Declining association with persistent gender asymmetric structure: patterns and trends in educational assortative marriage in Japan, 1950–1979

Sho Fujihara\textsuperscript{a,}\textsuperscript{*}, Fumiya Uchikoshi\textsuperscript{b}

\textsuperscript{a}Institute of Social Science, The University of Tokyo, Japan

\textsuperscript{b}Department of Sociology and Center for Demography and Ecology, University of Wisconsin-Madison, USA

Abstract

This paper investigates the patterns and trends of educational assortative marriage in Japan. Using data from the Employment Status Survey and the Comprehensive Survey of Living Conditions of the People on Health and Welfare, we investigated the trends of association between husbands’ and wives’ educational attainment (481,144 couples) by applying log-linear, log-multiplicative layer effects, and regression-type models. The analysis revealed that, in general, educational assortative marriage has decreased continuously. In terms of the log-odds ratios, the association of educational attainment between spouses for women born between 1975 and 1979 decreased by about 25%, in comparison with that of women born between 1950 and 1954. The regression-type models showed that the pattern of association was asymmetric while patterns of change were symmetric with respect to sex. We discuss what caused the decline in educational assortative marriage with a persistent gender asymmetric structure.

Keywords

Educational assortative marriage; Homogamy; Intermarriage; Log-multiplicative layer effect models; Regression-type models; Japan

1. Introduction

Educational assortative marriage refers to the similarity in educational attainment within married couples and indicates closure in social structure and social life (Blossfeld, 2009; Mare, 1991).\textsuperscript{1} Moreover, educational assortative marriage can impact earning inequality and reproduce social inequality in the next generation (Breen & Andersen, 2012; Breen & Salazar, 2010; Esping-Andersen, 2007; Torche, 2010). In addition, it is associated with differentials in family behavior, such as fertility (Mare & Schwartz, 2006), divorce (Tzeng, 2013).\textsuperscript{1}

\textsuperscript{*}Corresponding author at: Institute of Social Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033 Japan. sho.fujihara@iss.u-tokyo.ac.jp (S. Fujihara).

\textsuperscript{1}For reviews of assortative marriage in a broader sense, see Kalmijn (1998) and Schwartz (2013).
Reflecting the abovementioned reasons, this topic attracts many sociologists and demographers. In fact, many studies have investigated the patterns and levels of educational assortative marriage across countries (Halpin & Chan, 2003; Hou & Myles, 2008; Smits & Park, 2009; Smits, Ultee, & Lammers, 1998; Torche, 2010; Ultee & Luijkx, 1990) as well as trends within them (Birkeland & Heldal, 2003; Mare, 1991; Park & Smits, 2005; Raymo & Xie, 2000; Schwartz & Mare, 2005; Wang & Wong, 2017; Wong, 2003). Since these studies show mixed empirical evidence on changes in educational assortative marriage in different countries (Blossfeld, 2009), as we review below, multiple hypotheses have been proposed to explain cross-cultural differences in trends in educational assortative marriage.

Previous research also found ambiguous results regarding the trends of educational assortative marriage in Japan. While some scholars argue that educational homogamy has remained stable (Shida, Seiyama, & Watanabe, 2000; Shirahase, 1999; Yoshida, 2011), other studies reveal a decreasing trend in assortative marriage (Fukuda, Yoda, & Mogi, 2017; Miwa, 2007a; Raymo & Xie, 2000). These mixed results make it difficult to use the Japanese case as evidence for a comparative investigation.

An examination of the Japanese case enables us to understand not only trends in educational assortative marriage per se, but also much broader contexts thought to affect the consequences of educational assortative marriage (and its associated changes) differently. Prior studies on the relationship between educational assortative marriage and family inequality or future intergenerational inequality mostly explored Western contexts. However, since basic patterns of assortative marriage may vary between Western and East Asian societies, these findings, derived from the former contexts, might not be applicable to the latter. Therefore, it is worth asking whether a couple’s educational pairing matters for these outcomes in East Asian countries. In Japan, as well as in most other East Asian societies, the relationship between women’s earning potential and education is rather “loose” because of the relatively persistent gender division of labor, both in the public and private spheres (Brinton & Lee, 2001: 134). Thus, the structure of women’s educational hypergamy has been consistent over the decades. This suggests that educational assortative marriage might not be related to household income inequality. However, a couple’s educational resemblance – especially in the case of highly educated homogamous couples – might affect educational inequality in the next generation, as mothers are strongly expected to play the role of “the best teachers” for their children at home (Brinton, 1993; Hirao, 2001), and both parents’ educations contribute to financial investment in their children’s private schooling, as well as attitudes toward child-rearing (Shirahase, 2010).

Based on those reasons, in this paper, we aim to clarify patterns and trends in educational assortative marriage in Japan by using largesample data, which provide information on the educational attainment of more than 480,000 married couples.
2. Theories on trends in educational assortative marriage

There are several hypotheses predicting trends in educational assortative marriage (Blossfeld, 2009; Schwartz & Mare, 2005; Smits et al., 1998). Smits et al. (1998) offer three hypotheses pertaining to the relationship between the levels of economic development and the degree of educational homogamy. One is called the “romantic love” or “general openness” hypothesis, which insists that modern society has become individualized and open, thus diminishing social boundaries. Hence, as modernization (or industrialization) progresses, educational attainment becomes less important as a criterion for selecting partners. Therefore, the level of educational homogamy will decrease.

Modernization may, however, lead to the opposite outcome. Modernization brings about a change from ascriptive to universalistic achievement criteria, which replace social origins with educational attainment as the main factor predicting one’s future socio-economic status. Therefore, individuals who attempt to achieve the highest possible socio-economic status tend to take educational level into account when selecting their partners (Smits et al., 1998). This “status attainment hypothesis” predicts that the level of educational homogamy will increase as modernization proceeds.

Smits et al. (1998) proposed a hypothesis combining the above two consequences of modernization. In the early phase of modernization, the shift from ascription to achievement occurs, which increases educational homogamy. At later stages, socio-economic status becomes less important when selecting partners, and romantic love becomes a more prominent basis for marriage, which decreases educational homogamy. This hypothesis predicts an inverted U-shape relationship between educational homogamy and level of economic development. An analysis by Smits et al. (1998), which used the proportion of employment outside agriculture and energy consumption per capita as indicators of economic development, supported this hypothesis.

However, they tested the inverted U-shape hypothesis using a crosssectional comparative study instead of focusing on temporal changes within a given country (Raymo & Xie, 2000). Thus far, no study has found an inverted U-shape in a single society (Birkelund & Heldal, 2003; Halpin & Chan, 2003; Hou & Myles, 2008; Miwa, 2007b; Raymo & Xie, 2000; Schwartz & Mare, 2005; Wong, 2003). For example, Schwartz and Mare (2005) analyzed trends in educational assortative marriage in the U.S. and revealed that educational homogamy fell during the period 1940–1960, but rose from 1960 to 2003. The result depicts a U-shape relationship. Wong (2003) also found an elongated U-shape relationship in Taiwan, where there was a rapid decline in the association between spouses’ educational attainment from the mid1970s to the late 1980s. Subsequently, the association stabilized and started to increase gradually after 1997.

Schwartz and Mare (2005) offer three explanations for the increased association between husbands’ and wives’ educational attainment, focusing on educational expansion and its relationship to the labor market, women’s labor force participation, and timing of marriage (instead of on modernization and industrialization). First, the time gap between school completion and marriage may lead to changes in educational assortative marriage (Halpin &
Chang, 2003; Hou & Myles, 2008). Mare (1991) hypothesized that the odds of crossing an educational barrier are positively associated with the time gap. At any given average age at marriage, the increase in average educational attainment narrows the time gap and shortens the period for seeking a potential partner; therefore, individuals are more likely to meet their partners in school. In contrast, an increase in the average age at marriage extends the gap, and this prolonged period for seeking potential partners gives individuals opportunities to meet their partners outside school, such as at the workplace or in other educationally heterogeneous settings, leading to heterogamous marriage (Kalmijn, 1998).

Second, men’s and women’s preferences for partners have become more symmetric than before because of women’s increased access to the labor market, which results in a positive relationship between education and earning potential (Oppenheimer, 1988). Thus, men are more likely to seek well-educated and high-earning women. Hence, in the competition for partners, greater symmetry between men and women increases educational homogamy (Schwartz & Mare, 2005).

Third, growing socio-economic disparities in educational attainment may lead to higher levels of educational homogamy (Schwartz & Mare, 2005). Widening social distances between educational groups makes it difficult to cross academic barriers, thus decreasing intermarriage and increasing educational homogamy (Monaghan, 2015; Torche, 2010).

3. The Japanese case

3.1. Trends in educational assortative marriage in Japan

What trends do the hypotheses proposed by Smits and associates and Schwartz and Mare predict for Japan? Using the proportion of employment outside agriculture as an indicator of economic development 15 years before the survey year (ranging from 1970 in Israel and Taiwan to Rwanda in 1983), Smits et al. (1998) showed that the level of educational assortative marriage reached a maximum when about 30% of the population worked outside agriculture 15 years before the survey was conducted. In Japan, the percentage of the labor force not in agriculture was already 51.4% in 1950 – when the oldest women in the data for this paper were born – and increased continuously thereafter (Statistical Bureau, 2010). This suggests that in the 1950s, Japan became economically developed and entered the later phase of modernization based on the criteria of Smits et al. (1998). Moreover, Japan witnessed rapid economic growth from 1950 to 1970, followed by stable economic development until the early 1990s, when it experienced low economic expansion. Thus, socio-economic status became increasingly less important, and romantic love became more valued with respect to marriage. From this argument, we expect that educational homogamy has decreased from the oldest cohorts (1950–1954) to the youngest cohorts (1975–1979).

As for Schwartz and Mare’s hypothesis on symmetric preferences between men and women (based on women’s increased access to higher education and the labor market), these shifts in preference might not be readily apparent in Japanese society, since Japan is known as a society where many women are willing to marry up (female hypergamy) while men desire to marry less educated women (Raymo & Iwasawa, 2005); this trend results from strong patriarchal norms (Therborn, 2004). This asymmetric pattern of assortative marriage by
gender is also found in other East Asian nations (Park & Smits, 2005; Wong, 2003). The National Institute of Population and Social Security Research (2016) reported on factors that single individuals in Japan take into consideration for prospective partners, covering the period 1992–2015. Single men tend to consider what their partner is like (93–95%) and appearance (74–84%), and were less likely to take economic status (27–42%), occupation (36–47%), or education (21–31%) into account. On the contrary, women tend to not only consider what their partner is like (97–98%) and appearance (67–78%), but also economic status (89–94%), occupation (78–86%), and education (44–57%). Although Fukuda et al. (2017) argue that single men are more likely to rely on their spouse’s economic potential than before, the asymmetric preference between men and women has remained nearly stable over the past 23 years (National Institute of Population & Social Security Research, 2016). Thus, Schwartz and Mare’s second hypothesis (pertaining to symmetric men’s and women’s preferences) predicts that educational assortative marriage has seen little change in Japan, at least in the last two decades. Although there are no available data before that time to capture the asymmetric pattern of preferences for spouses, we assume that the structure has been persistent throughout the century, as many scholars have claimed that it is rational for women to achieve upward mobility through marriage, since women’s access to higher education and professional occupations has generally been very limited (Brinton, 1993; Raymo & Iwasawa, 2005).

Stratification studies of Japan have not documented dramatic increases in socio-economic disparities via education, as seen in the U.S., where the differentials in occupational and economic success by education have increased (Schwartz & Mare, 2005); on the contrary, the structure and strength of the associations have experienced very little change over time in Japan (Ishida, 1999). Therefore, Schwartz and Mare’s third hypothesis (on increasing disparities via education) predicts that the level of educational homogamy has not changed in Japan.

However, substantial shifts have occurred in Japan regarding average educational attainment and the average age at marriage. Fig. 1 describes trends in the average age at first marriage. Although the average age at first marriage stabilized and decreased slightly from the early 1960s to the mid-1970s, it rose from the early 1950s to the early 1960s, and from the mid-1970s to the 2010s for both men and women. For the most part, the average age at first marriage for each educational category has also risen over time (Equal Employment, Children & Families Bureau, Health, Labour & Welfare Ministry, 2008; Equal Employment, Children & Families Bureau, Health, Labour & Welfare Ministry, 1999). Thus, Schwartz and Mare’s first hypothesis predicts a continuous decline in educational assortative marriage in Japan.

Although the above hypotheses suggest a continuous decrease in educational assortative marriage in Japan, empirical studies on Japanese society provide mixed findings. Using data from the Social Stratification and Social Mobility Survey (hereinafter referred to as “the SSM”) in 1995, Shida et al. (2000) indicated that the rate of educational homogamy – which

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2 However, it seems that men’s preference toward women’s occupational prospects and economic status has changed slightly. We interpret this trend in the conclusion.
means the proportion of couples in which the spouses share the same level of education – has remained constant between the cohort married before 1955 and the cohort married during the period 1986–1995. Using the data from the 2005 SSM, Yoshida (2011) also showed that the structure of educational homogamy was rather stable, its strength remained unchanged from the 1931–1940 and 1971–1980 (wives’) birth cohorts. Using the data from the SSM in 1985, 1995, and 2005, Shirahase (2011) found that the association between husbands’ and wives’ education weakened as marriage cohorts became younger (the cohorts married before 1969, married during the period 1970–1985, and married after 1986), but this change was not statistically significant.

In contrast, Raymo and Xie (2000) used data from the 10th National Fertility Survey, conducted in 1992, to demonstrate that the association between husbands’ and wives’ education decreased between the 1970–1974 and 1988–1992 marriage cohorts through the log-multiplicative layer effects model (Erikson & Goldthorpe, 1992; Xie, 1992). Miwa (2007a) also found that the level of educational homogamy was stable between the 1950–1959 and 1970–1979 marriage cohorts, and then declined over cohorts, when the log-multiplicative layer effects model was applied to the pooled data, which consisted of data from the SSM in 1995, the Japanese General Social Survey from 2000 to 2002, and the National Family Research of Japan surveys in 1998 and 2003. The latest study by Fukuda et al. (2017), using log-linear models to analyze microdata from the Population Census, revealed a constant decline in educational homogamy in Japan from 1980 to 2010.

The differences among existing literature on homogamy/hypergamy mainly stem from two reasons. First is the differences in their sample sizes (Miwa, 2007a). Although previous studies have mostly used loglinear models, sample sizes vary by study. For example, Shirahase (1999) and Yoshida (2011) failed to reveal any statistically significant trends using relatively small sample sizes (shown in Appendix A). In contrast, Miwa (2007a) and Fukuda et al. (2017) showed a decline in educational homogamy, using large sample sizes (16,136 and 25,949,319, respectively).

The second source of the disagreement is the use of different types of categorization. Shirahase (1999) and Yoshida (2011) demonstrated stable educational homogamy and employed the 3-category version of educational attainment, while Fukuda et al. (2017); Raymo and Xie (2000), and Miwa (2007a) used the 4-category version. According to Wong (2003) and Hou and Myles (2008), trends in assortative marriage differ by level of categorization.

### 3.2 Patterns of educational assortative marriage in Japan

Compared with the general tendency of educational assortative marriage, few studies have addressed its patterns and diverging trends. The most basic pattern of educational assortative marriage is educational homogamy, in which couples have the same levels of education in a narrow sense.\(^3\) In the literature on educational assortative marriage in Western nations, for example, Schwartz and Mare (2005) maintain that recent increase in educational homogamy has occurred at both ends of the educational spectrum. On the other hand, Smits

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\(^3\)In a broad sense, educational homogamy denotes that couples have similar levels of education.
and Park (2009), who examined the trend in educational assortative marriage in 10 East Asian countries over five decades, assert that homogamy has fallen during the process of modernization, while educational homogamy among the less educated has remained stable.

In Japan, using log-linear models, Shirahase (2005) showed that educational homogamy rose in the highest educational category and fell in the middle and lowest educational groups. These findings suggest that divergent trends in educational homogamy could be observed depending on each educational category.

Therefore, we focus not only on the general trend of educational assortative marriage, but also on the patterns of (and changes in the patterns) of educational assortative marriage. Studies on educational assortative marriage in Japan have mainly explored trends instead of patterns and their associated changes. This lack of concern over the patterns of educational assortative marriage is partly due to two technical problems. One is the absence of large sample data, which makes it difficult to apply finer detailed educational categories. The other is the application of statistical methods to investigate not only trends, but also patterns, of educational assortative marriage. In this paper, we investigate the patterns of educational assortative marriage and their changes as well as the trend itself, applying multiple log-linear and log-multiplicative models to large sample data, which allows us to use sharper, more nuanced classifications of educational levels.

4. Method

4.1. Data

We used the data from the Employment Status Survey (ESS) and the Comprehensive Survey of Living Conditions of the People on Health and Welfare (CSLC). The ESS, one of the surveys for Fundamental Statistics stipulated by the Statistics Act in Japan, was conducted every three years from 1956 to 1982, and has been carried out every five years since 1982 (Statistics Bureau, 2017). From 1956 to 2002, the ESS used a four-category version of educational attainment of household members in their surveys: (1) junior high, (2) high school, (3) junior college and college of technology, and (4) university and graduate school. In 2007, the ESS started to use a six-category version of educational attainment, including professional training college and distinguishing between university and graduate school. Therefore, we used the data from the ESS in 2007 and 2012. The ESS in 2012 used the two-stage stratified sampling technique, which randomly selected about 32,000 geographical areas in Japan and then identified about 47,000 households from within chosen areas to participate. The respondents were all household members aged 15 years and over. The ESS in 2007 adopted almost the same method.

We also used data from the CSLC conducted in 2010 and 2013. The CSLC is also one of the surveys for Fundamental Statistics. The Ministry of Health, Labour and Welfare (MHLW) began the CSLC in 1986 and conducted it every three years thereafter. The CSLC began to inquire about the educational attainment of household members in 2010, randomly selecting about 290,000 households in Japan and interviewing about 229,000 of them. In 2013, the CSLC was conducted in the same manner. The CSLC in 2010 and 2013 collected
information about the six-category version of educational attainment of household members, in addition to aspects such as occupation, health condition, and health insurance options.

We used information about age and educational attainment of married couples (the head of the household and his/her spouse, parents of the head and his/her spouse, and a child of the head and the child’s spouse). When the head had two or more married children (or two or more married grandchildren), we could not identify their spouses (570 cases). Accordingly, we eliminated such unidentified cases from the analysis. Considering differential marital timing and differential mortality by education, we restricted couples to those in which the wife’s age was between 28 and 62 during the survey. After omitting cases with missing educational information (4.7%), 481,144 couples remained.

There are several possible biases in investigating the trends of assortative marriage from cross-sectional data. Birkeland and Heldal (2003) pointed out that divorce, remarriage, mortality, and cohabitation may cause bias. For example, studies show that the likelihood of getting divorced varies on the basis of the partner’s education or other socioeconomic traits. In particular, heterogamous couples are more likely to experience divorce among both married (Tzeng, 1992) and cohabiting couples (Mäenpää & Jalovaara, 2014). Use of cross-sectional data includes both younger and older cohorts; thus, homogamous couples could be more overestimated among the latter cohorts (Kalmijn, 1991: 500).

4.2. Variables

The ESSs in 2007 and 2012, and the CSLC in 2010 and 2013, allow for finer distinctions of educational classifications. We used six categories of the wife’s and husband’s educational attainment: 1 = junior high school (chugakko, Level 2 of the International Standardized Classification of Education [ISCED], United Nations Educational, Scientific and Cultural Organization UNESCO Institute for Statistics, 2012), 2 = high school (koutou gakko, Level 3 of the ISCED), 3 = professional training college (senmon gakko, Level 5 of the ISCED), 4 = junior college or college of technology (tanki daigaku or koutou senmon gakko, Level 5 of the ISCED, hereafter junior college), 5 = university (daigaku, Level 6 of the ISCED), and 6 = graduate school (daigakuin, Level 7 or 8 of the ISCED). Professional training colleges offer vocational training programs and were incorporated into Japan’s higher education system in 1975 (Ishida, 2007). We focused on prevailing marriages rather than newlywed couples because the data contain no information on age and date at the time of marriage to identify newlywed couples. In addition, because the ESS did not ask about the 6-category version of family members’ educational levels until 2007, and the CSLC did not ask about educational attainment until 2010, it is impossible to describe trends in educational assortative marriage from a period perspective. Therefore, we investigated trends in educational assortative marriage by comparing wives’ birth cohorts. We established six cohorts based on the wife’s year of birth: 1 = 1950–1954, 2 = 1955–1959, 3 = 1960–1964, 4 = 1965–1969, 5 = 1970–1974, and 6 = 1975–1979.

According to the National Fertility Surveys, the cross-sectional proportion of non-married cohabiting couples has been marginal and stable. Among couples in which women are under age 50, the proportion of non-married cohabiting population was 0.9% in 1987 and 0.4% in 2015 (National Institute of Population & Social Security Research, 2016). Considering this trend, we expect that an increase in cohabitation would not lead to serious bias in this analysis.
4.3. Statistical models

Our main concern focuses on the relative rates of educational homogamy captured by odds ratios, rather than the absolute ones, because the relative rates capture the association between couples’ educational attainment, after controlling for the effect of changes in educational distribution. Therefore, we applied log linear and logmultiplicative models to the three-way tables of the husband’s educational attainment $H(i = 1, \ldots, 6)$, the wife’s educational attainment, $W(j = 1, \ldots, 6)$, and based on the wife’s birth cohort, $C(k = 1, \ldots, 6)$.

We established several models to reveal both the patterns and strength of educational homogamy. First, we show the five log-linear models to examine the basic patterns of educational assortative marriage. These models center on the association between the husband’s and wife’s education (the HW association) after controlling for marginal distributions. Model 1 is the conditional independence model, assuming that there is no HW association. Model 1 can be written as follows:

$$\ln F_{ijk} = \lambda + \lambda_i^H + \lambda_j^W + \lambda_k^C + \lambda_{ik}^{HC} + \lambda_{jk}^{WC}$$

where $F_{ijk}$ is the expected frequency of the $(i, j, k)$ cell, consisting of husbands with education $i$ and wives with education $j$ born in cohort $k$ under a given model. This model is expected to show poor fit, but serves as the baseline in considering the following models.

Model 2 represents strict educational homogamy (quasi-independence) model, as follows:

$$\ln F_{ijk} = \lambda + \lambda_i^H + \lambda_j^W + \lambda_k^C + \lambda_{ik}^{HC} + \lambda_{jk}^{WC} + \delta_{ij}^{HW}$$

where $\delta_{ij}^{HW} = 0$ for $i \neq j$ (Model 2: Homogamy)

Model 2 estimates the different parameters on the main diagonal, setting $\delta_{ij}^{HW} = 0$ for $i \neq j$. This model captures the strength of association in each cell on the main diagonal, in comparison to the off-diagonal cells. This model is also referred to as the quasi-independence model and allows us to test for no HW association after blocking out the main diagonal cells.

Model 3 focuses on the difficulty of crossing educational barriers, as follows:

$$\ln F_{ijk} = \lambda + \lambda_i^H + \lambda_j^W + \lambda_k^C + \lambda_{ik}^{HC} + \lambda_{jk}^{WC} + \gamma_{ij}^{HW}$$

where $\gamma_{ij}^{HW} = \sum_{q=j}^{i-1} \gamma_{jq}$ for $i > j$, $\gamma_{ij}^{HW} = \sum_{q=j}^{i-1} \gamma_{jq}$ for $i < j$, and $\gamma_{ij}^{HW} = 0$ for $i = j$ (Model 3: Crossing)

For example, if the husband’s education is junior high ($i = 1$) and the wife’s is high school ($j = 2$), then $\gamma_{12}^{HW} = \gamma_1$. If the husband’s education is university ($i = 5$) and the wife’s is high school ($j = 2$), then $\gamma_{52}^{HW} = \gamma_2 + \gamma_3 + \gamma_4$. The parameters of the crossing model identify interpretable and insightful patterns of data, indicating “which educational differences between prospective spouses are serious barriers to intermarriage and which differences are relatively permeable boundaries” (Mare, 1991: 19)
Model 4 of the quasi-symmetric pattern assumes that there is no tendency for women to marry up, if we control for the gender differences in educational attainment (Halpin & Chan, 2003).

\[
\ln F_{ijk} = \lambda + \lambda_i^H + \lambda_j^W + \lambda_k^C + \lambda_{ik}^{HC} + \lambda_{jk}^{WC} + \lambda_{ij}^{HW},
\]

where \(\sigma_{ij}^{HW} = \sigma_{ji}^{HW}\). (Model 4: Quasi-symmetry)

This model imposes a constraint whereby the associations are symmetric between husbands and wives, \(\sigma_{ij}^{HW} = \sigma_{ji}^{HW}\). In fact, Model 3 also assumes a symmetric pattern of association and a special case of Model 4: The former only describes barriers to intermarriage, while the latter fully specifies the symmetric patterns.

Model 5 allows for unrestricted (full) HW association \(\psi_{ij}^{HW}\), but assumes the association to be the same across birth cohorts. Models 2–4 restrict the full HW association of Model 5.

\[
\ln F_{ijk} = \lambda + \lambda_i^H + \lambda_j^W + \lambda_k^C + \lambda_{ik}^{HC} + \lambda_{jk}^{WC} + \psi_{ij}^{HW},
\]

(Model 5: Full interaction)

Although these models are of use in capturing overall patterns of HW association, they assume that the patterns and strength of association are the same between cohorts. In order to investigate the trends in the underlying components of educational assortative marriage, we applied the two models based on Mare (1991) and Schwartz and Mare (2005).5 Model 6 (changing homogamy pattern) can be written as:

\[
\ln F_{ijk} = \lambda + \lambda_i^H + \lambda_j^W + \lambda_k^C + \lambda_{ik}^{HC} + \lambda_{jk}^{WC} + \lambda_{ij}^{HW} + \delta_{ijk}^{HW C},
\]

where \(\delta_{ijk}^{HW C} = 0\) for \(i \neq j\). (Model 6: Homogamy)

The \(\delta_{ijk}^{HW C}\) terms of Model 6 represent the changes in the relative rates of educational homogamy captured by the main-diagonal parameters relative to the baseline cohort. We set parameters for the oldest cohort to be 0. While the stable pattern of association is fully specified, Schwartz and Mare (2005) constrained changes in all homogamy (main diagonal) parameters across cohorts to be the same. However, this model allows homogamy parameters to have different values from each other.

Model 7 (changing crossing pattern) can be written as follows:

\[
\ln F_{ijk} = \lambda + \lambda_i^H + \lambda_j^W + \lambda_k^C + \lambda_{ik}^{HC} + \lambda_{jk}^{WC} + \lambda_{ij}^{HW} + \gamma_{ijk}^{HW C},
\]

where \(\psi_{ij}^{HW C} = \sum_{q=j}^{i-1} \gamma_{iq}^k\) for \(i > j\), \(\gamma_{ij}^{HW C} = \sum_{q=i}^{j-1} \gamma_{jq}^k\) for \(i < j\), and \(\gamma_{ijk}^{HW C} = 0\) for \(i = j\). (Model 7: Crossing)

5Torche (2010) utilized these models to compare educational assortative marriage among three Latin American countries.
Model 7 imposes the constraints that $\gamma^{HC}_{ijk} = \sum_{q=i}^{j} \gamma_{qk} - 1$ for $i > j$, $\gamma^{HC}_{ij} = \sum_{q=i}^{j} \gamma_{qk} - 1$ for $i < j$, and $\gamma^{HC}_{ij} = 0$ for $i = j$, and captures the variation in the difficulty of crossing educational barrier $q$ in cohort $k$ relative to the baseline cohort. We constrained parameters for the oldest cohort to be 0. These two different kinds of models of educational assortative marriage measure how each specific component changed across cohorts, as Mare (1991) and Schwartz and Mare (2005) examined in the U.S. (see also Powers and Xie (2008)).

We also applied the log-multiplicative layer effects models (Erikson & Goldthorpe, 1992; Xie, 1992), which assume that the overall patterns are the same, but the strength of the associations varies over time. The standard log-multiplicative layer effects model (Model 11) is as follows:

$$\ln F_{ijk} = \lambda + \lambda_j^H + \lambda_j^W + \lambda_k^C + \lambda_{ik}^{HC} + \lambda_{jk}^{WC} + \beta_k \psi_{ij}^{HW}$$  (Model 11: Full interaction)

where $\psi_{ij}^{HW}$ denotes the unrestricted (full) HW association and $\beta_k^C$ denotes the log-multiplicative parameter. These log-multiplicative layer effect models allow us to capture and interpret changes in the strength of the HW association in a parsimonious way. Let $\theta_{ij}$ and $\theta_{ijk}$ denote the local odds ratios and the conditional local odds ratios for the $k$th cohort, respectively. In Model 11, the log-odds ratio is simplified to $\log \theta_{ijk} = \beta_k^C \log \theta_{ij}$ (Powers & Xie, 2008; Xie, 1992). Thus, the ratio of the conditional local odds ratios of the $k$th cohort to the $k'$th cohort is $\log \theta_{ik} / \log \theta_{ij} = \beta_k^C / \beta_{k'}^C$ and constant, irrespective of $(i, j)$ cells. Generally, the $\beta$ of the oldest cohort is set to be 1, and if $\beta$ of a given cohort is greater than 1, this means the association in the cohort is stronger than that of the oldest cohort. If $\beta$ of a given cohort is less than 1, this indicates that the association in the cohort is weaker than that of the oldest cohort. Models 8–11 set the log-multiplicative parameter $\beta_k^C$ on the HW association of Models 2–5, respectively.

Although the log-multiplicative layer effects models measure an overall change in the HW association across cohorts in a parsimonious way, the models do not capture the change in the patterns of HW association. Thus, we also applied the regression-type models for log-odds ratios (Goodman & Hout, 1998, 2001). Regression-type models are novel statistical techniques to compare two-way tables across layer variables (such as periods, cohorts, and countries), and provide similarities and differences in the patterns of two-way associations across the layers. However, regression-type models have rarely been applied to empirical studies (Bouchet-Valat, 2014; Vallet, 2004; Wang & Wong, 2017). The regression-type model sets up two HW association patterns: the baseline and deviation characteristics of HW associations for each cohort. For example, in Model 15, the $\lambda_{ij}^{HC}$ terms establish the baseline pattern of the HW association, and $\phi_k^C \psi_{ij}^{HW}$ adjusts that baseline pattern for cohort $k$.

$$\ln F_{ijk} = \lambda + \lambda_j^H + \lambda_j^W + \lambda_k^C + \lambda_{ik}^{HC} + \lambda_{jk}^{WC} + \lambda_{ij}^{HW} + \phi_k^C \psi_{ij}^{HW}$$  (Model 15: Full interaction)
We set $\phi$ for the oldest cohort to be 0, which means that the oldest cohort provides the baseline pattern of the HW association, $\lambda_{ij}^{HW}$. We also set the $\phi$ for the youngest cohort to be 1; thus, the HW association for the youngest cohort is $\lambda_{ij}^{HW} + \psi_{ij}^{HW}$. The regression-type approach does not require the $\lambda_{ij}^{HW}$ terms and the $\psi_{ij}^{HW}$ to be the same structure (Goodman & Hout, 1998). We assumed full interaction $\lambda_{ij}^{HW}$ for the baseline association because comparisons of Models 1–5 in the following analysis suggested that the general pattern of the HW association is asymmetric, which can be properly captured by the full interaction model. We imposed constraints on the patterns of deviation characteristics of the HW association $\psi_{ij}^{HW}$, except for Model 15. The patterns of changes in the HW association, which are assumed to be full interaction in Model 15, are homogamy (quasi-independence) in Model 12, crossing barriers in Model 13, and quasi-symmetry in Model 14.

The comparison of the log-multiplicative layer effects and regression-type models allow for a test of the hypothesis that association varies in strength – but not in patterns – across cohorts. All analyses were implemented in $\ell$EM (Vermunt, 1997).

5. Results
5.5. Changes in observed rates of educational assortative marriage

Fig. 2 shows the distributions of husbands’ and wives’ educational attainment separately. In the 1950–1954 cohort, men are more likely to enter university and graduate school, and less likely to attend professional training and junior colleges than women. Japan experienced educational as well as other industrial changes (Ishida, 2007), leading to a general increase in women’s educational attainment. Despite the general rise in access to education among women, gender differences persist in educational attainment for younger cohorts. While gender differences in university education have declined, those in junior college and graduate school have grown. The index of dissimilarity (ID), which indicates differences in educational distributions between husbands and wives, are 21.6%, 26.5%, 28.0%, 25.5%, 23.8%, and 23.2% from the oldest to the youngest cohorts, respectively.

To calculate the rates of hypergamy and hypogamy with detailed educational categories, we need to properly rank Japanese educational classifications. However, both professional training college (senmon gakko) and junior college (tanki daigaku or kotou senmon gakko) are at the same level of the ISCED (Level 5), although the latter offers associate’s degrees, while the former does not. To clarify the ordering of educational attainment in terms of educational assortative marriage, we applied association models (Wong, 2010) to estimate the scores of husbands’ and wives’ educational categories (which maximized the association between them), and to rank the levels of educational attainment. The ranking of educational levels, estimated by the association model with diagonal parameters, is as follows from the lowest levels upward (values in the parentheses indicate estimated scores for the husband’s and wife’s education, respectively): junior high school (−1.654 and −1.541), high school (−0.692 and −0.639), professional training college (−0.318 and −0.226), junior college (0.253 and −0.082), university (1.090 and 0.811), and graduate school (1.320 and 1.677). This outcome corresponds to the ordering of the ISCED, and clarifies that junior college can
be located at a higher level of educational hierarchy than professional training college. Using 
this ranking, we created Fig. 3, which portrays changes in observed rates of educational 
homogamy among women who married up (female hypergamy) and women who married 
down (female hypogamy) on the left-hand side. In the oldest cohort, more than 50% of 
marriages were homogamous, whereas homogamy accounts for about 40% of the youngest 
cohort. In contrast, rates of women who married up and married down increased a little 
from the oldest cohort to the youngest cohort. However, changes in educational distributions 
affect these observed rates. On the right-hand side of Fig. 3, we display expected rates 
of educational homogamy among women who married up and married down, estimated 
by assuming that the husband’s and wife’s education are independent of each other. The 
expected rates show trends similar to those observed: the rate of educationally homogamous 
couples decreased, while that of hypergamy and hypogamy slightly increased.

5.2. Patterns and trends in educational assortative marriage

To investigate the relative HW association, we applied the loglinear, log-multiplicative layer 
effects, and regression-type models. Table 1 provides goodness of fit for the models: the 
log-likelihood ratio chi-square statistic ($G^2$), the degrees of freedom (df), the index of 
dissimilarity ($ID = \sum |f_{ijk} - f_{ijk}|/2n$, where $f_{ijk}$ denotes the observed frequencies of the $(i, j, k)$ cell), and the Bayesian information criterion ($\text{BIC}$). The $ID$ is the proportion of misclassified 
cases under a model; thus, a smaller $ID$ means a better fit to the data. More negative $\text{BIC}$ 
statistics mean a better model in terms of model fit and parsimony.

As expected, the model of independent HW association (Model 1) fits the data poorly. About 
21.5% of cases are misclassified in this model. Adding homogamy parameters (Model 
2) improves the model’s fit relative to Model 1 by the $\text{BIC}$; but the $\text{BIC}$ is positive, 
indicating that the saturated model ($\text{BIC} = 0$) is preferred (Raftery, 1995), and 9% of cases 
are misclassified by the $ID$. Adding crossing parameters (Model 3) instead of homogamy 
parameters improved the fit relative not only to Model 1, but also to Model 2 by the $\text{BIC}$ 
and $ID$; however, the $\text{BIC}$ is still positive. Model 4 provides a better fit than Model 3 by 
both the $\text{BIC}$ and $ID$. Neither the homogamy model nor the crossing model is adequate 
to capture patterns of assortative marriage; thus, we need to consider other symmetric 
associations that are not reducible to the associations of main diagonals or five educational 
barriers (Mare, 1991). Model 5 fits the data better than Model 4, which means that there 
is an asymmetric HW association. These model comparisons demonstrate that the basic 
pattern of HW association is not homogamy, crossing, or symmetry, but rather an inherently 
asymmetric structure with more complex patterns of association. The basic pattern of HW 
association is more than just a strict preference for equal educational levels or a reluctance to 
cross educational barriers. Table 2 presents the parameters estimated by Model 5. Parameters 
on the lower diagonal cells tend to be larger than those on the upper diagonal cells. Twelve 
of the fifteen corresponding parameters in the off-diagonal cells were bigger for lower 
diagonal cells than for upper diagonal cells, which indicates that women are more likely to 
marry up than down.

Models 6 and 7 add parameters to changes in each component of educational assortative 
marriage to Model 5. Model 7 has a lower $\text{BIC}$ than that of Models 5 and 6, but showed
poorer fit to the data than other models discussed later in terms of $G^2$ and $BIC$. Although we need to interpret the results with caution because of such poor fit, the models allow us to compare outcomes in Japan with findings of previous studies (Mare, 1991; Schwartz & Mare, 2005). Therefore, using this model, we describe the changes in educational assortative marriage. Fig. 4 shows changes in each educational homogamy parameter compared to the baseline association estimated using Model 6. Homogamy parameters decreased between the 1950–1954 and 1975–1979 cohorts, except for junior college and graduate school. Fig. 5 shows changes in each crossing parameter estimated using Model 7. An increase in the parameters means that the difficulty in crossing each educational barrier is reduced, compared to the oldest cohort. Generally, the parameters for educational barriers increased across cohorts, which means that crossing these educational barriers is now easier than before, especially between professional training and junior colleges. The parameter for the educational barrier between high school and professional training college has changed little, while that between university and graduate school did not show a clear trend. On the whole, decreases in difficulties crossing a few educational barriers reflect more incidents of intermarriage between different educational groups.

The log-multiplicative layer effects models, which postulate the same patterns of HW association as in previous models – but allow the strength of that association to vary across cohorts – fit the data well. Among Models 8–11, Model 11 fits the best by the $BIC$, and only misclassifies 1%. Model 11 also fits better than Model 6 and 7 in terms of $BIC$. The right side of Table 1 shows the log-multiplicative parameters $\beta^C_k$ estimated by Models 8–11. In Model 11, fixed at 1 for the 1950–1954 cohort, the $\beta^C$ for the 1975–1979 cohorts are estimated at 0.750, indicating near 25% decrease in the association between the husband’s and wife’s educational attainment in terms of the log-odds ratios, from the oldest to the youngest cohorts. We also estimated the slope of the trend ($\beta$) by constraining the parameter $\beta^C_k$ to be $1 + \beta(k - 1)$ (the results are not shown here); it was −0.049, meaning that the HW association decreased by about 5% as the cohort advanced 5 years. Models 9 and 10 showed similar trends regarding the strength of the association, as is the case with Model 11. However, Model 8, showing the poorest fit from Models 9–11, indicated rather stable trends (11.4% decrease in the association between the husband’s and wife’s educational attainment). This finding suggests that strict homogamy has not weakened clearly in comparison to other components of the HW association.

The regression-type models – which relaxed the assumption of the log-multiplicative layer effects models, whereby the pattern of the HW association is the same across cohorts – provided us with more detailed information about changes in the association. Models 12–15 include the time-invariant interaction effects of the HW association (i.e., $\lambda^{W,H}_{ij}$), as suggested by the investigation of Models 2–5. Thus, the fit of the models was basically good. Model 12, which postulated that changes in the HW association only occurred in the main diagonal, shows a relatively poorer fit than Models 13–15. Therefore, changes in the HW association across cohorts occurred not only on the main diagonals but also on the

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6We cannot directly estimate homogamy and crossing parameters for the 1950–1954 cohort (Schwartz & Mare, 2005: 636–637, Note 8). Therefore, we focus on changes in the parameters.
non-diagonal components. Out of Models 13–15, Model 14 shows the best fit to the data, which means that changes in the HW association took place symmetrically between men and women, but changes in the HW association cannot be captured only by changes in the difficulties of crossing five educational barriers. Model 15 fits well, but is not parsimonious relative to Model 14. Moreover, Model 14 is preferred over Model 11 in terms of the model fit and parsimony. These model comparisons also suggest that Model 14 should be selected as the most preferred model, demonstrating that not only the strength but also the pattern should be considered in capturing changes in educational assortative marriage in Japan.\textsuperscript{7}

Table 3 presents the estimated parameters from Model 14: baseline associations in the 1950–1954 cohort, $\lambda_{ij}^{WH}$ (Panel A), and the estimated association in the 1975–1979 cohort, $\lambda_{ij}^{WH} + \sigma_{ij}^{WH}$ (Panel B). The baseline associations (Panel A) are asymmetric, and women tend to marry up rather than down for both cohorts, as in Table 2.

Model 14 assumes that differences in the parameters between these two cohorts are symmetric for the off-diagonal cells. Therefore, the log-odds ratios in Panel B are also asymmetric, like those in Panel A. Panel C shows the ratios of the parameters of the HW association for the 1950–1954 cohort ($\lambda_{ij}^{WH}$) to those for the 1975–1979 cohort ($\lambda_{ij}^{WH} + \sigma_{ij}^{WH}$). The ratios are postulated to be constant in Model 11 and equal to $\beta^C$ for the 1975–1979 cohort ($\beta_6 \psi_{ij}^{WH} / \beta_1 \psi_{ij}^{WH} = \beta_6 = 0.750$). The ratios of the logodds ratios for the 1950–1954 cohort to those for the 1975–1979 cohort are also constant ($\log \theta_{ij} / \log \theta_{ij}^{11} = \beta_6 \log \theta_{ij} / \beta_1 \log \theta_{ij} = \beta_6 = 0.750$). On the other hand, the ratios from Model 14 vary across cells, and many of the ratios are positive and less than 1 (28 of 36 cells), which indicates that the HW association decreased as a whole, but the magnitude of change differs based on the combination of the husband’s and wife’s education. The ratios for the main diagonal ranged from 0.742 (junior high school) to 0.837 (professional training college), while most of those for the off-diagonal cells were less than 0.742 (25 out of 30 off-diagonal cells), indicating that the off-diagonal coefficients decreased more than the diagonal coefficients. The ratios for off-diagonal cells related to professional training college (PTC) tend to be much smaller. This suggests that the social standing of PTC has changed: it was close to high school, but became closer to junior college.

The right side of Table 1 shows the trends of changes in the HW association, estimated using Model 14. The strength of adjustment of the association, $\varphi$, increases monotonically from the 1950–1954 cohort to the 1975–1979 cohort (0.000, 0.343, 0.441, 0.666, 0.831, 1.000), indicating that educational homogamy has declined, and intermarriage between different educational groups has increased at a nearly constant pace.

### 5.3. Comparisons of the observed and expected log-odds ratios

Although both the log-multiplicative layer effects model (Model 11) and the regression-type model (Model 14) depict similar trends (a decline in the HW association at an almost constant rate over the six successive 5-year birth cohorts), the latter was preferred over the

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\textsuperscript{7}We added time-varying hypergamy parameters to Model 14 and analyzed it. The results (not shown here) indicated that Model 14 fit better than the revised model ($G^2 = 342.6, df = 100, ID = 0.7\%, BIC = -965.8$).
former. This outcome suggests that the regression-type model (Model 14) captures nuanced changes in the HW association. To explore such changes, we compared the observed log-odds ratios and the expected log-odds ratios from the models that we had already investigated: Model 6 (changing homogamy pattern) and Model 7 (changing crossing pattern), as well as Models 11 and 14.

Fig. 6 shows the observed log-odds ratios and the estimated log-odds ratios produced by Models 6, 7, 11, and 14. The observed log-odds ratios are shown as circles, with error bars representing the 95% confidence interval (CI). Many of the observed log-odds ratios change across birth cohorts, but Models 6 and 7 failed to correctly capture the true trends of the log-odds-ratios. For example, the observed log-odds ratios pertaining to the husbands’ junior college/professional training college (JC/PTC) and the wives’ high school/junior high (HS/JH) education decrease over time, while both of the estimated log-odds ratios from Models 6 and 7 remain stable.

Compared to Models 6 and 7, Models 11 and 14 capture the trends of the log-odds ratios more accurately. However, Models 11 fails more often to predict the trends, in comparison to Model 14. For example, the observed log-odds ratio regarding the husbands’ JC/PTC and the wives’ HS/JH decreased from the 1950–1954 cohort to the 1975–1979 cohort. However, the estimated log-odds ratios from Models 11 remain stable. Models 11 also estimates incorrect trends in the log-odds regarding the husbands’ HS/JH and the wives’ PTC/HS, the husbands’ HS/JH and the wives’ JC/PTC, and the husbands’ PTC/HS and the wives’ HS/JH. These comparisons include PTC, which changed its position in educational ranking in terms of the HW association. Models 11 failed to capture the change in the relative standing of PTC and tended to show stable associations related to PTC. Model 14 (the regression-type model) correctly capture the trends of these associations.

5.4. Robustness check using different categorizations

Using an aggregated table might lead to a different result, as Wong (2003) pointed out the possibility that using highly aggregated tables could cause bias. Therefore, we also used the 3-category version of educational attainment (1 = junior high school, 2 = high school and professional training college, 3 = junior college, college of technology, university, and graduate school) and the 4-category version (1 = junior high school, 2 = high school and professional training college, 3 = junior college or college of technology, 4 = university and graduate school). The log-multiplicative layer effects model (Models 11) showed that the trends were very similar between the three ways of classifying educational attainment, and revealed a consistent decrease in the β, indicating less educational assortative marriage across the cohorts (from the oldest to the youngest cohorts, βs from the 4-category version of education were 1.000, 0.926, 0.898, 0.829, 0.765, and 0.702, respectively, and βs from the 3-category version were 1.000, 0.917, 0.879, 0.832, 0.773, and 0.727, respectively). This result suggests that the use of a relatively smaller sample size – rather than the use of different types of categorization – is the main source of disagreement in previous studies about trends in educational assortative marriage in Japan.
6. Conclusion and discussion

This paper investigated the patterns and trends of educational assortative marriage in Japan. In general, educational homogamy has decreased, and intermarriage among different educational groups has experienced an increase. The log-multiplicative layer effects model estimated that the association between the husband’s and wife’s education decreased by about 25% between the two cohorts of the wife’s birth (1950–1954 and 1975–1979, respectively). Because we used cross-sectional data, the decline in educational assortative marriage among cohorts could be overestimated. However, the result of a constant decline in educational assortative marriage concurs with that found by Fukuda et al. (2017) who analyzed microdata from the Population Census between 1980 and 2010 (wives were 30 to 39 years old at the time of each survey).

Our results largely support the hypotheses derived from Smit et al. (1998) and Schwartz and Mare (2005), who both prompt us to predict a decline in educational assortative marriage in Japan. This outcome, found in the Japanese context, also concurs in Norway (Birkeland & Heldal, 2003). A similar overall pattern emerged in a comparative study on East Asian societies (Smits & Park, 2009), but the pattern differs somewhat from that of Taiwan, where the trend in the association has an elongated U-shape form, rather than a linear shape (Wong, 2003). The outcome of Japan is opposite to that found in the U.S., Canada, and Korea (Hou & Myles, 2008; Mare, 1991; Park & Smits, 2005; Schwartz & Mare, 2005).

In these countries, the association between husbands’ and wives’ educational attainment has increased over time.

The regression-type model also showed changes not only in the strength but also in the patterns of the HW association. The HW association decreased symmetrically with respect to sex, while maintaining an asymmetric structure for gender: women tend to marry up rather than down. This means that the pattern of assortative mating in Japan has been characterized by the large prevalence of female hypergamy, which reflects a persistent gender specialization in terms of market and domestic labor within marriage (Raymo & Iwasawa, 2005). This asymmetric pattern is also found in other East Asian countries, such as South Korea (Park & Smits, 2005) and Taiwan (Wong, 2003). On the other hand, after controlling for different distributions of educational attainment between men and women, the associations have a symmetric structure in Ireland and England (Halpin & Chan, 2003), as well as in Brazil, Chile, and Mexico (Torche, 2010). This evidence indicates that the asymmetric association between husbands’ and wives’ educational attainment is remarkable in East Asia, while it is not necessarily the case in Western or Latin American countries.

By applying advanced methods in the analysis of contingency tables, we extended our knowledge about trends in educational assortative marriage by providing a unique pattern of husbands’ and wives’ education in an East Asian society.

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8 Schwartz and Mare (2005): 635–636, Note 7) also found that the trends in the HW association were symmetrical with respect to sex in the U.S.

9 For more information on the prevalence of hypergamy in other countries, see Esteve, García-Román, and Permanyer (2012).
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Appendix A.: Summary of past studies on trends in educational homogamy in Japan

| No | Study          | Year | N     | Description of Sample                                | Ncat | Results |
|----|----------------|------|-------|------------------------------------------------------|------|---------|
| 1  | Shirahase      | 1999 | 1,519 | SSM1995, Men and women born from 1925–1970          | 3    | Stable  |
| 2  | Shida et al.   | 2000 | 2,172 | SSM1995, Men and women born from 1925–1970          | 4    | Stable  |
| 3  | Raymo and Xie  | 2000 | 3,183 | NFS1992, Married women aged 18–49.                  | 4    | Decline |
| 4  | Shirahase      | 2005 | 4,161 | SSM1985 and 1995, men and women married from 1932–1995 | 3    | Diverging |
| 5  | Miwa           | 2007 | 16,136| SSM1995, JGSS2000–2002, and NFRJ 1998, 2003, men and women aged 28–69 | 4    | Decline |
| 6  | Yoshida        | 2011 | 3,989 | SSM2005, aged 25–70                                 | 4    | Stable  |
| 7  | Fukuda et al.  | 2017 | 25,949,319 | Population Census data (women aged 30–39 in 1980, 1990, 2000, and 2010) | 4    | Decline |

Note 1. Ncat means the number of educational categories
Note 2. SSM: Social Stratification and Mobility Survey; NFS: National Fertility Survey, JGSS: Japanese General Social Survey; NFRJ: National Family Research of Japan

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Fig. 1. Trends in average age at first marriage in Japan.
Source: Vital Statistics (Ministry of Health, Labour and Welfare).
Fig. 2.
Distributions of educational attainment of husbands and wives according to wives’ birth cohorts (n=481,144).
Fig. 3. Observed and expected distributions of homogamous, hypergamous, and hypogamous marriages according to wives’ birth cohorts (n=481,144).

Note: *Expected* means the expected rate based on the assumption that the husband’s and wife’s education levels are independent of each other.
- Homogamous: wife’s education = husband’s education.
- Hypergamous: wife’s education < husband’s education.
- Hypogamous: wife’s education > husband’s education.
Fig. 4. Changes in the homogamy parameters $\delta$ according to wives’ birth cohorts, estimated by Model 6 ($n=481,144$).

Note: JH=junior high school, HS=high school, PTC=professional training college, JC=junior college or college of technology, UNIV=university, and GS=graduate school.
Fig. 5. Changes in the crossing parameters according to wives’ birth cohorts, estimated by Model 7 (n=481,144).

Note: JH=junior high school, HS=high school, PTC=professional training college, JC=junior college or college of technology, UNIV=university, and GS=graduate school.
Fig. 6. Observed log-odds ratios and estimated log-odds ratios by Model 6, 7, 11, and 14.

Note: The observed log-odds ratios are represented as circles, with the error bars representing a 95% confidence interval (CI). The lines indicate the estimated log-odds ratios by Model 6 (changing homogamy patterns), Model 7 (changing crossing patterns), Models 11 (log-multiplicative layer effects), and Model 14 (regression type). JH=junior high school, HS=high school, PTC=professional training college, JC=junior college or college of technology, UNIV=university, and GS=graduate school.
Table 1

Goodness of fit for the models and log-multiplicative layer coefficients (n = 481,144).

| Models | Goodness of fit of models | $\phi^C$ or $\psi^C$ | 1950–1954 | 1955–1959 | 1960–1964 | 1965–1969 | 1970–1974 | 1975–1979 |
|--------|---------------------------|-----------------------|------------|------------|------------|------------|------------|------------|
|        |                           | $\chi^2$ | d.f. | ID | BIC | 1950–1954 | 1955–1959 | 1960–1964 | 1965–1969 | 1970–1974 | 1975–1979 |
| Log-linear models |                           |          |     |    |    |          |         |          |          |          |          |
| 1: [HC WC] |                           | 153216.3 | 150 | 21.5% | 151253.7 |          |         |          |          |          |          |
| 2: [HC WC $\delta^{HW}$] |                           | 52950.3 | 144 | 9.0% | 51066.2 |          |         |          |          |          |          |
| 3: [HC WC $\gamma^{HW}$] |                           | 9814.6 | 145 | 3.9% | 7917.4 |          |         |          |          |          |          |
| 4: [HC WC $\sigma^{HW}$] |                           | 2268.8 | 135 | 1.8% | 502.5 |          |         |          |          |          |          |
| 5: [HC WC $\psi^{HW}$] |                           | 1722.3 | 125 | 1.7% | 86.8 |          |         |          |          |          |          |
| Models for changing homogamy and crossing patterns |                           |          |     |    |    |          |         |          |          |          |          |
| 6: [HC WC HW $\delta^{HWC}$] |                           | 1200.8 | 95 | 1.0% | –42.1 |          |         |          |          |          |          |
| 7: [HC WC HW $\gamma^{HWC}$] |                           | 627.9 | 100 | 0.8% | –680.5 |          |         |          |          |          |          |
| Log-multiplicative layer effect models |                           |          |     |    |    |          |         |          |          |          |          |
| 8: [HC WC $\delta^{HW}C^C$] |                           | 52670.1 | 139 | 8.9% | 50851.5 | 1.000 | 1.040 | 1.041 | 0.994 | 0.928 | 0.886 |
| 9: [HC WC $\gamma^{HW}C^C$] |                           | 9044.4 | 140 | 3.8% | 7212.7 | 1.000 | 0.940 | 0.914 | 0.869 | 0.825 | 0.777 |
| 10: [HC WC $\sigma^{HW}C^C$] |                           | 1209.7 | 130 | 1.2% | –491.2 | 1.000 | 0.939 | 0.918 | 0.855 | 0.799 | 0.742 |
| 11: [HC WC $\psi^{HW}C^C$] |                           | 729.0 | 120 | 1.0% | –841.0 | 1.000 | 0.939 | 0.918 | 0.857 | 0.806 | 0.750 |
| Regression-type models |                           |          |     |    |    |          |         |          |          |          |          |
| 12: [HC WC HW $\delta^{HW}C^C$] |                           | 1288.1 | 115 | 1.2% | –216.5 | 0.000 | 0.333 | 0.431 | 0.575 | 0.782 | 1.000 |
| 13: [HC WC HW $\gamma^{HW}C^C$] |                           | 717.8 | 116 | 0.9% | –799.9 | 0.000 | 0.336 | 0.420 | 0.607 | 0.814 | 1.000 |
| 14: [HC WC HW $\sigma^{HW}C^C$] |                           | 349.1 | 106 | 0.7% | –1037.8 | 0.000 | 0.343 | 0.441 | 0.666 | 0.831 | 1.000 |
| 15: [HC WC HW $\psi^{HW}C^C$] |                           | 260.3 | 96 | 0.7% | –995.7 | 0.000 | 0.308 | 0.415 | 0.641 | 0.818 | 1.000 |

Note: Model terms (number of parameters): H = husband’s education (5); W = wife’s education (5); C = wife’s birth cohort (5); HC = husband’s education and wife’s birth cohort full interactions (25); WC = wife’s education and birth cohort full interactions (25); $\delta^{HW}$ = homogamy (6); $\gamma^{HW}$ = crossing (5); $\sigma^{HW}$ = symmetry (15); $\psi^{HW}$ = HW full interactions (25); HW = baseline HW full interactions (25); $\delta^{HWC}$ = homogamy by cohorts (30); $\gamma^{HWC}$ = crossing by cohorts (25); $\phi^C$ = log-multiplicative layer effect parameters (5); $\psi^C$ = regression-type parameters (4).
Table 2
Parameters of association between husband’s and wife’s educational attainment, estimated by Model 5 (n = 481,144).

| Husband’s education | Wife’s education | JH | HS | PTC | JC | UNIV | GS |
|---------------------|-----------------|----|----|-----|----|------|----|
| JH                  |                 | 3.082 | 0.896 | 0.231 | −0.731 | −1.414 | −2.063 |
| HS                  |                 | 0.999 | 0.829 | 0.082 | −0.083 | −0.700 | −1.126 |
| PTC                 |                 | 0.339 | 0.105 | 0.620 | −0.060 | −0.320 | −0.684 |
| JC                  |                 | −0.281 | 0.155 | 0.003 | 0.463 | −0.106 | −0.234 |
| UNIV                |                 | −1.345 | −0.463 | −0.353 | 0.317 | 0.985 | 0.860 |
| GS                  |                 | −2.795 | −1.522 | −0.581 | 0.095 | 1.556 | 3.248 |

Note: JH = junior high school, HS = high school, PTC = professional training college, JC = junior college or college of technology, UNIV = university, and GS = graduate school. We used effect coding (ANOVA-type coding) to identify \( \sum_{i=1}^{6} \psi_{ij}^{HW} = 0 \).
Table 3
Change in parameters of association between husband’s and wife’s educational attainment between the 1950–54 and 1975–79 cohorts, estimated by Model 14 (n = 481,144).

|       | Husband’s education | Wife’s education |
|-------|---------------------|------------------|
|       | JH                  | HS               | PTC              | JC    | UNIV  | GS    |
| Panel A: Wife’s birth cohort = 1950–1954 | 3.550             | 1.152            | 0.670            | −0.799| −1.689| −2.884|
|       | 1.198              | 0.941            | 0.133            | −0.070| −0.794| −1.409|
|       | 0.737              | 0.168            | 0.769            | −0.179| −0.544| −0.951|
|       | −0.408             | 0.127            | −0.144           | 0.483 | −0.032| −0.026|
|       | −1.614             | −0.599           | −0.583           | 0.348 | 1.094 | 1.353 |
|       | −3.463             | −1.789           | −0.846           | 0.217 | 1.965 | 3.916 |
| Panel B: Wife’s birth cohort = 1975–1979 | 2.634             | 0.794            | −0.104           | −0.530| −1.103| −1.691|
|       | 0.840              | 0.744            | 0.087            | −0.073| −0.617| −0.981|
|       | −0.037             | 0.122            | 0.639            | 0.053 | −0.195| −0.582|
|       | −0.139             | 0.123            | 0.089            | 0.404 | −0.178| −0.298|
|       | −1.028             | −0.421           | −0.234           | 0.201 | 0.848 | 0.634 |
|       | −2.270             | −1.362           | −0.477           | −0.056| 1.245 | 2.919 |
| Panel C: B/A | 0.742             | 0.689            | −0.155           | 0.663 | 0.653 | 0.586 |
|       | 0.701              | 0.791            | 0.654            | 1.053 | 0.777 | 0.696 |
|       | −0.050             | 0.726            | 0.831            | −0.297| 0.358 | 0.612 |
|       | 0.341              | 0.971            | −0.617           | 0.837 | 5.601 | 11.514|
|       | 0.637              | 0.704            | 0.401            | 0.579 | 0.775 | 0.468 |
|       | 0.655              | 0.761            | 0.564            | −0.256| 0.634 | 0.745 |

Note: JH = junior high school, HS = high school, PTC = professional training college, JC = junior college or college of technology, UNIV = university, and GS = graduate school. We used effect (ANOVA-type) coding to identify the parameters.

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\sum_{i=1}^{6} \psi_{ij}^{HW} = \sum_{j=1}^{6} \psi_{ij}^{HW} = \sum_{i=1}^{6} \sigma_{ij}^{HW} = \sum_{j=1}^{6} \sigma_{ij}^{HW} = 0
\]