Human Capital Accumulation through Interaction between a Married Couple: Comparison between a Housewife and a Working Wife

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12 February 2011

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Abstract

Japanese household-level data describing a husband's earnings, his wife's working status, and their schooling levels are used to test the implications of a model proposing a time-consuming process of human capital accumulation within marriages, in which an educated wife is more productive. The empirical results support the model's predictions: in particular (i) a housewife's schooling has a greater positive effect on her husband's earnings than a working wife's schooling does; and (ii) the effect of a housewife's schooling increases with the length of marriage, whereas the effect of a working wife's schooling does not change over the course of marriage. (100 words)

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1. Introduction

While human capital is accumulated through each individual's costly investment, such as formal education and working experience (e.g., Becker 1964; Heckman and Polachek 1974; Mincer 1974; Ashenfelter and Krueger 1994; Behrman, Rosenzweig, and Taubman 1994; Card 1999), it is also highly influenced by interaction with the surrounding people. In fact, economic outcomes such as one's earnings are often associated with family and community backgrounds (e.g., Behrman and Wolfe 1984; Boulier and Rosenzweig 1984; Hauser and Sewell 1986; Corcoran, 1992). For instance, one's earnings are positively associated with parents' schooling (e.g., Heckman and Hotz 1986; Lam and Shoeni, 1993, 1994; Behrman, *et al.* 1999), while learning from neighbors can help a person increase productivity and increase income (Foster and Rosenzweig 1995; Conley and Udry, 2010).

It is thus natural to expect that such human capital accumulation through social interaction also occurs between a husband and wife. Benham (1974) was the first to argue that an educated wife improves her husband's productivity and thus increases his earnings; the so-called "cross-productivity effect within marriage" (see also, Scully, 1979; Kenny, 1983; Wong, 1986; Lam and Schoeni, 1993; Jepsen 2005; Lefgren and McIntyre, 2006; Mano and Yamamura, 2011), which is considered to occur in addition to the assortative mating, picking up the effect of the unobserved husband's ability (Welch, 1974; Liu and Zhang, 1999).[2] Disentangling the cross-productivity effect

[2] It is widely observed that a wife's human capital positively influences a husband's earnings; for instance, in Israel (Neuman and Ziderman 1992), Iran (Scully 1979), the Philippines (Boulier and Rosenzweig 1984), Malaysia (Amin and Jepsen, L., 2005), and Brazil (Lam and Shoeni, 1993,

from the assortative mating effect has been one of the major challenges in this literature. Using twins data to control for the unobserved mating effect, Huang *et al*. (2009) find that cross productivity is important in explaining the earnings among Chinese households. As Huang *et al*'s study lacks a formal model, however, their finding is not readily generalizable beyond the Chinese case, and, more importantly, it is not clear under what conditions the cross-productivity effect works. The current paper attempts to better understand the mechanism underlying the cross-productivity effect by testing a simple model on recent Japanese household data, describing the earnings, human capital characteristics, and working status of the husband and wife.

It is well established that when one's schooling improves his/her own productivity and earnings, both the quantity and quality of education play important roles (Welch, 1966; Johnson and Stafford, 1973; Behrman and Birdsall, 1983; Card and Krueger, 1992). The quantity of schooling is often measured by the number of years of schooling, while the quality of schooling could be measured by the educational level of the teachers. The analogous framework should apply to the cross-productivity effect, in which a wife improves her husband's productivity and earnings. While the "quality" may be measured by a wife's schooling in this case, the "quantity" may be measured by the number of years of marriage and by a wife's time dedicated to improving her husband's knowledge and physical fitness.[3]

1994).

[3] Using U.S. census data from 1960 to 2000, Jepsen (2005) finds that a husband's earnings increase with his wife's education. However, the magnitude of the effect declines over cohorts, and Jepsen conjectures that the rapid increase in a wife's labor participation reduced her time to improve her husband's productivity.

In fact, we find through our analysis on the Japanese household data that the positive effect of a housewife's education on her husband's earnings is greater than the effect of a working wife's schooling.[4] Moreover, the effect of a wife's schooling further increases with the number of years of marriage only in the case of a housewife, who has more time to improve her husband's human capital than a working wife does. We also find evidence that a wife's schooling is positively associated with at least one particular aspect of her husband's human capital; that is, health. In the analysis below, we will use the switching regression model to correct a possible endogeneity bias arising from a wife's labor supply decision.

The rest of this paper is organized as follows. In the following section we will extend the conceptual framework discussed here. Section 3 contains a description of the dataset and some descriptive statistics. Section 4 sets out our estimation strategy, while the estimation results are presented in Section 5. Finally, Section 6 concludes this paper.

2. Conceptual framework and estimation strategy

2.1 Model

A simple model will help us understand the mechanism of the cross-productivity

[4] Using the same dataset, Mano and Yamamura (2011) investigate the relationships of a husband's education to labor supply and earnings among married Japanese women. Whereas educated husbands reduce the labor supply of wives, their human capital is positively associated with productivity and earnings of the wives once they participate in the labor market.

effect between the husband and wife. Let us consider a married couple with members *M* (male) and *F* (female). Each member is endowed with total available time *T*, and is characterized by schooling level *s* and ability θ. Given the schooling and ability of the household members, each member allocates time Z to improving the other member's productivity and the remaining $(T-Z)$ to labor supply, and consumes a private Hicksian composite consumption good in quantity *C*, so that the household utility will be maximized. Berliant and Fujita (2009) emphasize the importance of the contribution of each member of a couple, especially the heterogeneity in the state of knowledge which each member brings into a couple, in successful joint human capital accumulation. In the current setting, time Z is allocated to activities that broaden the knowledge of the household members (e.g., suggesting ideas and exchanging thoughts on certain issues) or that promote better health (e.g., preparing nutritious meals). The price of the consumption good is set to one, while member *M*'s market wage rate $w_{\mathrm{M}} \equiv w\ (Z_{\mathrm{F}};\ s_{\mathrm{M}}, \theta_{\mathrm{M}},\ s_{\mathrm{F}}, \theta_{\mathrm{F}})$ is equal to the value of his marginal product of labor, which increases with member *F*'s contribution Z_{F}, and members *M* and *F*'s schooling level *s* and ability θ. Member F's wage rate w_{F} is analogously defined.

Let us formally state the household utility maximization problem. The household maximizes the utility function:

$$\max_{\{C_M, C_F, Z_M, Z_F\}} U(C_M, C_F) \quad s.t.\ C_M + C_F = (T - Z_M)w_M + (T - Z_F)w_F$$

The household utility function is assumed to increase with both members' consumption, and the market wage function takes a form of $w_M(Z_F; s_M, \theta_M, s_F, \theta_F) = s_M \theta_M (1 + \phi s_F \theta_F Z_F)$ with $\phi \geq 0$, which captures all the characteristics assumed above. In the interior solution, in which both members work

in the market, the optimal time allocation for productivity improvement, and the resulting wage rates are,[5]

$$Z_M^* = \frac{1}{2}\left(T - \frac{1}{\phi s_F \theta_F}\right) \quad , \quad Z_F^* = \frac{1}{2}\left(T - \frac{1}{\phi s_M \theta_M}\right) \quad ,$$

$$w_M^* = \frac{1}{2} s_M \theta_M \left(1 + \phi s_F \theta_F T\right), \text{ and } \; w_F^* = \frac{1}{2} s_F \theta_F \left(1 + \phi s_M \theta_M T\right).$$

In the case of a corner solution in which only member *M* works in the market;[6]

$$Z_M^* = T, \; Z_F^* = 0, \text{ and } \; w_M^* = s_M \theta_M \left(1 + \phi s_F \theta_F T\right).$$

2.2 Analytical results

Let us conduct a comparative statics on member *M*'s wage rate and working time in the optimum. The derivative of member *M*'s optimal wage rate with respect to his own education is always positive; $\partial w_M^* / \partial s_M = \theta_M \left(1 + \phi s_F \theta_F T\right)/2 > 0$ in the interior solution, and $\partial w_M^* / \partial s_M = \theta_M \left(1 + \phi s_F \theta_F T\right) > 0$ in the corner solution where only member M works in the market. These results imply that:

Lemma 1 (Own education on wage rate) *The wage rate of household member M increases with his own schooling.*

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[5] Comparing the total household earnings, we find that the parametric condition for the interior solution, in which both members work in the market, to be chosen over the corner solutions, in which either member does not work in the market, is

$$\phi\left(s_M^2 \theta_M^2 + s_F^2 \theta_F^2 - 2 s_M^2 \theta_M^2 s_F^2 \theta_F^2 T^2\right) \geq 2 s_M \theta_M s_F \theta_F T \left| s_M \theta_M - s_F \theta_F \right|.$$

[6] The parametric condition for the corner solution in which only member *M* works is

$$\phi\left(s_M^2 \theta_M^2 + s_F^2 \theta_F^2 - 2 s_M^2 \theta_M^2 s_F^2 \theta_F^2 T^2\right) < 2 s_M \theta_M s_F \theta_F T \left(s_M \theta_M - s_F \theta_F\right).$$

We can also examine the association of one's productivity and earnings with the spouse's schooling, by taking the derivative with respect to spouse *F*'s education; $\partial w_M^* / \partial s_F = \phi s_M \theta_M \theta_F T / 2 > 0$ in the interior solution, and $\partial w_M^* / \partial s_F = \phi s_M \theta_M \theta_F T > 0$ in the corner solution, which imply that

Lemma 2 (Cross-productivity effect) *The wage rate of member M increases with member F's educational level.*

We will examine the following hypothesis in the empirical analysis below:

> ***Hypothesis 1****: A husband's earnings are positively associated with his wife's schooling.*

Even if there is no cross-productivity effect, however, we may still observe a positive correlation between a wife's educational level with her husband's wage rate. For the sake of argument, consider the case in which there is no cross productivity effect (i.e., $\phi = 0$). In this case, member *M*'s marginal productivity is determined solely by his own schooling and ability as $w_M^* = s_M \theta_M$. Suppose, furthermore, that the well-educated tend to marry people with high ability as well as education; i.e., $\mathrm{cov}(\ln s_F, \ln \theta_M) > 0$. The covariance between the logarithm of *M*'s wage rate and the logarithm of member *F*'s schooling conditional on *M*'s own schooling is $\mathrm{cov}(\ln s_F, \ln w_M^*)\big|_{S_M} = \mathrm{cov}(\ln s_F, \ln \theta_M)\big|_{S_M}$, which is positive by assumption. This is

the so-called assortative mating effect.

Lemma 3 (Assortative mating) *Suppose there is no cross productivity effect* (*i.e.,* $\phi = 0$). *Suppose also that the well-educated tend to marry people with higher ability; i.e.,* $\text{cov}(\ln s_F, \ln \theta_M)|_{s_M} > 0$. *We observe a positive correlation between a wife's schooling with her husband's wage rate conditional on his own schooling.*

Therefore, member *M*'s wage rate can be positively associated with his wife's schooling either due to the cross-productivity effect or due to the assortative mating effect. Further analysis of the model will provide an identification strategy. The idea is that the assortative mating effect does not change with the length of marriage, whereas the cross-productivity effect is expected to increase with the length of marriage. To see this, take a derivative of the cross productivity effect $\left(\partial w_M^* / \partial s_F\right)$ with respect to length of marriage *T*, and we obtain $\left(\partial^2 w_M^* / \partial s_F \partial T\right) = \phi s_M \theta_M \theta_F / 2 > 0$ in the interior solution, and $\left(\partial^2 w_M^* / \partial s_F \partial T\right) = \phi s_M \theta_M \theta_F > 0$ in the corner solution. By contrast, suppose that there is no cross-productivity effect ($\phi = 0$) but assortative mating; i.e., $\text{cov}(\ln s_F, \ln \theta_M)|_{s_M} > 0$. As ability here is inherently given and does not change over the course of life, a change in this assortative mating effect with the length of marriage is expected to be nil.

Lemma 4 (The length of marriage) *The assortative mating effect does not change with the length of marriage, whereas the cross-productivity effect increases with the length of marriage.*

Based on this identification strategy in Lemma 4, we will postulate the following hypothesis.

Hypothesis 2: *The positive association between a husband's earnings and his wife's schooling increases with the length of marriage.*

Furthermore, we can obtain the main proposition of the current paper, by comparing the partial derivatives of member *M*'s wage rate with respect to member *M*'s schooling, and with respect to member *F*'s schooling, respectively, between the interior solution and the corner solution.

Proposition 5 (Working wife and housewife) *The effects on member M's wage rate of his own schooling and member F's schooling are both greater in the corner solution than in the interior solution.*

Proposition 5 leads us to the following hypothesis.

Hypothesis 3: *The positive associations between a husband's earnings and his own and his wife's schooling are greater for couples with a housewife than for couples with a working wife.*

We will describe how to test these hypotheses on our data.

2.3 Estimation strategy

Based on the conceptual framework advanced in the previous subsection, we will empirically examine the cross-productivity effect within marriage, and particularly compare the effect between a housewife and a working wife. To control for the endogeneity of a wife's labor force participation, we will rely on the Type 5 Tobit method to estimate the switching regression model (Amemiya, 1985).

Labor participation equation

Mincer (1962) has triggered a large number of studies on the labor supply of married women; it is now well understood that their labor force participation is determined by their own human capital characteristics and their diverse socio-economic environments.[7] The first equation models the labor supply decision among married women, which can be expressed as follows:

$$y_{1i}^{*} = x_i'\alpha_1 + z_i'\beta + u_{1i}, \text{ for } i = 1, \ldots, n, \qquad \text{(I)}$$

where it is assumed that only the sign of y_{1i}^{*} is observed, it is positive if and only if married woman i participates in the labor market, and n denotes the number of observations. The first vector of explanatory variables, x_i, consists of years of own and spousal schooling, own and spousal ages and their squared terms, size dummies for the city of residence, and year dummies. We expect that an educated wife, expecting a higher market wage, is more likely to participate in the labor market, while an educated

[7] For an overview of labor supply among women, see Killingsworth and Heckman (1986) and Blundell and MaCurdy (1999).

husband receives higher earnings and allows his wife to stay at home, which can be considered as a division of labor within a household (Becker, 1991; Devereux, 2004; Kalenkoski *et al*., 2009).

This labor supply model incorporates another set of explanatory variables, z_i, consisting of the number of children under age six, which supposedly measures the burden of childcare, and four dummy variables, each indicating co-residence with own or spousal fathers and mothers, respectively. Childcare is time-consuming and takes up much of the mother's time, especially when the children are young. In consequence, we expect that married women with more young children tend to stay at home and not participate in the labor force (Ribar, 1992, 1995; Angrist and Evans, 1998).

Furthermore, we also expect to observe positive effects of co-residence with the mother or the mother-in-law on the wife's labor force participation; these effects will be compared with the corresponding effects of co-residence with the father or the father-in-law. Existing studies only look at the effects of co-residence with one's parents and in-laws as a whole (Hill, 1983; Yamada, Yamada, and Chaloupka, 1987; Ogawa and Ermisch, 1996; Sasaki, 2002). However, it is reasonable to expect that the effects on the labor supply of co-residence with one's own or spousal mother will be different from the effects of co-residence with one's own or spousal father. In many societies, women are responsible for a greater portion of the housework (Becker, 1991); this is the case in the traditional sexual division of labor in a Japanese household (Juster and Stafford, 1991; Kamo, 1991; Hakim, 1996; Strober and Chan, 1998). In general, wives tend to shoulder most of the housework and childcare, thereby accumulating the human capital specifically useful for these tasks. Therefore, own or spousal mothers are more able to facilitate their married daughters or daughters-in-law in working in the

market by reducing their burden of household work; own or spousal fathers do not usually share housework and thus they are less able to affect the labor supply of daughters or daughters-in-law.

This second set of explanatory variables, z_i, will be excluded from the husband's earnings equation. This identification strategy is based on the assumption that these factors do not directly affect the husband's productivity and earnings in the labor market. However, a husband making greater earnings may choose to have more children or tend to accommodate his own and spousal parents.[8] Based on these considerations, we alternatively estimate the system of equations dropping these variables as a robustness check. Notice that even without the exclusion restrictions we can still rely on the non-linearity of the probit model as an identification strategy.

Earnings equation

The husband's earnings equation can be expressed as:

$$y_{2i}^{*} = x_i'\alpha_2 + u_{2i}, \text{ for } i = 1, \ldots, n, \qquad \text{(II)}$$

where y_{2i}^{*} is the logarithm of husband's earnings, $\{u_{1i}, u_{2i}\}$ are i.i.d. drawings from a bivariate normal distribution, and the vector of explanatory variables x_i is the same as in

[8] Sasaki (2002) addresses the endogeneity of family structure, in which a married woman may choose to co-reside with parents or with in-laws in an attempt to reduce her housework and to consequently participate in the labor force. His results suggest that the effect of co-residence with parents or in-laws on the labor supply of married women only marginally changes when the endogeneity of family structure is addressed by the instrumental variable method.

the labor force participation model expressed by equation (I). In addition to analyzing the effect of a husband's education on his labor earnings (Lemma 1), our main focus here is to examine the effect of his wife's years of schooling on his earnings (Lemma 2). We will thus examine Hypothesis 1, which states that a husband's earnings are positively associated with his wife's education.

As we discussed in Subsection 2.2, a husband's wage rate can be positively associated with his wife's schooling either due to the cross-productivity effect or due to the assortative mating effect. We will test Hypothesis 2, which states that the positive association between a husband's earnings and his wife's schooling is reinforced with the length of marriage, in an attempt to establish that the cross-productivity effect at least partly explains the positive association between a husband's earnings and his wife's education. More importantly, we will compare the effects of his own and his wife's schooling on a husband's earnings between the working wife sample and the housewife sample in order to see whether the evidence supports Hypothesis 3, which states that the positive associations between a husband's earnings and his own and his wife's schooling are greater for households with a housewife than for households with a working wife.

The next section will describe the dataset in detail, and basic statistics will document the situation of a wife's labor supply and a husband's earnings in Japan.

3. Data and descriptive statistics

This paper uses Japanese General Social Survey (hereafter, JGSS) data.[9] These surveys adopted a two-step stratified sampling method and were conducted throughout Japan between 2000 and 2002. They asked standard questions about an individual and his/her family characteristics through face-to-face interviews. These data included information on marital and demographic (such as age and gender) status, annual earnings, years of schooling, age, and size of residential area. Importantly, the spouses' socioeconomic information was also collected and made available for analysis.

Table 1 presents the average characteristics of the sampled married couples in our study by the labor participation status of the wife; the number of observations—that is, the size of the sample of married couples—is 3500. The average husband with a working wife earned over 5.6 million yen (or around 56 thousand USD), while the average husband with a housewife earned 5.8 million yen (or 58 thousand USD), where the difference is not statistically significant. We can observe the annual earnings only for working wives; their average earnings are 2 million yen (or 20 thousand USD).[10] The average working wife and housewife are remarkably similar to each other in terms of their human capital characteristics, and they are around 46 years old and, more importantly, have 12.3 years of schooling. In Japan, compulsory education consists of

[9] Data for this secondary analysis, "Japanese General Social Surveys (JGSS), Ichiro Tanioka," were provided by the Social Science Japan Data Archive, Information Center for Social Science Research on Japan, Institute of Social Science, University of Tokyo.

[10] In the original dataset, annual earnings are grouped into 19 categories; we assumed that everyone in each category earned the midpoint value. For the top category of "23 million yen and above," we assumed that everybody earned 23 million yen. Since only a single observation was in this category, the top-coding problem should not be serious.

six years of primary schooling and three years of junior-high, which is followed by three years of high school and four years of college education. As we have discussed above, while an educated wife is more likely to participate in the labor market on one hand, her husband tends to receive relatively higher earnings due to the cross productivity effect or the assortative mating effect and thus allow her to stay at home on the other hand. On average, these two forces seem to offset each other. As for a husband's human capital characteristics, we find that a housewife's husband is significantly younger and more educated than a working wife's husband. This higher educational level may, at least partly, explain why a housewife's husband tends to make relatively higher, though not statistically significant, earnings than a working wife's husband. We will conduct the regression analysis below to disentangle the cross-productivity effect from these other determinants of a husband's earnings.

The household characteristics are also consistent with the discussion above. A housewife tends to have more children under age six than a working wife. Furthermore, a working wife tends to reside with her own mother and her husband's parents more often than a housewife does. Moreover, a married couple tends to live with the husband's parents more often than with the wife's parents, reflecting the traditional family structure in Japan. Overall, these observations are consistent with the results of Ogawa and Ermisch (1996), which used a survey conducted by the Mainichi newspapers in June 1990, and of Sasaki (2002), which used another Japanese micro-level dataset, the Panel Study on Consumption and Living, 1993 (*Shohi Seikatsu ni kansusru Paneru Chousa*), conducted by the Institute for Household Economy (Kakei Keizai Kenkyujo). This indicates the representativeness of our dataset and of the following analysis of the husband's earnings in Japan.

Health is another important aspect of human capital, besides knowledge (Schultz, 1961; Schultz, 2002). Table 1 also presents a husband's health status assessed by himself and his wife, respectively, in five grades, ranging from 1 (poor) to 5 (good). The comparison between the working wife sample and the housewife sample suggests that a husband married to a housewife tends to be in a better state of health according to both his own and his wife's assessments, but the differences are not statistically significant.

Table 2 presents this assessment on a husband's health status by wife's labor participation and schooling. The education levels are divided into two groups, 12 years or less of schooling and 13 years or more.[11] In three out of the four cases, the husband's health condition is significantly higher among the couples with more educated wives, while the difference is not statistically significant in the remaining case. In particular, among the housewife sample, a husband's health condition is always significantly better among couples with a more educated wife than with a less educated wife. It is well established in the literature that a husband in a better state of health tends to perform better at work and make higher earnings (Pitt, Rosenzweig, and Hassan, 1990; Thomas and Strauss, 1997; Strauss and Thomas, 1998), and it may also be reasonable to assume that a wife attempts to improve her husband's health condition, motivated by this consideration in addition to many others. In particular, an educated housewife may have sufficient time to implement her better knowledge about a balanced diet and a healthy lifestyle, and successfully improve her husband's fitness.

We actually observe that a husband's earnings tend to be positively associated

[11] Alternatively, we divided the sample between a wife with 12 years or less of schooling and 13 years or more. The results were essentially the same as the one reported here.

with his wife's education (Table 3), which renders support to our Hypothesis 1. The upper panel in Table 3 presents the descriptive statistics for the working wife sample, while the lower panel presents the corresponding statistics for the housewife sample. Column (1) in Table 3 presents the labor earnings of a husband married to a wife with 12 years or less of schooling, while Column (2) presents the labor earnings of a husband married to a wife with 13 years or more of schooling. Similarly, Rows (i) and (iii) present the labor earnings of a husband with 12 years or less of schooling, while Row (ii) and (iv) present the labor earnings of a husband with 13 or more of schooling. Among the working wife sample with her husband with 12 years or less of schooling (Row i in Table 3), his annual earnings are 5.04 million yen when his wife has 12 years or less of education, while he annually earns 5.90 million yen when his wife has 13 years or more of schooling. The corresponding difference is not statistically significant for the working wife sample with a husband with 13 years or more of schooling (Row ii) between Columns (1) and (2). Among the housewife sample (the lower panel of Table 3), a husband's earnings are significantly higher when his wife has 13 years or more of schooling (Column 2) than when she has 12 years or less of schooling (Column 1), regardless of the husband's educational level. This appears to suggest that a housewife's education has a greater positive effect on her husband's earnings than a working wife's education, which is congruent to our Hypothesis 3.

4. Estimation results

To see the importance of controlling for a married woman's self-selection into the labor force, we simply estimate the earnings equation (II) by using OLS. Columns (1),

(2), and (3) of Table 4 present a husband's earnings equations for the working wife sample, and Columns (4), (5), and (6) for the housewife sample. We begin our analysis with the simplest specification of the earnings equations presented in Columns (1) and (4), in which the explanatory variables include a husband's own education, his age as a proxy for experience, and its squared term. An additional year of a husband's schooling increases his own earnings by 5.5 percentage points among the working wife sample (Column 1), whereas among the housewife sample an additional year of his schooling increases his earnings even more significantly by 8.7 percentage points (Column 4). This estimation result is in line with Hypothesis 3.

When we additionally include a wife's schooling as an explanatory variable, the estimated effect of an additional year of her schooling on her husband's earnings is 4.5 percentage points in the working wife sample (Column 2), while it is 4.1 percentage points in the housewife sample (Column 4). These results are consistent with Hypothesis 1. When a wife's schooling is controlled for, the estimated effect of a husband's own schooling declines from 5.5 percentage points in Column (1) to 3.6 percentage points in Column (2) in the working wife sample, while the effect declines from 8.7 percentage points in Column (4) to 7.0 percentage points in Column (5) in the housewife sample, due to the alleviation of the omitted variable bias arising from the positive correlation between a husband's and his wife's schooling. Furthermore, when we additionally include the interaction term of a wife's education with the years of marriage as an explanatory variable, the estimated effect of this interaction term is significantly positive (Columns 3 and 6), which renders support to Hypothesis 2. The estimated coefficients also imply that the effect of a husband's own schooling is greater among the housewife sample (Columns 4, 5, and 6) than among the working wife

sample, which is partially in line with Hypothesis 3. We will next attempt to address the possible endogeneity in a wife's labor force participation and to mitigate an associated bias by way of the switching regression.

Table 5 presents the estimated model of a husband's earnings and his wife's labor participation described by the system of equations (I) and (II). The husband's earnings equation in Model A includes a wife's schooling as well as a husband's schooling, his age, and its squared term among the explanatory variables, while Model B additionally includes the interaction term of a wife's schooling with the years of marriage. The wife's labor supply equation also includes her age and its squared term, the number of children under age 6, the dummy variables indicating whether a husband's parents and his wife's parents co-reside with the married couple (Columns A-1 and B-1). The estimation result of the wife's labor participation equation (I) suggests that a husband's education significantly decreases his wife's labor supply (Columns A-1 and B-1), while the tendency of an educated wife to participate in the labor market increases with the years of marriage (Column B-1). A wife's labor supply initially increases with her age but it starts to decline beyond a certain threshold age. More importantly, a wife is less likely to participate in the labor market when she has more children under age six, which is consistent with the existing studies (Ribar, 1992, 1995; Angrist and Evans, 1998). The estimation result also provides remarkable evidence that co-residence with a husband's mother increases his wife's labor supply, while co-residence with a wife's mother increases it even more significantly. By contrast, co-residence with a wife's father or her father-in-law does not have any significant effect on her labor participation, which is consistent with the previous studies on the Japanese family structure (Juster and Stafford, 1991; Kamo, 1994; Hakim, 1996; Strober and Chan, 1998).

The bottom of Table 5 indicates that *rho_1*, the correlation coefficient between the error terms in a wife's labor participation equation and in her husband's earnings equation in the working wife sample, is significantly negative, while the corresponding correlation coefficient in the housewife sample *rho_2* is also significantly negative. These results imply that a wife's labor supply decision is endogenous, and this justifies our estimation strategy by using the switching model.

In the husband's earnings equation (Columns A-2, A-3, B-2, and B-3), a husband's own schooling has a significantly positive effect on his earnings, and the estimated effect tends to be greater in the housewife sample (Columns A-3 and B-3) than in the working wife sample (Columns A-2 and B-2). When we drop the number of children under age six and the coresidence variables from the equation system as a robustness check, the results hardly change (Table 6). The difference in the effect of a husband's schooling seems to reflect that a housewife can spend more time to help her husband maintain his best health than a working wife does, so that he is able to give his best performance at work. This result is consistent with Hypothesis 3.

The effect of his wife's schooling on a husband's earnings is also significantly positive in the three cases (Columns A-2, A-3, and B-3), which is consistent with Hypothesis 1, with the exception of Column (B-2). Furthermore, the effect of a wife's schooling is greater and more highly statistically significant in the housewife sample (Columns A-3 and B-3) than in the working wife sample (Columns A-2 and B-2). In Table 6, a wife's years of schooling has a significantly positive effect in the housewife sample (Columns C-3 and D-3), whereas it is insignificant in the working wife sample (Columns C-3 and D-3). One reasonable way to interpret this result is that as a housewife can usually spend more time to help her husband improve his human capital,

perhaps through discussion and the provision of useful advice regarding his work, than a working wife does, her schooling level makes a greater difference in affecting her husband's earnings. These results render support to Hypothesis 3. In sum, these findings indicate that an educated wife is better at improving her husband's productivity, while the productivity of an educated husband improves more substantially with his wife's dedicated support.

Furthermore, the interaction term of a wife's schooling with the years of marriage has a statistically significantly positive coefficient only in the housewife sample (Column B-3). Thus, the effect of a housewife's schooling on her husband's earnings increases with the years of marriage, which is consistent with Hypothesis 2. By contrast, this interaction term is not statistically significant in the working wife sample (Column B-2), which means that the effect of a working wife's schooling on her husband's earnings does not significantly change with the years of marriage. We also obtain the same results in Table 6. In all likelihood, a working wife has less time to help her husband improve his human capital than a housewife does, and, thus, the "cumulative" cross productivity effect is also significantly weaker in the working wife sample than in the housewife sample[12].

6. Conclusion

The existing literature provides substantial evidence on human capital accumulation through social interactions. However, due primarily to the lack of data,

[12] We are assuming here that a working wife has been working most of her married life, whereas a housewife has rarely worked. We do not have data to confirm this argument directly.

the underlying mechanism has not been sufficiently understood, even for one of the smallest social units, a married couple. Thus, this paper attempted to reveal the nature of human capital accumulation through interaction between a husband and wife by testing a simple model on recent household-level data from Japan.

Our model describes human capital accumulation within a marriage as a time-consuming process, in which an educated wife is more productive, and it predicts that: (1) a husband's earnings increase with his wife's schooling; (2) this positive effect of a wife's schooling further increases with the length of marriage, which is not predicted by the alternative assortative mating hypothesis; and (3) the effects on a husband's earnings of his own and his wife's schooling are both greater in the housewife sample than in the working wife sample. We used the switching regression model to address the endogeneity in a wife's labor participation decision, and obtained the supportive evidence for these predictions.

Specifically, the regression results suggest that an educated wife is likely to improve her husband's human capital more effectively. Consistently, the descriptive analysis finds that a husband's health human capital tends to increase with his wife's educational level. In all likelihood, her schooling similarly improves the other aspects of her husband's human capital. In these situations it is reasonable to expect that this positive effect of a wife's schooling increases with the amount of time that she spends to improve her husband's human capital. In fact, an educated housewife increases her husband's earnings more substantially than a similarly educated working wife does. Furthermore, the magnitude of the positive effect of a housewife's schooling on her husband's earnings increases with the years of marriage, whereas the magnitude of the corresponding effect of a working wife's schooling does not significantly change with

the years of marriage. These findings indicate the importance of education in human capital accumulation within a marriage, which is often neglected in the discussion of the division of labor between a husband and wife.

Overall, our model of human capital accumulation within a marriage and the associated supportive empirical evidence extend our understanding of the nature of human capital accumulation through social interaction. More detailed information about household activities, such as more detailed data on time allocation within households, nutritional intake, and more objective health indicators, would certainly allow us to examine this issue more closely. It is highly beneficial to combine these attempts to reveal the underlying mechanism of human capital accumulation through social interactions with such ideal data sets, such as the twins data used in Huang *et al*. (2009), allowing cleaner identification. These are the remaining challenges to be addressed in a future study.

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Table 1. Average Characteristics of the Sample Married Couples by Wife's Labor Participation.

	Working wife (1)	Housewife (2)	*p*-value for *t*-test with H_0: (1) - (2) = 0
Annual earnings			
Husband (million yen)	5.65	5.83	0.121
Wife	2.03	---	---
Human capital characteristics			
Husband's age	49.6	48.8	0.057*
Wife's age	46.9	46.3	0.144
Husband's years of schooling	12.7	13.0	0.0003***
Wife's years of schooling	12.3	12.3	0.803
Household characteristics			
Years of marriage	22.6	21.4	0.008***
No. of children aged under 6	0.14	0.38	0.000***
Coresidence with husband's mother	20.2	14.0	0.000***
Coresidence with husband's father	11.0	8.4	0.014**
Coresidence with wife's mother (%)	5.7	3.3	0.001***
Coresidence with wife's father	2.8	2.1	0.181
Husband's health			
Husband's assessment	3.43	3.50	0.231
Wife's assessment	3.87	3.90	0.525
No. obs.	1862	1638	---

Notes. The unit of annual earnings is million yen. Husband's health is assessed in five grades, ranging from 1 (poor) to 5 (good). *, **, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

Table 2. Husband's Health Status by Wife's Labor Participation and Schooling.

	Working wife		*p*-value for	Housewife		*p*-value for
	Wife's years of schooling:		for *t*-test with	Wife's years of schooling:		*t*-test with
	12 or less	13 or more	H_0: (1) - (2) = 0	12 or less	13 or more	H_0: (3) - (4) = 0
	(1)	(2)		(3)	(4)	
Husband's health						
Husband's assessment	3.39	3.55	0.058*	3.45	3.59	0.093*
Wife's assessment	3.90	3.87	0.525	3.83	3.95	0.089*

Notes. The assessment is in five grades, ranging from 1 (poor) to 5 (good). In Japan, compulsory education consists of six years of primary schooling and three years of junior-high. Three years of high school education and four years of college education often follow that. *, **, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

Table 3. Husband's annual earnings by wife's labor participation and couple's years of schooling (in million yen).

		Wife: 12 years or less	Wife: 13 years or more	*p*-value for *t*-test with
		(1)	(2)	H_0: (1) - (2) = 0
Working wife				
Husband: 12 years or less	(i)	5.04	5.90	0.000***
		(n=1092)	(n=168)	
Husband: 13 years or more	(ii)	6.48	6.84	0.169
		(n=242)	(n=360)	
p-value for *t*-test with				
H_0: (i) - (ii) = 0		0.000***	0.001***	
Housewife				
Husband: 12 years or less	(iii)	4.55	5.82	0.000***
		(n=850)	(n=116)	
Husband: 13 years or more	(iv)	6.57	8.01	0.000***
		(n=262)	(n=410)	
p-value for *t*-test with				
H_0: (iii) - (iv) = 0		0.000***	0.000***	

Note. The number of total observations is 3500. *, **, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

Table 4. Estimated models of the log of a husband's annual earnings by his wife's labor participation status. (OLS)

	Working wife			Housewife		
	(1)	(2)	(3)	(4)	(5)	(6)
Husband's years of schooling	0.055***	0.036***	0.038***	0.087***	0.070***	0.069***
	(8.36)	(4.88)	(5.33)	(14.14)	(10.01)	(10.01)
Wife's years of schooling	---	0.045***	0.020*	---	0.041***	0.025***
	(---)	(4.38)	(1.91)	(---)	(3.98)	(2.60)
(Wife's schooling)×(Years of marriage)	---	---	0.001***	---	---	0.0007***
	(---)	(---)	(3.70)	(---)	(---)	(2.73)
Husband's age	0.142***	0.141***	0.125***	0.151***	0.148***	0.138***
	(11.82)	(11.88)	(10.10)	(16.90)	(16.38)	(15.37)
Husband's age squared	-0.002***	-0.001***	-0.001***	-0.002***	-0.002***	-0.001***
	(-11.45)	(-11.33)	(-11.20)	(-16.62)	(-15.86)	(-15.46)
Constant	2.403***	2.065***	2.731***	1.900***	1.651***	2.086***
	(9.05)	(7.65)	(9.02)	(9.33)	(7.76)	(10.07)
R-squared	0.223	0.233	0.243	0.412	0.419	0.417

Notes. The number of husbands with working wives is 1862, while the number of husbands with housewives is 1638. Numbers in parentheses are *t*-statistics obtained by robust standard errors. *, **, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively. Although not reported here, large and medium-sized city, and year dummies are also controlled for.

Table 5. Estimated endogenous switching models of husband's earnings (FIML).

	Model A			Model B		
	First stage	Second stage		First stage	Second stage	
	Wife's labor participation	Log of husband's earnings		Wife's labor participation	Log of husband's earnings	
		Working wife	Housewife		Working wife	Housewife
	(A-1)	(A-2)	(A-3)	(B-1)	(B-2)	(B-3)
Husband's years of schooling	-0.054***	0.063***	0.073***	-0.053***	0.065***	0.073***
	(-5.06)	(7.40)	(9.67)	(-5.00)	(7.69)	(9.61)
Wife's years of schooling	0.021	0.026**	0.039***	-0.008	0.015	0.026**
	(1.49)	(2.36)	(3.93)	(-0.54)	(1.22)	(2.35)
(Wife's schooling)×(Years of marriage)	---	---	---	0.001***	0.0004	0.0006***
	(---)	(---)	(---)	(3.49)	(1.46)	(2.61)
Husband's age	0.028	0.053***	0.140***	0.035	0.047***	0.132***
	(1.28)	(4.94)	(15.73)	(1.59)	(4.21)	(14.62)
Husband's age squared	-0.0001	-0.001***	-0.002***	-0.0003	-0.0005***	-0.001***
	(-0.90)	(-4.98)	(-16.87)	(-1.42)	(-5.01)	(-16.80)
Wife's age	0.054**	---	---	0.023	---	---
	(2.48)	(---)	(---)	(1.05)	(---)	(---)
Wife's age squared	-0.0007***	---	---	-0.0005**	---	---
	(-3.04)	(---)	(---)	(-2.18)	(---)	(---)
Number of children under age 6	-0.364***	---	---	-0.348***	---	---
	(-9.46)	(---)	(---)	(-9.17)	(---)	(---)
Living with wife's mother	0.264***	---	---	0.236**	---	---

	(2.59)	(---)	(---)	(2.34)	(---)	(---)
Living with wife's father	-0.164	---	---	-0.166	---	---
	(-1.22)	(---)	(---)	(-1.25)	(---)	(---)
Living with husband's mother	0.092*	---	---	0.080	---	---
	(1.76)	(---)	(---)	(1.55)	(---)	(---)
Living with husband's father	0.020	---	---	0.011	---	---
	(0.30)	(---)	(---)	(0.17)	(---)	(---)
Constant	-1.329***	4.448***	1.736***	-0.403	4.692***	2.106***
	(-3.83)	(15.46)	(8.61)	(-0.95)	(14.00)	(8.79)
Self-selection bias for the working wife (rho_1)	-0.922***	---	---	-0.925***	---	---
	(-76.8)			(-84.09)		
Self-selection bias for the housewife (rho_2)	-0.211*	---	---	-0.183	---	---
	(-1.86)			(-1.57)		
Log likelihood	-5274.9	---	---	-5226.32	---	---
p-value for Wald test	0.000***	---	---	0.000***	---	---

Notes. The number of husbands with working wives is 1862, while the number of husbands with housewives is 1638. Numbers in parentheses are *z*-statistics obtained by robust standard errors. *, **, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively. Although not reported here, large and medium-sized city, and year dummies are also controlled for.

Table 6. Estimated endogenous switching models of husband's earnings (FIML).

	Model C			Model D		
	First stage	Second stage		First stage	Second stage	
	Wife's labor participation	Log of husband's earnings		Wife's labor participation	Log of husband's earnings	
		Working wife	Housewife		Working wife	Housewife
	(C-1)	(C-2)	(C-3)	(D-1)	(D-2)	(D-3)
Husband's years of schooling	-0.057***	0.067***	0.135***	-0.051***	0.067***	0.074***
	(-5.81)	(8.05)	(6.83)	(-4.81)	(7.80)	(9.61)
Wife's years of schooling	0.052***	0.014	0.050*	-0.016	0.017	0.025**
	(3.95)	(1.29)	(1.90)	(-0.98)	(1.31)	(2.31)
(Wife's schooling)×(Years of marriage)	---	---	---	0.001***	0.0003	0.0006**
	(---)	(---)	(---)	(4.25)	(1.14)	(2.48)
Husband's age	-0.021*	0.050***	-0.011	0.049**	0.038***	0.130***
	(-1.86)	(4.94)	(-0.52)	(2.30)	(3.33)	(14.16)
Husband's age squared	-0.0001	-0.0005***	-0.0001	-0.0004**	-0.0004***	-0.001***
	(-0.81)	(-4.42)	(-0.60)	(-2.05)	(-4.04)	(-16.24)
Wife's age	0.177***	---	---	0.044**	---	---
	(22.35)	(---)	(---)	(2.04)	(---)	(---)
Wife's age squared	-0.001***	---	---	-0.0006**	---	---
	(-19.95)	(---)	(---)	(-3.06)	(---)	(---)
Constant	-3.315***	4.542***	3.107***	-1.394***	4.911***	2.106***
	(-11.57)	(15.78)	(5.56)	(-3.43)	(14.44)	(8.74)
Self-selection bias for the working wife	-0.883***	---	---	-0.936***	---	---

(rho_1)	(-51.9)			(-103.07)		
Self-selection bias for the housewife	-0.999	---	---	-0.255*	---	---
(rho_2)	(---)			(-1.94)		
Log likelihood	-6359.3	---	---	-5277.73	---	---
p-value for Wald test	0.000***	---	---	0.000***	---	---

Notes. The number of husbands with working wives is 1862, while the number of husbands with housewives is 1638. Numbers in parentheses are *z*-statistics obtained by robust standard errors. *, **, and *** indicate statistical significance at the 10, 5, and 1 per cent levels, respectively. Although not reported here, large and medium-sized city, and year dummies are also controlled for.