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A Structural Estimation of the Effects of Spousal Tax Deduction and Social Security Systems on the Labor Supply of Japanese Married Women†

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Japanese spousal tax deduction and social security systems cause a non-convex piece-wise budget constraint for married women. Using a pooled sample from the Japanese Panel Survey of Consumers, we structurally estimated a labor supply model that explicitly takes into account the nonlinearity in the budget constraint. Our results suggest that the effects of spousal deduction and social security reforms on the labor supply of Japanese married women would be much smaller than what the past reduced form studies suggest. The reform to completely eliminate the spousal tax deduction would increase the population labor supply only by 0.7%, though the labor supply responses of the most affected workers would be nontrivial, with their desired hours worked increasing by as much as 4%. The policy reform to require all women to pay the social security premium regardless of their income level would have almost no effects on the population labor supply. Our results also suggest that lump-sum income transfer programs, such as the current child care support program, would have negligible effects on female labor supply unless the transfers are substantially large.

Keywords: Structural estimation; Non-convex budget set; Female labor supply; Spousal deduction; Social Security System, *JEL Classification*: J20, H24

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1. Introduction

The spousal tax deduction and the social security systems in Japan cause a non-convex piecewise linear and discontinuous budget constraint for married women; due to the spousal tax deduction which decreases with the wife's income, a typical wife faces a high marginal tax rate for the income range between 0.7 million yen and 1.41 million yen. A typical wife who is dependent on the husband's income does not have to pay for social security coverage up to her income equal to 1.3 million yen. However, she begins to pay the social security premium after her income exceeds 1.3 million yen, creating a sudden dip in her budget constraint. The work disincentive effects of the spousal tax deduction and the social security systems have long been pointed out.

Structural estimation of the labor supply which explicitly takes into account the piecewise budget constraint is useful for the investigation of the work disincentive effects since it permits researchers to evaluate the effects of alternative policies by using the estimated parameters. However, few past studies have employed a structural estimation approach. Abe and Ohtake (1995) used the fact that spousal tax deduction is irrelevant for single women and highlighted the work disincentive effects by comparing the wage elasticities of married women and single women. Oishi (2003) used the fact that the dip in the budget constraint caused by the social security system occurs only for wives whose husbands are covered by the Category II social security system (coverage for private and public sector employees). Oishi, thus, measured the work disincentive by including a 'Category II husband' dummy in an hours worked equation. Kantani (1997) and Higuchi (1995) included in an hours worked equation a dummy variable for those who considered the spousal deduction and social security payment in deciding hours worked.

Although the above past studies have shed light on many aspects of the work disincentive effects, their models are of 'reduced form' in which econometric models are not explicitly linked to the underlying economic theory of a piece-wise budget constraint. This creates ambiguity in the interpretation of the results. Moreover, their implied work disincentive effects are implausibly large as compared to the estimated effects of income transfer programs with comparable magnitudes in the US: the estimated work disincentive effects of the above mentioned studies range between 22% to 150% reduction in hours worked, as will be reviewed in Section 4.

A structural estimation model which explicitly takes into account the piece-wise budget constraint, on the other hand, provides a clear-cut interpretation of the results. The only study that uses a structural estimation is Akabayashi (2006). By using a sample from the *General Survey of Part-Time Workers* (GSPT) which contains part time workers only, he showed that the work disincentive effect is a 5.5% reductions in hours worked. This effect is much smaller than the 'reduced form' evidence. Considering this discrepancy, additional studies using a structural estimation are essential in providing an accurate picture of the work disincentive effects.

The purpose of our study is two folds. First, we structurally estimate the labor supply of Japanese married women. Second, we evaluate the effects that various changes in the spousal deduction and social security systems would have on the labor supply of these women by using the estimated parameters. We improve upon the preceding work of Akabayashi (2006) in several ways. First, as will be noted in details in Section 5, the likelihood function in Akabayashi (2006) separates the sample into observed segments, implicitly assuming that a worker's observed budget segment choice is her true segment choice. This is inconsistent with his model specification which incorporates two error terms. We have alleviated this problem.

Second, in a structural model of female labor supply, a worker can react to a policy change through two channels: (i) changing the hours worked within a budget segment, or (ii) changing the choice of the budget segment (and changing the hours worked at the same time). In the evaluation of alternative policies, we quantitatively evaluate both types of workers' reactions, thus providing much more detailed expositions of how alternative policies would affect the labor supply of Japanese married women.

The evaluation of channel (ii) above is particularly important. There is a well-known cluster of Japanese married women near the income equal to 1.03 million yen, the income threshold where the highest tax rate starts due to the combination of spousal tax deduction and income tax. An implicit assumption in past studies is perhaps that a reform of spousal deduction and social security systems would increase labor supply by shifting these women into higher budget segments. However, reduced form models are not able to examine whether this conjecture is true, since joint determination of tax brackets and hours worked are not modeled in these models. Thus, one contribution of our study is to shed light on this issue.

In addition, we evaluate the effects of the lump sum payment that the current government is providing for households with young children (the child care support program). We use a sample from the *Japanese Panel Survey of Consumers* (JPSC) which contains not only part time workers but also full time workers, thus enabling us to better evaluate the population average responses to various policy changes.

We organize our paper as follows: Section 2 describes the tax and the social security systems in Japan. Section 3 details the shape of budget segments, then presents the computation of after tax hourly wage rates and virtual incomes. Section 4 discusses existing estimates. Section 5 details the estimation methods. Section 6 presents the data and variables. Section 7 presents the estimation results. Section 8 discusses the effects of alternative policies, and Section 9 concludes.

2. Tax and social security systems in Japan

Table 1 shows the 2002 income tax schedule. Salary/wage earners are entitled to receive employee tax deductions. Table 2 shows the employee tax deduction schedule. The amount of deduction depends on one's income. Due to the tax deduction schedule, workers begin to pay tax only after their income exceeds 1.03 million yen. Besides the employee deduction, a married worker is entitled to receive a spousal tax deduction, depending on the spouse's income level. In the following, we explain the spousal tax deduction system in Japan. Throughout this section, we refer to the husband as the primary income earner and the wife as the secondary income earner.

In 2002, the husband is given the annual tax deduction of 760 thousand yen when the wife's annual income is less than 700 thousand yen. When the wife's income exceeds this threshold, this spousal tax deduction is reduced by 50 thousand yen for each 50 thousand yen earned by the wife. Thus, the reduction in the spousal tax deduction is almost one-to-one. When the husband's income is less than 10,000 thousand yen, the reduction in the spousal deduction continues until the wife's income reaches 1,410 thousand yen. When the husband's income is greater than 10,000 thousand yen, the reduction continues until the wife's income reaches 1,030 thousand yen, then the spousal deduction is completely (and discretely) eliminated once the wife's income exceeds the 1,030 thousand yen threshold. In our sample, almost all working married women have husbands with income less than 10,000 thousand yen (99.2%). Thus, we decided to analyze only these women, by dropping women whose husbands have income greater than 10,000 thousand yen.

When the husband's income is less than 10,000 thousand yen, the spousal deduction can be approximated by the following:

$$SpousalDeduction = 760 \qquad for\ 0 \leq Y_w < 700 \tag{1}$$

$$= \quad 1,410 - Y_w \quad for\ 700 \leq Y_w \leq 1,410 \tag{2}$$

$$= \quad 0 \qquad\qquad for\ Y_w > 1,410 \tag{3}$$

where Y_w is the wife's annual income. All the variables above are in thousand yen.

This tax deduction system causes a highly non-linear budget constraint for married women, a majority of whom are secondary income earners. To see this more clearly, let w be the wife's hourly wage, h be the wife's annual hours of work, t_W be the wife's income tax rate, t_H be the husband's income tax rate, X be the husband's annual income considered exogenous, D be the tax deduction that the husband could claim other than the spousal deduction and Q be the household income from other sources, such as interest income. The wife's employee tax deduction has the form $aY+b$. Thus, the total household income can be written as:

$$Household\ \ Income$$

$$= wh - [wh - \underbrace{(awh+b)}_{Employee\ deduction}]t_W + X - [X - D - \underbrace{(1410-wh)}_{Spousal\ deduction}]t_H + Q \tag{4}$$

$$= \underbrace{w[1-(1-a)t_W - t_H]}_{Wife's\ after-tax\ wage} h + \underbrace{bt_W + 1410t_H + \underbrace{X(1-t_H) + Dt_H + Q}_{Non-wife\ income}}_{Virtual\ income} \tag{5}$$

Thus, the effective marginal tax rate for the wife is $(1-a)t_W + t_H$ in the income range between 1,030 and 1,410 thousand yen. When the wife's income is less than 1,030 thousand, the marginal tax rate is equal to the husband's tax rate since she does not have to pay her own income tax until her income reaches that threshold. Thus, the wife's effective marginal tax rate jumps at the threshold income of 1,030 thousand yen. When the wife's income exceeds 1,410 thousand yen, the wife's marginal tax rate is equal to $(1-a)t_W$ only, since the spousal deduction is eliminated.

The social security system in Japan causes an additional complication to the budget constraint. There are three categories of coverage in the social security system. Category I covers the self-employed and the non-employed. Category II includes (i) the Employee's

Pension Plan (EPP) that covers private sector employees and (ii) the Mutual Aid Association (MAA) that covers the public sector employees. Category III covers dependent spouses of the workers covered by the Category II social security system. When the wife's income is less than 1,300 thousand yen, the wife is entitled to the Category III retirement plan with no payment. However, when the wife's income exceeds 1,300 thousand yen, the wife is required to pay the MAA premium of 135.6 thousand yen per year.[1] This causes a sudden drop in the budget constraint.

3. The budget segments, after tax wage rates and virtual incomes

Figure 1 shows a typical budget constraint for a married woman. The spousal deduction and the social security systems create 5 segments in the budget constraint. The budget segment 1 is the income range between 0 and 0.7 million yen where a wife faces a zero marginal tax rate (and where her husband receives a lump sum amount of 0.76 million yen in spousal deduction). When the wife's income reaches 0.7 million yen (kink 1), the spousal tax deduction begins to phase out. Budget segment 2 is the income range between 0.7 million and 1.03 million yen where the wife's effective marginal tax rate is equal to her husband's marginal tax rate.

Budget segment 3 begins at income 1.03 million yen where the wife starts to pay her own income tax, and ends at income 1.41 million yen where the spousal tax deduction is completely phased-out. In this segment, she faces a combined marginal tax rate of her husband's and her own. The kink point at 1.03 million yen (kink 2) is often termed the '1.03 million yen ceiling'. The literature has pointed out a considerable cluster of observations near this kink point (Abe and Ohtake 1995, Oishi 2003, Kantani 1997, Higuchi 1995).

There is one complication in segment 3: the wife begins to pay her social security

[1] This is the premium in 2002.

payment when her income exceeds 1.3 million yen, causing a dip in the budget segment. We smooth budget segment 3 by extending the segment until it reaches budget segment 4. The following two reasons justify this approximation. First, theoretically, nobody would choose to work where the budget segment is dipped. Second, as will be noted in Section 6, we observe no obvious cluster of data near income equal to 1.3 million yen.

In segment 4, the usual income tax schedule resumes (10%). Thus, segment 3 and 4 form a non-convex budget set. This non-convexity will be explicitly incorporated in our model. Segment 4 ends when the wife moves to a higher income tax bracket (20%) at *taxable* income 3.3 million yen (kink 3). We compute the corresponding gross income at kink 3 assuming that the wife claims only the employee tax deduction and the social-security-payment deduction of 50 thousand yen. We assume that other deductions, such as the dependent-family-member deduction (fuyou-koujo), are claimed by the husband.[2] The gross income at kink 3 will be 5.34 million yen.

Segment 5 is the segment with income tax rate 20%. The income tax rate increases to 30% when the wife's taxable income exceeds 9 million yen (≈ gross income of 11.7 million yen), creating the 6^{th} budget segment. However, there are only 4 usable observations in the 6^{th} segment in our data. Thus, we have ignored the 6^{th} segment by dropping these four observations. Our final model contains five segments only.

In the discussions above, we did not consider the employee tax deduction schedule which also varies with the worker's income. The brackets for the employee tax deduction schedule do not exactly match the budget segments, thus further segmenting the budget constraint. In order to avoid unnecessarily complication in the model, we maintain the five segment model by approximating the employee tax deduction schedule as described in Figure 2.

[2]We accrue the dependent-family deduction, a major tax deduction item in Japan, to husband's income when computing the husband's after tax income.

The slope of each budget segment in Figure 1 equals the after tax wage. The virtual income is given by the intercept of each budget segment at hours worked equal to zero. The computation of after tax wage and virtual income is given by Table 3. We denote after tax wage and virtual income at the k^{th} segment by W_k and N_k. The dip in the budget constraint in segment 4 and 5 is captured by the term -SS which is the amount of annual social security payment. We use the notation H^*, H^{**} and H^{***} to denote the hours worked at Kink 1, Kink 2 and Kink 3.

There are two additional complications in the Japanese tax system that are not fully taken into account. First, even if the wife's income is below 1.3 million yen, she becomes eligible for EPP if her working hours exceed 3/4 of regular employees' working hours. If she chooses to be covered by EPP in this case, she will pay the social security premium even before her income reaches 1.3 million yen, though she is still entitled for Category III social security without payment. To avoid complications, we assume that no women will switch from Category III to EPP. Second, the residential tax (juumin zei)[3] of 5% for the taxable income below 2 million yen, and 10% above that threshold would create additional kinks. Since taking into account every possible tax is not the scope of this study, we ignore the residential tax. However, we provide a robustness check in Section 8 to examine how sensitive our results may be to omitting this tax.

Women whose husbands are covered by the Category I retirement plan are not eligible for the Category III retirement. These women have to pay the MAA premium regardless of their income level. Thus, there is no dip in the budget constraint at 1.30 million yen for these women. Since there are few women who fall into this category in our data (0.8% of the observations), we have dropped women whose husbands are covered by the Category I retirement plan to keep our data relatively homogeneous.

[3]Residential tax is the sum of the prefectural tax and the city tax.

4. Existing estimates of the effects of the spousal deduction and social security systems

Oishi (2003) used the fact that the dip in the budget constraint due to the social security payment occurs only for wives whose husbands are covered by the Category II social security system. By using a sample of 423 married women from the *Kokumin Seikatsu Kiso Chousa*, she found that Category II coverage is associated with 22% less hours worked, which is interpreted as the work disincentive effect of the social security system.

Abe and Ohtake (1995) used the fact that single women are not subject to the spousal tax deduction system, and not subject to the dip in the budget constraint caused by the social security system. They estimated hours worked equations separately for single working women and for married working women without kids (DINKS) using a sample from the *General Survey of Part-Time Workers* (GSPT). They found that the wage elasticity is more negative for DINKS (-0.506) than for single women (-0.24). They interpreted the more negative wage elasticity for DINKS as due to the 'income adjustment behavior', the behavior of women to contain their income below the 1.03 million yen threshold to avoid a high marginal tax rate. The difference in wage parameters indicates that eliminating the spousal deduction and social security systems would increase log hours worked by 1.5 (i.e, approximately 150% increase in hours worked).[4]

The GSPT asks respondents if they have adjusted their labor supplies so as to contain their income below the 1.03 million yen ceiling or the 1.3 million yen ceiling (income adjustment dummy). Kantan (1997) included this income adjustment dummy in the hours worked equation. He found that married women who 'adjust their hours' work 35% less.

The above estimates of the work disincentive effects are implausibly large as compared to the estimated effects of income transfer programs with comparable magnitudes in the US.

[4] Computed as [-0.24-(-0.56)]×(average log wage). Since they do not report the intercept term, we were not able to compare the expected log hours worked between the two groups.

Fraker and Moffitt (1988) estimated the work disincentive effects of the Aid to Families with Dependent Children Program (AFDC). Annual payment of AFDC at zero hours worked is about $3,900,[5] while the increase in household income at zero hours worked due to Japanese spousal tax deduction and the social security systems is about $2,800.[6] Thus, the amount of income transfer for AFDC is comparable (although slightly larger) to the above Japanese income transfer system. However, the work disincentive effect of AFDC estimated by Fraker and Moffitt (1988) is only a 2.8% decrease in the expected hours worked.[7] In addition, Moffit (1979) found that the Gary negative income tax has almost no work disincentive effects for married women. Burtless and Hausman (1978) showed that the Gary negative income tax has almost no effects on prime-age males.

Akabayashi (2006) is the only study that takes into account the non-linearity in the budget constraint by structurally estimating a model. His model is similar to Hausman (1980) and Moffit (1986). In addition, his model allows for the effects of the husband's tax on the wife's labor supply to be different from the effects of the wife's own tax. His results suggest that hours worked by Japanese married women would increase by 5.5% if the spousal tax deduction is completely eliminated.

5. Estimation method

We consider the following simple labor supply model with two error terms:

$$H = \beta W + \delta N + \alpha + \varepsilon \tag{6}$$

where H is the number of annual hours worked, W is the wife's after tax hourly wage, and N is the virtual income. Following Moffitt (1986), we adopt a two-error-term model. The

[5]Based on Fraker, Moffitt and Wolf (1985): average effective guarantee for a family of four is $324 per month in 1982

[6]Annual social security payment is about 13 thousand yen in 2002. For a husband with 20% tax rate, the increase in household income due to spousal tax deduction is 76 thousand yen×0.2=15.2 thousand yen. The exchange rate of $1=100 yen is used.

[7]Based on their results that the hours worked for the program participants will increase by 0.6 hours from the average weekly hours worked of 20.7 (see p46 of their study).

term, α, captures unobserved preference heterogeneities. The term, ε, captures optimization errors, measurement errors and specification errors. We simply refer to ε as measurement errors.

The fact that our model contains two error terms is important. On one hand, if the model contains only measurement errors, ε, there will be only one utility maximizing point conditional on the observed variables, and any observed variation in the segment choice will be attributed to measurement errors. This also means that any shift in the budget segments, other than the segment where the utility maximization is located, have zero effect on the hours worked. Thus, a measurement-error-only model would severely limit how the hours worked could respond to a shift in the budget constraint (see Moffitt 1986). On the other hand, if the model contains only the preference heterogeneity, the model implicitly assumes that the observed segment choice of a worker is her true segment choice.

To highlight the difference between our estimation model and that of Akabayashi's (2006), we provide some details of the likelihood function. We begin with the description of how a worker chooses one of these segments/kinks. First, consider the convex segments. A worker will choose one of the convex segments if her desired hours of work, $\beta W + \delta N + \alpha$, falls in that segment. Taking segment 1 as an example, the choice is described as:

$$Choose\ Segment\ 1\ if \quad -\beta W_1 - \delta N_1 \leq \alpha < H^* - \beta W_1 - \delta N_1 \tag{7}$$

Second, consider the choice of a kink point. Taking kink 1 as an example, a worker will choose kink 1 if her desired hours of work given W_1 and N_1 exceed kink 1, but her desired hours of work given W_2 and N_2 fall below kink 1. This situation is described in Figure 1. The choice of kink 1 is written as:

$$Choose\ Kink\ 1\ if \quad H^* - \beta W_1 - \delta N \leq \alpha < H^* - \beta W_2 - \delta N_2 \tag{8}$$

Finally, consider the choice of the non-convex segments, segment 3 and segment 4. In a non-convex case, there is a unique value of α, denoted by α^*, where the indifference curve is tangent to both segment 3 and segment 4 as described in Figure 1. Thus, the choice of these non-convex segments is written as:

$$Choose\ Segment\ 3\ if \quad \alpha < \alpha^* \ and\ \beta W_3 + \delta N_3 + \alpha > H^{**}, \tag{9}$$

$$Choose\ Segment\ 4\ if \quad \alpha \geq \alpha^* \ and\ \beta W_4 + \delta N_4 + \alpha < H^{***} \tag{10}$$

For maximum likelihood estimation we need to compute α^* for each worker at each iteration. As described in Hausman (1980), our model given by (6) implies the following indirect utility function:

$$V(W, N, \beta, \delta, \alpha) = e^{\delta W}(N + \frac{\beta}{\delta}W - \frac{\beta}{\delta^2} + \frac{\alpha}{\delta}) \tag{11}$$

Thus, α^* is the solution to the following equality:

$$V(W_3, N_3, \beta, \delta, \alpha^*) = V(W_4, N_4, \beta, \delta, \alpha^*) \tag{12}$$

If we *erroneously* specify a preference-heterogeneity only model, any observed choice of a segment/kink is the worker's true location, leading to the following likelihood function, which *separates the sample into observed segments.*

$$Likelihood\ of\ the\ preference\ heterogeneity\ only\ model = \tag{13}$$

$$\prod_{obs\ in\ seg\ 1} P(\alpha = H - \beta W_1 + \delta N_1) \prod_{obs\ in\ Kink\ 1} P(Choosing\ Kink\ 1) \tag{14}$$

$$\prod_{obs\ in\ seg\ 2} P(\alpha = H - \beta W_2 + \delta N_2) \prod_{obs\ in\ Kink\ 2} P(Choosing\ Kink\ 2) \tag{15}$$

$$\prod_{obs\ in\ seg\ 3} P(\alpha = H - \beta W_3 + \delta N_3) \prod_{obs\ in\ seg\ 4} P(\alpha = H - \beta W_3 + \delta N_3) \tag{16}$$

$$\prod_{obs\ in\ Kink\ 3} P(Choosing\ Kink\ 3) \prod_{obs\ in\ seg\ 5} P(\alpha = H - \beta W_5 + \delta N_5) \tag{17}$$

However, since we employ a two-part-error model, the observed choice of a segment/kink is not necessarily the worker's true location due to the presence of measurement errors. This means that the likelihood contribution of a worker will be the summation of the likelihood that the worker could have been located in each budget segment/kink. The correct likelihood contribution of the i^{th} worker in the two-part-error model is, thus, given by:

$$Likelihood\ of\ the\ two-error-term\ model\ for\ i^{th}\ worker =$$

$$L_i = P(\alpha + \epsilon = H - \beta W_1 - \delta N_1,\ -\beta W_1 - \delta N_1 \leq \alpha < H^* - \beta W_1 - \delta N_1) \quad (18)$$

$$+P(H - H^* = \epsilon,\ H^* - \beta W_1 - \delta N_1 \leq \alpha < H^* - \beta W_2 - \delta N_2) \quad (19)$$

$$+P(\alpha + \epsilon = H - \beta W_2 - \delta N_2,\ H^* - \beta W_2 - \delta N_2 \leq \alpha < H^{**} - \beta W_2 - \delta N_2) \quad (20)$$

$$+P(H - H^{**} = \epsilon,\ H^{**} - \beta W_2 - \delta N_2 \leq \alpha < H^{**} - \beta W_3 - \delta N_3) \quad (21)$$

$$+P(\alpha + \epsilon = H - \beta W_3 - \delta N_3,\ H^{**} - \beta W_3 - \delta N_3 \leq \alpha < \alpha^*) \quad (22)$$

$$+P(\alpha + \epsilon = H - \beta W_4 - \delta N_4,\ \alpha^* \leq \alpha < H^{***} - \beta W_4 - \delta N_4) \quad (23)$$

$$+P(H - H^{***} = \epsilon,\ H^{***} - \beta W_4 - \delta N_4 + \leq \alpha < H^{***} - \beta W_5 - \delta N_5) \quad (24)$$

$$+P(\alpha + \epsilon = H - \beta W_5 - \delta N_5,\ \alpha \geq H^{***} - \beta W_5 - \delta N_5) \quad (25)$$

where each term, from top to bottom, shows the likelihood when the worker's true segment choice is segment 1, kink 1, segment 2, kink 2, segment 3, segment 4, kink 3 and segment 5, respectively. The likelihood function is then computed as $\prod_{i=1}^{N} L_i$, where N is the number of observations.

Thus, for a two-error model, there will be no sample separation in the likelihood function since each worker could have been located in any segment regardless of her observed location. This is the point emphasized by Moffitt (1986, p.323). Akabayashi (2006) also employs a two-error model. However, his likelihood separates the sample into observed segments as if it were a preference-heterogeneity only model, implicitly assuming that a worker's observed budget segment choice is her true segment choice (see p. 365 of his study). This is inconsistent with his model specification which incorporates two error terms. Our likelihood with two error term model alleviates this inconsistency. We did not control for self-selection into labor force by using a non-working sample. However, the condition in equation (18) that the desired hours worked in segment 1 should be greater than zero captures the truncation at zero hours worked.

Assumptions regarding error terms are as follows; the preference heterogeneity α is a function of observed characteristics Z and a random error which is distributed normally. The measurement error ε is also normally distributed. θ and ε are independent. Thus, we have:

$$\alpha = Z\gamma + \theta, \quad \theta \sim N(0, \sigma_\theta^2), \quad \varepsilon \sim N(0, \sigma_\varepsilon) \tag{26}$$

We include in Z the wife's age and the number of children aged 6 or below. We also include a dummy variable indicating if the wife is living with parents (her own parents and/or her husband's parents). Since parents can provide household work, this variable would positively affect the wife's hours worked. Sasaki (2002) showed that living with parents increases the labor force participation of Japanese married women. The years of education are included as they would positively affect the wife's taste for work.

Note that past reduced form studies estimated the work disincentive effects by including in Z a control-group dummy. Such models estimate the work disincentive effects in terms of a preference shift (a shift in hours worked equation), failing to capture the fact that a tax reform affects labor supply by changing after tax wage rate and virtual income, not by changing preference.

We estimate the model with FORTRAN programs with analytical derivatives using the GQOPT optimizer.

There is one caveat in our model. When the wife's income is less than 1.03 million yen, the husband often receives an allowance from his employer as a fringe benefit. This fringe benefit is completely (and discretely) eliminated when the wife's income exceeds 1.03 million yen (see Abe 2009 for a more detailed discussion). Thus, this fringe benefit causes a dip in the budget segment at kink 2. If the dip is large, as illustrated in Figure 3, a worker will choose kink 2. Ideally, this discontinuity should be explicitly modeled in order to separate the effect of spousal tax deduction from the effect of the dip in the budget segment. However, this is not a simple matter; for wives who have exceeded 1.03 million yen ceiling, we do not know how much the fringe benefits could had been. For wives whose income is within 1.03 million yen, we do not know the amount of fringe benefit separately from the husband's annual salary. Thus, we leave this issue for future research.

6. Data, variables and summary statistics

We use a pooled sample from the the *Japanese Panel Survey of Consumers* (JPSC) for the period 1994 to 2003. This is a panel of randomly chosen 1500 Japanese women who were between age 23 and 34 at the initial survey which was in 1993, and an added panel of 500 women aged 24 to 27 in 1997. There are several reasons why we use the JPSC. First, most of the past studies use data sets that contain only part time workers (Akabayashi 2006, Abe and Ohtake 1995, and Kantani 1997). The JPSC contains full time workers as well as part time workers, allowing us to better evaluate the population responses to alternative policies. Second, the JPSC contains a much richer set of personal characteristics than the GSPT, commonly used data in the literature. For example the JPSC contains information regarding the number of children or whether the wife is living with parents. Such variables would be crucial determinants of the preference heterogeneity, yet they are not contained in the GSPT. Akabayashi's model (2006) contains only age and its squared term as the determinants of the preference heterogeneity. The disadvantage of the JPSC is its small cross sectional units. The GSPT contains 13,000 workers (1995 Survey). The JPSC contains only 1500 cross sectional observations, and we are using only the working sub-sample. This has led to our decision to pool the observations.

Since these are panel data, some readers may consider that the analysis should be based on a life cycle framework. Since there is a lack of studies which structurally estimate the effects of Japanese taxes, we believe that our static analysis can still add new insights into the labor supply behavior of Japanese married women.[8]

Before-tax hourly wage is constructed as follows. Respondents report whether they are paid hourly, daily, weekly or monthly. When respondents are paid hourly, we use their reported hourly wage as the wage variable. When respondents are paid daily, we use (Reported Daily Wage)/8 as the wage variable, assuming that they work 8 hours per day. Annual hours worked is then computed as (Annual Before-Tax Income)/(Hourly Wage). This construction of wage and annual hours worked variables is similar to Akabayashi (2006). Since it would be easier for workers to recall their hourly wages and annual income than to recall their hours of work, this construction of annual hours worked minimizes potential division bias.

When women are paid weekly or monthly, they report the monthly equivalent amount of salary. Unlike jobs that pay hourly or daily, jobs that pay weekly or monthly would also entail bonuses. This needs to be incorporated in the computation of hourly wage. Thus, we compute the hourly wage as (Annual Before-Tax Income)÷(Annual Hours Worked). Annual before-tax income is reported by each respondent. Annual hours worked is constructed as (Annual Days Worked)×(Weekly Hours Worked)/5. Both annual days worked and weekly hours worked are reported in ranges in the JPSC. We chose the middle point of each range for computation. To eliminate outliers, we have dropped the observations whose before tax hourly wage is below 300 yen or greater than 5000 yen.

The non-wife income is constructed as follows. First, we compute the husband's after tax annual income considering employee tax deduction, social-security-payment deduction (50 thousand yen), and the dependent-family-member deduction. The amount of

[8]Kuroda and Yamamoto (2008a,b) estimate a life cycle labor supply model of Japanese women. Their focus is not on the effects of tax on labor supply, however.

dependent-family-member deduction is computed based on the ages of the family members who are living together. We subtract from the after-tax husband's income the estimated amount of the husband's social security payment.[9] We then add to this amount the income earned from assets by the wife and the husband to construct non-wife income. Our construction of non-wife income takes into account the income tax, but ignores other taxes such as the tax on the interest income. We could alternatively use the reported amount of tax and social security payments to construct the non-wife income. However, this infomation is missing for a significant portion of the sample. Thus, in order to increase the sample size, we construct the non-wife income as described above.

After tax wages and the virtual incomes are computed according to Table 3. The amount of social security payments are estimated by assuming that the wife is covered by the MAA when her income exceeds 1.30 million yen. The hours worked at each kink point (H^*s) are computed as (threshold income)/(before tax hourly wage)

6.1 Summary statistics

Table 4 shows the summary statistics of the variables utilized in this study, separately for workers in the five budget segments. Kink points are included as the right end point of their corresponding segments. Annual hours worked and before-tax hourly wages are generally increasing with the observed segments.

The pooled sample average of W_1 (after tax wage rate for segment 1) is 1235 yen while W_3 (after tax wage rate for segment 3) is 961. Thus, after tax wage rate substantially decreases due to the spousal tax deduction and income tax. Pooled sample averages of virtual income ranges between 4,258 thousand yen and 4,752 thousand yen. Though not reported in Table 4, 20% of the sample is found in segment 1, 2% in kink 1, 24% in segment 2, 0.7% in kink 2, 7% in segment 3, 40% in segment 4, 0% in kink 3 and 5% in segment 5.

[9] We assume that the husband is covered by the EPP. In 2002, the payment for the EPP is 8.65% of the salary.

Figure 4-A shows the wife's before-tax annual income in 10,000 yen. Observations are heavily concentrated in the income range between 0.9 million yen and 1 million yen. This data cluster has motivated many of the past studies to investigate the possible work disincentive effects of the income tax and spousal deduction systems. There is no obvious data cluster at income 1.3 million yen which justifies the approximation we applied to Segment 3 (see Section 3). Figure 4-B shows the histogram of the wife's before-tax hourly wage rate. The wage rate peaks between 700 yen and 800 yen.

7. Estimation results

Table 5 shows our structural estimation results as well as the OLS results. For the OLS, after tax wage and virtual income are computed based on each worker's observed segment choice. Let us first describe the OLS results. The estimated coefficients are conventional. The wage coefficient is positive and statistically significant (0.17). The estimated uncompensated wage elasticity is 0.13.[10] The coefficient for the virtual income is negative and statistically significant (-0.72). The estimated income elasticity is -0.22.[11] Living with parents would increase the hours worked by nearly 235 hours annually. Hours worked are increasing with education when the years of education are greater than 12 years. The number of young children has a negative effect on hours worked.

Now, we turn our attention to the results for our structural estimation. The wage coefficient increases substantially from the OLS estimate of 0.15 to 0.25. The estimated wage elasticity increases from the OLS estimate of 0.12 to 0.19.[12] This wage elasticity estimate is close to Akabayashi's (2006) estimate of 0.16. The coefficient for the virtual income increases to -0.82. The income elasticity for the structural estimation is -0.25[13],

[10] This is computed as the sample average of $\beta W/\widehat{hours}$.

[11] Computed as the sample average of $\delta N/\widehat{hours}$.

[12] See the note in Table 5 for how we computed this elasticity.

[13] See the note in Table 5 for how we computed this elasticity.

which is also close to the Akabayashi's (2006) estimate of -0.21. Other coefficients do not change appreciably from the OLS results.

The estimated standard deviation for the preference heterogeneity, σ_θ, is large (390 hours). The model also estimates the standard deviation for v=θ+ε (σ_v=735 hours). This suggests that the standard deviation for the measurement error, σ_ε, is large ($\sigma_\varepsilon=\sqrt{\sigma_v^2-\sigma_\theta^2}=$ 623 hours). The large measurement errors indicate that a wife's observed segment choice could be quite different from her true segment choice.

8. The effects of spousal deduction and social security system on hours worked: A sensitivity analysis

8.1 Computation method

This section investigates the impacts of changing the spousal tax deduction and social security system on the labor supply of Japanese married women. To do so, we need to compute the expected hours worked for each worker under alternative policies. A worker's actual hours worked is written as:

$$H = \beta W + \delta N + Z\gamma + \theta + \varepsilon \tag{27}$$

Because of the measurement error, a wife's observed location may be different from her true choice of segment. Thus, we cannot determine, from the observed segment, which after-tax wage rate (W_j) and virtual income (N_j) a wife had faced. Thus, the computation of the expected hours worked requires one to integrate the hours worked equation (27) over each budget segment. A simple computation shows that the expected hours worked for i^{th} worker is given by:

$$Expected\ hours\ worked = \sum_{K=1}^{5} P(Seg_k)(Hours)_k + \sum_{J=1}^{3} P(Kink_J)H^{*J} + \widehat{\theta} \tag{28}$$

where $P(Seg_k)$ and $P(Kink_J)$ are the probabilities that the worker's true location is segment k or kink J.[14] $(Hours)_k = \beta W_k + \delta N_k + Z\gamma$ is the expected desired hours worked 'at k-th segment'. H^{*J} is the hours worked at kink J. $\widehat{\theta}$ is the expected residual term, which does not integrate out to zero due to the truncation at zero hours worked.

Thus, a change in policy would affect the expected hours worked through two channels. (i) First, it will affect the hours worked by affecting the desired hours worked, $(Hours)_k$, in each segment. (ii) Second, it would affect the expected hours worked by affecting the segment choice of a worker, $P(Seg_k)$ and $P(Kink_J)$. As noted earlier, an implicit assumption in the literature is perhaps that a reform in the spousal tax deduction and social security systems would increase hours worked of married women by shifting women near the 1.03 million yen ceiling into higher budget segments. By evaluating channel (ii), we are able to verify if such a conjecture is in fact true. In Akabayashi (2006), these details are not available. Thus we provide a more detailed exposition of how alternative policies would affect the labor supply of Japanese married women.

8.2 Sensitivity analysis results

Table 6 shows the segment choice probabilities and desired hours worked in each segment as well as the expected annual hours worked under the current system, and under three alternative policies. Some explanations are necessarily. First, all the numbers are computed as the sample average of the equation (28). Second, expected desired hours worked 'at the k^{th} segment', $(Hours)_k$, does not necessarily fall in that segment since it is simply the predicted hours worked given W_k and N_k. Even if it does not fall in the k^{th} segment, actual

[14] Let $f(\theta, \varepsilon)$ be the joint distribution function of θ and ε, where θ and ε are independent by assumption. For segment 1, an individual chooses the budget segment 1 if $-\beta W_1 - \delta N_1 - Z\gamma \leq \theta < H^* - \beta W_1 - \delta N_1 - Z\gamma$. Thus, we integrate the hours worked equation (27) as: $\int_{-\infty}^{\infty} \int_{-\beta W_1 - \delta N_1 - Z\gamma}^{H^* - \beta W_1 - \delta N_1 - Z\gamma} [\beta W_1 + \delta N_1 + Z\gamma + \theta + \varepsilon] f(\theta, \varepsilon) d\theta d\varepsilon = P(Seg_1)[\beta W_1 + \delta N_1 + Z\gamma] + \widehat{\theta}_{seg_1}$ where P(Seg1)=$\int_{-\beta W_1 - \delta N_1 - Z\gamma}^{H^* - \beta W_1 - \delta N_1 - Z\gamma} f(\theta) d\theta$ and $\widehat{\theta}_{seg1}$, is equal to $\int_{-\beta W_1 - \delta N_1 - Z\gamma}^{H^* - \beta W_1 - \delta N_1 - Z\gamma} \theta f(\theta) d\theta$. Computation for other segments/kinks is similar. Summing the expected hours worked for all segments and kinks leads to the expression (28).

desired hours worked could fall in that segment depending on the value of the unobserved preference, θ.

First, let us look at the results for the current system. The probability that an individual chooses segment 3 or below is about 33%. Since the current spousal deduction and social security systems affect workers in these segments, any reforms would affect a relatively small portion of the population. The expected annual hours worked under the current system is 1455.

Second, let us consider a tax reform that completely eliminates the spousal tax deduction. Figure 5, Scenario 1, shows how the budget constraint is affected by this reform. Segments 1 through 3 shift downward. Segment 1 and 2 will have the same slope. Segment 3 becomes steeper, but kink 2 still remains. To provide some sense of this change, the drop in N_1 is approximately 150 thousand yen.[15] Segment 4 will be slightly flatter than segment 3 since segment 4 is subject to employee tax deduction which increases with the wife's income. To compute the probability of choosing segment 3 and 4, we need to find α^{**} such that the indifference curve touches the edge of segment 3 and, at the same time, is tangent to segment 4 as illustrated in Figure 5.[16] We use the fact that our model corresponds to the following direct utility function (see Hausman 1980):

$$U(H,I) = exp[-(1+\delta\frac{I+\widetilde{\alpha}}{c-H})](\frac{H-c}{\delta}) \tag{29}$$

where I is the household income, $\widetilde{\alpha}$=$\alpha/\delta - \beta/\delta^2$ and c=β/δ. Then, α^{**} is the value of α where U(H,I) at the edge of segment 3 is equal to the indirect utility at segment 3 given by equation (11).[17]

Table 6, Scenario 1, shows the estimates. Although this reform would shift workers to

[15] The drop in N_1 is (760 thousand yen)$\times$(husband's tax rate). The median husbands' tax rate of 20% is used.

[16] We can no longer deal with the discontinuity at the 1.3 million yen by extending segment 3, because segment 3 will not intersect with segment 4.

[17] We used GQOPT REGFAL subroutine to compute this value.

higher budget segments, the magnitude of such effect is extremely small; the decreases in the choice probabilities through segment 1 to kink 2 are 1 percentage point or less. Increases in the choice probability through segment 3 to 5 are also 1 percentage point or less. Thus the conjecture that, once the spousal tax deduction is removed, a significant number of married women who are clustered near the 1.03 million yen ceiling will move to higher segments is not correct. The expected annual hours worked increases only slightly, from 1455 to 1465, or 0.7% increase in hours worked. Thus, the population average response to this tax reform is small.

Nevertheless, the labor supply responses of the most affected workers would be nontrivial. Note that 19% of the population would still choose segment 2 after this reform. For these workers, the expected desired hours worked would increase substantially from the before-reform 1430 hours to the after-reform 1482 hours. This is an increase of 4%. Thus, this reform has nontrivial effects 'locally'.

Third, we consider a reform of the social security system, a reform which requires all wives to pay social security premium regardless of their income level. Figure 5, Scenario 2, illustrates how this reform would affect the budget constraint. This will shift segment 1 through segment 3 downward in a parallel fashion. To provide some sense of this change, the shift in the budget constraint is 135.6 thousand yen in 2000. Table 6, Scenario 2, shows the estimates. The segment choice probabilities are almost unaffected by this reform. The expected hours worked would only increase from 1455 to 1456. Thus, this reform will have almost no effect on the labor supply of Japanese married women.

Finally, we consider the reform to both completely eliminate the spousal tax deduction, and to require all wives to pay a social security premium regardless of their income levels. Table 6, Scenario 3, shows the results. The effect on hours worked is still small; the expected hours worked would increase from 1455 hours to 1466 hours, only a 0.8% increase in the population labor supply.

As noted already, our model ignores the residential tax. Now, we provide a robustness check in order to examine how sensitive the results may be to the omission of this tax. Residential tax is 5% for the taxable income below 2 million yen, and it is 10% beyond this threshold. Due to the deduction schedule specific to the residential tax, the wife will start paying the tax at income 0.98 million yen. The 10% bracket begins somewhere on segment 4. To simplify the matter, we added an additional 5% tax rate through segment 2 to segment 3, and added an additional 10% tax rate for segment 4 and above, then re-estimated the model. As such, wage coefficient increased from 0.24 to 0.29, and the income coefficient decreased from -0.82 to -0.84. The effect of scenario 1 reform was an 0.8% increase in the expected hours worked. The effect of scenario 2 reform was close to zero. The effect of scenario 3 reform was an 0.9% increase in the expected hours worked. Thus, omission of residential tax appears to underestimate the effects of policy reforms, but the magnitude of underestimation would be quite small.[18]

8.3 Comparisons with existing estimates

Let us compare our results with Akabayashi (2006). According to his results, the spousal deduction reform (scenario 1) would increase hours worked by 5.53%, while the social security reform (scenario 2) would increase hours worked only by 0.6%. Thus, our results show smaller responses to both reforms. This is perhaps due to the fact that Akabayashi's model allows the effects of the husband's tax to be different from the effect of the wife's own tax. Akabayashi's results suggest that the wife's labor supply is more responsive to the husband's tax than the wife's own tax. When he constrained his model such that the husband's tax and the wife's tax have the same effect, the effect of spousal deduction reform

[18] All the results are available upon request from the author.

decreases to 1.9%, and the effect of social security reform decreases to 0.4%.[19]

However, Akabayashi's result that wives are more responsive to their husbands' tax is somewhat counter-intuitive. For example, kink 1 is caused solely by the husband's tax rate while kink 2 is caused solely by the wife's tax rate. If wives are more responsive to the husband's tax rate, we would expect that the observations would cluster more around kink 1 than around kink 2 in order to avoid higher tax rate. However, the data show the reverse pattern (see Figure 4), suggesting that wives may be more responsive to their own tax.

Now, let us emphasize some important similarities between our results and Akabayashi's (2006) results. First, estimated effects of spousal tax and social security reforms are much smaller than the 'reduced form' evidence. As reviewed in Section 4, Oishi (2003) indicates that social security reform would increase hours worked by 22%. Abe and Ohtake's results (1995) suggest that spousal tax deduction and social security reforms would increase the hours worked by as much as 150%. Kantani's results (1997) of the effect of 'income adjustment behavior' suggest a 35% increase in hours worked due to spousal tax deduction and social security reforms.

Such disparate estimates of the effects of the tax reforms would lead to substantially different policy recommendations. Based on our estimate, a policy recommendation would be to not reform the spousal tax deduction and social security systems as these reforms would have little impact on labor supply while harming household income. The recommendation would be reversed if the decision was based on the reduced form evidence. Since the estimated effects of work disincentive effects can affect actual policy decisions, this discrepancy means that more studies are necessary to accurately estimate the effects of these tax reforms.

Note that the reduced form studies estimate the effects of spousal deduction and social

[19] We have attempted to estimate a model similar to Akabayashi (2006). In his model, the effect of the husband's tax is estimated by incorporating an extra parameter γ as: $W^{Aftertax} = W[1-(1-a)t_W - \gamma t_H]$. For our data, this model failed to converge with σ_θ approaching to zero.

security systems as a preference shift (a changes in wage parameters for Abe and Ohtake 1995; a shift in hours worked equation for Oishi 2003, Kantani 1997 and Higuchi 1995), failing to capture that tax reform affects hours worked by changing the net wage and virtual income, not by changing the preference. Thus, large effects of reduced form studies perhaps capture the unobserved differences between comparison groups rather than the effects of policy reforms.

Second, the effects of social security reform (scenario 2) are extremely small for both our study and for Akabayashi's study. Since this is a reform that shifts the budget segment without changing the slopes, the weak effect of the social security reform may indicate that the effects of a lump sum income transfer program in general is small. For example, consider the child care support program that the current government provides. This is a not-mean-tested income transfer program for households with young children. As of June 2010, each child under age 12 receives 13 thousand yen per month. The possible work disincentive effect of this program has begun to receive much attention. Consider a family with two children between the ages of 6 and 12. This family will receive the lump sum amount of 312 thousand yen annually. If *every* woman in our sample receives 312 thousand yen, the expected hours worked would reduce from 1455 only to 1430 hours, or 1.7% reduction in population labor supply. Since women who have 2 children under 12 years old are a smaller fraction of the population, the actual population effect would be negligible. Thus, a lump sum income transfer program would have negligible effects on female labor supply unless the transfers are substantially large.

9. Conclusion

Japanese spousal tax deduction and social security systems cause a non-convex piece-wise and discontinuous budget constraint for married women. Using a pooled sample from the

Japanese Panel Survey of Consumers, we structurally estimated a labor supply model for Japanese married women that explicitly takes into account the nonlinearity in the budget constraint. The estimated parameters were then used to evaluate the effects of alternative policies on the labor supply. Our results suggest that the spousal deduction and social security reforms would have much smaller effects on the female labor supply than what the past reduced form studies suggest. The policy to completely eliminate the spousal tax deduction would only increase the population labor supply by 0.7%, though the labor supply responses of the most affected workers would be nontrivial, with their desired hours worked increasing by as much as 4%. The policy reform which requires all wives to pay the social security premium regardless of their income levels would have almost no effect on the female labor supply. Our results also suggest that lump sum income transfer programs, such as the current child care support program, would have negligible effects on female labor supply unless the transfers are substantially large.

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Table 1: National Income Tax Brackets in 2002

Taxable Income Range in 1000 yen (y)	Marginal tax rate (%)
$1 \leq$ y $<$ 3,300	10%
3,300 $\leq$ y $<$ 9,000	20%
9,000 $\leq$ y $<$ 18,000	30%
18,000 and more	37%

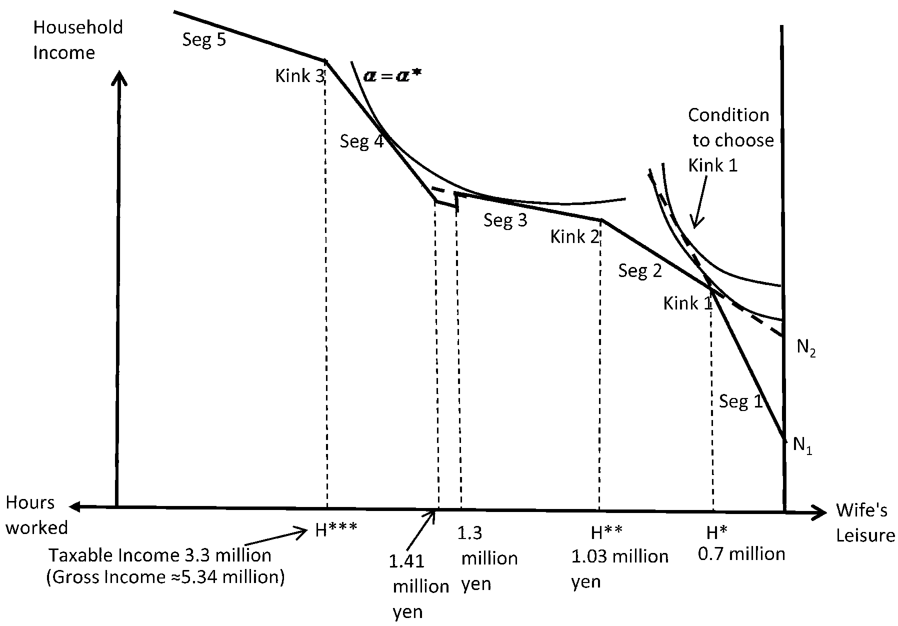
The tax schedule has been changed in 1995. We took into account this change when we computed the after tax wage rate and virtual income.

Table 2: Employee Tax Deduction Schedule in 2002

Gross Income Range in 1000 yen (y)	Total Deduction (Basic + Employer deduction)
$1 \leq$ y $<$ 1,625	1,030
1,625 $\leq$ y $<$ 1,800	0.4y+380
1,800 $\leq$ y $<$ 3,600	0.3y+560
3,600 $\leq$ y $<$ 6,600	0.2y+920
6,600 $\leq$ y $<$ 10,000	0.1y+1,580
10,000 and more	0.05y+2,080

The tax schedule has been changed in 1995. We took into account this change when we computed the after tax wage rate and virtual income.

Figure 1: Budget Constraint for a Typical Wife



(a) 0.7 million yen: The spousal deduction begins to phase out. (b) 1.03 million yen: The wife begins to pay her own income tax. (c) 1.3 million yen: The wife begins to pay the social security premium. (d) 1.41 million yen: The spousal deduction completely phases out. (e) 3.3 million yen: The income tax rate increases to 20%.

Figure 2: Employee Tax Deduction Schedule

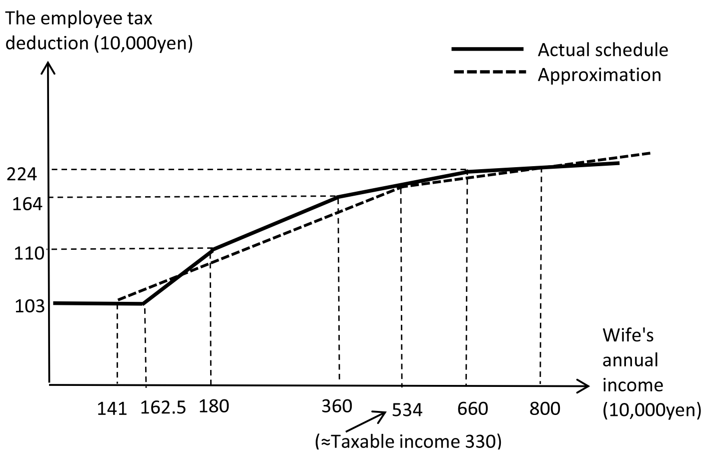


Table 3: Computation of After-tax Wage Rates and Virtual Incomes

Segment	Gross Income range (y) (in 1000 yen)	After tax hourly wage (in 1 yen)	Virtual income (in 1000yen)	
1	$0 \leq y < 700$	W	$760t_H$	+Non-wife-income
2	$700 \leq y < 1{,}030$	$W[1-t_H]$	$1{,}410t_H$	+Non-wife-income
3	$1{,}030 \leq y <$ around 1,410	$W[1-t_H-(1-a_3)t_W]$	$1{,}410t_H+b_3t_W$	+Non-wife-income
4	Around $1410 \leq y < 5337.5$	$W[1-(1-a_4)t_W]$	$b_4t_W+50t_W$-SS	+Non-wife-income
5	$y \geq 5337.5$	$W[1-(1-a_5)t_W]$	$b_5t_W+50t_W$-SS+330	+Non-wife-income

W: Wife's before-tax hourly wage	**Parameter values**			
t_H: Husband's income tax rate	Segment 3:	$a_3=0$	$b_3=1{,}030$	$t_W=0.1$
t_W: Wife's income tax rate	Segment 4:	$a_4=0.244$	$b_4=686.3$	$t_W=0.1$
	Segment 5:	$a_5=0.147$	$b_5=1{,}200.7$	$t_W=0.2$

(a) W is the wife's before-tax hourly wage rate. (b) t_H is the husband's marginal tax rate. (c) SS is the amount of annual social security premium paid by the wife. We computed SS based on the MAA premium, which has gradually increased overtime. (d) The income tax and the employee tax deduction schedule changed in 1995. The above parameter values are for the period on and after 1995. We used different parameter values for year 1994.

Figure 3: A Dip in the Budget Constraint due to the Elimination of the ‘Dependent Spouse Allowance’ Fringe Benefit

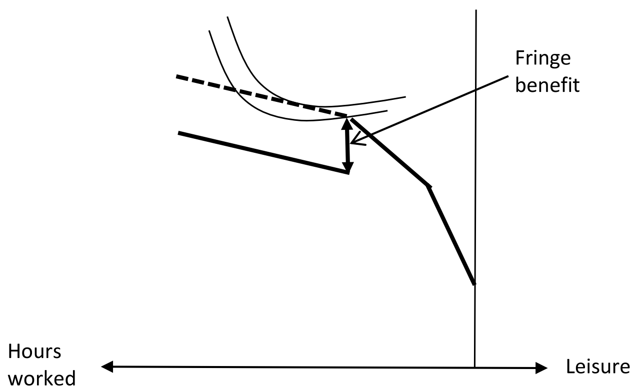


Table 4: Summary Statistics

	All	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
# Obs	3430	770	863	251	1360	183
Annual hours	1461.268	518.974	1176.212	1547.422	2045.159	2303.360
worked	(767.417)	(317.203)	(333.965)	(520.116)	(530.018)	(500.200)
Before-tax	1234.941	868.996	844.319	899.524	1542.512	2786.060
hourly wage (in 1 yen)	(736.162)	(412.810)	(371.173)	(474.152)	(689.449)	(631.596)
Wife's age	34.617	34.290	35.607	34.665	33.698	38.115
	(4.563)	(4.357)	(4.392)	(4.343)	(4.614)	(3.418)
Living with	0.428	0.349	0.431	0.382	0.467	0.519
parents	(0.495)	(0.477)	(0.496)	(0.487)	(0.499)	(0.501)
# children age $\leq$6	0.555	0.655	0.446	0.570	0.566	0.536
	(0.755)	(0.775)	(0.711)	(0.752)	(0.772)	(0.693)
Wife's education	14.238	14.129	14.087	13.996	14.316	15.169
in years	(1.138)	(1.052)	(1.099)	(1.418)	(1.112)	(0.919)

After-tax hourly wage rate in 1 yen (Sample average)		**Virtual income in 10,000 yen (Sample average)**	
W_1	1234.941	N_1	435.450
	(736.162)		(152.406)
W_2	1084.782	N_2	442.984
	(636.305)		(154.465)
W_3	961.288	N_3	453.164
	(563.192)		(154.469)
W_4	1141.463	N_4	425.781
	(680.457)		(150.867)
W_5	1024.179	N_5	475.182
	(610.562)		(150.924)

Inside the parentheses are standard deviations. Wage and virtual income variables are expressed in terms of 2002 constant yen.

Figure 4: Graphs of Annual Income and Wage

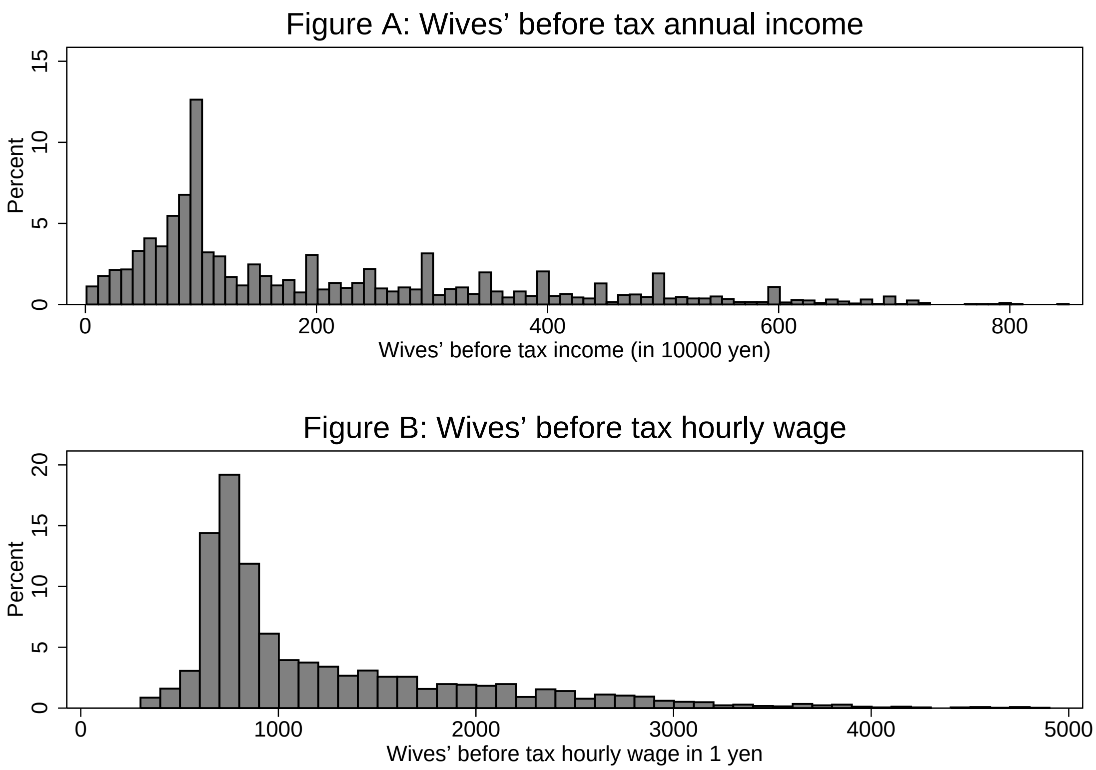


Table 5: Estimation Results

Dependent variable = Annual hours worked		
	OLS	Structural estimation
β: After tax hourly wage	0.170***	0.253***
(in 1 yen)	(0.020)	(0.023)
δ: Virtual income	-0.724***	-0.819***
(in 10,000 yen)	(0.089)	(0.096)
Wife's age	-115.772***	-111.200***
	(38.398)	(39.704)
Wife's age^2	1.676***	1.602***
	(0.557)	(0.581)
Living with parents	234.698***	239.602***
	(26.117)	(26.848)
# Children age ≤ 6	-88.417***	-91.530***
	(17.870)	(17.616)
Wife's years of education	-501.796***	-441.500***
	(95.431)	(96.381)
Wife's years of education^2	21.408***	18.753***
	(3.664)	(3.712)
Constant	6274.332***	5822.469***
	(902.622)	(906.240)
σ_v: Sd.dev for $v=\varepsilon+\theta$		734.655***
		(11.952)
σ_θ: Sd.dev for θ		389.746
		(239.822)
R-squared	0.077	
# obs	3430	3430
Uncompensated wage elasticity	0.127	0.185
Uncompensated income elasticity	-0.216	-0.250

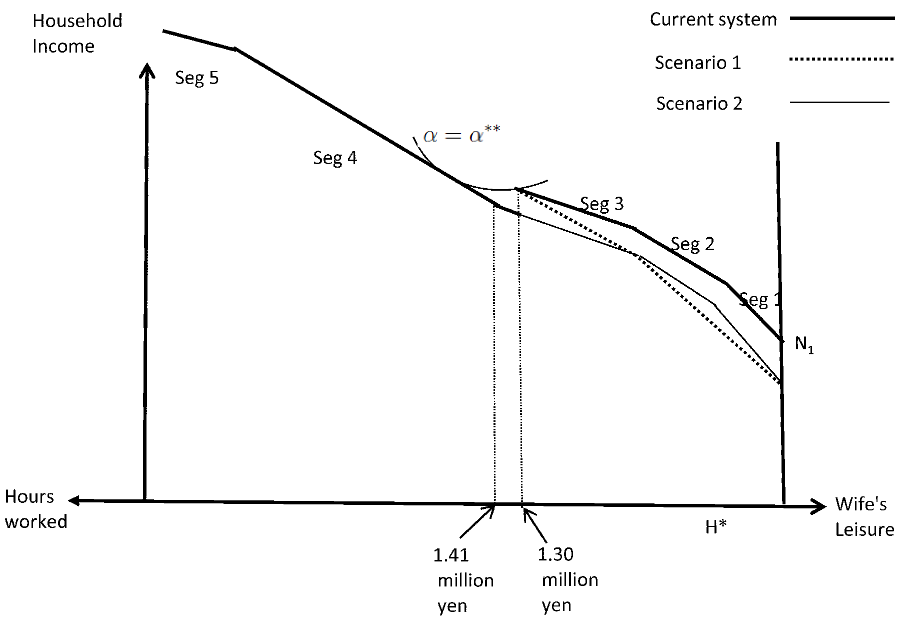
(a) Inside the parentheses are standard errors. For a structural estimation they are the square roots of the diagonal elements of the inverse of the outer products of the score vector. For the OLS they are heteroscedasticity robust standard errors. (b) *Significant at 0.1, ** at 0.05, *** at 0.01. (C) Wage elasticity is computed as the sample average of $\sum_{K=1}^{5} P(Seg_k)\beta W_k/(Hours)_k$ where $P(Seg_k)$ and $(Hours)_k$ are defined by equation (28). Income elasticity is computed as the sample average of $\sum_{K=1}^{5} P(Seg_k)\delta N_k/(Hours)_k$.

Table 6: Sensitivity Analysis

	Current system			Scenario 1 Eliminate spousal deduction only	
	Segment choice prob	Desired hours worked		Segment choice prob	Desired hours worked
Segment 1	11.72%	1474.280	Segment 1	11.47%	1481.527
Kink 1	0.00%	723.954	Kink 1	0.00%	723.954
Segment 2	20.13%	1430.083	Segment 2	19.46%	1481.527
Kink 2	1.59%	1063.107	Kink 2	1.53%	1063.107
Segment 3	0.00%	1390.472	Segment 3	0.33%	1441.978
Segment 4	61.36%	1458.531	Segment 4	62.34%	1458.531
Kink 3	0.90%	5486.719	Kink 3	0.90%	5486.719
Segment 5	4.30%	1388.367	Segment 5	4.30%	1388.367
	$\widehat{\theta} =$	5.253		$\widehat{\theta} =$	5.202
Expected hours worked= 1454.620			**Expected= hours worked 1465.059**		
	Scenario 2: Require everybody to pay the social security premium regardless of her income level			Scenario 3: Eliminate spousal deduction & require everybody to pay the social security premium	
	Segment choice prob	Desired hours worked		Segment choice prob	Desired hours worked
Segment 1	11.61%	1480.998	Segment 1	11.36%	1488.245
Kink 1	0.00%	723.954	Kink 1	0.00%	723.954
Segment 2	20.02%	1436.800	Segment 2	19.35%	1488.245
Kink 2	1.58%	1063.107	Kink 2	1.52%	1063.107
Segment 3	0.00%	1397.190	Segment 3	0.32%	1448.695
Segment 4	61.59%	1458.531	Segment 4	62.57%	1458.531
Kink 3	0.90%	5486.719	Kink 3	0.90%	5486.719
Segment 5	4.30%	1388.367	Segment 5	4.30%	1388.367
	$\widehat{\theta} =$	5.236		$\widehat{\theta} =$	5.186
Expected hours worked= 1455.785			**Expected hours worked= 1466.063**		

Computations are based on equation (28) . This table shows the sample averages.

Figure 5: Reforms of Spousal Deduction and Social Security Systems



Appendix: The likelihood function

Let v=θ+ε, σ_v^2=$VAR(v)$, and $\rho = corr(v, \theta)$. Let f(v,θ) be the joint distribution of v and θ. Let $f(v, \theta)$ be the joint distribution function of v and θ. Using the properties of the joint normal density function that $P[v = A, B < \theta < C] = \int_B^C f(v = A, \theta)d\theta$=$\int_B^C f(\theta|v = A)f(v = A)d\theta$, the likelihood contribution for i^{th} individual can be written as:

$$\begin{aligned}
L_i &= \frac{1}{\sigma_v}\phi(A1)[\Phi(BA1) - \Phi(BA0)] + \frac{1}{\sigma_\varepsilon}\phi(HH^*)[\Phi(B2) - \Phi(B1)] && (30)\\
&+ \frac{1}{\sigma_v}\phi(A2)[\Phi(CA2) - \Phi(BA2)] + \frac{1}{\sigma_\varepsilon}\phi(HH^{**})[\Phi(C3) - \Phi(C2)] && (31)\\
&+ \frac{1}{\sigma_v}\phi(A3)[\Phi(CZA3) - \Phi(CA2)] + \frac{1}{\sigma_v}\phi(A4)[\Phi(D4) - \Phi(CZA4)] && (32)\\
&+ \frac{1}{\sigma_\varepsilon}\phi(HH^{***})[\Phi(D5) - \Phi(D4)] + \frac{1}{\sigma_v}\phi(A5)[1 - \Phi(DA5)] && (33)
\end{aligned}$$

where

$$\begin{array}{ll}
A0 = (-\beta W_1 - \delta N_1 - Z\gamma)/\sigma_v & A1 = (H - \beta W_1 - \delta N_1 - Z\gamma)/\sigma_v \\
A2 = (H - \beta W_2 - \delta N_2 - Z\gamma)/\sigma_v & A3 = (H - \beta W_3 - \delta N_3 - Z\gamma)/\sigma_v \\
A4 = (H - \beta W_4 - \delta N_4 - Z\gamma)/\sigma_v & A5 = (H - \beta W_5 - \delta N_5 - Z\gamma)/\sigma_v \\
B0 = (-\beta W_1 - \delta N_1 - Z\gamma)/\sigma_\theta & B1 = (H^* - \beta W_1 - \delta N_1 - Z\gamma)/\sigma_\theta \\
B2 = (H^* - \beta W_2 - \delta N_2 - Z\gamma)/\sigma_\theta & C2 = (H^{**} - \beta W_2 - \delta N_2 - Z\gamma)/\sigma_\theta \\
C3 = (H - \beta W_3 - \delta N_3 - Z\gamma)/\sigma_\theta & D4 = (H^{***} - \beta W_4 - \delta N_4 - Z\gamma)\sigma_\theta \\
D5 = (H^{***} - \beta W_5 - \delta N_5 - Z\gamma)/\sigma_\theta & CZ = (\alpha^* - Z\gamma)/\sigma_\theta \\
HH^* = (H - H^*)/\sigma_\varepsilon & HH^{**} = (H - H^{**})/\sigma_\varepsilon \\
HH^{***} = (H - H^{***})/\sigma_\varepsilon &
\end{array} \quad (34)$$

and

$$\begin{array}{ll}
BA0 = (B0 - \rho A1)/\sqrt{1-\rho^2} & BA1 = (B1 - \rho A1)/\sqrt{1-\rho^2} \\
BA2 = (B2 - \rho A2)/\sqrt{1-\rho^2} & CA2 = (C2 - \rho A2)/\sqrt{1-\rho^2} \\
CA3 = (C3 - \rho A3)/\sqrt{1-\rho^2} & DA4 = (D2 - \rho A4)/\sqrt{1-\rho^2} \\
DA5 = (D5 - \rho A5)/\sqrt{1-\rho^2} & CZA3 = (CZ - \rho A3)/\sqrt{1-\rho^2} \\
CZA4 = (CZ - \rho A4)/\sqrt{1-\rho^2} &
\end{array} \quad (35)$$

and

$$\begin{array}{l}
\rho = \sigma_\theta/\sigma_v \\
\sigma_\varepsilon = \sqrt{1-\rho^2}\sigma_v \\
\alpha^* = -\frac{\beta}{\delta} + \frac{[\beta W_4 + \delta N_4]e^{\delta(W_4 - W_3)} - [\beta W_3 + \delta N_3]}{e^{\delta(W_4 - W_3)} - 1}
\end{array} \quad (36)$$

The likelihood function is given by $\prod_{i=1}^N L_i$. We estimate β, δ,γ, σ_v and σ_θ. The parameters,σ_ε and ρ, are determined by equations (36).