pareto weight can be. If  $\tau_A = \tau_B = 1$  the effective Pareto weight is equal to one, independent of the size of  $\tilde{\mu}_t$ , and distribution factors do not enter the allocation problem (a unitary model).

### A.2 The estimating equations

Taking logs of the optimality conditions in equations (1) to (13) and rewriting them as zero equations, we have the following set of residuals ( $e$ ) to form orthogonality conditions.

#### Home production technology

$$\log \left( \frac{\pi_t}{1 - \pi_t} \right) + (\gamma - 1) \log \left( \frac{h_{At}}{h_{Bt}} \right) - \log \left( \frac{w_{At}}{w_{Bt}} \right) = e_{1t}, \quad (15)$$

$$\log\left(\frac{\rho}{1-\rho}\right) + \log \pi_t + (\gamma - 1) \log h_{At} - \log H_t + \log g_t - \log w_{At} = e_{2t}, \quad (16)$$

$$\log\left(\frac{\rho}{1-\rho}\right) + \log(1 - \pi_t) + (\gamma - 1) \log h_{Bt} - \log H_t + \log g_t - \log w_{Bt} = e_{3t}, \quad (17)$$

### Own private consumption and leisure

$$\log\left(\frac{\alpha_{1t}}{\alpha_{2t}}\right) + (\phi - 1) \log\left(\frac{c_{At}}{\ell_{At}}\right) + \log w_{At} = e_{4t}, \quad (18)$$

$$\log\left(\frac{\beta_{1t}}{\beta_{2t}}\right) + (\varphi - 1) \log\left(\frac{c_{Bt}}{\ell_{Bt}}\right) + \log w_{Bt} = e_{5t}, \quad (19)$$

### Relative consumption and leisure

$$\begin{aligned} \log \mu_t + \log\left(\frac{\zeta_t}{\xi_t}\right) + \log\left(\frac{\alpha_{2t}}{\beta_{2t}}\right) + \left(\frac{1 - \sigma - \phi}{\phi}\right) \log A_t - \left(\frac{1 - \varsigma - \varphi}{\varphi}\right) \log B_t \\ + (\phi - 1) \log \ell_{At} - (\varphi - 1) \log \ell_{Bt} - \log\left(\frac{w_{At}}{w_{Bt}}\right) = e_{6t}, \end{aligned} \quad (20)$$

$$\begin{aligned} \log \mu_t + \log\left(\frac{\zeta_t}{\xi_t}\right) + \log\left(\frac{\alpha_{1t}}{\beta_{1t}}\right) + \left(\frac{1 - \sigma - \phi}{\phi}\right) \log A_t - \left(\frac{1 - \varsigma - \varphi}{\varphi}\right) \log B_t \\ + (\phi - 1) \log c_{At} - (\varphi - 1) \log c_{Bt} = e_{7t}, \end{aligned} \quad (21)$$

### Household public consumption and private leisure and consumption

$$\begin{aligned} \log \mu_t + \log \zeta_t + \log \alpha_{2t} - \log \pi_t - \log \rho + \left(\frac{1 - \sigma - \phi}{\phi}\right) \log A_t + (\phi - 1) \log \ell_{At} \\ - (\gamma - 1) \log h_{At} - \left(\frac{\rho - \gamma}{\gamma}\right) \log H_t - (1 - \rho) \log g_t - \log D_t = e_{8t}, \end{aligned} \quad (22)$$

$$\begin{aligned} \log \mu_t + \log \zeta_t + \log \alpha_{1t} - \log(1 - \rho) + \left(\frac{1 - \sigma - \phi}{\phi}\right) \log A_t \\ + (\phi - 1) \log c_{At} + \rho \log g_t - \frac{\rho}{\gamma} \log H_t - \log D_t = e_{9t}, \end{aligned} \quad (23)$$

$$\begin{aligned} \log \xi_t + \log \beta_{2t} - \log(1 - \pi_t) - \log \rho + \left( \frac{1 - \varsigma - \varphi}{\varphi} \right) \log B_t + (\varphi - 1) \log \ell_{Bt} \\ - (\gamma - 1) \log h_{Bt} - \left( \frac{\rho - \gamma}{\gamma} \right) \log H_t - (1 - \rho) \log g_t - \log D_t = e_{10t}, \end{aligned} \quad (24)$$

$$\begin{aligned} \log \xi_t + \log \beta_{1t} - \log(1 - \rho) + \left( \frac{1 - \varsigma - \varphi}{\varphi} \right) \log B_t + (\varphi - 1) \log c_{Bt} \\ + \rho \log g_t - \frac{\rho}{\gamma} \log H_t - \log D_t = e_{11t}, \end{aligned} \quad (25)$$

### Euler equations

$$\begin{aligned} \Delta \log \mu_t + \Delta \log \zeta_t + \Delta \log \alpha_{1t} + \left( \frac{1 - \sigma - \phi}{\phi} \right) \Delta \log A_t \\ + (\phi - 1) \Delta \log c_{At} + \log R_t + k_A = e_{12t}, \end{aligned} \quad (26)$$

$$\Delta \log \xi_t + \Delta \log \beta_{1t} + \left( \frac{1 - \varsigma - \varphi}{\varphi} \right) \Delta \log B_t + (\varphi - 1) \Delta \log c_{Bt} + \log R_t + k_B = e_{13t}, \quad (27)$$

where  $\Delta \log(\alpha_{1t}) = \alpha'_1 \Delta x_{1At} - \Delta \log(1 + \exp(\alpha'_1 x_{1At}) + \exp(\alpha'_2 x_{1At}))$ ,  $\Delta \log(\beta_{1t}) = \beta'_1 \Delta x_{1Bt} - \Delta \log(1 + \exp(\beta'_1 x_{1Bt}) + \exp(\beta'_2 x_{1Bt}))$ ,  $k_A$  and  $k_B$  contain the discount factor and the approximation error (with finite number of years it is unlikely that the realized forecasting errors average to zero).

### A.3 Robust Estimation of the Sharing Rule and Degree of Commitment

Note that the underlying Pareto problem has substantial structure. As a robustness exercise, we can exploit this structure without imposing additional functional form assumptions (such as homothetic preferences). Consider using only the following first-order conditions (which are necessary, but do not use the full information implied by the system):

$$\begin{aligned} \mu_t \frac{\partial u^A / \partial \ell_{At}}{\partial u^B / \partial \ell_{Bt}} &= \frac{w_{At}}{w_{Bt}}, \\ \mu_t \frac{\partial u^A / \partial c_{At}}{\partial u^B / \partial c_{Bt}} &= 1, \end{aligned}$$

Table 4: Details of parameter estimates

Preferences			Home production		
$\phi$	0.294	(0.046)	$\gamma$	0.550	(0.084)
$\varphi$	0.296	(0.073)	$\pi_0$ : constant	0.298	(0.259)
$\sigma$	-0.791	(0.196)	$\pi_1$ : children 0-6	-0.082	(0.113)
$\varsigma$	-0.739	(0.186)	$\rho$	0.081	(0.005)
$\alpha_{10}$ : constant	0.348	(1.420)	Pareto weight		
$\alpha_{11}$ : wife's age	0.030	(0.029)	$\mu_{01}$ : $\omega_{0A} - \omega_{0B}$	0.625	(0.073)
$\alpha_{12}$ : wife's education	-0.077	(0.051)	$\mu_{02}$ : $\nu_0$	-0.042	(0.026)
$\alpha_{13}$ : children	-0.414	(0.170)	$\mu_{03}$ : $\log(\text{ed}_A/\text{ed}_B)$	-0.199	(0.137)
$\alpha_{20}$ : constant	-0.630	(1.283)	$\mu_{04}$ : $\log(\text{xp}_{A0}/\text{xp}_{B0})$	-0.056	(0.028)
$\alpha_{21}$ : wife's age	0.044	(0.029)	$\mu_{13}$ : $z_{1t} \times \mathbf{1}\{q_1 < z_{1t} < q_3\}$	0.018	(0.234)
$\alpha_{22}$ : wife's education	-0.064	(0.048)	$\mu_{14}$ : $z_{1t} \times \mathbf{1}\{z_{1t} \leq q_1 \cup z_{1t} \geq q_3\}$	0.254	(0.064)
$\alpha_{23}$ : children	-0.382	(0.164)	Censoring correction		
$\beta_{10}$ : constant	-0.472	(0.405)	$\psi_1$	-0.468	(0.423)
$\beta_{11}$ : husband's age	-0.010	(0.010)	$\psi_2$	-10.860	(2.986)
$\beta_{12}$ : husband's education	0.023	(0.012)	$\psi_3$	0.240	(0.409)
$\beta_{13}$ : children	0.034	(0.082)	$\psi_4$	0.024	(0.301)
$\beta_{20}$ : constant	-1.795	(0.551)	$\psi_5$	0.251	(0.489)
$\beta_{21}$ : husband's age	0.019	(0.010)	$\psi_7$	-0.317	(0.239)
$\beta_{22}$ : husband's education	0.032	(0.015)	$\psi_8$	10.011	(2.966)
$\beta_{23}$ : children	0.028	(0.083)	$\psi_9$	-0.213	(0.328)
$\zeta_1$ : household size	-0.094	(0.029)	$\psi_{10}$	-0.241	(0.410)
$\xi_1$ : household size	-0.096	(0.034)	$\psi_{11}$	0.108	(0.519)
$k_A$	0.084	(0.061)	$\psi_{12}$	-0.152	(0.100)
$k_B$	0.030	(0.073)	$\psi_{13}$	-0.199	(0.227)

*Notes:* Standard errors in parentheses are computed by block bootstrap with 100 replications. All variables in the Pareto weight are measured in log. Parameter  $\psi_i$  is the coefficient on the inverse Mills ratio in  $i$ th estimation equation.

Note that, after taking logs, we have the following zero equations:

$$\log \mu_t + \log \left( \frac{\partial u^A(c_{At}, \ell_{At}, q(h_{At}, h_{Bt}, g_t))}{\partial \ell_{At}} \right) - \log \left( \frac{\partial u^B(c_{Bt}, \ell_{Bt}, q(h_{At}, h_{Bt}, g_t))}{\partial \ell_{Bt}} \right) - \log \left( \frac{w_{At}}{w_{Bt}} \right) = 0 \quad (28)$$

$$\log \mu_t + \log \left( \frac{\partial u^A(c_{At}, \ell_{At}, q(h_{At}, h_{Bt}, g_t))}{\partial c_{At}} \right) - \log \left( \frac{\partial u^B(c_{Bt}, \ell_{Bt}, q(h_{At}, h_{Bt}, g_t))}{\partial c_{Bt}} \right) = 0. \quad (29)$$

We can also work with the within-household versions:

$$\Delta \log \mu_t + \Delta \log \left( \frac{\partial u^A(c_{At}, \ell_{At}, q(h_{At}, h_{Bt}, g_t))}{\partial \ell_{At}} \right) - \Delta \log \left( \frac{\partial u^B(c_{Bt}, \ell_{Bt}, q(h_{At}, h_{Bt}, g_t))}{\partial \ell_{Bt}} \right) - \Delta \log \left( \frac{w_{At}}{w_{Bt}} \right) = 0 \quad (30)$$

$$\Delta \log \mu_t + \Delta \log \left( \frac{\partial u^A(c_{At}, \ell_{At}, q(h_{At}, h_{Bt}, g_t))}{\partial c_{At}} \right) - \Delta \log \left( \frac{\partial u^B(c_{Bt}, \ell_{Bt}, q(h_{At}, h_{Bt}, g_t))}{\partial c_{Bt}} \right) = 0. \quad (31)$$

Theory implies this log-separability, both in the cross-section and when looking at within-household changes. Specifically, the only place that the wage can appear in the consumption equations (29) and (31) is in the Pareto weight, and the coefficient on the relative wage in equations (28) and (30) must be equal to one. The only additional requirements from theory is that the Pareto weight is positive, and that the marginal utility from consumption and leisure are positive.

The following system of equations defines a robust (but not efficient) estimator for the Pareto weight:

$$\begin{aligned} Z_0 \mu_0 + Z_{1t} \mu_1 + X_{At} \Gamma_A - X_{Bt} \Gamma_B - \log \left( \frac{w_{At}}{w_{Bt}} \right) &= 0 \\ Z_0 \mu_0 + Z_{1t} \mu_1 + X_{At} \Lambda_A - X_{Bt} \Lambda_B &= 0 \\ \Delta Z_{1t} \mu_1 + \Delta X_{At} \Gamma_A - \Delta X_{Bt} \Gamma_B - \Delta \log \left( \frac{w_{At}}{w_{Bt}} \right) &= 0 \\ \Delta Z_{1t} \mu_1 + \Delta X_{At} \Lambda_A - \Delta X_{Bt} \Lambda_B &= 0, \end{aligned}$$

where  $X_{At}$  contains  $\{c_{At}, \ell_{At}, h_{At}, h_{Bt}, g_t, x_{At}\}$ , plus all the squares, and  $X_{Bt}$  contains



Table 5: Robust estimation

Pareto weight		
$\mu$ (at sample mean)	0.509	(0.179)
$\mu_{01}$ : $\omega_{0A} - \omega_{0B}$	0.823	(0.363)
$\mu_{02}$ : $\nu_0$	-0.011	(0.193)
$\mu_{03}$ : $\log(\text{ed}_A/\text{ed}_B)$	-0.253	(1.130)
$\mu_{04}$ : $\log(\text{xp}_{A0}/\text{xp}_{B0})$	0.014	(0.121)
$\mu_{11}$ : $z_{1t}$	0.520	(0.206)
$\mu_{12}$ : $z_{2t}$	-0.000	(0.100)

Notes: Notation is as in Table 2. Standard errors in parentheses are computed by block bootstrap with 100 replications.

$\{c_{Bt}, \ell_{Bt}, h_{At}, h_{Bt}, g_t, x_{Bt}\}$ , plus all the squares not already included in  $X_{At}$ .

This specification is robust to unobserved heterogeneity in the marginal utility of consumption and leisure (with expectation equal to zero), and can accommodate multiplicative measurement error in wages, consumption, and leisure (use lags as instruments).

We present estimates of the Pareto weight using these equations in Table 5. The robust estimates are less precise, but are fully consistent with the efficient estimates in column 1 of Table 2.

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