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Estimating the Returns to Education Using a Sample of Twins - The case of Japan -

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Estimating the Returns to Education Using a Sample of Twins - The case of Japan -[1]

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Abstract

The objective of this paper is to measure the causal effect of education on earnings using a sample of twins in Japan, with information collected through a web-based survey. The empirical results show that although the conventional OLS estimate is 10.0%, we obtain 9.3% as the estimated rate of return to education after the omitted ability bias and measurement errors in self-reported schooling were corrected. Our findings suggest that the conventional OLS estimate is not largely contaminated by potential biases.

Keywords: Identical twins, Endogeneity, Economic return to education, Measurement error
JEL classification codes: I21; J30

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Introduction

Economists have long sought unbiased estimates of the rate of return to education since a series of Jacob Mincer's prominent works were released (e.g., Mincer 1974), but it is not considered a simple task to accomplish even today. There is a methodological issue that researchers must address: the causal inference between earnings and education. Regarding the conventional estimate of the rate of return to education, one must consider the possibility that the results may be affected by the problem of omitted variables, such as unobserved differences in ability and family characteristics. It is well known that this omitted variable bias leads the OLS estimates to be biased and inconsistent.

An innovative way economists have attempted to deal with aforementioned potential bias is to use a sample of identical twins and look at the differences in earnings and education between twin pairs. Identical twins (monozygotic twins; hereafter, MZ twins) are produced in the same pregnancy, when a single zygote splits up to result in two separate embryos by chance. The two are genetically identical, which hence enables us to hypothesize that a pair of MZ twin share the same innate abilities. In addition to genetic endowments, they also share the same family and neighborhood environments. The objective of using a sample of MZ twins is to control for unobserved ability and family characteristics that influence the incentives for educational investments and reduce the possibility of omitted variable bias from unobserved heterogeneity, which is often referred to as ability bias in literature[3].

The advantages of using a sample of twins include not only isolation of the effects of education of earnings, holding differences in ability and family endowments constant, but also the ability to compare MZ twins with non-identical twins (dizygotic twins; hereafter, DZ twins). Because DZ twins are produced when two eggs are fertilized to form two embryos in the uterus at the same time, DZ twins are not genetically identical. Rather, they are regarded as ordinary siblings of the same age. This setting enables us to measure the extent of the effect of unobserved ability in the estimated rate of return to education through the comparison of MZ and DZ twins.

Pioneering literature in this field of study is Ashenfeller & Krueger (1994) and subsequent works, such as Ashenfeller & Rouse (1998) & Rouse (1999).

[3] It is important to remind that "ability bias" here is caused not only by genetic endowments but also by family characteristics that may be correlated with determinants of the optimal level of schooling. Ashenfeller & Rouse (1998) defined an omitted ability as "unobserved family components" (p. 256), which are a disproportional combination of inherited ability, family environments, and other unobserved skills.

They estimated the rate of return to education using data from a survey collected at the annual Twinsburg Twins Festival in Ohio—the so-called Princeton Twins Survey. According to their empirical results drawn from this survey, the conventional OLS estimate is upward biased, but after correction for the measurement errors in self-reported schooling, it is not considerably different from the bias-corrected estimate. Research using other twin surveys in the U.S. also yields the similar outcomes (e.g., Behrman, Rosenzweig & Taubman 1994; Behrman & Rosenzweig 1999), as does research in other western countries, such as Australia (Millar, Mulvey & Martin 1995), Sweden (Isacsson 1999; 2004), the UK (Bonjour et al 2003), and Denmark (Bingley 2005). As the comprehensive survey by Card (1999) concluded, economists almost reached a consensus that the conventional estimate of the rate of return to education imparts only a small upward or downward bias. Previous literature is summarized in Table 1, which extends the review in Card (1999), Bingley et al (2005) and Li et al (2011).

Light has recently been shed on the use of twins in studying the economic return to schooling by Li et al (2011), who use a sample of twins collected in major urban areas of China. Their findings are that within-twin estimates of return to education are significantly lower than the corresponding OLS estimates. Contrary to the case in western countries, ability bias is large in China. They argue that the low rate of return in China is in part due to the competitive and exam-oriented education system. Because schools have placed more emphasis on sending their students to a higher ranking high school or college than on teaching skills and knowledge highly valued or remunerated in the labor market later on students' lives, the return to educational investments is quite low.

Li et al (2011) also mention in their article that education systems in East Asian countries, including Japan, are very similar to that in China, particularly in terms of the presence of selective entrance exams to enter high schools or colleges. In fact, the Japanese education system is often called "examination hell" (Ono 2004, p. 597), meaning that students in middle or high schools must exert their very best efforts to pass entrance examinations in which applicants are screened through performance in paper-based tests. As a result, cram schools, tutoring, and distance learning have proliferated in Japan: according to Benesse Educational Research and Development Center (2009), approximately 50% of middle school and 20% of high school students were engaged in such educational activities outside of school to prepare for upcoming entrance examinations. Children's access to the education outside of school may be heavily reliant on unobserved family components, such as household expenditures on education or enthusiasm for education across families. Considering this educational setting

in Japan, it is possible that, as Li et al (2011) allude, the rate of return to education in Japan is low (in a manner similar to the case of China) after controlling for potential biases.

There are a large number of studies on the labor market return to education in Japan (Hashimoto & Raisian 1985; Tachibanaki 1988; Yano & Shima 2000; Trostel et al 2002); however, few have yet addressed ability bias. The exceptions are Ono (2004) and Sano & Yasui (2009): Ono (2004) and Sano & Yasui (2009) control for academic records in G9 as a proxy of innate ability, while Sano & Yasui (2009) control for parental education and standard of living at home at the age of 15 as proxies of family characteristics as well. The main finding of Sano & Yasui (2009) is that the rate of return to education in base-line model with education, tenure, tenure squared, and gender as the independent variables is 9.04%, but it is reduced to 4.98% after controlling for ability and family characteristics. It clearly suggests that omitted ability bias in Japan is significant. However, to our best knowledge, no studies address the causal question of how education affects earnings or show the estimated rate of return to education using a sample of twins in Japan.

This brings us the main questions of interest: what is the estimated rate of return to education in Japan after controlling for potential biases through a comparison between twins? And also, how large is ability bias in the estimation? Our goal in this article is thus to measure the causal effect of education on earnings using a sample of twins, which may be the largest dataset of twins complied nationwide in Japan. Moreover, our dataset conveys wide-ranging socioeconomic information.

Estimating the rigorous rate of return to education deserves more attention. Both the Government of Japan and households have placed a greater emphasis on educational investments in recent years. More specifically, the Democratic Party of Japan, the administration party, has advocated an increase in public spending on education in its policy agendas (referred to as manifestos); indeed, it increased the same by 9.0% during the period between the 2009 and 2012 fiscal budgets. According to the Ministry of Education, Culture, Sports, Science and Technology (2012), household expenditures for every level of education have been significant and counter-cyclical over the past decade, although millions of households in Japan suffered significantly from the global economic downturn, such as in the wake of Lehman's fall, during the same period of time. Such findings open up the question of whether it is true or not that these intensive investments in education bring a higher return than alternative investments. Japan presents a very intriguing context to explore this question.

Our empirical results show that the conventional OLS estimate is 10.0%. Once we account for omitted ability bias, the estimated rate of return is dramatically reduced to 4.5%. The within-twin pair estimate has indeed biased the conventional OLS estimate upward. Then, we corrected the measurement errors using the instrumental variable method and obtained 9.3% as the estimated rate of return to education, suggesting that measurement errors have biased within-twin pair estimates downward. Taken as a whole, the bias-corrected estimate is very close to the conventional estimate, which leads us to conclude the conventional OLS estimate is not largely contaminated by potential biases. The Japanese education system is very similar to that in China, but, paradoxically, the rate of return to education in Japan is, in fact, relatively high.

The rest of this article is organized as follows: the next section introduces the empirical models to be estimated. The third and fourth sections introduce data collection strategies and variables defined for empirical analyses. The fifth section presents the empirical results and identifies the key empirical issues emerging in the econometric analysis. The final section provides conclusions.

Analytical Framework

Our empirical work basically follows that of Ashenfelter & Rouse (1998). We outline a simple Mincerian equation model that is expressed in the following mathematical equation, where the wage (W) of a twin i (i=1,2) in a family j is a function of years of schooling (S) and unobserved ability (A) in combination with other characteristics shared by both twins (X), such as parental education, those that vary between twins (Z), such as marital status, and random disturbance with mean zero and constant variance (e).

$$\mathrm{W}_{1j} = A_j + \alpha S_{1j} + X_j\beta + Z_{1j}\delta + e_{1j} \qquad (1)$$

$$\mathrm{W}_{2j} = A_j + \alpha S_{2j} + X_j\beta + Z_{2j}\delta + e_{2j} \qquad (2)$$

There are two approaches to obtain unbiased estimates of return to education. In the first approach, we assume that A is correlated with a mean of twin's years of schooling, because we can generally see that family-level endowments, such as the marginal cost to schooling, create a difference in schooling across families. Therefore, we may mathematically express A as follows:

$$A_j = \theta[\frac{S_{1j}+S_{2j}}{2}] + v_j \qquad (3)$$

We also assume that A is not correlated with X and Z, which are other individual-level characteristics. We then follow Ashenfelter & Rouse (1998)'s protocol and substitute (3) into (1) and (2), which gives reduced form correlated random effects. This equation is estimated by GLS.

$$\mathrm{W}_{1j} = \theta(S_{1j} + S_{2j}) + \alpha S_{1j} + X_j\beta + Z_{1j}\delta + e_{1j} + v_j \qquad (4)$$

$$\mathrm{W}_{2j} = \theta(S_{1j} + S_{2j}) + \alpha S_{2j} + X_j\beta + Z_{2j}\delta + e_{2j} + v_j \qquad (5)$$

The idea behind this procedure is to directly estimate the effect of family-level endowments in an estimated rate of return to education. Moving on to the second approach, we take a first difference of (4) and (5) and obtain a within-twin fixed effects estimate of α.

$$(\mathrm{W}_{1j} - \mathrm{W}_{2j}) = \alpha(S_{1j} - S_{1j}) + (Z_{1j} - Z_{2j})\delta + (e_{1j} - e_{2j}) \qquad (6)$$

Obviously, both A and X are eliminated from the equation, reliving us of the concern that the earnings are partly explained by individual unobserved characteristics.

Data Collection Strategy

The data used for our empirical analysis was collected through a web-based survey in Japan between the months of February and March 2012. We conducted the survey through Rakuten Research, which is affiliated with Rakuten, a major Internet shopping site (similar to Amazon.com or eBay, for example), and monitors over 2.2 million people. In order to analyze the effect of education on earnings, our sample targeted twins who are non-students between the ages of 20 and 60. Through this web-based survey, one member of a twin pair is responsible for reporting regarding him/herself and his/her twin sibling at one time, and the results are designed differently from those of the other twin survey filled out by both members of the twin pair.

Once the monitor(s) filled out the questionnaires, they would be given a certain amounts of cash-equivalent "points" that could be spent on Rakuten. In order to exclude "fake" twins, who pretend to be twins to collect the cash-equivalent points, we carefully developed the following data collection strategy: we did not inform respondents that the purpose of our survey was to collect data from twins. Furthermore, we started with five questions on family and siblings that were *not* related to twin status and then, at the sixth question, for the first time, asked whether or not a respondent was a twin. If the respondent answered "No" in this question, s/he would be automatically excluded from the survey. We discovered 23 twin pairs, each member of which was included in this survey, then thoroughly checked the responses of both twins, and eliminated one of twins randomly from our sample.

Web-monitoring surveys, which have been making huge strides in Japan, necessarily entail sampling bias (Couper 2000), however. Such surveys tend to draw on highly educated individuals who are computer-savvy and affluent enough to afford various forms of computing equipment. Nevertheless, this may be one of the best possible options where random sampling is nearly impossible to draw data from twins over 16 years old due to lack of information on maiden names in the current resident registration system in place.

On the plus side regarding the web-based survey, we were able to draw data from a large number of samples nationwide, while previous studies captured only a particular demographic segment of the population (for example, Behrman et al 1994), making it difficult to represent and generalize the country's entire twin population. Another advantage of a web-based survey is that there is no concern regarding data attrition, while previous literature dealt with a large numbers of missing values in a key variable, such as earnings, through imputation (for example, Miller, et al 1995).

Our web-based survey overcame the disadvantages of the data collection in previous literature. As shown in Table 2, we collected 2,360 complete pairs of twins (4,720 individuals): 1,371 MZ twin pairs (2,742 individuals), 882 DZ twin pairs (1,764 individuals), and 107 twin pairs (214 individuals) who did not know whether they were monozygotic or dizygotic. To the best of our knowledge, this is the first and the largest database of twins complied in Japan nationwide, and it conveys a wide range of socioeconomic information. Furthermore, according to Rakuten Research, approximately 0.7% of its monitored subjects are twins, which is consistent with the fact that the general probability of MZ twins being born is approximately 0.8% (Ando, 2011). It is also worth mentioning that the proportion of MZ twins in our sample is consistent with existing representative

sample of twins in previous literature, such as Li et al (2011).

The questionnaires were designed with reference to the Princeton Twins Survey and Employment Status Survey (Ministry of Internal Affairs and Communications in Japan), although we added several questions. In particular, we carefully developed the questions on respondents' educational backgrounds. This is because, as Li et al (2011) point out, a cross reported response within twins on the *level* of education is more accurate than a response on the *years* of education, and there may be substantial amounts of institutional misreporting. To avoid this possibility, in our question, we listed every type and level of educational institution (26 categories, including "don't know"), and then asked respondents to select the highest degree earned. The choice "dropout or stopped" for each type and level of institution was inserted between the questions on each type and level of institution in order to disentangle cases of leaving school without a diploma (See data appendix for details). We also asked whether or not a respondent experienced a "*Ronin*" year (for students who failed an entrance examination and are preparing for the exam next year), and whether or not s/he repeated a grade in a high school or a college. Moreover, we also asked respondents to record the names of high schools and the names of the schools from which they obtained the highest degree. We converted this information into a measure of "deviation value (*hensachi*)" – which represents the ranking of each educational institution with mean 50 and standard deviation 10 – and will discuss it in later section.

For the purpose of our analysis, we needed to confirm that the substantial portion of twin pairs has acquired different years of education. As illustrated in Table 3, 38.4% of twin pairs in our sample acquired different years of education, while some of them had different educational experiences, such as *Ronin* or repeated years. Table 3-a shows that the variations in educational experiences between twins become larger with the passage of time: only 5.9% or 10.9% of twin pairs attended different types of schools when they were primary or middle school students. Moreover, it can be said that MZ twins are more likely to have similar educational experiences than DZ twins across the board. However, this difference between MZ and DZ twins also becomes larger coincident with duration of time as well.

Variables

The dependent variable is the natural logarithm of annual wage before the deduction of tax earned during the fiscal year of 2009 (April 2009 to March

2010)[4]. The response category in the original questionnaire ranged from 1 (= no income or less than 0.5 million JPY) through 16 (= more than 15 million JPY). We set the minimum (1 = no income and less than 0.5 million JPY) to zero and maximum (16 = more than 15 million JPY) to 15 million JPY. Then, we took the median value for categories between 2 (= 0.5 million to 0.99 million JPY) and 15 (= 10 million to 14.99 million JPY).

The key independent variable is a measure of human capital accumulation, thus defined as years of schooling. Previous literature has paid less attention to the extra years spent as a *Ronin* or a holdover, but one may think, particularly based on the human capital theory, that it would be more appropriate to incorporate these circuitous routing years into years of schooling because, even during the *Ronin* or repeated years, a majority of people, in fact, take education. We thus create an alternative measure of years of schooling, which accounts for the numbers of years that a respondent actually spent in educational institutions. In addition to these key variables, some control variables deemed to affect productivity, and hence earnings, are included in the models. They are age, gender (= 1 male), marital status (= 1 if married), hours worked per day, and number of years in current employment, as follows the line of previous research (e.g., Ashenfelter & Rouse 1998; Li et al 2011)

The descriptive statistics for all the variables are summarized in Table 4. The table shows that the average respondent in our sample is 39 years old with 15 years of schooling and has been engaged in his or her current employment for 10 years, working 8 hours a day. The average annual earnings of 4.09 million JPY is very close to the national average, 4.12 million JPY, among all employees in Japan in 2010 (National Tax Agency). There is no significant difference in the variables between the samples of MZ and DZ twins, although the average annual earnings for MZ twins seem to be slightly higher than that for DZ twins.

Empirical Results

Conventional OLS

Our analysis begins with conventional OLS estimates of the Mincerian equation. The standardized coefficients estimated by OLS are reported in Table 5, along with the heteroskedasticity robust standard errors. In estimation, information on respondents' twin siblings retrieved from respondents was treated as if it were directly provided by such twin siblings themselves. Our

[4] This survey asked about earnings during the fiscal year of 2010, instead of 2011, because earnings during the fiscal year of 2011 could have been affected by the Great East Japan Earthquake that occurred on March11th, 2011.

primary interest is presented in the first row in Table 5, the coefficient on years of schooling. The estimated rate of return to education for the entire sample is 9.19%, which is very close to the estimates for other developed countries, such as the United States (Ashenfelter & Rouse 1998; Behrman, Rosenzweig & Taubman 1994; Behrman & Rosenzweig 1998), and Japan (Sano & Yasui 2009). Most importantly, Sano and Yasui (2009) present their OLS estimate as 9.04%, which assures us of the extent to which the results for our twins are generalizable.

The coefficient on years of schooling restricted with the sample to MZ twins is 10.0%. The results, coupled with the coefficients for gender, marital status, length of years in current employment and hours worked suggest that the variables included in the model have almost statistically significant and predicted relationships with earnings. In sum, being male and married increases earnings, as do longer hours worked and longer tenure in current employment.

Within-Twin Pair Estimations

As shown in column 5 of Table 5, once we employ GLS restricted with the sample of MZ twins, the coefficients on years of schooling are dramatically reduced to 4.6%, holding other factors constant. The coefficient on θ in equation (4) and (5) is statistically significant at a 1% level. Column 3 of Table 5 presents the within-twin fixed effects restricted to MZ twins. This coefficient on years of schooling is also reduced to 4.5%. Taken as a whole, these estimates are approximately 55% lower than corresponding OLS estimate. Other control variables are statistically significant with expected signs. The results illustrate quite a gender disparity in earnings: even after controlling for ability bias, women are likely to earn approximately 35-40% less than men. In addition, the coefficient on the marital status becomes statistically insignificant after employing either GLS or fixed effects to control for ability bias. It is clearly consistent with a great amount of "marriage premium" literature, such as Cornwell & Rupert (1997), Hersch & Stratton (1997), and Korenman & Neumark (1991).

As a next step, we compared the MZ to DZ estimate. For both of GLS and within-twin fixed effects, DZ estimates (5.1% and 5.4% respectively) are slightly larger than corresponding MZ estimates (4.6% and 4.5% respectively) as presented in Table 5. As mentioned earlier, DZ twins share family environments but are not genetically identical, and DZ estimate are more likely to be affected by omitted ability bias. As discussed in Bound and Solon (1999), if the DZ estimate is larger than the MZ estimate, it can be said that omitted ability is positively correlated with years of schooling. Apparently, this is the case for our results.

We then repeated the above protocol with years of schooling adjusted for *Ronin* and repeating years of schooling. As shown in Table 5-a, the results look similar to the results in Table 5. In other words, extra years of schooling as a *Ronin* or students repeating years of schooling present the same return as the standard and formal years of schooling. Anecdotally, it is known in Japan that *Ronin* or students repeating years of schooling are disadvantaged in the job recruitment processes to some extent, and this is especially true for new graduates. However, the evidence drawn from this study suggests that it is not true. It can be said that the Japanese local labor market does not discriminate against *Ronin* or students repeating years of schooling. On the other hand, in Table 5, we can note that there is no difference in the within-twin fixed effects estimates between the samples of MZ and DZ twins, indicating that omitted ability is neither positively nor negatively correlated with years of schooling.

In sum, within-twin pair estimate of economic returns to education is around 4.5%, and ability bias has indeed biased the conventional OLS estimate upward. Compared to previous literature, approximately 55% of the OLS estimate is composed of unobserved ability and family background in Japan, with the figures being 35% in the U.S. and 65% in China, respectively.

Potential Bias in Within-Twin Pairs Estimations

The central idea for addressing causal questions of how education affects earnings using the sample of twins is that identical twins have identical ability by nature. In other words, twins chose different years of schooling due to events or interventions that randomly occurred in the courses of their lives. However, one may question this assumption. As Bound and Solon (1999) point it out, if there exists a difference in unobserved ability between MZ twins, the bias still remains in within-twin pairs estimates.

Previous literature deals with this problem by testing the correlations between years of schooling and other observable characteristics that may be correlated with ability and comparing the between-family to between-twin correlations. The authors in previous literature summarize that correlations between families are larger than those between twins, suggesting that the cross-sectional OLS estimate may be more affected by differences in ability between MZ twins than the within-twin pair estimate.

By the same token, we conducted correlation analysis using several observed characteristics (e.g., smoking habits, the numbers of job transfers, spousal education, etc.). Table 5-c shows strong correlations of between-family difference in education with observed characteristics, although the correlations of

within-twin pair difference are neither statistically insignificant nor small. However, it is too early to conclude that our estimate is less likely to be contaminated by the difference in ability between MZ twins. There probably is a systematic relationship between education and *unobserved* characteristics. As Bound (1999) argued, it should be considered that this literature can contribute to tightening the bound of the estimated rate of return to education ranging from upper (OLS) to lower (within-twin pair estimations).

Identification Strategy

Previous literature also tackles measurement errors in self-reported education. Classical literature, such as Griliches (1977), argues that a first-differenced equation exacerbates biases due to measurement errors in schooling. Ashenfelter and Krueger (1994) suggest employing the instrumental variable, which is cross-reported education filed out by the other twin pair. All the previous studies, except for Isacsson (1999; 2004) and Bingley (2005), follow Ashenfelter and Krueger (1994), but unfortunately, this information is not available in our survey.

Instead, we instrument deviation values that represent the ranking of each high school for the years of schooling. We obtained a series of deviation values from Kanjuku, a large-scale cram school, which releases "A Comprehensive List of the Deviation Values of Japan's High- and Junior High Schools" every year, and using the latest information, we converted the names of high schools from which respondents graduated into deviation values[5]. In Japan, according to the School Basic Survey (Ministry of Education, Culture, Sports, Science and Technology), 98.1% of junior high graduates have advanced to high schools, indicating that almost all junior high school students must have taken the entrance examinations for high schools, except for, albeit a few, students in private integrated junior high and senior high schools.

This information is also self-reported, but this is (i) not the final or the highest level of education completed and (ii) based on a written, not a multiple choice, questionnaire, leading to minimization of measurement errors. The rationale for this instrument is that the performance of written examinations at the age 15 is correlated with the true educational background of a respondent, but does not directly affect the labor market outcome[6].

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[5] We exclude schools which were already closed, run only distance-learning courses, and have the exact same names with other schools in different regions (there exist several "Jouhoku High School" e.g., in Kumamoto, in Tokushima and in Tokyo, etc.), and international and foreign schools.

[6] In the field of economics of education, a large numbers of studies find only a weak link between standardized test scores and labor market outcomes (e.g., Murane, Willet & Levy 1995). There is a history of the controversy of the "money matters" debate – the fact that labor market outcomes show a positive effect of school expenditures

Our proposed instrument can correct not only measurement errors but also bias arising from the difference in ability between MZ twins discussed in 5-3. To test for instrument relevance, we ran the first stage regressions and confirmed the strong predicative power of the deviation values on years of schooling: this instrument is positive and statistically significant at the 1% level as expected. In addition, according to the test statistics proposed by Stock and Yogo (2005), our IV estimate presents no problem of weak identification. Based on the Hausman test for endogeneity, we rejected the null hypothesis that education is exogenous.

The fifth column of Table 5 presents the IV estimate restricted to the sample of MZ twins. The IV estimated rate of return to education is 9.3%, which is much larger than the within-twin pair estimate. Surprisingly, it is almost the same level as the conventional OLS estimate, 10.0%. The implication here is that potential endogeneity bias, including measurement errors, has biased the within-twin pair estimate downward. Compared to previous literature, our results are quite similar with those from the U.S. and other western countries, which eventually allows the conclusion that the conventional OLS estimate is not contaminated by potential biases.

On the other hand, the striking fact is that the results for China are completely different: even after corrected measurement errors, and the estimate of 3.8% is still much lower than the conventional OLS estimate. Li et al (2011) analyze that this result may be in part due to the Chinese education system, which is highly selective and exam oriented (Li et al 2011). However, a counterintuitive result is drawn from our study: although Japanese education is quite similar to that in China and is characterized by the presence of selective entrance exams to enter high schools or colleges, the rate of return to education in Japan, after controlling for potential biases, is relatively high.

We need further investigations on the causes of the difference between Japan and China, but at least at this moment, we propose several possible reasons: first, student selection places more emphasis on the earnings potential than written examinations in recent days. To be more specific, some colleges have started screening applicants through essays, discussions, and experiences in volunteer and extracurricular activities that may be strongly related to their motivations, interests, and interpersonal skills and may not be reflected in performance on written examinations. This type of screening is referred to as AO [Admissions Office] entrance examinations, and although it is not yet dominant, it is expected to increase throughout the country. In our

(Card & Krueger, 1992) is in apparent conflict with the widely-held view that school expenditures have little or no impact on standardized test scores (Hanushek 1989; 2003).

questionnaire, we asked about the types of entrance examinations that respondents took in entering colleges from which respondents obtained degrees: approximately 15% of them were selected through AO entrance examinations and other non-paper-based selection processes.

Second, the quality of governance differs significantly between Japan and China. According to the Worldwide Governance Indicator (WGI) developed by Kaufmann et al (2010) and released by the World Bank on yearly basis, Japan has been more likely to formulate and implement country policies with greater respect for their citizens than China over past decades (see Table 6). Many studies suggest that governance environments and economic policies that hamper market forces tend to dramatically reduce the positive effect of human capital on productivity (e.g., Pritchett 2011). In other words, past research suggests that the larger and more competitive the market is, the more productive knowledge and skills are useful. In short, educational setting is not the only reason why the rate of return to education in China is low after controlling for potential biases. The ways in which local labor markets reward human capital accumulated through education is also of key importance.

Conclusion

The objective of this article is to measure the causal effect of education on earnings using the sample of twins. Our data is collected through a web-based survey administered by Rakuten Research, which may be the largest dataset in Japan nationwide. Previous literature employing samples of twins in the U.S. and other western countries, such as Australia, Sweden, the UK, and Denmark, yields similar outcomes and has almost reached the consensus that the conventional estimate of the rate of return to education imparts only a small upward or downward bias. However, Li et al (2011) shows that the estimated rate of return to education in China, even after corrected potential biases, is quite low, suggesting that ability bias is considerably large. They speculate that the reason why the economic return to education in China is low is in part due to the presence of a selective and exam-oriented educational system, which also characterizes Japanese education. The research objective of this article is thus to empirically estimate the rate of return to education after controlling for ability bias using a sample of twins. In addition, this article tries to answer the question of whether or not the rate of return to education in Japan is relatively lower than that in western countries, similarly to the case of China.

Our empirical results show that the conventional OLS estimate is 10.0%,

which is consistent with existing literature. However, we discovered that within-twin pair estimates become significantly lower than the conventional OLS estimate: GLS and fixed effects estimates are 4.6% and 4.5%, respectively. It can be said that within twin-pair estimates have indeed biased the conventional OLS estimate upward. Then, we corrected the measurement errors using the instrumental variable method and obtained 9.3% as the estimated rate of return to education. This suggests that measurement errors have biased within-twin pair estimates downward. Taken as a whole, the bias-corrected estimate is very close to the conventional estimate, which leads us to conclude the conventional OLS estimate is not largely contaminated by potential biases. The Japanese education system is very similar to that of China, but, paradoxically, the rate of return to education in Japan is, in fact, high. There may be other factors to explain what causes the difference between the rate of return to education in Japan and in China.

Table 1: Literature Review

	Source	Date	MZ twins	Country	Gender	OLS	FE	FEIV
Ashenfelter & Krueger (1994)	Princeton Twins Survey	1991	147	US	Both	0.084 (0.014)	0.092 (0.024)	0.129 (0.030)
Berhman, Rosenzweig & Taubman (1994)	NAS-NRC	1973	141	US	Both	0.094 (0.011)	0.035 (0.004)	0.101 (0.012)
Miller, Mulvey & Martin (1995)	Australian Twins Register	1985	602	Australia	Both	0.064 (0.002)	0.025 (0.005)	0.048 (0.010)
Ashenfelter & Rouse (1997)	Princeton Twins Survey	1991-93	333	US	Both	0.110 (0.009)	0.070 (0.019)	0.088 (0.025)
Berhman & Rosenzweig (1997)	Minnesota Twins Register	1993	720	US	Both	0.113 (0.005)	0.104 (0.017)	NA
Rouse (1998)	Princeton Twins Survey	1991-93, 1995	453	US	Both	0.105 (0.008)	0.075 (0.017)	0.110 (0.023)
Isacsson (1999)	Swedish Twin Registry	1990	2,492	Sweden	Both	0.046 (0.001)	0.022 (0.002)	0.024 (0.008)
Isacsson (2004)	Swedish Twin Registry	1990	2,609	Sweden	Both	0.066 (0.009)	0.028 (0.009)	0.052 (0.036)
Bonjour, Cherkas, Haskel, Hawkes & Spector (2003)	St Thomas Hospital Twin Register	1999	187	UK	Female	0.077 (0.001)	0.039 (0.023)	0.077 (0.033)
Bingley, Christensen & Walker (2005)	Danish Twins Registry	2002	2,185 2,000	Denmark	Male Female	0.030 (0.001) 0.037 (0.001)	0.005 (0.001) 0.009 (0.001)	0.045 (0.010) 0.044 (0.008)
Li, Liu & Zhang (2010)	Chinese Twins Survey	2002	488	China	Both	0.084 (0.006)	0.027 (0.012)	0.038 (0.018)
Nakamuro & Inui (2012)	Rakuten Twins Survey	2012	1,371	Japan	Both	0.100 (0.007)	0.045 (0.012)	0.093 (0.045)

(Note) This review extends the review in Card (1999), Bingley et al (2005), and Li et al (2011).

Table 2: The Characteristics of Twins in the Web-Based Survey

MZ twins	DZ twins	Don't know
2,742 (1,371 pairs) 58.09%	1,764 (882 pairs) 37.37%	214 (107 pairs)

(Source) Authors' calculations

Table 3: The Differences in Educational Experiences within Twin Pairs

	Years of schooling	*Ronin*	Repeated
Total	38.4%	12.5%	7.2%
MZ twins	32.0%	10.3%	5.9%
DZ twins	48.8%	14.5%	8.0%

(Note) The term "*Ronin*" means students who failed an entrance examination and are preparing to re-take the exam next year. During the *Ronin* period, many students attend cram schools that specialize in preparation courses for college entrance exams.
(Source) Authors' calculations

Table 3-a: The Difference in Educational Experiences within Twin Pairs (Restricted Sample)

	Took an entrance exam for private primary school	A type of primary school enrolled	Took an entrance exam for private middle school	A type of middle school enrolled
Total	6.8%	5.9%	7.5%	10.9%
MZ twins	7.0%	5.6%	7.1%	8.1%
DZ twins	6.5%	6.5%	7.7%	15.1%

(Note) "Types of school" are classified as public, private and others, such as international schools. According to the latest School Basic Survey (Ministry of Education, Culture and Sports), 1.1% of students enroll in private primary schools and 7.2% enroll in private middle schools, respectively.
(Source) Authors' calculations

Table 4: Descriptive Statistics

	All		MZ twins		DZ twins	
	Mean	SD	Mean	SD	Mean	SD
Earnings	409.55	365.52	420.27	365.60	400.28	369.49
Years of schooling	14.63	2.10	14.64	2.09	14.61	2.10
Age	39.40	9.52	39.43	9.30	39.36	9.67
Age squared	1642.77	778.43	1641.49	759.77	1642.74	790.67
Gender	0.53	0.50	0.55	0.50	0.50	0.50
Married	0.65	0.48	0.67	0.47	0.64	0.48
Hours	7.93	3.90	8.05	3.81	7.86	4.02
Tenure	10.02	8.56	10.18	8.48	9.78	8.59
Deviation	55.42	10.39	55.75	10.56	54.92	10.10
Observations	4,490		2,626		1,674	
(Pairs)	2,245		1,313		837	

(Source) Authors' calculations

Table 5: Estimation Results

	OLS MZ	**FE** MZ	**GLS** MZ	**FEIV** MZ	**FE** DZ	**GLS** DZ	**FEIV** DZ
Years of schooling	0.100*** (0.007)	0.045*** (0.012)	0.046*** (0.012)	0.093* (0.045)	0.054** (0.019)	0.051** (0.018)	0.141** (0.047)
Sum of years of schooling			0.062*** (0.014)			0.057** (0.021)	
Age	0.011 (0.015)		0.026 (0.019)			0.016 (0.022)	
Age squared	0.000 (0.000)		0.000 (0.000)			0.000 (0.000)	
Gender	0.355*** (0.035)		0.379*** (0.042)		0.262*** (0.055)	0.327*** (0.043)	0.234*** (0.049)
Married	0.139*** (0.033)	-0.071 (0.049)	0.037 (0.036)	-0.032 (0.032)	-0.158* (0.062)	0.009 (0.046)	-0.025 (0.051)
Tenure	0.027*** (0.002)	0.022*** (0.003)	0.025*** (0.002)	0.015*** (0.002)	0.027*** (0.004)	0.027*** (0.003)	0.020*** (0.003)
Hours	0.156*** (0.008)	0.143*** (0.014)	0.150*** (0.009)	0.094*** (0.007)	0.158*** (0.018)	0.139*** (0.013)	0.092*** (0.013)
Observations	2,257	2,257	2,257	1,320	1,390	1,390	712
(pairs)		1,128		660	695		356
R squared	0.573	0.404		0.296	0.474		0.444

(Note) Standard errors in parentheses reflect robust heteroskedasticity and clustering at the family level. ***, **, and * represent 0.1%, 1%, and 5% significance level, respectively.
(Source) Author's calculations

Table 5-a: Estimation Results (Adjusted for *Ronin* and Repeating Years of Schooling)

	OLS MZ	**FE** MZ	**GLS** MZ	**FEIV** MZ	**FE** DZ	**GLS** DZ	**FEIV** DZ
Years of Schooling	0.088*** (0.007)	0.045*** (0.012)	0.043*** (0.011)	0.083* (0.040)	0.045* (0.019)	0.052** (0.017)	0.125** (0.041)
Sum of years of schooling			0.057*** (0.014)			0.057** (0.021)	
Age	0.012 (0.012)		0.021 (0.019)			0.020 (0.021)	
Age squared	0.000 (0.000)		0.000 (0.000)			0.000 (0.000)	
Gender	0.356*** (0.028)		0.392*** (0.045)		0.243*** (0.057)	0.313*** (0.044)	0.224*** (0.049)
Married	0.125*** (0.028)	-0.071 (0.051)	0.034 (0.037)	-0.033 (0.032)	-0.169** (0.063)	-0.003 (0.046)	-0.032 (0.050)
Tenure	0.027*** (0.002)	0.021*** (0.004)	0.025*** (0.002)	0.014*** (0.002)	0.027*** (0.005)	0.027*** (0.003)	0.020*** (0.003)
Hours	0.142*** (0.007)	0.148*** (0.014)	0.148*** (0.010)	0.094*** (0.007)	0.156*** (0.018)	0.136*** (0.014)	0.094*** (0.012)
Observations	2,160	2,160	2,160	1,320	1,331	1,331	712
(pairs)				660			356
R squared	0.544	0.415		0.291	0.472		0.451

(Note) Standard errors in parentheses reflect robust heteroskedasticity and clustering at the family level. ***, **, and * represent 0.1%, 1%, and 5% significance level, respectively.
(Source) Author's calculations

Table 5-c: The Correlation of Years of Schooling and Other Variables

	Between-family correlation	Within-twin-pair correlation
Smoking at age of 16	-0.953**	-0.420
	(0.293)	(0.513)
Smoking at age of 18	-0.736***	-0.381
	(0.157)	(0.215)
Job transfer	-0.265***	-0.039
	(0.023)	(0.035)
Firm size	0.191***	-0.021
	(0.016)	(0.023)
Marital status	0.137	0.018
	(0.097)	(0.115)
Spousal education	0.506***	0.208***
	(0.025)	(0.049)

(Note) Standard errors in parentheses reflect robust heteroskedasticity and clustering at the family level. ***, **, and * represent 0.1%, 1%, and 5% significance level, respectively.
(Source) Author's calculations

Table 6: Worldwide Governance Index

1996

	Voice and accountability	Political stability and absence of violence	Government effectiveness	Regulatory quality	Rule of law	Control of corruption
Japan	1.05	1.11	0.96	0.69	1.32	1.05
Chine	-1.30	-0.17	-0.25	-0.14	-0.43	-0.25

2010

	Voice and accountability	Political stability and absence of violence	Government effectiveness	Regulatory quality	Rule of law	Control of corruption
Japan	1.02	0.97	1.35	0.90	1.27	1.50
Chine	-1.64	-0.70	0.12	-0.20	-0.46	-0.67

(Note) Indicators range from approximately -2.5 (weak) to 2.5 (strong) for governance performance.
(Source) World Bank

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