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Xiangdan Piao, Hitotsubashi University

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The Research Center for Economic and Social Risks
Institute of Economic Research
Hitotsubashi University

2-1 Naka, Kunitachi, Tokyo, 186-8603 JAPAN
http://risk.ier.hit-u.ac.jp/

In search of a comprehensive picture of the gender gap:
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Xiangdan Piao*

Abstract

This paper investigates single individuals' different choices over time use (labor supply, home production time input, and leisure) and consumption (market consumption goods, home production goods). To this effect, I use the structural model of the Almost Ideal Demand System with a Cobb-Douglas home production function. Consequently, the simulation results indicate that, if women are paid the same hourly wages as men, they receive a similar income (98.7%), and the market labor supply gap almost disappears. However, in home production, the gender gap persists. That is, women are more involved in home production than men, even if their wages are identical. Women's home production technology reduces the labor supply by only 1.7% compared to men's. Overall, the results indicate that the income gap would disappear by diminishing the hourly wage gap. However, the home production gap is not likely to disappear, and it most probably caused by gender identity.

Keywords: single households, labor supply, consumption, home production, almost ideal demand system
JEL classification: D13; J12; J16

* X. Piao, Hitotsubashi University, 2-1 Naka, Kunitachi, Tokyo 186-8601, Japan, e-mail: ed134003@g.hit-u.ac.jp, phone: +81-80-4193-8878.

1. Introduction

Examining the gender gap in labor supply, time spent on home production, and consumption behavior is important. This paper focuses on single male and single female households to explore differences in gender-specific identity is because the gender identity exists due to differences in individuals' social categories (female category and male category) Akerlof and Kranton's (2000).

There are two popular methods for analyzing intra-household couples' resource (income and time) allocation gap. One is the collective model, which explores how resource-management power is distributed between husband and wife in the household. The other method analyzes the issue through the viewpoint of gender identity. Much of the previous research on decision making has focused on married couples.

The collective model, proposed by Chiappori (1992), examines intra-household resource allocation. The sharing rule, the sharing of monetary resources between household members, is commonly used to proxy the husband and wife's bargaining position. Some studies determined that, on average, a wife's resource sharing is less than that of her husband (Couprie 2007; Lise and Seitz 2011).

Some previous studies explain the tendency towards women doing more housework than men in terms of gender identity. Baxter and Tai (2016) point out that this gender gap in housework is common, existing across multiple countries. Alvarez and Miles (2003) obtained similar results studying European households. Bertrand et al. (2013) outline how gender identity causes married working women, who earn more than their husbands, to do more chores as well, leading them to be less satisfied with their marriages and more likely to get divorced. Similarly, Baxter and Tai (2016) discuss how the housework gap between husband and wife increases the time pressure who do more housework, causing marital conflict and reducing overall levels of happiness.

Evaluating the effects of gender identity and bargaining positions is important; each problem requires different methods to solve. For example, if a couple's intra-household resource allocation gap is due to one party's bargaining position, then it is the government's responsibility to improve the weaker party's position through factors like wage. If the allocation gap is caused by gender identity, the government should instead adopt methods like encouraging husbands to do more housework.

Unfortunately, couples' preferences and bargaining positions cannot be obtained from merely observing data. Thus, we need to analyze couples' monetary bargaining positions and utility function. Effects on a husband and wife's bargaining, including individual preferences, are not identical from case to case. According to Akerlof and Kranton (2000), gender identity[1] in such

[1] Akerlof and Kranton's (2000) study conceives gender identity existing due to differences in individuals' social categories.

situations exists when a husband and wife belong to different social categories. Single female and male households are not affected by bargaining positions, but still show the impacts of gender identity because single females and males also belong to different social categories. Exploring single households may present a unique opportunity to learn more about gender identity. Evaluates how much the identity contributes the gap.

In Japan, the gender gap is significant in wages and home production, Japan's gender pay gap being the third highest in the Organisation for Economic Co-operation and Development (OECD) countries in 2015, with women's average wages at 73% (see OECD, 2015). Regarding housework sharing among married couples, Baxter and Tai (2016) show that Japan is one of the most unequal countries on the division of the housework. Therefore, investigating the reason for this significant gender gap in Japan is important. Kato et al. (2013) provide evidence that shorter working hours of wives, caused by their role in housework and caring for children explains only partly the gender wage gap.

This study contributes to the extant gender gap literature in two ways. First, it takes into account consumption information, not making a strong assumption of separable consumption and leisure in exploring the gender gap. Second, to quantify the effects from utility, wage, and home production technology on investigating the gender gap using simulation.

In order to measure the effect of these factors on individual decision making, I assume individuals maximize their utility function under budget constraints and minimize their home production cost. As such, this study uses the following two-procedure estimation. I adopt the Almost Ideal Demand System (AIDS) as the utility function, which is the second approximation for the arbitrary utility function of Deaton and Muellbauer (1980), and use the Cobb-Douglas function to represent home production technologies. On the first procedure, I estimate the home production technology parameter using a Hicksian function (ordinary least squares, OLS). Second, I estimate the demand system (generalized method of moments, GMM) to obtain the utility parameters given the price of home production.

The simulation results indicate that gender income gap is mostly explained by the labor supply time gap if women receive similar wages to men (98.7%). However, women practice more home production than men regardless of their wage. Women's home production technology reduces the labor supply by only 1.7% compared to men's.

The remainder of this paper is structured as follows. Section 2 presents the individual decision-making model. Section 3 explores the model's empirical applications, discusses the two-procedure estimation for obtaining preferences and home production technology parameters, and presents a simulation. Section 4 presents a robustness check, and Section 5 concludes the paper.

2. Model

This section presents a model for individuals' decision-making regarding market consumption (c), leisure time (l), and home production $(D(n,h))$. Since this study investigates whether the gender gap disappears or not when women and men are applied the same hourly wage and family structure, I focus on single individual households $(i = m, f)$. The individuals obtain utility from consumption of market goods (c), leisure time (l), and home production goods $(D(n,h))$. The utility function $u(c,l,D)$ is twice differentiable, strictly increasing, and strictly concave in its arguments. Home production is calculated based on the inputs of time (h) and home production consumption of goods (n). The home production function $D(n,h)$ is twice differentiable, strictly increasing, and strictly concave in its arguments.

Individuals are assumed to have two constraints. First, there is the time constraint: the sum of the leisure time (l), the home production time input (h), and the market working time (z) is normalized to unit. Second, there is a consumption constraint: given the price of market consumption goods (p_c) and home production consumption goods (p_n), individuals' consumption expenditures are no greater than the sum of their non-labor income (y) and their working income, which is calculated as working time (z) multiplied by wage (w).

I assume that there are two types of individuals: single women $(i = f)$ and single men $(i = m)$. Individuals seek to maximize their utility under the two constraints, while minimizing their home production technology cost. An individual's optimal decision can be illustrated as the solution of the following optimization problem:

$$\begin{aligned} &\max_{c^i,l^i,n^i,h^i} U^i\left(c^i, l^i, D^i\left(n^i, h^i\right)\right), \\ &s.t. \quad p_c w^i + p_n n^i \leq w^i z^i + y^i, \\ &\quad\quad l^i + h^i + z^i = 1 (i = f, m). \end{aligned} \tag{1}$$

The corresponding cost minimization problem for home production can be written as follows:

$$\begin{aligned} &\min p_n n^i + w^i h^i, \\ &s.t. \; D^i\left(n^i, h^i\right) = D^i. \end{aligned} \tag{2}$$

Solving the maximization problem for utility and the minimization problem for home production, the optimal decisions can be obtained as follows:

$$\left.\begin{aligned} c^i &= F_c^i\left(p_c, p_n, w^i, y^i\right) \\ l^i &= F_l^i\left(p_c, p_n, w^i, y^i\right) \\ h^i &= F_h^i\left(p_c, p_n, w^i, y^i\right) \\ n^i &= F_n^i\left(p_c, p_n, w^i, y^i\right) \end{aligned}\right\} (i = f, m). \tag{3}$$

Given individuals' market consumption goods (c), leisure time (l), home production time input (h), home production consumption goods input (n), prices (p_c), (p_n), wage (w), and non-labor income (y), the model reveals the different choices of single individuals.

3. Empirical application

3.1. Data

For the empirical application, I use consumption data from the 2004 National Survey of Family Income and Expenditure (NSFIE), time use data from the 2006 Basic Survey of Social Life (BSSL), and price information from the Retail Price Survey (RPS). All three data sets are collected by Japan's Ministry of Internal Affairs and Communications Bureau of Statistics. The NSFIE is conducted every five years, and studies households' daily account books to obtain detailed data on household demographics, income, and property. Data averages from October and November are used to determine data for single households. The BSSL is also conducted every five years, and it includes information on demographics, income, and one day's worth of detailed time use data. The survey is conducted from October 14 to October 22. Finally, the RPS is conducted monthly, and includes detailed information on commodity and service price levels.

The sample includes single employed women and men, who do not care for the elderly or young children on the survey date, and are between the ages of 25 and 59. I exclude observations that are missing values of necessary variables for the analysis. For the BSSL, I exclude observations for which the studied individual had a job, but was on holiday on the survey date. Since consumption and time use information come from different data sets, I use exact matches using gender, age, occupation,[2] and three major metropolitan areas. Previous research studies adopt the same matching method (Price 2008; van Klaveren and van den Brink 2007).

Market consumption and home production consumption prices are the weighted averages of the respective commodity prices. The weights stem from consumption data, and the commodity prices are obtained from RPS. The aggregated prices differ by household.

Table 1 shows summary statistics for the matched data (summary statistics before matching are shown in the appendix), revealing a gender gap in hourly wages, such that single women earn 76% of the wages earned by men. Similarly, there is a gap in labor supply time, such that single women contribute 88% of the labor supply contributed by men. Single women also spend more time (282%) and consumption (129%) on home production than single men.

[2] The occupation categories include agriculture, forestry, and fishery workers; administrative and managerial workers; employers; and others.

Table 1. Descriptive statistics for single households with matched data

	Single women		Single men		
Variable	Mean	Std. dev.	Mean	Std. dev.	Ratio
Market consumption (JPY/day)	5,501.22	3,558.47	6,450.80	3,044.51	0.85
Home production consumption (JPY/day)	465.75	172.39	362.35	173.95	1.29
Home production time (minutes/day)	78.91	39.01	27.95	14.97	2.82
Market labor supply (minutes/day)	508.60	85.86	575.20	61.28	0.88
Leisure (minutes/day)	852.49	74.25	836.86	58.35	1.02
Total resource (JPY/day)	30,273.93	14,427.15	36,966.88	13,897.60	0.82
Hourly wage	1,583.07	763.23	2,095.30	807.59	0.76
Age	43.43	10.70	43.61	9.78	
Cell	28		31		

Note: Data are from the 2004 NSFIE, the 2006 BSSL, and the 2004 RPS. The 2006 BSSL includes only annual income information and weekly working hours, so wages are calculated by dividing annual income (from the 2004 NSFIE) by 51.48 weeks to obtain weekly income, which is subsequently divided by weekly working hours to obtain the hourly wage. Home production consumption includes cereals, meat, seafood, dairy items, vegetables, oils, fats, condiments, domestic durable goods, general furniture, domestic utensils, and domestic nondurable goods.[3] Market consumption expenditure includes all expenditures other than those included in home production consumption. The total resource is defined as the sum of home production, market consumption expenditure, leisure, and home production time. The leisure and home production time are evaluated at wage value. Home production time includes housework time and shopping time. Leisure time is total time (1,440 minutes) excluding market labor supply and home production time. The market labor supply includes working time and commute time.

3.2. Almost ideal demand system (AIDS) for women and men

The AIDS model proposed by Deaton and Muellbauer (1980) is a second-order approximation of the arbitrary utility function. The AIDS function is very general, and, thus, widely used.[4] Individuals' $(i = f, m)$ demand system equations are specified in equation (3), which can be transformed into the specifications proposed by Deaton and Muellbauer (1980).[5] The three categories are denoted as follows: market consumption (c) with the price (p_c), leisure (l) with the wage (w), and home production $(D(n,h))$ with the aggregated price $g(p_n, w)$ of the home production consumption goods price (p_n) and the home production time wage price (w). The total resource m for a given time period, such as one day, is the sum of the consumption

[3] These categories are from the 2004 NSFIE.

[4] See (Unayama 2008; Cherchye et al. 2015; Sahinli and Fidan 2012).

[5] Since market consumption expenditures $p_c c$ and leisure time l can be observed directly from the data, the function emanates from equation (3), which can be transformed from the equation proposed by Deaton and Muellbauer (1980).

expenditure and the time consumed. I use the parameters $\left(\alpha_c^i, \alpha_l^i, \alpha_d^i, \beta_c^i, \beta_l^i, \beta_d^i, \gamma_{cc}^i, \gamma_{cl}^i, \gamma_{cd}^i \right.$

$\left. , \gamma_{lc}^i, \gamma_{ll}^i, \gamma_{ld}^i, \gamma_{dc}^i, \gamma_{dl}^i, \gamma_{dd}^i; i = f, m \right)$ to capture the different preferences of single individual.

$$p_c c^i = \left(\alpha_c^i + \beta_c^i \ln \frac{m^i}{a^i(p_c, p_n, w^i)} + \gamma_{cc}^i \ln p_c + \gamma_{cl}^i \ln w^i + \gamma_{cd}^i \ln g^i(p_n, w^i) \right) m^i,$$
$$l^i = \left(\alpha_l^i + \beta_l^i \ln \frac{m^i}{a^i(p_c, p_n, w^i)} + \gamma_{lc}^i \ln p_c + \gamma_{ll}^i \ln w^i + \gamma_{ld}^i \ln g^i(p_n, w^i) \right) \frac{m^i}{w^i},$$
$$g^i(p_n, w^i) D^i(n^i, h^i) = \left(\alpha_d^i + \beta_d^i \ln \frac{m^i}{a^i(p_c, p_n, w^i)} + \gamma_{dc}^i \ln p_c + \gamma_{dl}^i \ln w^i + \gamma_{dd}^i \ln g^i(p_n, w^i) \right) m^i,$$

(4)

where $a^i(p_c, p_n, w^i)$ is as shown in equation (5).

$$a^i(p_c, p_n, w^i) = \alpha_0 + \alpha_c^i \ln p_c + \alpha_l^i \ln w^i + \alpha_d^i \ln g^i(p_n, w^i) + \frac{1}{2}\gamma_{cc}^i \ln p_c \ln p_c + \frac{1}{2}\gamma_{cl}^i \ln p_c \ln w^i + \frac{1}{2}\gamma_{cd}^i \ln p_c \ln g^i(p_n, w^i) + \frac{1}{2}\gamma_{lc}^i \ln w^i \ln p_c + \frac{1}{2}\gamma_{ll}^i \ln w^i \ln w^i + \frac{1}{2}\gamma_{ld}^i \ln w^i \ln g^i(p_n, w^i) + \frac{1}{2}\gamma_{dc}^i \ln g^i(p_n, w^i) \ln p_c + \frac{1}{2}\gamma_{dl}^i \ln g^i(p_n, w^i) \ln w^i + \frac{1}{2}\gamma_{dd}^i \ln g^i(p_n, w^i) \ln g^i(p_n, w^i).$$

(5)

Parameter restrictions for AIDS are as follows: the summation conditions are $\sum_j \alpha_j^i = 1$, $\sum_j \beta_j^i = 0$, and $\sum_j \gamma_{jk}^i = 0$; the homogeneity condition is $\sum_k \gamma_{jk}^i = 0$; and the symmetry condition is
$\gamma_{jk}^i = \gamma_{kj}^i$; $(j = c, l, d; k = c, l, d)$.

3.3. Home production

The level of home production is a function of the time input (h) and the consumption goods for home production (n). I assume both categories of single individuals $(i = f, m)$ to have a Cobb-Douglas home production function as per equation (6). δ^i captures the difference in home production technologies between single men and women.

$$D^i(n^i, h^i) = (n^i)^{(1-\delta^i)}(h^i)^{\delta^i}. \quad (6)$$

Single individuals are assumed to minimize costs by choosing the optimal time (h) and home production consumption goods (n) inputs. Therefore, an individual's cost function takes the following form: $g^i(p_n^i, w^i)D(n^i, h^i)$. Here, $g(p_n, w)$ is the aggregated price of the home production, where:

$$g^i(p_n, w^i) = \left(\left(\frac{\delta^i}{1-\delta^i}\right)^{-\delta^i} + \left(\frac{\delta^i}{1-\delta^i}\right)^{1-\delta^i}\right) p_n^{1-\delta^i}(w^i)^{\delta^i}. \quad (7)$$

3.4. Parameter estimation

The purpose of this study is to compare the differences in the choices of single women and men regarding labor supply, market consumption, leisure, and home production, assuming that individuals try to maximize utility and minimize home production costs. This paper uses a two-procedure estimation, which estimates the Hicksian demand function to obtain the home production price parameters δ^i first, and, given the aggregated home production price, estimates the AIDS demand system.

In the first procedure, I estimate the Hicksian demand function as shown in equation (7). Parameter δ^i is unknown, but we can observe the cost of home production from the data. From the cost function $g^i(\mathrm{p}_n^i, w^i)D(n^i, h^i)$, the Hicksian demand function can be obtained using Shephard's Lemma. Since the home production function is assumed to be a Cobb-Douglas function, the Hicksian function of the home production time input (h) becomes as follows:

$$h^i = \delta^i x^i + \varepsilon_h^i, \quad (8)$$

where $(i = f, m)$, $x^i = \frac{g^i(p_n, w^i)D^i(n^i, h^i)}{w^i}$, and the error term is ε_h^i. Home production cost is derived from home production consumption expenditure and wage evaluated time input. The AIDS demand function requires the log function of the aggregated home production price, and I used the following function $\ln g^i(p_n, w^i) = \ln p_n^{1-\delta^i} + \ln(w^i)^{\delta^i}$ in the second procedure. Note that the omitted constant term $\ln\left(\left(\frac{\delta^i}{1-\delta^i}\right)^{-\delta^i} + \left(\frac{\delta^i}{1-\delta^i}\right)^{1-\delta^i}\right)$ does not create any parameter bias in the AIDS demand function.

In the second procedure, given the home production price, I estimate the AIDS demand system as shown in equation (8). The price index $a^i(p_c, p_n, w^i)$ is the same as in (4), and the parameter restrictions are as previously discussed. The third equation, $g^i(p_n, \mathrm{w}^i)D^i(n^i, h^i)$, is omitted due to the summation condition.

The market consumption price p_c and the home production consumption price p_n are the weighted averages of the commodity prices, whose weights come from consumption data. Therefore, price levels are different among households.[6] m is the total resource for the households, that is, the sum of consumption expenditures, the wage-valued leisure time, and home production time inputs, as used by Cherchye et al. (2015). The market consumption price p_c, the home production consumption price p_n, and the total resource m are endogenous variables, causing estimation biases. To address this endogenous problem, I adopt the GMM, with the instrument variables for single male households being age, occupation, monthly income, ln(wage), wage, house, and three major metropolitan areas for both equations p_cc and l. The instrument variables for single female households are occupation, monthly income, square age, ln(wage), three major metropolitan areas, and education for market consumption and house room for leisure for equations p_cc and l.

$$
\begin{aligned}
p_c c^i &= \left(\alpha_c^i + \beta_c^i \ln\frac{m^i}{a^i(p_c, p_n, w^i)} + \gamma_{cc}^i \ln p_c + \gamma_{cl}^i \ln w^i + \gamma_{cd}^i \ln g^i(p_n, w^i)\right) m^i + \varepsilon_c^i, \\
l^i &= \left(\alpha_l^i + \beta_l^i \ln\frac{m^i}{a^i(p_c, p_n, w^i)} + \gamma_{lc}^i \ln p_c + \gamma_{ll}^i \ln w^i + \gamma_{\mathrm{l}d}^i \ln g^i(p_n, w^i)\right) \frac{m^i}{w^i} + \varepsilon_l^i.
\end{aligned} \tag{9}
$$

Table 2 shows the main results for the two procedures using single woman and single man household cells. The first-procedure estimation results come from estimating equation (8) using OLS. δ^i is the parameter for home production technology; the value of 0.826 for this parameter for women indicates that the time input contributes 0.826 for each unit of home production. The technology parameter for women is larger than the parameter for single men (0.709). This result means that the women tend to input more time into home production.

The second-procedure estimation results come from estimating equation (9) using GMM with the parameter constraints shown in Section 3.2. The parameters for single women and single men have the same sign, except in the case of β_c. The over-identification test statistics for single women, Hansen's J chi^2(7), is 4.69328 (p = 0.6973); for single men, Hansen's J chi^2(9) is 5.68167 (p = 0.7713). Neither of the over-identification tests is rejected.

[6] Kano et al. (2013) use the similar aggregated method for each area.

Table 2. OLS estimates for the first procedure and GMM estimates for the second procedure

	Single Women		Single Men	
First procedure				
δ	0.826***	(0.019)	0.709***	(0.019)
R-squared	0.987		0.979	
Cell	28		31	
Second procedure				
α_c	-1.205**	(0.483)	-0.884	(0.593)
γ_{cc}	0.141***	(0.021)	0.127***	(0.015)
γ_{cl}	-0.162***	(0.044)	-0.150***	(0.028)
β_c	0.020	(0.066)	-0.006	(0.105)
α_l	2.903*	(1.667)	2.420*	(1.422)
γ_{ll}	0.120	(0.133)	0.143	(0.142)
β_l	-0.103	(0.188)	-0.070	(0.242)
Cell	28		31	

Note: Standard errors are in parentheses for the first procedure. Robust standard errors are in parentheses for the second procedure. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. $a(p_c, p_n, w)$ has a constant parameter α_0 that cannot be estimated; thus, I followed Poi (2008) and chose 5. $a(p_c, p_n, w)$ ranges from 1.033 to 3.979 for female households and from 4.034 to 6.072 for male households.

Table 3. Simulation results from estimated parameters for women and men data

	(1) Women home production technology and women preferences			(2) Men home production technology and women preferences		
Variable	Mean	Std. dev.	Ratio	Mean	Std. dev.	Ratio
Predicted market labor supply (minutes/day)	567.790	56.903		577.771	56.318	
Market labor supply (minutes/day)	575.197	61.285	0.987	575.197	61.285	1.004
Predicted leisure (minutes/day)	827.360	57.156		824.875	56.903	
Leisure (minutes/day)	836.856	58.352	0.989	836.856	58.352	0.986
Predicted home production time (minutes/day)	44.850	13.488		37.354	11.444	
Home production time (minutes/day)	27.950	14.963	1.605	27.950	14.963	1.336
Predicted market consumption (JPY/day)	6,267.405	3,147.168		6,376.643	3,089.824	
Market consumption (JPY/day)	6,450.796	3,044.514	0.972	6,450.796	3,044.514	0.989
Predicted home production consumption (JPY/day)	323.100	162.047		526.955	277.960	
Home production consumption (JPY/day)	362.347	173.947	0.892	362.347	173.947	1.454
Predicted home production price	109.040	27.659		120.658	24.083	
Cell	31			31		

Table 4. Simulation results from estimated parameters for men and women data

	(1) Men home production technology and men preferences			(2) Women home production technology and men preferences		
Variable	Mean	Std. dev.	Ratio	Mean	Std. dev.	Ratio
Predicted market labor supply (minutes/day)	532.183	67.948		522.459	69.858	
Market labor supply (minutes/day)	508.598	85.858	1.046	508.598	85.858	1.027
Predicted leisure (minutes/day)	875.568	63.455		879.743	64.262	
Leisure (minutes/day)	852.493	74.252	1.027	852.493	74.252	1.032
Predicted home production time (minutes/day)	32.249	10.463		37.799	12.359	
Home production time (minutes/day)	78.909	39.010	0.409	78.909	39.010	0.479
Predicted market consumption (JPY/day)	6,224.897	3,690.464		6,127.457	3,694.295	
Market consumption (JPY/day)	5,501.216	3,558.465	1.132	5,501.216	3,558.465	1.114
Predicted home production consumption (JPY/day)	336.916	183.468		202.936	110.044	
Home production consumption (JPY/day)	465.753	172.388	0.723	465.753	172.388	0.436
Predicted home production price	107.167	26.425		91.242	28.439	
Cell	28			28		

3.5. Simulation results

Women and men utility (preferences), wages, and home production technologies have complex effects on their choices. Using the developed simulation, I differentiate these effects by exploring market labor supply, consumption, and leisure.

Table 3 shows the simulation results based on estimated structural parameters drawn from data on single men. Column 1 displays the results based on the estimated parameters (women's preference parameters and women's home production technology parameters) for single women, as applied to men's condition (wage, aggregated market consumption price, aggregated home production consumption price, and total resource,[7] as presented in Table 1). Using these data, the simulation predicts market labor supply, leisure, home production time input, market consumption expenditure, and home production consumption expenditure. Column 2 shows the simulation results for the estimated parameters (women's preferences and men's home production technology) for single women as applied to men's condition. The simulation results for the estimated parameters using data on single women are shown in Table 4. Column 1 of Table 4 shows men's preferences and home production technology parameters as applied to women's condition. Column 2 shows the simulation results from women's data, men's preferences, and women's home production technology parameters.

The preference parameters are the AIDS model parameters $\left(\alpha_c^i, \alpha_l^i, \beta_c^i, \beta_l^i, \gamma_{cc}^i, \gamma_{cl}^i, \gamma_{ll}^i\right.$ $\left.; i = f, m\right)$; the home production technology parameter is δ^i, as displayed in Table 2.

Column 2 of Table 3 compares the preferences of women and men with a high wage level and the same home production technologies. The simulation results suggest that women have the same labor supply as men. Furthermore, women prefer home production goods more than men (women spend 133.6% and 145.4% of men's spending on home production time and home production consumption, respectively). The difference in home production preferences is probably due to the fact that girls get more training on home production. Comparing columns 1 and 2 of Table 3 reveals that women and men choose different optimal responses to home production technology. Women's cost minimization on home production uses significant time input compared to men, since it reduces the female labor supply by 1.7% and increases home production time input by seven minutes.

Comparing Tables 3 and 4, and regardless of the wage level, men produce lower levels of home production goods. If men's hourly wages are the same as women's, they prefer leisure, market

[7] "Total resource" is the sum of consumption expenditure, wage-valued leisure, and home production.

labor supply, and market consumption.

4. Robustness check

Hitherto, this paper studied how women's and men's utility (preferences), home production technologies, and wages affect their choices concerning consumption, leisure, labor supply, and home production. The aggregated prices are calculated from detailed prices obtained from the RPS, and the weights are taken from the NSFIE. Prices differ among households. Households consume numerous consumption goods and services, and the aggregated prices of market consumption and home production consumption depend on unit price (e.g., meat is measured in JPY/100 g, and Internet services in JPY/month). Fortunately, food prices depend on both price and volume and, thus, can be transformed into prices with the same volume (per 100 g or 100 ml). As such, I use food to check whether the above estimation and simulation results are robust.

Table 5 shows summary statistics for the matched data. Home production consumption includes cereals, meat, seafood, dairy items, vegetables, oils, fats, condiments. Market consumption includes eating out, alcohol, drinks, sweets, and cooked food.

Table 6 displays the estimation results of equations (8) and (9). Tables 7 and 8 show the simulation results. The results are largely similar to the results in Tables 3 and 4.

Table 5. Statistics for single households with matched data (food for consumption)

	Single women		Single men		
Variable	Mean	Std. dev.	Mean	Std. dev.	Ratio
Market consumption (JPY/day)	608.65	346.97	1303.93	613.65	0.47
Home production consumption (JPY/day)	380.17	142.89	316.86	155.05	1.20
Home production time (minutes/day)	78.91	39.01	27.95	14.97	2.82
Market labor supply (minutes/day)	508.60	85.86	575.20	61.28	0.88
Leisure (minutes/day)	852.49	74.25	836.86	58.35	1.02
Total resource (JPY/day)	25,295.78	11,507.42	31,774.53	12,019.93	0.80
Hourly wage	1,583.07	763.23	2,095.30	807.59	0.76
Age	43.43	10.70	43.61	9.78	
Cell	28		31		

Table 6. OLS estimates for the first procedure and GMM estimates for the second procedure (food for consumption)

	Single Women		Single Men	
First procedure				
δ	0.852***	(0.017)	0.736***	(0.019)
R-squared	0.990		0.981	
Cell	28		31	
Second procedure				
α_c	-0.015	(0.021)	-0.253***	(0.032)
γ_{cc}	0.016***	(0.002)	0.042***	(0.004)
γ_{cl}	-0.034***	(0.005)	-0.072***	(0.016)
β_c	-0.039***	(0.006)	-0.003	(0.021)
α_l	1.352***	(0.154)	1.366***	(0.158)
γ_{ll}	0.014	(0.022)	0.196***	(0.075)
β_l	-0.141**	(0.069)	0.064	(0.086)
Cell	28		31	

Note: The instruments for single women households, p_cc and l, include house, wage, occupation, monthly income, age, age cubed, age squared, ln(w), and the three major metropolitan areas. The Hansen's J chi2(13) = 14.0695 (p = 0.3690). The instruments for single men household's leisure, l, include education, house room, age, monthly income, ln(wage), three major metropolitan areas. The instruments for single men household's consumption, p_cc, include house, education, occupation, monthly income, age, ln(wage), and three major metropolitan areas. Hansen's J chi2(9) = 9.81544 (p = 0.3656).

Table 7. Simulation results from estimated parameters for women and men data (food for consumption)

	(1) Women home production technology and women preferences			(2) Men home production technology and women preferences		
Variable	Mean	Std. dev.	Ratio	Mean	Std. dev.	Ratio
Predicted market labor supply (minutes/day)	574.773	59.964		582.053	57.987	
Market labor supply (minutes/day)	575.197	61.285	0.999	575.197	61.285	1.012
Predicted leisure (minutes/day)	812.899	46.770		812.592	46.458	
Leisure (minutes/day)	836.856	58.352	0.971	836.856	58.352	0.971
Predicted home production time (minutes/day)	52.328	13.300		45.355	11.689	
Home production time (minutes/day)	27.950	14.963	1.872	27.950	14.963	1.623
Predicted market consumption (JPY/day)	1,390.455	589.089		1,386.963	571.064	
Market consumption (JPY/day)	1,303.930	613.650	1.066	1,303.930	613.650	1.064
Predicted home production consumption (JPY/day)	309.624	127.011		552.650	222.823	
Home production consumption (JPY/day)	316.865	155.050	0.977	316.865	155.050	1.744
Predicted home production price	99.849	26.908		99.655	19.795	
Cell	31			31		

Table 8. Simulation results from estimated parameters for men and women data (food for consumption)

	(1) Men home production technology and men preferences			(2) Women home production technology and men preferences		
Variable	Mean	Std. dev.	Ratio	Mean	Std. dev.	Ratio
Predicted market labor supply (minutes/day)	521.660	81.902		514.943	82.656	
Market labor supply (minutes/day)	508.598	85.858	1.026	508.598	85.858	1.012
Predicted leisure (minutes/day)	886.543	86.147		894.393	87.176	
Leisure (minutes/day)	852.493	74.252	1.040	852.493	74.252	1.049
Predicted home production time (minutes/day)	31.797	20.714		30.664	19.619	
Home production time (minutes/day)	78.909	39.010	0.403	78.909	39.010	0.389
Predicted market consumption (JPY/day)	1,014.696	529.849		987.375	567.179	
Market consumption (JPY/day)	608.648	346.965	1.667	608.648	346.965	1.622
Predicted home production consumption (JPY/day)	241.599	116.776		143.131	61.959	
Home production consumption (JPY/day)	380.172	142.891	0.635	380.172	142.891	0.376
Predicted home production price	86.611	20.125		82.928	24.514	
Cell	28			28		

5. Conclusion

This paper investigated single men and women's different choices over time use (labor supply, home production time input, and leisure) and consumption choice (market consumption goods, home production goods). For the empirical application, I sampled single employed households, who do not care for elderly or children. The consumption data is from the 2004 NSFIE, time use data from the 2006 BSSL, and price information is from RPS, with exact matching based on gender, age, occupation, and three major metropolitan areas.

Given utility maximization and cost minimization, I use the Cobb-Douglas function for home production and the AIDS model for the preferences. The two-procedure estimation are as follows: estimate the Hicksian function to obtain the home production price parameters δ first, and, given, the home production price, estimate the AIDS demand system. The single households are estimated separately based on gender.

The simulation results based on the estimated parameters show that, if single women (single men) are given the same market consumption goods price, home production goods price, wage, and total resource as single men (single women), single women (single men) make their optimal choice over market labor supply, leisure, home production time, market consumption expenditure, and home production consumption expenditure. However, women receive 98.7% of men's income. Women devote a higher time input to home production, reducing the labor supply by 1.7%. Men have lower levels of home production goods than women, regardless of wage. Given the same wage and home production technology as men, women spend 133.6% and 145.4% of men's expenditures on home production time and home production consumption, respectively.

The simulation results show that women choose less leisure, and as much of the labor supply as men when they earn the same wage as men; however, men have less home production than women and consume more leisure when they earn lower wages (equal to women's wages).

For future gender equality, studies on diminishing the non-labor gap (such as home production, caring for children and for parents), due to traditional gender identity is important to investigate as well.

Appendix

Table A1 shows the time use statistics for single women and men before matching. The table illustrates that single women spend more time on home production and leisure and less on market labor supply. Table A2 shows the consumption of single women and men before matching. It illustrates that single women consume more home production consumption goods and fewer market consumption goods than single men. Table A3 shows the aggregated price of market consumption goods and home production consumption goods. Single women pay higher prices for these two kinds of goods than single men.

Table A4 compares the variables drawn from the data and the variables predicted in the estimation. Table A5 predicts the robustness check for the estimation results.

Table A1. Statistics of time use before matching

	Single women		Single men	
Variable	Mean	Std. dev	Mean	Std. dev
Home production time (minutes/day)	75.719	78.355	27.526	48.736
Market labor supply (minutes/day)	514.546	173.014	587.361	184.586
Leisure (minutes/day)	849.735	154.669	825.112	171.037
Observations	1,564		2,668	

Note: Data is from the 2006 BSSL.

Table A2. Statistics of consumption of single women and men before matching

	Single women		Single men	
Variable	Mean	Std. dev.	Mean	Std. dev.
Market consumption (JPY/day)	5,874.339	4,745.171	6,256.903	3,523.943
Home production consumption (JPY/day)	493.818	295.395	354.404	278.179
Observations	561		814	

Note: Data is from the 2004 NSFIE.

Table A3. Statistics of price information on single women and men before matching

	Single women		Single men	
Variable	Mean	Std. dev.	Mean	Std. dev.
Price of market consumption	6,682.939	9,788.471	5,759.920	7,573.349
ln(Price of market consumption)	11.910	0.557	12.018	0.503
Price of home production consumption	2,241.666	9,564.131	1,516.294	4,706.195
ln(Price of home production consumption)	9.432	0.612	8.967	0.893
Observations	561		814	

Note: The data are drawn from the 2004 RPS and 2004 NSFIE. The RPS is composed of the retail prices of major items arranged by city (71 cities in Japan). Price information was organized as follows. (1) The volume was first transformed into identity for cases in which it differed among the 71 cities. (2) The average price per detailed category of the 71 cities was taken. (3) The food price was transformed into unit volume (100 g, 100 ml); the same was done for electricity and gas. These categories included volume and price; thus, I was able to transform the prices. (4) The RPS and NSFIE categories were matched, and the average prices were taken in cases for which several RPS categories were merged to match a single NSFIE category. (5) I took the weighted price average (price of market consumption and price of home production consumption). Since the weight was drawn from the NSFIE, the prices differ by household. The price of automobiles was excluded.

Table A4. Comparison between data and predicted variables

	Single women		Single men	
Variable	Mean	Std. dev.	Mean	Std. dev.
Predicted market labor supply (minutes/day)	513.275	69.773	587.872	54.626
Market labor supply (minutes/day)	508.598	85.858	575.197	61.285
Predicted leisure (minutes/day)	871.136	68.117	827.504	52.208
Leisure (minutes/day)	852.493	74.252	836.856	58.352
Predicted home production time (minutes/day)	55.589	18.272	24.624	7.585
Home production time (minutes/day)	78.909	39.010	27.950	14.963
Predicted market consumption (JPY/day)	5,757.290	3,584.670	6,962.956	3,201.962
Market consumption (JPY/day)	5,501.216	3,558.465	6,450.796	3,044.514
Predicted home production consumption (JPY/day)	303.648	185.273	340.677	157.430
Home production consumption (JPY/day)	465.753	172.388	362.347	173.947
Predicted home production price	91.242	28.439	120.658	24.083
Cell	28		31	

Table A5. Comparison between data and predicted variables (food for consumption)

	Single women		Single men	
Variable	Mean	Std. dev.	Mean	Std. dev.
Predicted market labor supply (minutes/day)	511.458	82.144	590.729	63.764
Market labor supply (minutes/day)	508.598	85.858	575.197	61.285
Predicted leisure (minutes/day)	862.138	62.675	816.726	70.775
Leisure (minutes/day)	852.493	74.252	836.856	58.352
Predicted home production time (minutes/day)	66.404	19.664	32.545	16.889
Home production time (minutes/day)	78.909	39.010	27.950	14.963
Predicted market consumption (JPY/day)	817.526	464.022	1,796.084	765.523
Market consumption (JPY/day)	608.648	346.965	1,303.930	613.650
Predicted home production consumption (JPY/day)	289.193	121.798	347.236	122.749
Home production consumption (JPY/day)	380.172	142.891	316.865	155.050
Predicted home production price	82.026	26.045	99.655	19.795
Cell	28		31	

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