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ABSTRACT

Education Expansion, Assortative Marriage, and Income Inequality in China

We use census and household survey data to document China's educational assortative marriage and its evolution between 1990 and 2009. Empirical results suggest that men are increasingly likely to marry with women with similar education levels in China since the early 1990s, which is also true for urban areas and for different provinces. We then calculate the counterfactual Gini coefficients that would prevail if marriage matching was random in terms of education. For China in 2005, the inequality of per capita household income would drop from 0.508 to 0.476 if marriage was random. For urban areas in 2009, assortative marriage in education also increased the Gini coefficients by around 2 percentage points (from 0.316 to 0.337). The decomposition exercise shows that the increase in the return to education is the major contributor to the increase in urban household income inequality between 1990 and 2009, and the change in the assortative marriage pattern plays a minor role.

JEL Classification: J12, I24, O15
Keywords: education expansion, assortative marriage, income inequality

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1. Introduction

Along with world record economic growth, China's income inequality increased significantly in the last three decades. Among the factors contributing to increased inequality, education has attracted considerable attention. It has long been recognized that education is not evenly distributed across individuals and that an income gap exists between educated and less-educated individuals. The continuous increase in the returns to education has been identified as the driving force for increased urban inequality from the early 1990s (see Liu et al. 2010, for example). Rural areas experienced a slower increase in the returns to education, but education also plays an important role in determining rural residents' earnings and employment opportunities both within and outside of the countryside (de Brauw *et al.*, 2002; Chen and Xing, 2006; Xing 2013).

Given the income gap between educated and less-educated workers, the share of educated individuals in the population influences income inequality, which is often referred to as the composition effect. Many researchers look at this composition effect using individual level data. Others, who are interested in the determination and distribution of household income, look at the education level of the household head or the average education levels of household members. In both cases, the educational matching pattern of married couples is largely neglected. This paper looks at China's educational assortative marriage and its impact on inequality of household income in China.

As pointed out by Becker (1973; 1974), whether marriage is positively or negatively assortative has major implications for inequality. If there are positive assortative marriages in education (as observed in many societies), human capital will be more unevenly distributed between households. Meanwhile, Becker (1973) argues that wage rates, which represent opportunity cost of home production, should be negatively sorted. It is also possible that well-educated couples choose only one household member to participate in the labor market to realize labor division and to maximize household production. If this is the case, educational assortative marriage will not have a significant impact on household income inequality. On the contrary, if both husband and wife within a household participate in the labor market, educated couples will earn much more than those couples with less education, increasing household income inequality. Thus, the extent of educational assortative marriage and its impact on household income inequality depend on the forces of these different aspects, opening these questions to empirical investigation.

The investigation of assortative marriage and its impact on income inequality are of special interest for China for the following reasons. First, as mentioned, the returns to education and income inequality have increased continuously from the 1990s (see Li and Ding, 2003; Zhang *et al.*, 2005; Meng *et al.*, 2010; Chi *et al.*, 2012). Marriage patterns can influence the distribution of human capital between households. Second,

China experienced dramatic education expansion in the reform period. In particular, the scale of its higher education expanded sharply beginning in the late 1990s. While the human capital distribution for individuals following the expansion has been well documented, little is known about its impact on the distribution of education between households. Third, the education level for females has been catching up with males, as occurred in the United States. It has become easier for a male with a college education to find a female with a similar education level. While this is easily imagined, efforts are needed to quantify the impact of this asymmetric increase in education levels on assortative marriages and their income distribution consequences. These latter two aspects also bring forth another question: to what extent is the change in educational assortative marriage due to composition change versus changes in the marriage pattern itself? Finally, it is important to understand the assortative marriage pattern and its impact on income inequality to inform the Chinese government's reforms or redesigns of the tax system to reduce income inequality, as suggested by the literature on optimal tax for couples (Kleven *et al.*, 2009; Frankel, 2014).[1]

In this paper, we document China's educational assortative marriage and its evolution using census and household survey data between 1990 and 2009. The results suggest that positive educational assortative marriage increased significantly since the early 1990s, which is true not only for urban areas but also for different provinces. To assess the impact of assortative marriage on income inequality, we calculate several counterfactual income inequalities. In particular, we calculate Gini coefficients that would prevail if marriage was random. For China in 2005, the inequality of per capita household income would drop from 0.508 to 0.476 if marriage was random. For urban areas in 2009, education assortative marriage also increased Gini coefficients by around 2 percentage points (from 0.316 to 0.337).

Although assortative marriage plays an important role in shaping household income inequality, little income inequality change can be attributed to the increase in educational assortative marriage. Instead, changes in the relative income across different types of households explain a major part of the increase in household income inequality. Education expansion, which changed the marginal distributions of the husbands' and wives' education, also plays a non-trivial, but relatively small role. The fact that assortative marriage plays a minor role is expected, as changes in returns to education and education levels are more significant than the changes in assortative marriage in the period we study. However, our exercises suggest that both education expansion and the increase in the returns to education have made assortative marriage more important in shaping income inequality.

To our knowledge, our paper is the first to evaluate the importance of education

[1] Kleven *et al.* (2009) prove that, when the couples' earnings are uncorrelated, the optimal marginal tax rates for couples are negatively correlated (negative jointness). That is, when one's marginal tax rate increases, his or her spouse's decreases. However, Frankel (2014) finds that when assortative mating is sufficiently positive, an individual's taxes do not depend on his or her spouse's income. The "negative jointness" of marginal tax rates for couples is attenuated in the presence of assortative mating.

assortative marriage in shaping China's household income inequality. Using counterfactual analysis to assess the relative importance of educational expansion, increasing returns to education, and educational assortative marriage on income inequality constitutes a major contribution of this paper. In addition, we use more recent nationally representative datasets and employ a method that allows us to investigate the changing pattern of assortative marriage, holding education levels constant. Our finding that positive assortative marriage has increased is consistent with the findings in Han (2010). However, it is worth mentioning that the increase in educational assortative marriage does not necessarily mean an increase in assortative marriage in other aspects. A recent study by Du *et al.* (2015) finds that positive assortative matching has been declining since the 1980s. They use a different data set and consider family wealth, individual income, and Hukou status, instead of education. Similarly, Mu and Xie (2014) examine the change of age gap in Chinese couples and find that age homogamy decreased in recently born cohorts. Our study complements rather than contradicts those studies.[2]

This paper is organized as follows. The next section briefly introduces related literature and background information. Section 3 introduces and describes the census data for 1990, the one percent population survey for 2005, and the urban household survey data for 1990 and 2009, which are used for our analysis. Section 4 documents the assortative marriage pattern for China since the early 1990s. Section 5 estimates the effect of assortative marriage on income inequality by calculating counterfactual inequalities under different scenarios. Section 6 concludes the paper and points out weaknesses of the current research and possible further research directions.

2. Background and literature

A growing literature studies how marriage assortativeness evolves and how it influences income inequality. A number of sociological studies show that education levels of husbands and wives became increasingly positively correlated in the United States in the mid-20th century (Mare, 1991; Qian and Preston, 1993; Schwartz and Mare, 2005). Economists assess the strength of educational assortativeness mainly through comparisons of the actual distribution of the marriage patterns and the counterfactual distributions. The simplest indicator, for example, is homogamy rate, which is the ratio between the actual frequency of couples with identical education and counterfactual frequency under random matching or perfect positive assortative mating (Liu and Lu, 2006; Greenwood *et al.*, 2014; Siow, 2015).[3] The results also show that educational assortative marriage has increased since the 1960s.[4]

[2] Variables other than education, such as income, wealth, and Hukou status, are often determined by many other factors and are not as stable (or pre-determined). Second, they are often endogenously determined by the marital matching pattern. For example, couples with one individual earning a high income may choose to have the other leave the labor force. Or, when one has a high income, his/her spouse may choose a low-paid and less time consuming job. It is also difficult to determine the wealth that belongs to an individual, as wealth is usually shared by couples and is measured at the household level.

[3] Choo and Siow (2006) and Dupuy and Galichon (2014) build a static competitive equilibrium model to analyze the joint marital surplus and matching pattern. Chiappori *et al.* (2015) point out that the female's education will

Many are concerned with the possibility that positive marital assortativeness on the basis of education leads to greater household income inequality (see Fernandez *et al.*, 2005 and Kremer, 1997 for theoretical discussions). The research of Burtless (1999) is an early example of an evaluation of the effect of educational assortativeness on inequality using counterfactual analysis. By comparing the actual income distribution observed in 1996 with the counterfactual distribution that holds the marital sorting pattern constant at the 1979 level, he finds that marriage assortativeness is an important factor affecting household income inequality. Recently, Greenwood *et al.* (2014) use the method that we follow in this paper to construct the counterfactual of income inequality and to show that the change in marital patterns accounts for nearly 100% of the change in Gini coefficient between 1960 and 2005. However, Eika *et al.* (2014) find that shifts in sorting patterns have no impact on inequality; the changes in labor market participation and the returns to education are the main causes of the increase in income inequality in Norway and the United States.

China's education expansion and rising household income inequality make this investigation important. China has experienced tremendous educational expansion in recent decades. In the period 1990-2012, its GDP grew at an annual rate of 10 percent, and the amount of fiscal expenditure on education grew even faster. In the mid-1990s, the share of fiscal expenditure on education in GDP was below 2.5 percent, and by 2011 it had reached 4 percent (National Bureau of Statistics, 2012). By 1990, middle school had become compulsory by law. The share of primary school graduates admitted to middle school increased from 80 percent in the early 1990s to around 98 percent in the early 2010s due to the enforcement of the Law of Compulsory Education and increased subsidies for food and/or boarding, especially in poor regions.

Significant changes in higher education happened when the central government increased the number of students admitted to tertiary education by over half a million in 1999 (the number was 1.08 million in 1998). In subsequent years, the number of new college students kept increasing. In 2005, the number of new college students was 5.04 million, 4.7 times the number of new students in 1998. The number of college graduates increased dramatically starting in early 2000; the number of college graduates in 2000 was 1.03 million, reaching 6.25 million by 2012. Meanwhile, the total number of college students in China ranked first in the world, amounting to 23 million, and the gross enrollment rate of higher education increased by 11.2 percentage points, reaching 21%.

affect the returns to education and the returns to marriage. They use the structural model to explain the change of female education distribution and marriage patterns.

[4] For example, Siow (2015) uses data from the 2000 census in the United States to empirically test education positive assortative matching and finds that except for 2% of the couples matched with extremely different education levels, the education level of couples is positively assortatively matched.

The share of middle school graduates admitted to high school increased continuously from around 50 percent in the late 1990s to nearly 90 percent in the early 2010s. As the returns to high school are relatively low and the main function of high schools is preparation for college examinations, the expansion in high school can be regarded largely as a response to the expansion in tertiary education (Xing, 2013; Du and Yang, 2014).

Two features are worth mentioning about China's education expansion. First, the education level of females increased faster than that of males. In the 2010 population census, among the population aged 40 to 44 the shares of those with college or above degrees are 10 percent and 7 percent for males and females, respectively. In contrast, the shares for both genders reached 21 percent for those aged 20 to 24. Second, educated workers are increasingly located in urban areas. In particular, most rural residents who obtain college degrees stay in urban areas, as the employment opportunities are better and the urban labor market offers higher returns.

Along with education expansion, the returns to education also increased significantly (Zhang *et al.*, 2005; Meng *et al.*, 2013; Liu *et al.*, 2010). The wage gap between individuals of different education levels has become a major contributor to overall wage inequality and its increase (Chen *et al.*, 2004). It is therefore of interest to see how human capital is distributed among households and its impact on household income inequality.

3. Data

We use a random sample of the census data for 1990 and a one-fifths random draw of the 1 percent population survey for 2005 to investigate the changes in the assortative marriage pattern for China as a whole. Both data sets are compiled by the Chinese National Bureau of Statistics (NBS) and are representative of Mainland China, covering 31 provinces, municipalities, and autonomous regions. They contain detailed information on family structure and the personal characteristics of each individual within households (age, gender, education levels, employment status, marital status, place of residence, place of household registration). Unfortunately, only the data for 2005 have income information, making it impossible to see the evolving role of assortative marriage in influencing income inequality.

We then turn to the Chinese Urban Household Survey (UHS), which is an annually repeated cross sectional survey that NBS also collects. Information on family structure, personal characteristics of individuals within households, and income are recorded. We use the data for 1990 and 2009 in this paper, which allows us to observe the changes in assortative marriage over a relatively long period. Because the sampling process is based on formal residence registration, the data we use exclude most migrant households in urban areas without formal residence permits. Considering the large number of rural-to-urban migrants (Cai *et al.*, 2009) and the fact

that they are usually worse off than local urban workers (Démurger *et al.*, 2009), our data may produce biased urban inequality. However, by focusing on a subsample with permanent urban residency, there is less need to consider the demographic changes caused by a large inflow of rural to urban migrants.

We use samples of married couples to investigate assortative marriage and its change over time. Observations of the divorced and the widowed are dropped. For married couples to be included in the sample, the ages of both husbands and wives are restricted to between 26 and 60. We focus mainly on assortative marriage pattern in terms of education, and we consider four education levels: *college or above* (including Ph.D., masters, college graduates, and professional school graduates), *high school graduates* (including technical school graduates), *middle school graduates*, and *primary school graduates or below* (including the illiterate). Thus, there are 16 possible combinations in terms of education levels for a married couple. The composition within some education categories may change over time. There will be more individuals with post-graduate degrees in the *college or above* category in more recent years; and there will be less illiterate individuals in the *primary or below* category. However, the shares of the illiterate and those with post-graduate degrees are small (at least in some years), and it is undesirable to consider those categories separately.

To look at income inequality, we also include single families (single men and single women). Every individual, either married or single, has two possible employment statuses: work or not work. Thus, for married couples, each has four possible outcomes in terms of employment status. We do not consider the number of children at this stage. To calculate the inequality of per capita income at the household level, we use average income (total income divided by two) for married couples and the total income for households of singles. Again, children are not considered. Finally, for households of singles, their education levels are also classified into four categories: college or above, high school graduates, middle school graduates, and primary school graduates or below.

4. China's assortative marriage and its evolution

4.1 Evidence from census data

A simple way to measure the extent of assortative marriage is to look at the correlation between the husband's and the wife's education. As we are using education levels instead of years of schooling, we calculate Kendall's τ. It was 0.50 in 1990, and by 2005 it has reached 0.58, indicating a sizable increase in assortative marriage (see Table 1).[5]

To examine the assortative marriage pattern in detail, Table 2 reports the

[5] The increase in Kendall's τ was around 6 to 7 percentage points between 1960 and 2000 (Greenwood *et al.*, 2014).

contingency table of educational marriage for China's married couples in 1990 and 2005. The 4X4 table includes all types of combinations of the husband's and wife's education levels, the number in each cell representing the share (denoted in fractions) of each type in the sample of married couples. Take the first two numbers in row one of panel A in Table 2 for example. For 0.8 percent of married households, both husbands and wives have college or above degrees (first row and first column). In around 1.2 percent of the married households, husbands have college or above degrees and wives are high school graduates (first row and second column). Other numbers can be interpreted in the same way.

Several features are worth noting. First, the education levels of Chinese married couples were low in 1990, and husbands were more educated than wives. Only 3 percent of husbands and 1 percent of wives had college or above degrees. Around one half of the husbands had primary school degrees or below, and the share was 70 percent for wives. In 46 percent of the households, both husband and wife had primary school degrees or below.

Second, males and females with similar education levels were more likely to marry each other. Seventy-three percent of females with college degrees married males with the same education level. The numbers are 47 percent, 55 percent, and 66 percent for females educated at the high school, middle school, and primary and below levels respectively. The corresponding shares for males of the four education levels (college and above, high school, middle school, and primary and below) are 27 percent, 30 percent, 34 percent, and 91 percent. The less educated the male, the more likely he is to marry a female of the same education level. Third, males were more likely to marry females with lower education levels, and the opposite is true for females. This is partly determined by tradition, and also partly determined by the fact that males were more educated than females in the population at this time. It is inevitable that males will marry females of lower education levels when the female population of the same education levels is small.

What if the married couples are matched randomly in terms of education levels? Panel B in Table 2 reports the pattern when females (males) of various education levels are randomly assigned to males (females) of different education levels. The share of couples in which both husband and wife have college or above degrees will become negligible, because a small number of college-educated females will be randomly assigned to males and the number of males with college degrees is also small. For similar reasons, the shares of couples with the same education levels become smaller than those in the observed pattern of panel A. This difference suggests a statistic that is also used to measure the extent of assortative marriage: the trace (the sum of the diagonal elements) in the observed data divided by that of the randomly matched table. This trace ratio was 1.444 in 1990.

Education levels increased significantly between 1990 and 2005. By 2005, 8.5

percent of the husbands and 5.8 percent of the wives had college or above degrees, and 4.5 percent of households had both husbands and wives with college or above degrees. For college educated males, 53 percent married females of the same education level, and 78 percent of college educated females married males of the same education levels. For males (females) of the lowest education levels—primary or below—85 percent (55 percent) married females (males) of the same education levels. Compared to the case of 1990, males of different education levels are less likely to marry less educated females, which is probably due to the rapidly increasing education levels of females. There are still relatively large shares of females married to males with higher education levels. Panel D in Table 2 reports the contingency table of the randomly matched couples. The trace ratio reached 1.848 in 2005, higher than that of 1990.

The pattern of assortative marriage differs across regions, and the variation across provinces is large. Table 3 reports Kendall's τ and the trace ratios by province in 1990 and 2005. In 1990, the three municipalities directly administered by the central government, Beijing, Tianjin, and Shanghai, had the highest level of assortative marriage when we consider the trace ratios. Tibet had the lowest level of assortative marriage. When we consider Kendall's τ, a similar pattern emerges. By 2005, assortative marriage increased in all provinces except in Tibet. It remains true that large municipalities had the highest level of assortative marriages and large regional variation remains as well. It is interesting to note this regional variation across cities as it may influence young individuals' location choice when they migrate. We leave this for future research.

4.2 Evidence from the Urban Household Survey

We examine assortative marriage in urban areas using Urban Household Survey data. Income levels, income inequality, and education levels in urban China increased significantly between 1990 and 2009 (see Table 4). Table 5 reports the contingency tables of the actual matching behavior and those under the assumption of random matching for 1990 and 2009. In 1990, college educated males were more likely to be married to females with lower education levels. One quarter of them married females with the same education degrees; 45 percent married females with high school degrees; and 30 percent married females with education levels below middle school (inclusive). For females, however, two thirds married males of the same education levels. Males are more likely to marry females with lower education levels, and the opposite is true for females. In general, people tend to marry to people with similar education levels, thus the trace ratio is above one (1.64). In 2009, both males and females became more likely to marry someone of the opposite gender with the same education level. The degree of assortative marriage increased significantly, with the trace ratio increasing to 1.91 in 2009.

It is worth mentioning that the results of Table 5 are drastically different from those in Table 2. This is mainly because the education level in urban China is significantly higher than the level in rural China. To illustrate this, we use the 1% population survey of 2005 to compare the distribution of couples' education levels in rural and urban China.[6] In results not reported here, we see that couples' education levels are significantly higher in the urban sample in the rural sample. While 13% of the urban couples both had the primary school degrees, the share is 36% for the couples in the rural sample. On the other hand, 9% of the urban couples are both college educated, while the share is merely 0.2% for rural couples.

4.3 Standardizing the contingency table

The fact that males are more likely to be married to females with the same education levels might be due to the fact that females have become more educated. In other words, the changes in the marginal distributions across the contingency tables can distort the comparison of the core patterns of assortative marriage (Greenwood et al., 2014). Will the degree of assortative marriage increase if we hold the education levels of males and females constant? We employ the iterative procedure outlined in Mosteller (1968) to standardize the marginal distributions associated with husband's and wife's education in the contingency table, which allows us to focus on changes in the assortative marriage pattern itself.

First, we rescale the distributions such that the row and column for marginal distributions are uniformly distributed (see also the appendix in Greenwood et al., 2014). The algorithm is an iteration procedure. For example, we want to standardize the contingency table of the 2005 census data. We calculate the marginal distribution for males by summing up the numbers in each row along the columns. We then divide each row through by 4 times its total. The marginal distribution for husbands' education is now (1/4, 1/4, 1/4, 1/4). As pointed out by Mosteller (1968), this process changes the numbers of males of different education levels, but it should not change the nucleus assortative mating pattern. Using the new contingency table, we perform the same exercise for each column along the rows, which changes the relative numbers of females of different education levels but not the assortative marriage pattern. We repeat this process until the resultant marginal distributions associated with rows and columns are (1/4, 1/4, 1/4, 1/4) (Sinkhorn and Knopp, 1967).

The standardized results for the 1990 census data are reported in panel A in Table 6. If both husbands' and wives' education are uniformly distributed and they are still matched according to the 1990 pattern, 61 percent of the married couples will have the same education levels. Both the highly educated and less educated are more likely to marry each other compared to the results in the non-standardized table. Panel C in Table 6 shows the standardized results for 2005 (one percent population survey).

[6] Unfortunately, the variable that indicates rural and urban areas is missing in our 1990 census data, and we cannot generate the matching tables for rural and urban China separately using this dataset.

Compared to the standardized results for 1990, people are more likely to marry someone of the opposite gender with the same education level. Again, we can calculate the trace ratio of these two standardized contingency tables, which is 1.056 (see Table 8), suggesting an increase in assortative marriage.

The same algorithm can also be used to standardize the contingency table so that the marginal distributions resemble some given distributions. Panel B of Table 6 reports the assortative marriage pattern in the 1990 census data, while the marginal distributions of husbands' and wives' education have been standardized to those of 2005. The difference between this standardized contingency table and the non-standardized table for 2005 (panel C in Table 2) reflects the changes in marriage patterns. The trace ratio of the 2005 table to the standardized table for 1990 is 1.059. Similarly, we can standardize the contingency table of 2005 to resemble the marginal distributions of 1990 (panel D) and compare it to the actual contingency table for the 1990 data. The trace ratio is 1.039. These results suggest an increasing rate of assortative marriage in China between 1990 and 2005.

Table 7 reports the standardized contingency tables for urban China in 1990 and 2009. Uniform distribution and marginal distributions in 1990 and 2009 are all considered in the standardization exercises. The results suggest that the degree of assortative marriage increased by over 10 percent, holding education distributions constant.

Exploring the underlying reasons for the increase in positive assortative marriage is challenging. We list several candidate explanations here and leave more concrete analysis for future research. First, as we mention in the introduction, the returns to education increased significantly in our period of study. It becomes more valuable for an educated individual to find a partner with a high degree, which also forces the less educated to marry to individuals of similar education levels. Second, along with urbanization, individuals in cities are more likely to meet potential partners with similar education levels than when they are in rural areas. Third, technological change and institutional arrangements may help reduce the search cost in the marriage market. The last two explanations are consistent with the facts that urban China, in particular large cities like Beijing and Shanghai, has a higher degree of positive assortative marriage.

5. Assortative marriage and income inequality

Next, we turn to the question of how marital sorting affects household income inequality. First, income statistics for married households by educational class are presented.

5.1 Household income of different types of households

China's income inequality increased significantly in the last two decades (see Figure 1 for the Lorenz curves for the income distributions of urban China in 1990 and 2009). The impact of assortative marriage on income inequality depends on the income of households relative to the average income across all households. The average incomes of different households relative to the mean income across all households are reported in Table 9. In 2005, the average income of a household in which both husband and wife have a college education was three times that of the mean income across all households. If a college educated male is married to a female with a middle school degree, their household income will only be 40 percent higher than the mean. For a female of the lowest education level, her household income will be only 54 percent of the mean if she marries a male of the same education level, but the household income will be 7 percent higher than the mean if she marries a college educated male (see panel A in Table 9).

Using the UHS data, we find that marriage patterns have become important in determining a household's income. In 1990, a college educated male married to a college educated female had a household income 1.2 times that of the average. If he was married to a female with primary school degree, his household income was 92 percent of the average. For households in which both husband and wife have a primary school degree, their household income is 82 percent of the mean. The income differences between households of different types increase in 2009. In 2009, a college educated male married to a college educated female had a household income 1.5 times that of the average. If he married a female with a primary school degree, their household income was 85 percent of the average. For households in which both husband and wife have a primary school degree, their household income is 52 percent of the mean (see panels C and E in Table 9). We admit that composition change might cause the changes in relative incomes for various groups. In particular, the increased relative income for the *college or above* category might be caused by composition change within that cell, that is, there are more post-graduates in that category in 2009. On the other hand, the relative income for less educated couples may be underestimated, as there are fewer illiterate people in recent years. We do not address this issue in this paper. However, even for the more homogenous groups, the middle school and high school graduates, their income gap also increased.

Table 9 also reports the share of the wife's income in total household labor income. Females with more education contributed larger shares of income to total household labor income than less educated females. In urban areas, the share of the wife's income in total household income decreased significantly, especially for households with more educated husbands. There are two potential reasons for this phenomenon. First, the female labor participation rate declined more than that of males. Second, the gender income gap has increased significantly in China since the institution of economic reform (Gustafsson and Li, 2000).

5.2 Assortative versus random matching

What would the income distribution be like if assortative marriage did not exist or if the matching were random? We use the method in Greenwood *et al*. (2014) to construct counterfactual Lorenz curves and Gini coefficients.

Some notations are needed to describe such experiments. Let *i* denote the type of household defined by marital status, education levels of both husband and wife, and female work status; let *j* denote income percentile. Let f_{ij} represent the share of *i*th type households in income percentile *j*, and r_{ij} denote the income of such households relative to mean household income. The share of aggregated income that percentile *j* accounts for, s_j, is given by $s_j=\Sigma_i f_{ij}r_{ij}$. The cumulative share of income at percentile *p*, l_p , is thus given by $l_p = \sum_j^p s_j = \sum_j^p \sum_i f_{ij} r_{ij}$. Percentile *p* can be calculated as $p = \sum_j^p \sum_i f_{ij}$. The Lorenz curve plots l_p against *p*. The Gini coefficient, *g*, is twice the area between the Lorenz curve and the 45^o line. If *p* is continuous, the Gini coefficient can be expressed as $g = 2\int_0^1 | l_s - s | ds$, where $0 \le g \le 1$. A higher value for *g* implies a greater degree of income inequality. The Gini coefficient and Lorenz curve are clearly functions of f_{ij} and r_{ij}, for all *i* and *j*, and we can represent them with Lorenz($\{f_{ij}\}$,$\{ r_{ij}\}$) and Gini($\{f_{ij}\}$,$\{ r_{ij}\}$). In other words, the income distribution is a function of shares of each household type and the income share of each household type.

To assess the impact of assortative marriage on income inequality, we ask the following question: What would have happened to the income distribution if matching were random instead of assortative? To answer this question, we conduct an experiment to replace the observed pattern of matching for married couples with the pattern that would occur if matching were random. That is, we replace $\left\{ f_{ij} \right\}_{\mathrm{M}}$, observed in the data, with $\left\{ \tilde{f}_{ij} \right\}_{\mathrm{M}}$, the pattern that would occur if the matching were random. We let **M** represent the sets of married couples and **S** represent the set of singles. The counterfactual Lorenz curve and Gini coefficient are given by Lorenz($\left\{ f'_{ij} \right\}, \left\{ r_{ij} \right\}$) and Gini($\left\{ f'_{ij} \right\}, \left\{ r_{ij} \right\}$), where $\left\{ f'_{ij} \right\} \equiv \left\{ \tilde{f}_{ij} \right\}_{\mathrm{M}} \cup \left\{ f_{ij} \right\}_{\mathrm{S}}$.

The results of the counterfactual experiments are reported in Table 10. In 1990, moving from the actual marriage pattern to random marriage barely changes the Gini coefficient of urban China (from 0.188 to 0.184). In 2009, however, random matching reduced the Gini coefficient by 2 percentage points (from 0.337 to 0.316). As for the whole of China, we only have data for 2005, and the exercise shows that if the

matching were random, Gini coefficient would decrease by over three percentage points. Assortative marriage plays an increasingly important role in shaping income inequality.

If wives do not work or earn much less, the effect of assortative marriage on income inequality would be small. Figure 2 shows that the shares of income in the household income contributed by wives decreased in most income percentiles between 1990 and 2009 in urban China. Figure 3 shows that the married female labor participation (MFLP) rate in all percentiles declined in the same period. What would happen to the experiment results if the MFLP had not changed since the 1990s? The counterfactual results are also reported in Table 10. For urban China in 2009, the Gini coefficient would become 0.315 under random matching and the MFLP of 2009, slightly lower than the Gini coefficient with the actual MFLP of 2009. For the whole of China in 2005, assuming that the MFLP of 1990 produces a smaller Gini coefficient of 0.468 in the random matching experiment, the lower MFLP actually makes the income distribution a little worse.

5.3 Marriage pattern, education expansion, and return to education: decomposition analysis

Next, we ask what income inequality would be if couples in 2009 (urban China) or in 2005 (whole China) got married according to the marriage pattern of 1990. We have shown that not only has the marriage pattern changed, but the marginal distribution of education levels and MFLP have also changed. To separate the effect of marriage pattern, we use the 1990 standardized contingency table to calculate counterfactual income inequality. In 2005, if couples got married according to the marriage pattern of 1990 (education levels being kept constant at the 2005 level), the Gini coefficient would be 0.506, slightly less than the one from the actual data. For urban China in 2009, if couples got married according to the marriage pattern of 1990 (education levels being kept constant at the 2009 level), the Gini coefficient would also change slightly from that observed in the data. Changes in MFLP have little impact on the results. These results suggest that the changes in marriage patterns have contributed little to income inequality. It is the changes in other aspects (particularly the increase in the return to education) that have made assortative marriage important in determining income inequality.

As mentioned, the Gini coefficient and Lorenz curve are functions of the f_{ij}s and r_{ij}s. Our experiment is conducted in the spirit of the decomposition method proposed by DiNardo, Fortin, and Lemieux (1996, hereafter DFL). The r_{ij}s reflects the return to education and f_{ij}s reflects the distribution of education, determined by the marginal distribution of couples' educations and the marriage pattern. The standardized contingency table is the counterfactual distribution when the marriage pattern is kept constant and the marginal distribution of education is changed. Thus, we can decompose the changes in income inequality based on change in the returns to

education, education expansion, and change of marriage pattern.

In Table 11, we calculate a series of Gini coefficients for the actual and counterfactual income distributions in urban households. The statistics in different rows correspond to different compositions in terms of the marginal distributions of couples' education levels and their assortative marriage patterns. In rows 1 and 2, we present marginal distributions of couples' education levels and marriage patterns in 1990 (row one) and 2009 (row two). In row three, while the marginal distributions of education are adjusted to resemble those of 2009, the 1990 marriage patterns are retained. In row four, the composition is a combination of the marginal distribution of education levels in 1990 and the marriage pattern in 2009. We apply the returns to education in 1990 and 2009 to different compositions to get income inequalities. In column one, all Gini coefficients are calculated using the returns to education in 1990, and in column two, the Gini coefficients are calculated using the returns to education in 2009. Therefore, the numbers in row 1, column 1 and in row 2, column 2 are the income inequalities observed directly from the data. All other numbers are counterfactual income inequalities, which are used to calculate the contributions of the composition change and the changes in the returns to education. The changes in the Gini coefficients across columns in a given row are caused by changes in returns to education (price effect), and changes across different rows in a given column are due to composition changes.

Comparing the Gini coefficients between columns 1 and 2 suggests that the increase in the returns to education played a major role in driving up the income inequality of urban households between 1990 and 2009. In row one, when we keep the composition at the 1990 level, the Gini coefficients increase from 0.188 to 0.285 due to the price effect. When we keep the composition at the 2009 level, the increase in income inequality caused by the increase in the returns to education is even higher (from 0.191 to 0.337). Rows 3 and 4 show a similar pattern. Differences across rows suggest that the composition effect depends on returns to education. When returns to education are low, as in 1990, composition changes (either changes in education levels or changes in assortative marriage) only alter the Gini coefficients slightly. However, when returns to education are kept at the 2009 level the composition change influences the Gini coefficients to a larger extent. When we change both the education levels and the marriage pattern from 1990 (row one) to 2009 (row two), the Gini coefficients increase from 0.285 to 0.337. The numbers in rows 3 and 4 help us further decompose the composition effects into two parts: education expansion effect and marriage pattern effect. The difference between the numbers in rows 1 and 4 is due to the change in marriage patterns, with education levels being kept constant at the 1990 level. The result suggests that the composition effect caused by marriage pattern is small. Most of the composition effects come from changes in education levels, as suggested by the difference between the numbers in rows 2 and 4 (or in rows 1 and 3) when we keep the marriage pattern constant and let the education level change.

Finally, note that the decomposition method we use here is one of many possible methods. One well-known alternative approach is the DFL decomposition method. We also use it to conduct a decomposition, and the results are similar, although not reported here.

6. Discussions and concluding remarks

In the last three decades, China has made huge progress in human capital development. The educational assortative pattern in marriages has important implications, not only for the well-being of individual households, but also for the structure of the whole society. In this paper, we document the assortative marriage pattern and its evolution since 1990. Our results indicate that the extent of positive assortative marriage has increased significantly since 1990. Although education expansion, especially the increased education levels of females, has played an important role, positive assortative marriage would become more prevalent even without education expansion.

To assess the impact of assortative marriage on income inequality, we run several experiments to calculate counterfactual inequalities. In one experiment, we replace the actual assortative marriage by random marriage, which reduces the Gini coefficient of household income by 2-3 points. Other experiments suggest that the changing pattern in assortative marriage alone explains little of the actual change in income inequality in urban China. The increased returns to education explain the major part of the increase in household income inequality. Education expansion also plays an important role, but its impact is relatively small. Our results suggest that, in an economy with higher returns to education, assortative marriage tends to have a larger impact on household income inequality.

Our findings also shed light on possible reform of China's income taxation system in the future, especially when the system is changed to be family rather than individual based. Frankel (2014) shows that the "negative jointness" of marginal tax rates for couples with uncorrelated earnings should be attenuated in the presence of assortative mating. The fact that marriages are increasingly positively assortative implies a lower "negative jointness" for the tax rates applied to couples if China's taxation system transforms into a family based system.

Compliance with Ethical Standards:

Conflict of Interest: The authors declare that they have no conflict of interest.

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Table 1 Summary statistics for the 1990 census and 2005 one percent population survey

Year	Kendall's tau	Trace ratio: raw/random	Labor Participation of Wives	Gini Coefficient	Monthly income
1990	0.500	1.444	0.845		
2005	0.580	1.848	0.744	0.508	580.60

Table 2 The actual and counterfactual random marital patterns of China in 1990 and 2005

Husband	Wife			
1990	College+	High school	Middle school	Primary and below
	Panel A: Raw data			
College+	0.008	0.012	0.007	0.003
High school	0.002	0.042	0.046	0.048
Middle school	0.001	0.028	0.110	0.182
Primary and below	0.000	0.007	0.037	0.464
	Panel B: Random matching			
College+	0.000	0.003	0.006	0.021
High schl	0.002	0.012	0.028	0.096
Middle school	0.004	0.029	0.065	0.225
Primary and below	0.006	0.046	0.102	0.355
	College+	High school	Middle school	Primary and below
2005	Panel C: Raw data			
College+	0.045	0.025	0.012	0.003
High school	0.010	0.057	0.065	0.030
Middle school	0.003	0.031	0.254	0.171
Primary and below	0.000	0.005	0.039	0.248
	Panel D: Random matching			
College+	0.005	0.010	0.032	0.039
High school	0.010	0.019	0.060	0.073
Middle school	0.027	0.055	0.171	0.208
Primary and below	0.017	0.035	0.108	0.132

Table 3 The marriage pattern (1990 and 2005) and income inequality (2005), by province

	1990		2005			
Province	Kendall's τ	Trace ratio	Kendall's τ	Trace ratio	Gini	Monthly income
Beijing	0.585	2.034	0.629	2.065	0.454	1261.725
Tianjin	0.527	1.762	0.593	1.946	0.335	825.284
Hebei	0.439	1.416	0.493	1.661	0.404	469.045
Shanxi	0.484	1.514	0.560	1.708	0.398	493.792
Inner Mongolia	0.503	1.547	0.571	1.935	0.408	609.061
Liaoning	0.512	1.745	0.585	1.789	0.416	525.800
Jilin	0.549	1.718	0.631	2.000	0.364	453.717
Heilongjiang	0.521	1.701	0.607	1.909	0.369	467.003
Shanghai	0.554	1.848	0.630	2.029	0.428	1229.926
Jiangsu	0.454	1.376	0.541	1.730	0.399	772.152
Zhejiang	0.505	1.356	0.536	1.650	0.400	958.233
Anhui	0.449	1.243	0.525	1.620	0.387	458.140
Fujian	0.431	1.220	0.510	1.558	0.403	689.701
Jiangxi	0.452	1.267	0.542	1.639	0.363	483.051
Shandong	0.457	1.374	0.501	1.641	0.382	548.946
Henan	0.453	1.426	0.540	1.656	0.412	350.899
Hubei	0.514	1.507	0.537	1.725	0.380	456.589
Hunan	0.508	1.411	0.550	1.752	0.399	482.312
Guangdong	0.462	1.388	0.554	1.803	0.502	823.596
Guangxi	0.479	1.397	0.531	1.732	0.413	418.603
Hainan	0.443	1.469	0.515	1.645	0.435	506.920
Chongqing			0.572	1.724	0.431	434.713
Sichuan	0.462	1.267	0.552	1.607	0.416	394.133
Guizhou	0.406	1.148	0.527	1.440	0.445	381.927
Yunnan	0.500	1.226	0.496	1.348	0.497	354.995
Tibet	0.397	1.031	0.328	1.028	0.544	278.292
Shaanxi	0.525	1.531	0.575	1.822	0.438	378.608
Gansu	0.486	1.263	0.559	1.657	0.464	385.592
Qinghai	0.515	1.305	0.633	1.798	0.499	454.306
Ningxia	0.500	1.319	0.612	1.968	0.419	540.648
Xinjiang	0.532	1.562	0.602	2.003	0.460	544.144

Table 4 Summary statistics for urban household survey data, 1990 and 2009

	1990	2009
Average household income (current Yuan)	2,441	25,895
Gini coefficient	0.188	0.337
Kendall's τ between husband and wife's education	0.430	0.562
Labor participation rate of women	0.967	0.923

Table 5 The actual marriage patterns and the counterfactual random marital matching in urban China, 1990 and 2009

Husband	Wife			
1990	College+	High school	Middle school	Primary and below
	Panel A: Raw data			
College+	0.050	0.089	0.045	0.014
High school	0.020	0.164	0.119	0.042
Middle school	0.006	0.072	0.189	0.088
Primary and below	0.000	0.009	0.028	0.066
	Panel B: Random matching			
College+	0.015	0.066	0.076	0.042
High schl	0.026	0.115	0.131	0.072
Middle school	0.027	0.118	0.135	0.074
Primary and below	0.008	0.034	0.039	0.021
Trace ratio	1.635			
	College+	High school	Middle school	Primary and below
2009	Panel C: Raw data			
College+	0.224	0.112	0.034	0.003
High school	0.049	0.184	0.089	0.011
Middle school	0.011	0.063	0.163	0.023
Primary and below	0.000	0.004	0.012	0.016
	Panel D: Random matching			
College+	0.107	0.135	0.111	0.020
High school	0.095	0.121	0.100	0.018
Middle school	0.074	0.095	0.078	0.014
Primary and below	0.009	0.011	0.009	0.002
Trace ratio	1.913			

Table 6 Standardized contingency table of marriage patterns of China, 1990 and 2005

Husband's education	Wife's education			
1990	College+	High school	Middle school	Primary and below
	Panel A: husband and wife's education follows uniform distribution			
College+	0.189	0.046	0.013	0.002
High school	0.044	0.122	0.066	0.019
Middle school	0.015	0.062	0.119	0.054
Primary and below	0.002	0.020	0.052	0.176
	Panel B: husband and wife's education follows marginal distribution of 2005			
College+	0.044	0.021	0.017	0.003
High school	0.009	0.048	0.073	0.033
Middle school	0.005	0.044	0.237	0.174
Primary and below	0.000	0.006	0.044	0.242
	College+	High school	Middle school	Primary and below
2005	Panel C: husband and wife's education follows uniform distribution			
College+	0.188	0.052	0.009	0.001
High school	0.049	0.133	0.053	0.014
Middle school	0.010	0.048	0.138	0.053
Primary and below	0.002	0.017	0.050	0.181
	Panel D: husband and wife's education follows marginal distribution of 1990			
College+	0.008	0.014	0.005	0.003
High school	0.003	0.050	0.042	0.043
Middle school	0.001	0.020	0.120	0.181
Primary and below	0.000	0.005	0.034	0.470

Table 7 Standardized contingency table of marriage patterns in urban China, 1990 and 2009

Husband	Wife			
1990	College+	High school	Middle school	Primary and below
	Panel A: husband and wife's education follows uniform distribution			
College+	0.160	0.060	0.022	0.008
High school	0.062	0.107	0.057	0.023
Middle school	0.023	0.057	0.111	0.059
Primary and below	0.005	0.026	0.059	0.161
	Panel B: husband and wife's education follows marginal distribution of 2009			
College+	0.204	0.118	0.046	0.005
High school	0.062	0.166	0.093	0.012
Middle school	0.018	0.072	0.146	0.025
Primary and below	0.001	0.006	0.014	0.012
	College+	High school	Middle school	Primary and below
2009	Panel C: husband and wife's education follows uniform distribution			
College+	0.178	0.054	0.015	0.004
High school	0.055	0.124	0.054	0.018
Middle school	0.016	0.056	0.130	0.049
Primary and below	0.002	0.017	0.052	0.180
	Panel D: husband and wife's education follows marginal distribution of 1990			
College+	0.058	0.093	0.038	0.010
High school	0.015	0.176	0.114	0.040
Middle school	0.003	0.060	0.208	0.082
Primary and below	0.000	0.005	0.021	0.077

Table 8 The increase in assortative marriage measured as the trace ratio

Trace ratio	
A: census data	
2005 standardized (uniform) / 1990 standardized (uniform)	1.056
2005 standardized (1990 marginal distribution) / 1990 data	1.039
2005 data/ 1990 standardized (2005 marginal distribution)	1.058
B: UHS data	
2009 standardized (uniform) / 1990 standardized (uniform)	1.133
2009 standardized (1990 marginal distribution) / 1990 data	1.108
2009 data / 1990 standardized (2009 marginal distribution)	1.113

Table 9 Marital income by education

Husband's education	Wife's education			
2005 Census	College+	High school	Middle school	Primary and below
	Panel A: Household income relative to mean income across all			
College+	2.982	2.003	1.371	1.066
High school	1.951	1.351	1.014	0.765
Middle school	1.476	1.019	0.846	0.662
Primary and below	1.198	0.763	0.715	0.538
	Panel B: The share of wife's income in total household labor income			
College+	0.428	0.305	0.201	0.170
High school	0.484	0.355	0.285	0.284
Middle school	0.513	0.358	0.318	0.328
Primary and below	0.555	0.368	0.336	0.349
1990 UHS	College+	High school	Middle school	Primary and below
	Panel C: Household income relative to mean income across all			
College+	1.203	1.111	1.063	0.924
High school	1.135	1.013	1.009	0.918
Middle school	1.072	1.032	0.980	0.884
Primary and below	1.056	0.986	0.956	0.822
	Panel D: The share of wife's income in total household labor income			
College+	0.484	0.464	0.428	0.289
High school	0.488	0.463	0.426	0.342
Middle school	0.495	0.464	0.433	0.364
Primary and below	0.531	0.454	0.424	0.358
2009 UHS	College+	High school	Middle school	Primary and below
	Panel E: Household income relative to mean income across all households			
College+	1.487	1.155	1.011	0.851
High school	1.125	0.904	0.749	0.659
Middle school	1.020	0.762	0.688	0.590
Primary and below	1.081	0.666	0.608	0.522
	Panel F: The share of wife's income in total household labor income			
College+	0.428	0.336	0.295	0.211
High school	0.469	0.397	0.332	0.293
Middle school	0.495	0.421	0.374	0.340
Primary and below	0.581	0.457	0.366	0.334

Table 10 Income inequality in the data and experiments

	1990	2009	2005
Data	0.188	0.337	0.508
Random matching	0.184	0.316	0.476
Random matching + 2009 MFLP	0.188		
Random matching + 1990 MFLP		0.315	0.468
Standardized table	0.189	0.334	0.506
Standardized table +2009 MFLP	0.193		
Standardized table +1990 MFLP		0.334	0.507

Table 11 Income inequality in the experiments

Composition of marriage and education	Return to education	
	1990	2009
1. Education distribution of 1990 & assortative marriage of 1990	0.188	0.285
2. Education distribution of 2009 & assortative marriage of 2009	0.191	0.337
3. Education distribution of 2009 & assortative marriage of 1990	0.190	0.334
4. Education distribution of 1990 & assortative marriage of 2009	0.189	0.287

Note: In row one, the marginal distributions of couples' education are as in 1990 and the assortative marriage pattern is like 1990; in row two, the marginal distributions of education and the assortative marriage pattern is like 1990; in row three, the marginal distributions of couples' education are as in 2009 and the assortative marriage pattern is like 1990; in row four, the marginal distributions of couples' education are as in 1990 and the assortative marriage pattern is like 2009.

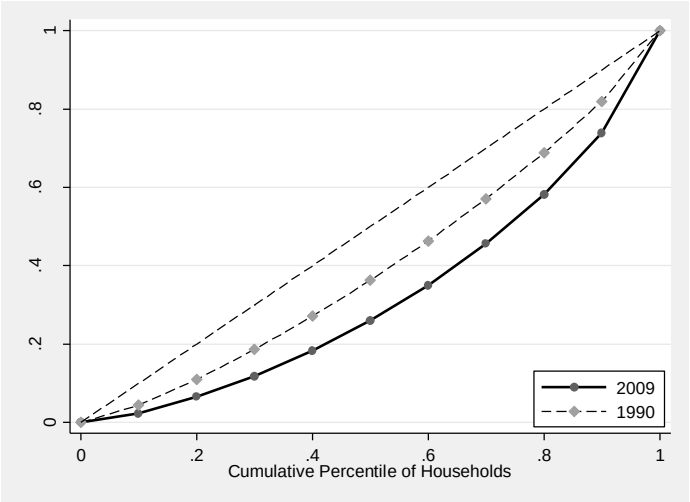

Figure 1 Lorenz curves for household income, 1990 and 2009

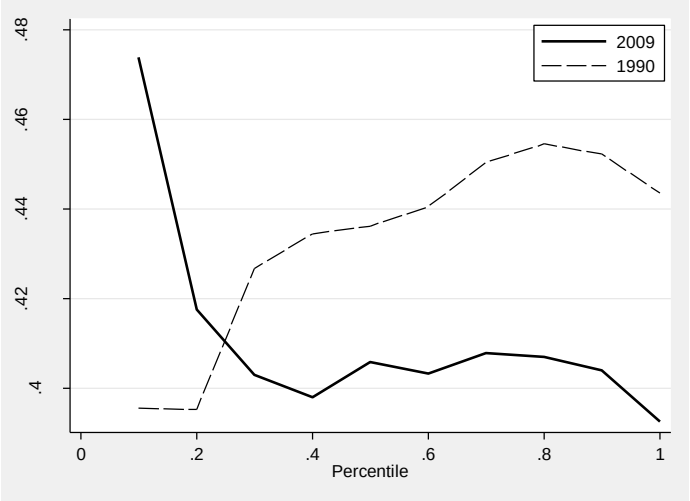

Figure 2 Contribution of wife's income to the household's total labor income

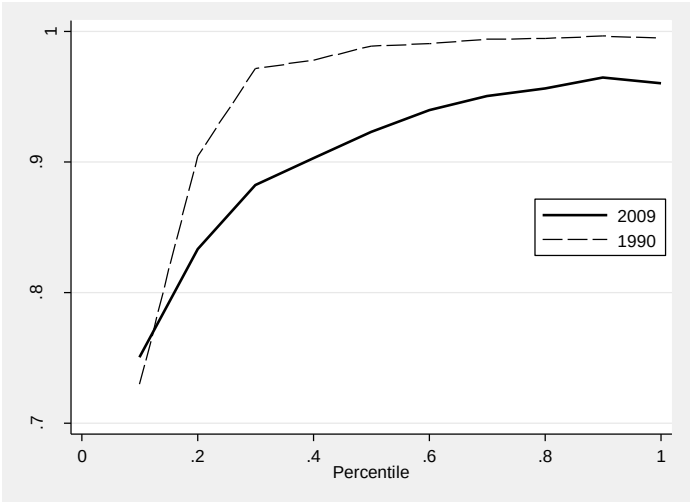

Figure 3 Married female labor participation (MFLP) rate in urban China, 1990 and 2009