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5 March 2012

The Influence of a Wife's Working Status on Her Husband's Accumulation of Human Capital

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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 non-working wife's schooling has a greater positive effect on her husband's earnings than a working wife's schooling; and (ii) the effect of a non-working wife'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.
(101 words)

1. Introduction

Although human capital accumulation often requires costly investment in 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 also results from interaction with the people in one's environment. In fact, economic outcomes, such as an individual'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 example, a person's earnings are positively associated with their parents' schooling (e.g., Heckman and Hotz 1986; Lam and Shoeni, 1993, 1994; Behrman, *et al.* 1999), and learning from neighbors can help a person increase both productivity and 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. This is 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). This effect is distinct from the assortative mating effect, i.e., educated women tend to be matched in marriage with high-ability men who have high earnings (Welch, 1974; Liu and Zhang, 1999).[2] As evident from the literature on the topic, disentangling the cross-productivity effect from the assortative mating effect has been a major challenge. Using data for twins to control for the unobserved mating effect, Huang *et al.* (2009) found that cross-productivity is significant in explaining the patterns of earnings among Chinese households. Because Huang *et al.*'s study lacked a formal model, their finding is not readily generalizable beyond the Chinese context. More importantly, the conditions that give rise to the cross-productivity effect have yet to be clarified. The current paper attempts to identify more clearly the mechanism underlying the cross-productivity effect by testing a simple model on recent Japanese household data relating to the earnings, human capital characteristics, and working status of the husband and wife.

It is well established that both the quantity and quality of education improve a person's productivity and earnings (Welch, 1966; Johnson and Stafford, 1973; Behrman and Birdsall, 1983; Card and Krueger, 1992). The quantity of education 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. It should therefore be possible to use an analogous framework to analyze the cross-productivity effect of how a wife improves her husband's productivity and earnings. The "quality" may in this case be measured by a wife's schooling; the "quantity" may be measured by the number of years of marriage and by the time the wife spends that is dedicated to improving her husband's knowledge and physical fitness.[3]

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[2] It is widely observed that a wife's human capital positively influences her husband's earnings: for example, 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, 1994).

[3] Using US census data from 1960 to 2000, Jepsen (2005) found that a husband's earnings increase

We found in fact through our analysis of the Japanese household data that the positive effect of a non-working wife's education on her husband's earnings is greater than that of a working wife's.[4] Moreover, the effect of a wife's schooling increases with the number of years of marriage only in the case of a non-working wife, who has more time to devote to improving her husband's human capital than a working wife. We also found evidence that a wife's schooling is positively associated with at least one particular aspect of her husband's human capital—health. In the analysis below, we will use a 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 next section, we will extend the conceptual framework discussed above. Section 3 contains a description of the dataset and some descriptive statistics. Section 4 sets out our estimation strategy; 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 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 remainder $(T-Z)$ to labor supply; each member consumes a private Hicksian composite consumption good in quantity *C*, so that the household utility will be maximized. Berliant and Fujita (2009) emphasized the importance of the contribution of each member in a couple, especially the heterogeneity in the state of knowledge that each member brings into the relationship, 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 1, while member *M*'s market wage rate, $w_M \equiv w(Z_F; s_M, \theta_M, s_F, \theta_F)$, 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,

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with his wife's education. However, the magnitude of the effect declines over cohorts, and Jepsen conjectured that the rapid increase in a wife's labor supply reduced her time to improve her husband's productivity.

[4] Using the same dataset, Mano and Yamamura (2011) investigated the relationship 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.

and the market wage function takes the 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]

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

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

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

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

2.2 Analytical results

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

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

We can also examine the association of one member'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. This result is summarized as

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

Thus, 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, we may still observe a positive correlation between a wife's educational level and her husband's wage rate. For the sake

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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

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

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

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

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 both high ability and high educational level, 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.

Result 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.,* $\mathrm{cov}(\ln s_F, \ln \theta_M)\big|_{S_M} > 0$. *We observe a positive correlation between a wife's schooling and 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 because of the cross-productivity effect or because of 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 observe this, take a derivative of the cross-productivity effect $(\partial w_M^* / \partial s_F)$ with respect to the length of marriage *T*, and we obtain $(\partial^2 w_M^* / \partial s_F \partial T) = \phi s_M \theta_M \theta_F / 2 > 0$ in the interior solution and $(\partial^2 w_M^* / \partial s_F \partial T) = \phi s_M \theta_M \theta_F > 0$ in the corner solution. By contrast, suppose that there is no cross-productivity effect ($\phi = 0$) but assortative mating, i.e., $\mathrm{cov}(\ln s_F, \ln \theta_M)\big|_{S_M} > 0$. Since 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.

Result 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 Result 4, we 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 regard to member *M*'s schooling and with regard to member *F*'s schooling, respectively, between the interior solution and the corner solution.

Result 5 (Working wife and non-working wife). *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.

Result 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 non-working wife 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 compare, in particular, the effect between a non-working wife 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).

2.3.1 Wife's labor-supply equation

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

$$y_{1i}^{*} = x_i'\alpha_1 + z_i'\beta + u_1 \text{ , for } i = 1, \ldots, n, \qquad \text{(I)}$$

where it is assumed that only the sign y_{1i}^{*} is observed; it is positive if and only if married woman i participates in the labor market; n denotes the number of observations, and u_{1i} is the error term. The first vector of explanatory variables, x_i, consists of years of schooling, one member's and the spouse's ages and their squared terms, size dummies for the city of residence, and year dummies. We suppose that an educated wife, expecting a higher market wage, is more likely to participate in the labor market, whereas an educated husband receives higher earnings, allowing his wife to stay at home, which can be considered 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 child care, and four dummy variables, each indicating co-residence with own or spousal fathers and mothers, respectively. Child care is time-consuming and takes up much of the mother's time, especially when the children are young. In consequence, we would 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 would also expect to observe positive effects of co-residence with the mother or 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 father-in-law. Existing studies consider only the overall effects of co-residence with one's parents and in-laws (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 child care, thereby accumulating the human

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

capital specifically useful for these tasks. Therefore, own or spousal mothers are more able to assist 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 their 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 a system of equations that drops these variables as a robustness check. It should be noted that even without the exclusion restrictions, we can still rely on the nonlinearity of the probit model as an identification strategy.

2.3.2 Earnings equation

The husband's earnings equation can be expressed separately for husbands with a working wife ($d = w$) and for husbands with a non-working wife ($d = h$) as follows:

$$y^*_{2di} = x'_{di}\alpha_{2d} + u_{2di}, \text{ for } i = 1, \ldots, n, \qquad \text{(II)}$$

where y_{2di}^* is the logarithm of husband's earnings, u_{2i} is the error term, and the vector of explanatory variables x is the same as in the labor-force participation model expressed by equation (I). In addition to analyzing the effect of a husband's education on his labor earnings (Result 1), our main focus here is to examine the effect of his wife's years of schooling on his earnings (Result 2). We will thus examine Hypothesis 1, which states that a husband's earnings are positively associated with his wife's education.

As discussed in subsection 2.2, a husband's wage rate can be positively associated with his wife's schooling either because of the cross-productivity effect or 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 by 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 non-working wife sample to examine 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 non-working wife than those with a working wife.

If the error term of regression equation (I), u_1, is correlated with the error term of regression equation (II), u_2, the standard estimation method applied to regression equation (II) yields biased results. For example, a wife whose husband makes higher

[8] Sasaki (2002) addresses the endogeneity of a family structure in which a married woman may choose to co-reside with parents or in-laws in an attempt to reduce her housework and consequently be able to 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 the family structure is addressed by the instrumental variable method.

earnings may be unlikely to choose to work, and this sample selection could result in biased estimates of regression parameters. We can alleviate this problem by using variables that affect whether a wife works or not but do not affect the level of her husband's earnings. Based on the previous argument, we will use as identifying variables for this purpose the number of children aged under six years and whether the married couple lives with their parents. To examine the importance of controlling for a married woman's self-selection into the labor force, we will first simply estimate the earnings equation (II) for the husband with a working wife and for the husband with a non-working wife, respectively, using the orthogonal least-squares (OLS) algorithm. We will next attempt to address the possible endogeneity in a wife's labor-force participation and to mitigate an associated bias by means of the switching regression model (Amemiya, 1985; pp. 401-402). To do this, we assume that $(u_{1i}, u_{2wi,} u_{2hi})$ are iid drawings from a trivariate normal distribution. The associated likelihood function of the model can be expressed as

$$L = \prod_{d=h} \int_{-\infty}^{0} f_h(y_{1i}^*, y_{2hi}) dy_{1i}^* \prod_{d=w} \int_{0}^{\infty} f_w(y_{1i}^*, y_{2wi})\, dy_{1i}^*,$$

where $f_h(\cdot,\cdot)$ is the joint density of y_{1i}^* and y_{2hi} and $f_w(\cdot,\cdot)$ is the joint density of y_{1i}^* and y_{2wi}. With the help of our identifying variables, we will be able to explicitly control for the correlation between u_1 and u_2 , and mitigate the selection bias.

The next section will describe the dataset in detail. 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 (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 or 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 according to the labor supply of the wife. The number of observations—that is, the size of the sample of married couples—was 3500. The average husband with a working wife earned over 5.6 million yen (or around US$56,000), while the average husband with a non-working wife earned 5.8 million yen (or $58,000); the difference is not statistically significant. We can observe the annual earnings for working wives only: their average earnings were 2 million yen (or $20,000).[10] The average working wife

[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, The University of Tokyo.

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

and non-working wife were remarkably similar in terms of their human capital characteristics: they were around 46 years old and, more importantly, had 12.3 years of schooling. In Japan, compulsory education consists of six years of elementary school, three years of junior high school, three years of high school, and four years of college education. As noted above, though an educated wife is more likely to participate in the labor market, her husband tends to receive relatively higher earnings owing to the cross-productivity effect and/or the assortative mating effect, thus allowing her to stay at home. On average, these two forces appear to offset each other. With regard to a husband's human capital characteristics, we find that a non-working wife'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 non-working wife'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 above discussion. A non-working wife tends to have more children under age six than a working wife. Furthermore, a working wife tends to reside more often with her own mother and her husband's parents than a non-working wife. Moreover, a married couple tends to live with the husband's parents more often than with the wife's parents, which reflects the traditional family structure in Japan. Overall, these observations are consistent with the results of Ogawa and Ermisch (1996), who used a survey conducted by Mainichi Newspapers in June 1990, and of Sasaki (2002), who used another Japanese microlevel 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 serves as an indication of the representativeness of our dataset and of the following analysis of the husband's earnings in Japan.

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

Table 2 presents the assessment on a husband's health status according to his wife's labor supply and schooling. The education levels are divided into two groups: 12 years or less of schooling; 13 years or more.[11] In three of the four cases, the husband's health condition was significantly higher among the couples with more educated wives, though the difference is not statistically significant in the fourth case. Notably, in the non-working wife sample, a husband's health condition was 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 achieve higher earnings (Pitt, Rosenzweig, and Hassan, 1990; Thomas and Strauss, 1997; Strauss and Thomas, 1998); it may be reasonable to assume that a wife attempts to improve her husband's health condition, being motivated by this

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

consideration of work achievement in addition to many others. In particular, an educated non-working wife may have sufficient time to implement her better knowledge about a balanced diet and healthy lifestyle, thereby improving her husband's fitness.

We observe that a husband's earnings tend to be positively associated 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 non-working wife sample. Column 1 in Table 3 presents the labor earnings of a husband married to a wife with 12 years or less of schooling; 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; rows ii and iv present the labor earnings of a husband with 13 years or more of schooling. In the working wife sample with a husband having 12 years or less of schooling (row i in Table 3), his annual earnings were 5.04 million yen when his wife had 12 years or less of education, though he annually earned 5.90 million yen when his wife had 13 years or more of schooling. The corresponding difference is not statistically significant for the working wife sample with a husband having 13 years or more of schooling (row ii) between columns 1 and 2. In the non-working wife sample (lower panel of Table 3), a husband's earnings were significantly higher when his wife had 13 years or more of schooling (column 2) than when she had 12 years or less of schooling (column 1)—irrespective of the husband's educational level. This appears to suggest that a non-working wife's education has a greater positive effect on her husband's earnings than a working wife's education, which is congruent with our Hypothesis 3.

4. Estimation results

To examine the importance of controlling for a married-woman's self-selection into the labor force, we simply estimate the earnings equation (II) using the OLS algorithm. Columns 1, 2, and 3 of Table 4 present a husband's earnings equations for the working wife sample, columns 4, 5, and 6 for the non-working wife 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 in the working wife sample (column 1), whereas in the non-working wife 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.[12]

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), though it is 4.1 percentage points in the non-working wife sample (Column 4). These results are consistent with

[12] There could be alternative explanations. Husbands with non-working wives may have greater incentive to work longer hours or put in more effort than those with working wives. This effect may show up as a higher earnings return to husband's schooling. Huang *et al.* (2009) suggest another possibility, whereby a more educated person may induce the spouse to exert greater effort in working, particularly in the Chinese context; however, their empirical result does not actually support this possibility. We owe these points to the referee.

Hypothesis 1. When a wife's schooling is controlled for, the estimated effect of the 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; however, the effect declines from 8.7 percentage points in column 4 to 7.0 percentage points in column 5 in the non-working wife sample owing 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. Note that the magnitude of the estimated coefficients suggests that an additional year of a wife's education is associated with a 2% increase in her husband's earnings when the years of marriage is 0, though it is associated with a 4.4% increase in her husband's earnings when the duration of marriage is at the sample mean of 22 years. The estimated coefficients also imply that the effect of a husband's own schooling is greater in the non-working wife sample (columns 4, 5, and 6) than in 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 supply described by the system of equations (I) and (II). The husband's earnings equation in model A includes the wife's schooling as well as the 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 six, and 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-supply equation (I) suggests that a husband's education significantly decreases his wife's labor supply (columns A-1 and B-1), whereas 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 result of previous 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, though co-residence with the wife's mother increases it even more significantly. By contrast, co-residence with the wife's father or her father-in-law does not have any significant effect on her labor-supply decision, which is consistent with the results of previous studies on Japanese families (Juster and Stafford, 1991; Kamo, 1994; Hakim, 1996; Strober and Chan, 1998).

At the bottom of Table 5, it is indicated that $\rho_w = \mathrm{corr}(u_1, u_{2w})$—the correlation coefficient between the error terms in a wife's labor-supply equation and in her husband's earnings equation in the working wife sample—is significantly negative; however, the corresponding correlation coefficient in the non-working wife sample, $\rho_h = \mathrm{corr}(u_1, u_{2h})$, is also significantly negative. These results imply that a wife's labor-supply decision is endogenous, and this justifies our estimation strategy in using the switching model.

In the husband's earnings equation (columns A-2, A-3, B-2, and B-3), the husband's own schooling has a significantly positive effect on his earnings, and the estimated effect tends to be greater in the non-working wife sample (columns A-3 and B-3) than in the working wife sample (columns A-2 and B-2). Even when we drop the number of children under age six and the co-residence variables from the equation system as a robustness check, the estimation result is qualitatively similar (Table 6).[13] The difference in the effect of a husband's schooling seems to reflect the fact that a non-working wife can spend more time helping her husband maintain his health than a working wife, such that he is able to deliver his best performance at work. This result is consistent with Hypothesis 3.

The effect of the 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 non-working wife 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 non-working wife sample (columns C-3 and D-3), whereas it is insignificant in the working wife sample (columns C-2 and D-2). One reasonable interpretation of this result is that as a non-working wife can usually spend more time helping her husband improve his human capital, perhaps by preparing a balanced diet and supporting a healthy lifestyle, than a working wife, the schooling level of the non-working wife has a greater effect on her husband's earnings. These results lend 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 non-working wife sample (column B-3). Thus, the effect of a non-working wife's schooling on her husband's earnings increases with the years of marriage, which is consistent with Hypothesis 2.[14] 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. Moreover, the coefficient of the interaction term is significantly different across columns B-2 and B-3 at the 1% level, though to save space the test statistic is not reported in the table. We also obtain the same results in Table 6. In all likelihood, a

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[13] Strictly speaking, a comparison between columns A-3 and C-3 shows that the magnitude of the husband's schooling coefficient is greater when the identifying variables are dropped and identification relies on the functional form. Theoretically, the functional-form identification is weaker than the exclusion-restriction identification, and we suspect that the inflated coefficient is due to the remaining selection bias that arises from the correlation between the wife's choice not to work and her husband's earnings.

[14] We should carefully interpret the empirical result here. Since in our sample, the married couples were married for a relatively long time (21–22 years on average), this potentially excluded couples that were poorly matched and eventually divorced. We might observe a higher correlation between the wife's education and the husband's earnings for successfully matched married couples owing to this sample selection mechanism. We owe this important point to the referee.

working wife has less time to help her husband improve his human capital than a non-working wife, and thus the "cumulative" cross-productivity effect is also significantly weaker in the working wife than in the non-working wife sample.[15]

5. Conclusions

The literature provides substantial evidence on human capital accumulation through social interactions. However, primarily because of the lack of data, the underlying mechanism has not been sufficiently understood even for one of the smallest social units, a married couple. Thus, the present paper attempted to reveal the nature of human capital accumulation through the 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 the following: (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 non-working wife sample than in the working wife sample. We used a switching regression model to address the endogeneity in a wife's labor-supply decision, and we obtained supportive evidence for the above predictions.

Specifically, the regression results suggest that a well-educated wife is likely to improve her husband's human capital more effectively than a poorly educated wife. Consistent with this, the descriptive analysis finds that the human capital of a husband's health 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. Thus, it is reasonable to expect that this positive effect of a wife's schooling increases with the amount of time that she spends improving her husband's human capital. In fact, an educated non-working wife increases her husband's earnings more substantially than a similarly educated working wife. Furthermore, the magnitude of the positive effect of a non-working wife'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 discussions 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 comprehensive 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

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

social interactions with ideal data sets, such as the twins data used in Huang *et al*. (2009), allowing clearer identification. These are challenges that remain to be addressed in a future study.

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

	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**
Coresidenc e 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 Supply 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 supply 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 supply 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 supply	Log of husband's earnings		Wife's labor supply	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 ($\rho_w = \mathrm{corr}(u_1, u_{2w})$)	-0.922***	---	---	-0.925***	---	---
	(-76.8)			(-84.09)		

Self-selection bias for the housewife ($\rho_h = \mathrm{corr}(u_1, u_{2h})$)	-0.211* (-1.86)	---	---	-0.183 (-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 supply	Log of husband's earnings		Wife's labor supply	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 ($\rho_w = \mathrm{corr}(u_1, u_{2w})$)	-0.883***	---	---	-0.936***	---	---
	(-51.9)			(-103.07)		
Self-selection bias for the housewife ($\rho_h = \mathrm{corr}(u_1, u_{2h})$)	-0.999	---	---	-0.255*	---	---
	(---)			(-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.