Does Education Pay in Urban China? Estimating Returns to Education Using Twins*

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Abstract

This paper empirically estimates the returns to education using twins data that the authors collected from urban China. Our ordinary least-squares estimate shows that one year of schooling increases an individual's earnings by 8.4 percent. However, once we use the within-twin-pair fixed effects model, the return is reduced to 2.7 percent, which suggests that much of the estimated returns to education in China that have been found in previous studies are due to omitted ability or the family effect. This finding suggests that well-educated people are faring well in China mainly because of their superior ability or family background advantages, rather than because of knowledge that they acquired at school. We further investigate why the true return is low and the omitted ability bias high, and find evidence that it may be a consequence of the distinct education system in China, which is highly selective and exam oriented. More specifically, we find that high school education mainly serves as a mechanism to select college students, and has zero returns in terms of earnings. In contrast, both vocational school education and college education have a large return that is comparable to that found in rich Western countries.

JEL Classification: J31; O15; P20

1 Introduction

Although estimating the return to education has been an important econometric exercise since the seminar work of Mincer (1974), only recently have economists begun to estimate it using Chinese data. Several studies that draw on data from urban China from the 1980s and 1990s find rather low returns, with one year of schooling increasing earnings by only 2-4 percent (Byron and Manaloto, 1990; Meng and Kidd, 1997). This finding has caught the attention of many labor economists, including James Heckman, who generally think that the estimates of the return to education in China were formerly low because most of the urban economy was still under a planned regime in the 1980s and 1990s. However, they believe that the return should have increased after more than two decades of economic transition from a planned regime to a market regime, as in market economies a large gradation in earnings according to the level of education reflects the return to the investment of individuals in education (Mincer 1974; Becker 1993).[1] Recent data have shown that the return to education has indeed risen in China. Heckman and Li (2004) find that the return to education had risen to 7 percent by 2000. Using a repeated cross-sectional dataset of a 14-year period (1988-2001), which is the best large-scale dataset of this kind, Zhang et al. (forthcoming) find a dramatic increase in the return to education in urban China from only 4 percent in 1988 to more than 10 percent in 2001.

Despite the rapid accumulation of evidence on the return to education in China, no study has yet established causality. An ordinary least-squares (OLS) estimation of the effect of education on earnings cannot prove causality, because well-educated people may have high earnings as a result of their greater ability or better family background. In other words, education may be correlated with unobserved ability or family background, which would

[1] In fact, this assertion has contributed to a lively debate among sociologists who study institutional transformation and social stratification in former state socialist societies (Rona-Tas, 1994; Bian and Logan, 1996; Parish and Michelson, 1996; Szelenyi and Kostello, 1996; Walder, 1996; Xie and Hannum, 1996; Gerber and Hout, 1998; Zhou, 2000).

make any correlation between education and earnings spurious. Because of the difficulty in breaking endogeneity due to unobserved ability, the true return to education in China remains elusive.

Our first goal in this paper is to empirically measure the causal effect of education on earnings by using twins data that two of the authors collected in urban China. As is argued in the literature (Ashenfelter and Krueger, 1994; Miller et al., 1995; Behrman and Rosenzweig, 1999; Bound and Solon, 1999; Isacsson, 1999),[2] as monozygotic (from the same egg) twins are genetically identical and have a similar family background, the effects of unobserved ability or family background should be similar for both twins. Thus, taking the within-twin-pair difference will, to a great extent, reduce the unobservable ability or family background effects that cause bias in the OLS estimation of the return to education. Intuitively, by contrasting the earnings of identical twins with different years of education, we can be more confident that the correlation that we observe between education and earnings is not due to a correlation between education and an individual's ability or family background.

Our empirical work shows that most of the effect of education on earnings from the OLS estimates is actually due to the effects of unobserved ability or family background. Our OLS estimate shows that the return to one more year of education is 8.4 percent, which is close to other recent estimates that use Chinese or Asian data (see, for example, Psacharopoulos, 1992; Heckman and Li, 2004; Zhang et al., forthcoming). However, once we use the within-twin-pair fixed effects model, the return is reduced to 2.7 percent, which suggests that much of the estimated return using the OLS model is due to the omitted ability or the family effect. In other words, education in China is more important for selecting people of high ability to progress through the system than it is for providing knowledge or training that

[2]The earliest attempt to look at siblings data in economics can be traced back to the dissertation of Gorseline (1932). Not satisfied with siblings data, economists started to use twins data in the late 1970s, when the work of Behrman and Taubman (1976), Taubman (1976a, 1976b), and Behrman et al. (1977) was published. The interest in using twins data was recently revived with the work of Ashenfelter and Krueger (1994) and Behrman et al. (1994).

will enhance earnings. This finding is confirmed by a generalized least-squares estimation that includes the co-twin's education as a covariate.

Thanks to the new advances in twins studies that have been made by Ashenfelter and Krueger (1994), Ashenfelter and Rouse (1998), Bounjour et al. (2003), Hertz (2003), and others, we have been able to obtain good-quality data and address several problems that are inherent in twins studies. First, our correlation tests that follow Ashenfelter and Rouse (1998) show that the between-family correlations of education with other family characteristics are all larger in magnitude than the within-twin-pair correlations, which suggests that the within-twin-pair estimate of the return to education may be less affected by omitted variables than the OLS estimate. Second, we address the potential bias that is caused by the measurement error in the education variable by using the instrumental variable approach of Ashenfelter and Krueger (1994). After the correction of measurement error, the estimated return to education rises by about one percentage point to 3.8 percent.

The low estimated return to education and high selectivity (or ability bias) differ sharply from evidence from twins data from other countries (see, for example, Ashenfelter and Rouse (1998), Behrman and Rosenzweig (1999) and Bonjour et al. (2003)). Our second goal in this paper is thus to ascertain what is so different about China. Although the remaining features of a planned economy could be used to explain the low return, we provide an alternative explanation in this paper. We argue that the low return and high selectivity may be a consequence of the distinct education system in China. Because of the huge population awaiting an education and the limited number of college (and university) places, entrance to college is extremely competitive. The Chinese solution to this is examinations. Only the very talented can score high enough in the college entrance exams to advance to higher education, and thus non-tertiary education, and in particular high school education and the associated entrance exams, has become a very important selection mechanism. This explains why the ability bias is so high in our OLS estimates. Moreover, to prepare students for college entrance exams, non-tertiary education in China, and in particular high school education, is totally exam oriented, and thus adds little value in terms of general knowledge or workplace skills. As a result, such exam-oriented high school education has a low return, which has also dragged down the overall return to education.

The twins data that we have collected allow us to test whether the Chinese education system should indeed be blamed for the low return to and high selectivity of education. To this end, we estimate the returns to different levels of education by using OLS, within-twin-pair, and IV estimations. Arguably, exam-oriented high school education should have the lowest return among all of the education levels, and the final-stage education levels, such as vocational and college education, should have higher returns because they are less exam oriented. Interestingly, these hypotheses are confirmed. We find that the return to high school education is almost zero, but that the return to college education is very large. According to our estimates, which control for omitted variable and measurement error biases, college graduates earn 40 percent more than those who have not been to college or vocational school. These findings suggest that going to high school does not pay unless an individual is also able to obtain a college degree. Moreover, although the return to high school education is zero, there is a large return to vocational school education. The return to vocational school education is as large as 22 percent, or 7.3 percent per year of schooling.

The idea of using twins data to control omitted ability bias excited many labor economists when it first came out, but its popularity waned when many twins studies found that the OLS estimates did not differ much from within-twin-pair estimates that controlled for omitted ability. Part of the reason for the low omitted ability bias in previous studies is that most of these studies draw on data from rich Western countries, where education is not very selective. To the best of our knowledge, this is the first study of the return to education that draws on twins data from China, and is probably also the first to draw on Asian twins data. The education systems of Asian countries, and especially East Asian countries and regions such as Japan, South Korea, Taiwan, Hong Kong, and mainland China, share similar features in that they all have very serious college entrance exams. Understandably, high schools in these countries or regions place a lot of emphasis on exam-taking techniques, and thus education may be more selective in these countries or regions than it is in Western countries. In this sense, twins studies, which largely separate the selection effect from the true return to education, may be more important for these countries than for Western countries. Our study is also one of the first to use twins data from developing countries. Twins studies in developing countries are particularly interesting, because the omitted variable bias may be larger in these countries, where liquidity constraints and family background are likely to be important determinants of both education and earnings (Lam and Schoeni, 1993; Herrnstein and Murray, 1994).

Knowing the true return to education is very important for China, which is experiencing a transition from a planned economy to a market economy. During the transition process, the Chinese government must reform all of the economic sectors, such as industry, banks, the medical system, and education. Given the limited resources that are available, the government needs to set priorities for government expenditure. Our findings suggest that the true return to one year of schooling is at most 3.8 percent, which may be far below the return to investment in physical capital. However, the return is not uniform for different education levels. We find that the return to high school education is zero, and that in terms of each year of schooling, the return to both a vocational degree and a college degree is high. Thus, cutting one year from the three years of high school and using the saved resources for other education levels may increase the overall efficiency of the economy.

The structure of the rest of this paper is as follows. Section 2 describes the estimation methods that draw on twins data. Section 3 describes the data and the variables. Section 4 empirically measures the return to education. Section 5 explains why the return to education is low and selectivity high in China. Section 6 concludes.

2 Method

Our empirical work focuses on the estimation of the log earnings equation, which is given as

$$y_i = X_i\alpha + Z_i\beta + \mu_i + \epsilon_i, \tag{1}$$

where the subscript i refers to individual i, y_i is the logarithm of earnings, X_i is the set of observed family variables, and Z_i is a set of observed individual variables that affect earnings, which includes education, age, age squared, gender, marital status, and job tenure. μ_i represents a set of unobservable variables that also affect earnings, that is, the effect of ability or family background. ϵ_i is the disturbance term, which is assumed to be independent of Z_i and μ_i.

The OLS estimate of the effect of education in equation (1), β, is generally biased. This bias arises because we normally do not have perfect measures of μ_i, which is very likely to be correlated with Z_i. Intuitively, the cross-sectional comparison of the earnings of workers with different levels of education will not identify the education effect even if these workers are identical with respect to other observed variables. This is because workers with different levels of education may differ in other unobserved characteristics that affect earnings. As discussed in the introduction, well-educated people may be more capable, motivated, or blessed with an advantageous family background, and if these advantages are not completely accounted for, then the OLS estimation will pick up the effect of these variables. It is therefore difficult to ascertain how much of the empirical association between earnings and education is due to the causal effect of education, and how much is due to unobserved factors that influence both earnings and education. The omitted variable bias depends on $\frac{cov(Z_i,\mu_i)}{var(Z_i)}$, which summarizes the relationship in the sample between the excluded μ_i and the included Z_i, which includes education.

Several approaches may be used to tackle this problem of omitted variable bias. The first approach is to seek richer datasets that can be used to control more extensively for measures of ability, family background, and the like. The main problem with this approach is that the controls inevitably remain incomplete. Nonetheless, we take advantage of our rich dataset and include many control variables to reduce the omitted variable bias.

A second approach to the omitted variable problem is to apply the fixed effects estimator to our twins sample. As monozygotic (from the same egg) twins are genetically identical and have a similar family background, they should have the same μ_i. Thus, taking the within-twin-pair difference will eliminate the unobservable ability and family effect μ_i, which causes the omitted variable bias in the OLS estimation. Intuitively, by contrasting the earnings of identical twins with different levels of education, we can ensure that the correlation that we observe between education and earnings is not due to a correlation between education and a worker's ability or family background.

The fixed effects model can be specified as follows. The earnings equations for a pair of twins are given as

$$y_{1i} = X_i\alpha + Z_{1i}\beta + \mu_i + \epsilon_{1i} \quad (2)$$

$$y_{2i} = X_i\alpha + Z_{2i}\beta + \mu_i + \epsilon_{2i}, \quad (3)$$

where y_{ji} $(j = 1, 2)$ is the logarithm of the earnings of both twins in the pair and X_i is the set of observed variables that vary by family but not between the twins, that is, the family background variables. Z_{ji} $(j = 1, 2)$ is a set of variables that vary between the twins.

A within-twin-pair or fixed effects estimator of β for identical twins, β_{fe} is based on the first-difference of equations (2) and (3):

$$y_{1i} - y_{2i} = (Z_{1i} - Z_{2i})\beta + \epsilon_{1i} - \epsilon_{2i}. \quad (4)$$

The first difference removes both the observable and unobservable family effects, that is, X_i and μ_i. As μ_i has been removed, we can apply the OLS method to Equation (4) without worrying about bias that is caused by the omitted ability and family background variables.

A third approach to solving the omitted variable bias is to directly estimate both the bias and the education effect using the approach that was developed by Ashenfelter and Krueger (1994). This approach also draws on monozygotic twins data. In this approach, the correlation between the unobserved family effect and the observables is given as

$$\mu_i = Z_{1i}\gamma + Z_{2i}\gamma + X_i\delta + \omega_i, \tag{5}$$

where we assume that the correlations between the family effect μ_i and the characteristics of each twin Z_{ji} $(j = 1, 2)$ are the same, and that ω_i is uncorrelated with Z_{ji} $(j = 1, 2)$ and X_i. The vector of the coefficients γ measures the selection effect that relates to the family effect and individual characteristics, including education.

The reduced form for equations (2), (3), and (5) is obtained by substituting (5) into (2) and (3) and collecting the terms as follows.

$$y_{1i} = X_i(\alpha + \delta) + Z_{1i}\beta_2 + (Z_{1i} + Z_{2i})\gamma + \epsilon'_{1i} \tag{6}$$

$$y_{2i} = X_i(\alpha + \delta) + Z_{2i}\beta_2 + (Z_{1i} + Z_{2i})\gamma + \epsilon'_{2i}, \tag{7}$$

where $\epsilon'_{ji} = \omega_i + \epsilon_{ji}$, $(j = 1, 2)$. Equations (6) and (7) are estimated using the generalized least squares (GLS) method, which is the best estimator that allows cross-equation restrictions on the coefficients. Although both the fixed effects and GLS models control for ability, and can produce unbiased estimates of the education effect β, the GLS model also allows the estimation of the selection effect γ.

3 Data

The data that we use are derived from the Chinese Twins Survey, which was carried out by the Urban Survey Unit (USU) of the National Bureau of Statistics (NBS) in June and July

2002 in five cities of China. The survey was funded by the Research Grants Council of Hong Kong. Based on existing twins questionnaires in the United States and elsewhere, the survey covered a wide range of socioeconomic information. The questionnaire was designed by two authors of this paper in close consultation with Mark Rosenzweig and Chinese experts from the NBS. Adult twins aged between 18 and 65 were identified by the local Statistical Bureaus through various channels, including colleagues, friends, relatives, newspaper advertising, neighborhood notices, neighborhood management committees, and household records from the local public security bureau. Overall, these channels permitted a roughly equal probability of contacting all of the twins in these cities, and thus the twins sample that was obtained is approximately representative. (The within-twin-pair estimation method that is used for this study controls for the first-order effects of any unobserved characteristics that may have led to the selection of twins pairs into the sample). Questionnaires were completed through household face-to-face personal interviews. The survey was conducted with considerable care, and several site checks were made by Junsen Zhang and experts from the National Bureau of Statistics. Following appropriate discussion with Mark Rosenzweig and other experts, the data input process was closely supervised and monitored by Junsen Zhang himself in July and August 2002.

This is the first socioeconomic twins dataset in China, and perhaps the first in Asia. The dataset includes rich information on the socioeconomic situation of respondents in the five cities of Chengdu, Chongqing, Harbin, Hefei, and Wuhan. Altogether there are 4,683 observations, of which 3,012 observations are from twins households. For the sample of twins, we can distinguish whether they are identical (monozygotic) or non-identical twins. We consider a pair of twins to be identical if both twins respond that they have identical hair color, looks, gender, and age. Completed questionnaires were collected from 3,002 individuals, of which 2,996 were twin individuals and 6 were triplet individuals. From these

3,002 individuals, we have 914 complete pairs of identical twins (1,828 individuals). We have complete information on earnings, education, and other variables for both twins in the pair for 488 of these pairs (976 individuals). The summary statistics of identical twins and all twins together are reported in the first two columns of Table 1.

For the purposes of comparison, non-twin households in the five cities were taken from regular households on which the USU conducts regular monthly surveys of its own. The Urban Survey Unit started regular monthly surveys in the 1980s. Their initial samples were random and representative, and they have made every effort to maintain these good sampling characteristics. However, their samples have become less representative over time. In particular, because of an increasingly high (low) refusal rate among young (old) people, the samples have gradually become biased toward the oversampling of older people over time. The survey of non-twin households was conducted at the same time as the twin survey, and the same questionnaire was used. The summary statistics of our non-twins sample are reported in the third column of Table 1.

Although our within-twin-pair estimation controls for possible sample selection, it is interesting to compare the identical twins sample to the other samples that we have. To facilitate such comparisons, we also provide the basic statistics for a large-scale survey that was conducted by the USU of NBS as a benchmark (henceforth the NBS sample, reported in column 4 of Table 1).[3] Column 1 shows that sixty percent of our identical twins were male, and on average the twins were 35 years old, had 12 years of schooling, and had spouses who also had an average of 12 years of schooling. They had worked for an average of 15 years, and had monthly average earnings of 888 yuan, where earnings include wages, bonuses, and subsidies. The individuals in the identical twins sample were younger than those in the NBS sample and also earned less. Finally, individuals in the non-twins sample (column 3) were

[3]The NBS has been conducting an annual survey of urban households from 226 cities (counties) in China since 1986. It is the best large-scale survey of this kind.

older than those in the NBS sample and the twins samples.

To ensure the good performance of the within-twin-pair estimation of the return to education, the within-twin-pair variation of education needs to be large enough. We check the within-twin-pair variation in education and find it to be rather large. Fifty-three percent of the twin pairs had the same education, 13 percent had one year's difference in education, about 10 percent had two years' difference, and the remaining 24 percent had a difference of more than two years. These numbers suggest that we have a large variation of within-twin difference in education, which is good for the fit of the regressions.

4 Returns to Education

In this section, we report the estimated return to education using different samples and methods. We start with the OLS regressions using the whole sample, including twins and non-twins, and then conduct the same OLS estimation using the monozygotic twins sample and compare the estimated coefficients to those that are estimated using the whole sample. This comparison may serve as a way to check the representativeness of the monozygotic twins sample. We then conduct the within-twin-pair fixed effects and GLS estimations using the twins sample, followed by examinations of possible bias in fixed effects estimates and the impact of measurement error.

4.1 OLS Regressions Using the Whole Sample

In the first two columns of Table 2, we report the results of the OLS regressions using the whole sample, including both twins and non-twins. The dependent variable is the logarithm of monthly earnings. The t-statistics are calculated using robust standard errors. In column 1, we show a simple regression with education, age, age squared, gender, and city dummies as independent variables. This simple regression shows that the return to education is quite large. One more year of schooling increases an individual's earnings by 6.7 percent, which is quite precisely estimated with a t-statistic of 16.71. The positive coefficient of age and the negative coefficient of age squared are both significant at the 10-percent level. Earnings increase with age before 55 years of age, but start to drop after that. The gender difference in earnings is quite large in urban China, with men having 21.7 percent higher earnings than women.

When we add other control variables in the second column, including marital status and tenure, the estimated coefficient of education remains unchanged, which suggests that omitting these variables results in no bias in the estimated return to education. We do not find a marriage premium in the sample, as the marriage dummy is not significant at the conventional level. Job tenure has a positive effect, with one more year at the post increasing earnings by 1.6 percent.

4.2 OLS Regressions Using the Monozygotic Twins Sample

In this subsection, we repeat the same OLS regressions using the monozygotic twins sample. Comparing the OLS results of the monozygotic (MZ) twins sample with those of the whole sample is a way to check the robustness of the estimated coefficients using different samples. As we only use the MZ twins sample, the sample size is reduced to 976 observations (or 488 pairs of twins).

The regression results that are reported in the third and fourth columns of Table 2 suggest that the return to education is larger for our MZ twins sample. The return to education is 8.2 percent for the simple regression in column 3, and becomes even larger when other control variables are included in column 4.[4] Thus, the OLS estimate of the return for the twins sample is about 1.5-1.7 percentage points more than that for the whole sample. The estimated coefficients of most of the other variables are very similar for the two samples.

[4]These OLS estimates are very close to those using the large NBS sample (Zhang et al., forthcoming).

To summarize, the OLS estimate of the return to education is rather large, even after we control for many covariates. The remaining effect is 0.084 (column 4). However, we still do not know how much of this effect is the true return to education, and how much is due to the effects of unobserved ability or family background. We resort to the within-twin-pair and GLS estimations to remove the unobservables and estimate the true return in the following.

4.3 Within-Twin-Pair and GLS Estimations

In columns 5 and 6 of Table 2, we report the results of the within-twin-pair fixed effects estimation, or the estimation using Equation (4). As MZ twins are of the same age and gender, these variables are dropped when taking the first difference.

The within-twin-pair estimation shows that much of the return to education that is found by the OLS estimation is the result of the effects of unobserved ability or family background. Note that the within-twin-pair estimate of the return to education is much smaller than the OLS estimate. Taking column 6 as an example, it can be seen that the education effect is 0.027, which is only about one third of the OLS estimate using the same twins sample. This suggests that two thirds of the OLS estimate of the return is actually the unobserved ability or family effect. Other control variables are not significant in the within-twin-pair estimation.

We next turn to the GLS estimator for Equations (6) and (7), which can directly estimate both the return to education and the ability or family background effect. In the last two columns of Table 2, we report the GLS estimates, including the covariates that are used in the OLS estimates. In addition to an individual's own education, we also include the sum of the education of both twins as an independent variable. The coefficient of this new variable will be the estimated ability or family effect, that is, γ in Equations (6) and (7). The GLS model is estimated by stacking Equations (6) and (7) and fitting them using the SURE model.

The GLS estimation again shows that the return to education is small, whereas the omitted ability or family effect is large. The coefficients of an individual's own education are only 0.025-0.027, which are exactly the same as the values for the within-twin-pair estimates. The estimated family effect, that is, the coefficients of the sum of the education of both twins, are larger than the return to education, and are significantly different from zero.

In the two next sub-sections, we conduct a series of sensitivity tests on the within-twin-pair estimates. As with the conventional OLS estimates, the within-twin-pair estimates may also be subject to biases that are caused by omitted variables and measurement errors.

4.4 Potential Biases of Within-Twin-Pair Estimates

Bound and Solon (1999) examine the implications of the endogenous determination of which twin goes to school for longer, and conclude that twins-based estimation is vulnerable to the same sort of bias that affects conventional cross-sectional estimation. The major concern of the within-twin-pair estimate is thus whether it is less biased than the OLS estimate, and is therefore a better estimate (Bound and Solon, 1999; Neumark, 1999). They argue that although taking a within-twin-pair difference removes genetic variation, that is, it removes μ_i from Equation (4), this difference may still reflect an ability bias to the extent that ability consists of more than just genes. In other words, within-twin-pair estimation may not completely eliminate the bias of conventional cross-sectional estimation, because the within-twin-pair difference in ability may remain in $\epsilon_{1i} - \epsilon_{2i}$ in Equation (4), which may be correlated with $Z_{1i} - Z_{2i}$. If endogenous variation in education comprises as large a proportion of the remaining within-twin-pair variation as it does of the cross-sectional variation, then within-twin-pair estimation is subject to as large an endogeneity bias as cross-sectional estimation.

Although within-twin-pair estimation cannot completely eliminate the bias of the OLS estimator, it can tighten the upper bound on the return to education. Ashenfelter and Rouse (1998), Bound and Solon (1999), and Neumark (1999) have debated the bias with

OLS and within-twin-pair estimation at length in recent papers. Note that the bias in the OLS estimator depends on the fraction of variance in education that is accounted for by variance in unobserved ability that may also affect earnings, that is, $\frac{cov(Z_i,\mu_i+\epsilon_i)}{var(Z_i)}$. Similarly, the ability bias of the fixed effects estimator depends on the fraction of within-twin-pair variance in education that is accounted for by within-twin-pair variance in unobserved ability that also affects earnings, that is, $\frac{cov(\Delta Z_i,\Delta\mu_i+\Delta\epsilon_i)}{var(\Delta Z_i)}$. If we are confident that education and the earnings error term are positively correlated both in the cross-sectional and within-twin-pair regressions, and if the endogenous variation within a family is smaller than the endogenous variation between families, then the fixed effects estimator is less biased than the OLS estimator. Hence, even if there is an ability bias in the within-twin-pair regressions, the fixed effects estimator can still be regarded as an upper bound on the return to education (if education and ability are positively correlated). In that case, we can credit the within-twin-pair estimates with having tightened the upper bound on the return to education.

To examine whether the within-twin-pair estimate is less biased than the OLS estimate, we follow Ashenfelter and Rouse (1998) and conduct some correlation analyses. We use the correlations of average family education over each twin pair with the average family characteristics that may be correlated with ability (for example, marital status, spousal education, membership of the Chinese Communist Party, working in a foreign firm, and job tenure) to indicate the expected ability bias in a cross-sectional OLS regression. We then use the correlations of the within-twin-pair differences in education with the within-twin-pair differences in these characteristics to indicate the expected ability bias in a within-twin-pair regression. If the correlations in the cross-sectional case are larger than those in the within-twin-pair case, then the ability bias in the cross-sectional regressions is likely to be larger than the bias in the within-twin-pair regressions.

The correlation tests that are reported in Table 3 suggest that the within-twin-pair estimation of the return to education may indeed be less affected by omitted variables than the OLS estimation. Note that the between-family correlations are all larger in magnitude than the within-twin-pair correlations. For example, the correlation between average family education and average spousal education is as large as 0.62 (column 1, row 2), which suggests that twins in families with a high average level of education marry highly educated people. This is consistent with the assumption that spousal education reflects an individual's ability and family background. The correlation of the within-twin-pair difference in education and the within-twin-pair difference in spousal education is about a quarter of the between-family correlation. This suggests that, to the extent that spousal education measures ability, the within-twin-pair difference in education is less affected by ability bias than the average family education. However, this within-twin-pair correlation is still statistically significant and large in magnitude, which suggests that within-twin-pair differencing cannot completely eliminate the ability bias that is embodied in education. Thus, the within-twin pair estimation may only establish an upper bound for the estimated return to education. The correlations of education with other variables provide similar evidence that the within-twin-pair estimation is subject to a smaller omitted ability bias. Of course, these characteristics are only an incomplete set of ability measures, but the evidence is suggestive.

4.5 Measurement Error

Another issue that we need to deal with is the measurement error problem. As is well known, classical errors in the measurement of schooling lead to a downward bias in the estimate of the effect of schooling on earnings, and the fixed effects estimator magnifies such measurement error bias (Woodridge, 2002).

One way to solve the problem of measurement error bias is to use the instrumental variable method. In this study, we follow the innovative approach of Ashenfelter and Krueger (1994) to obtain good instrumental variables. More specifically, in our survey we asked each twin to report both their own education and their co-twin's level of education. In the presence of measurement error in self-reported education, cross reported education is a potential instrument, as the report of the other twin should be correlated with the true education level of a twin but uncorrelated with any measurement error that might be contained in the self-report.

Following Ashenfelter and Krueger (1994), the instrumental variable approach can be applied as follows. Writing Z_j^k for twin k's report of twin j's schooling gives four different ways to express the schooling difference between the two twins.

$$\Delta Z' = Z_1^1 - Z_2^2 \tag{8}$$

$$\Delta Z'' = Z_1^2 - Z_2^1 \tag{9}$$

$$\Delta Z^* = Z_1^1 - Z_2^1 \tag{10}$$

$$\Delta Z^{**} = Z_1^2 - Z_2^2. \tag{11}$$

Assuming classical measurement error, that is, that measurement error in each of these reported education variables is uncorrelated with measurement error in the other variables, we can fit

$$\Delta y_i = \Delta Z_i' \beta + \Delta \epsilon_i, \tag{12}$$

using $\Delta Z''$ as an instrument for $\Delta Z'$. This approach is valid even in the presence of common family-specific measurement error, because the family effect is eliminated from both $\Delta Z'$ and $\Delta Z''$. We call this instrumental variable model the IVFE-1.

The IVFE-1 estimates of Equation (12) that are reported in the first two columns of Table 4 show that measurement error has biased downward the fixed effects estimates in columns (5) and (6) of Table 2, as other studies in the literature. The IVFE-1 estimates of the return rise by about 22 percent (from 0.027 by the fixed effects model to 0.033 by the IVFE-1 model), which suggests that a considerable fraction of the variability in the reported differences in the education levels of twins is due to measurement error. In other words, the conventional fixed effects method is producing serious underestimates of the economic returns to schooling.

However, the IVFE-1 estimates may also be biased if the measurement error terms in $\Delta Z'$ and $\Delta Z''$ are correlated. If there is an individual-specific component of the measurement error in reporting education, then Z_1^1 and Z_2^1 will contain the same reporting error. As a result, the error terms in $\Delta Z'$ and $\Delta Z''$ will be correlated, which makes $\Delta Z''$ an invalid instrumental variable for $\Delta Z'$.

Before discussing another instrumental variable, it is worth examining the correlations between the educations variables and their correlation with earnings as reported in Table 5. To facilitate this examination, we use the same correlations that are reported in Ashenfelter and Krueger (1994) as benchmarks. Interestingly, the correlations in our sample are very similar to those of Ashenfelter and Krueger. First, the correlations between the self-reported and co-twin-reported education of the same twin, that is, $cov(Z_1^1, Z_1^2)$ and $cov(Z_2^2, Z_2^1)$, are 0.932 and 0.923 in our sample, compared to 0.920 and 0.877 in the sample of Ashenfelter and Krueger. These high correlations suggest that the co-twin-reported level of education is a good instrumental variable for self-reported level of education in our sample. Second, our figures for the correlation between one twin's self-reported education and his/her report of the co-twin's education, that is, $cov(Z_1^1, Z_2^1)$ and $cov(Z_2^2, Z_1^2)$, are 0.739 and 0.720, whereas the same correlations in the paper of Ashenfelter and Krueger are 0.700 and 0.697. These correlations suggest that our sample may suffer from a slightly more serious correlated measurement error problem.

This correlated measurement error problem motivates us to implement a better instrumental variable that will be valid even in the presence of correlated measurement errors (Ashenfelter and Krueger, 1994). To eliminate the individual-specific component of the measurement error in the estimation, it is sufficient to use the schooling differences that are defined in (10) and (11), that is the education difference as reported by each twin, with one being used as an instrument for the other. More specifically, we can estimate the following equation,

$$\Delta y_i = \Delta Z_i^* \beta + \Delta \epsilon_i, \tag{13}$$

using ΔZ^{**} as an instrumental variable for ΔZ^*.

The estimates of the IVFE model that allows for correlated measurement errors, which we call the IVFE-2, are reported in the last two columns of Table 4. The new estimates of the return to education are 3.6-3.8 percent, or about 15 percent greater than the IVFE-1 estimates. Since our sample has correlated measurement error, which is similar to the sample of Ashenfelter and Krueger (1994), the IVFE-2 model should have the best estimates of the return to education.

5 What Is Distinct about China?

It is interesting to compare our estimates to other estimates in the literature that draw on data from different countries, mostly rich Western countries. Note first that our estimate of the raw return to education, that is, the OLS estimate, is 8.4 percent (column 4 of Table 2), which is very close to other estimates in the literature (first column of Table A1). However, our within-twin-pair estimate is only 2.7 percent, which is smaller than most estimates in the literature. Moreover, the ability bias in our sample, which stands at 5.7 percent, is larger than the ability bias that has been found in all other studies. These results together suggest that, in the Chinese case, most of the raw return to education is actually ability bias, which is different from the findings from other countries.

To ascertain why the true return to education is so low and the ability bias so high in China and to evaluate why China is so different from other countries, we need to understand the distinct education system in China, because this education system may explain the high ability bias and low return to education in these estimates.

5.1 The Chinese Education System

The Chinese education system is highly selective and exam oriented. It is composed of two stages: the compulsory stage and the non-compulsory stage. The compulsory stage comprises six years of primary school and three years of junior high school. Currently, most urban children finish nine years of compulsory education. Junior high school graduates have a choice of attending high school or vocational school,[5] and are required to take an entrance exam to gain a place at either type of institution. High school graduates are eligible for the college entrance exam, but vocational school graduates are generally not. In our monozygotic (MZ) twins sample, 74 percent had a high school or vocational school degree or above.[6] Because of the huge number of people waiting to be educated and the limited number of places at colleges and universities, entrance to college is extremely competitive, and only 13 percent of the workers in our sample obtained a college degree. To select those who will go on to college education, a nationwide college entrance exam system has been adopted, and the exam days of June 7, 8, and 9 determine the future of many young people each year:[7] Those who pass the examinations will become "white collar" workers, and those who fail them will most likely become "blue collar" workers.

Because of the competitive nature of the education system, schools, and in particular junior high schools and high schools, place great emphasis on exam-taking techniques.[8] Although high school in China lasts for three years, the whole curriculum is normally finished in one and a half years or an even a shorter time, with the rest of the time being spent on preparation for the college entrance exams. Although the first half of high school teaches

[5]There are several types of vocational schools in China, which are called vocational schools, technical high schools, or skilled workers' schools. In this paper, we group them together under the term "vocational schools."

[6]The percentage for the whole sample is 72 percent.

[7]The exam dates were formerly 7, 8, and 9 July, but were changed in 2003 to avoid the hot weather.

[8]It is no secret that the Chinese have very good exam taking skills. For example, among graduate school applicants in the United States, those from China normally have very high scores in GRE and other standard tests, and sometimes even have higher test scores in verbal English than native speakers. However, most Chinese people have never spoken English before coming to the United States because oral English is neither required by most US graduate schools nor emphasized in the English exams in China.

students new things, the teaching is also focused on exam-type problem-solving techniques. High school students need to finish a lot of homework every day, and normally need to go to school on weekends and vacations. All of this extra time is spent on training students to solve exam questions. Schools and teachers are rewarded solely on the basis of the success rate of their students in the entrance exams, and thus have no incentive to teach them anything else. These exam-taking techniques very often have little to do with the knowledge and skills that are needed for life and work, and it is thus unsurprising that such kind of schooling has a low return in the workplace.

Two other features of the Chinese non-tertiary education system are also distinct. First, the curricula (*jiao xue da gang* in Chinese) for primary school, junior high school, and high school are fixed by the Ministry of Education, and the most important part of these curricula is to specify what should be covered by the high school and college entrance exams. Schools and teachers then follow these curricula to prepare students for these exams. Second, high school students have to decide to take either arts or science for the rest of their education. Both arts and science students take Chinese, English, and political science, but arts students take geography, history, and basic mathematics, whereas science students take physics, chemistry, biology, and advanced mathematics. The college entrance exams also have two sets of papers, one for arts and the other for science. Because of the fixed curriculum, many students may not be able to study what they really are interested in, and having to make an early decision on whether to specialize in arts or science prevents students from obtaining the general education or training that are needed for life and work. Moreover, young students have to decide what they want to do before they even know what they are truly interested in, and as a result often choose badly.

Education that is not exam oriented only takes place in vocational schools and colleges. First, as vocational schools or colleges are different from each other and are administered by different ministries and provinces, they have the freedom to choose their own curricula. Second, and most importantly, vocational schools and colleges are usually the final stage of education, and thus exams are no longer important. Normally, vocational school graduates are not allowed to take the college entrance exams (and thus have no chance of going to college), and although college students may take the entrance exam to go on to graduate school, only a small proportion of students choose to do so. As exams are not important any more, students can spend more time on their true interests, and college students can select courses in different departments, although changing one's major (which is determined during the college admission process) is still difficult.

The distinct features of the Chinese education system can help to explain why the omitted ability bias (or selection effect) is high and the true return to education low in our estimations. Because of intense competition, only the very talented can advance to higher education, and thus education (or entrance exams) is a very good selection mechanism. Because of the exam-oriented education system, non-tertiary education, and in particular high school education, has little value-added in terms of general knowledge or workplace skills, except as a means of selecting talented candidates into college. High school graduates who are not able to get into college may thus have wasted three years on training in exam-taking techniques.

5.2 What Levels of Education Pay?

The distinct education system not only helps to explain why the return is low and ability bias high, but also suggests that the return to education may differ across education levels. It seems that exam-oriented high school education is the least useful level of education, and is valuable only as a selection mechanism for colleges. This means that the education that high school graduates who do not make it to college obtain should be least rewarded by employers. We investigate whether this is true by estimating the return to different levels of education by allowing the return to education to vary across education levels.

In the literature on twins studies, years of schooling is generally used as the measure of education (see, for example, Ashenfelter and Krueger, 1994; Ashenfelter and Rouse, 1998; Bonjour et al., 2003). However, little work has been carried out to examine the returns to different levels of education. As most of the literature draws on data from developed countries, and a large proportion of workers in these countries have some years of college education and have at least completed a high school education, it may not be necessary to examine the return to high school education versus the return to college education. However, knowing the returns to different levels of education is still very important for a developing country such as China, where college education is very limited. Knowing the returns to different levels of education could help the government to better allocate limited resources for education.

In Table 6, we report the regressions using three education dummies as measures of education. The high school dummy equals 1 if the last qualification that an individual obtained was a high school qualification, and 0 otherwise. Similarly, the vocational school dummy equals 1 if the last qualification that an individual obtained was a vocational school qualification, and 0 otherwise. The college dummy equals 1 if an individual had a college education or above, and 0 otherwise.

Our regression results show that it pays to attend vocational school or college, but not to attend high school only. The high school dummy is positive and significant in the two OLS estimations (columns 1 and 2 of Table 6), and high school graduates on average earn 7.0-10.5 percent more than those without a high school degree. However, this premium becomes almost zero and insignificant when we take the within-twin difference in columns 3-5. In contrast, the premiums that are associated with vocational school and college are large. With the OLS estimates, the vocational school premium is 32.4-34.4 percent and the college premium is as large as 61.1-62.3 percent. The positive premiums remain, although they become smaller, even after we control for omitted ability bias by taking the within-twin difference. For our best estimator, which is the IVFE-2 model, the estimated premiums for vocational school and college are 22.0 and 40.0 percent, respectively. These estimates mean that individuals with a vocational school degree earn 22.0 percent more and those with a college degree 40.0 percent more than individuals without a vocational school or college degree.

It is also interesting to calculate the return to each year of schooling for vocational school and college. As vocational school education usually lasts for three years, the return to each year of schooling is 7.3 percent. As it takes seven years (three years of high school plus four years of college) to gain a college degree, the average return to each year of schooling is only 5.7 percent. However, as high school has a zero return, the return to each year of college education can be as high as 10 percent.

These estimates have important policy implications. First, exam-oriented high school education has no return unless one also attends college. Given that vocational school is a substitute for high school in China, it is thus rather risky for an individual to go to high school, as the chance of getting into college is low. This partially explains why many children from poor families choose to go to vocational school, even if they are eligible for high school. With limited college places, exams may be the only possible mechanism to select students into college, but there may still be ways to make high school education more useful. For example, the decision about whether to specialize in arts or science could be postponed until college, which would thus make high school education more well rounded. As one major function of junior high school and high school education is to select students into the next level of education, the government could consider shortening junior high school and high school education, say, from three years each to two years each, and using the saved resources to expand the provision of vocational schools or college.

6 Conclusion

In this paper, we empirically measure the return to education in urban China. By using twins data to control for omitted ability and the family effect, we find that most of the return to education that is estimated by the OLS model is actually due to the effects of unobserved ability or family background. In other words, our findings seem to suggest that the selection role of education is more important than the knowledge that is acquired at school. The fixed effects estimate of the return to one year of education is only 2.7 percent, and the part of the education premium that is due to unobservable ability is as large as 5.7 percent. Our sensitivity analyses suggest that the within-twin-pair estimates are biased downward because of measurement error, and after the correction of this bias the estimated return rises to 3.8 percent. We further show that the return to high school education is zero, but that the returns to vocational school and college education are 22.0 percent and 40.0 percent, respectively.

The earlier findings of a low return to education in China, such as those of Byron and Manaloto (1990) and Meng and Kidd (1997), have generated a great deal of interest among economists. In the search for explanations of the low return, most economists have turned to the remaining elements of the planned economy. We agree that the return was low when the Chinese economy was under a planned regime and is likely to rise as the economy becomes more market-oriented (see, for example, Heckman and Li (2004) and Zhang et al. (forthcoming)), but argue that economic transition may not be the whole story. Because of the distinct education system in China, the returns to the various levels of education are different, and in particular we find that exam-oriented high school education has no return in terms of earnings; rather, it merely serves as a selection mechanism for colleges. Few previous studies have paid attention to the distinctive education system in China (or that of other Asian countries) and its consequences for the return to education.

Knowing the true return to education has important policy implications. Our findings show that the return to education is not universally low in China. The return to each year of vocational school is 7.3 percent, and the return for each year of college education is as high as 10.0 percent, both of which are comparable to estimates that draw on twins data from other countries. Thus, our findings support the argument of Heckman (2003 and 2005) and Fleisher and Wang (2004) that investing in human capital is worthwhile in China. However, our results also have some particular policy implications. Given that China has limited resources to devote to education, it is important to identify educational priorities. Our finding that the return to high school education is zero and that high school education only serves as a college selection mechanism in urban China suggests that nothing would be lost if high school education were shortened by one year. The resources saved could be invested in levels of education that yield higher returns, such as vocational school or college, or could be diverted to the provision of basic education in rural China, where many children are not fortunate enough to obtain the nine years of compulsory education (Brown and Park, 2002).

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Table 1: Descriptive Statistics of the Twins and Non-Twins Samples

Variable	MZ twins (1)	All twins (2)	Non-twins (3)	NBS sample (4)
Education (years of schooling)	12.22	12.16	11.73	11.62
	(2.89)	(2.91)	(3.07)	(2.83)
High school dummy	0.27	0.25	0.30	--
	(0.44)	(0.43)	(0.46)	--
Technical school dummy	0.34	0.35	0.32	--
	(0.47)	(0.48)	(0.47)	--
College dummy	0.13	0.12	0.10	--
	(0.33)	(0.33)	(0.30)	--
Age	34.78	33.77	43.27	40.80
	(9.64)	(9.22)	(8.42)	(11.98)
Gender (male)	0.60	0.59	0.48	0.55
	(0.49)	(0.49)	(0.50)	(0.50)
Married	0.66	0.64	0.94	--
	(0.47)	(0.48)	(0.24)	--
Tenure (the number of years in full-time work	15.03	14.03	21.70	18.45
since the age of 16)	(9.93)	(9.50)	(9.05)	(12.94)
Earnings (monthly wages, bonuses, and subsidies	887.85	872.52	845.84	1062.92
in RMB)	(517.91)	(546.00)	(549.08)	(840.09)
Spousal education	11.64	11.69	11.49	--
	(3.11)	(3.08)	(3.49)	--
Sample size	976	1620	1277	23288

Note: The mean and standard deviation (in parentheses) are reported in the table. For the MZ twins sample, we restrict the sample to those twin pairs (488 pairs) for which we have complete information on earnings, age, gender, years of education, job tenure, and marital status for both twins in the pair. The NBS sample is based on a large-scale survey by the National Bureau of Statistics in six provinces.

Table 2: OLS and Fixed Effects Estimates of the Return to Education for Twins and Non-twins from Urban China
(Dependent variable: log earnings)

Sample	Twins and non-twins		Twins		Twins		Twins	
Model	OLS		OLS		FE		GLS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Own education	0.067***	0.067***	0.082***	0.084***	0.025*	0.027*	0.025**	0.027**
	(16.71)	(16.91)	(13.85)	(14.14)	(1.68)	(1.87)	(2.06)	(2.22)
Sum of education							0.033***	0.033***
							(4.70)	(4.66)
Age	0.023**	0.011	0.041***	0.036*			0.039***	0.033**
	(2.49)	(0.89)	(2.60)	(1.88)			(2.71)	(2.00)
Age squared	-0.020*	-0.023*	-0.045**	-0.052**			-0.040**	-0.047**
	(1.68)	(1.67)	(1.99)	(2.13)			(2.04)	(2.26)
Gender (male)	0.217***	0.210***	0.205***	0.202***			0.206***	0.204***
	(9.05)	(8.72)	(5.32)	(5.25)			(5.36)	(5.30)
Married		-0.033		-0.027		-0.043		-0.025
		(0.75)		(0.53)		(0.83)		(0.58)
Tenure		0.016***		0.011*		0.015		0.012**
		(4.77)		(1.86)		(1.52)		(2.09)
Twin pairs					488	488	488	488
Observations	2255	2253	976	976	976	976	976	976
R-square	0.17	0.18	0.22	0.23	0.01	0.02		

Note: All of the OLS regressions include city dummies. Robust t statistics are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3: Between-Families and Within-Twin-Pair Correlations of Education and Other Variables (488 twin pairs)

Between-family correlations		Within-twin-pair correlations	
	Education		ΔEducation
Married	-0.1445*** (<0.01)	ΔMarried	-0.0173 (0.70)
Spousal education	0.6172*** (<0.01)	ΔSpousal education	0.1518** (0.02)
Party member	0.2571*** (<0.01)	ΔParty member	0.1166** (0.02)
Working in foreign firm dummy	0.0904* (0.06)	ΔWorking in foreign firm dummy	0.0214 (0.66)
Tenure	-0.2614*** (<0.01)	ΔTenure	-0.1253*** (0.01)

Note: The significance levels are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. The between-family correlations are the correlations between average family education (average of the twins) and average family characteristics, and the within-twin-pair correlations are the correlations between the within-twin-pair differences in education and the within-twin-pair differences in other characteristics.

Table 4: Instrumental Variable Fixed Effects Estimates of the Return to Education of Chinese Twins (Dependent variable: log earnings)

	IVFE-1 ($\Delta Z''$ as IV)		IVFE-2 (ΔZ^{**} as IV)	
	(1)	(2)	(3)	(4)
Education ($\Delta Z'$)	0.032*	0.033*		
	(1.65)	(1.77)		
Education (ΔZ^*)			0.036**	0.038**
			(1.99)	(2.14)
Married		-0.043		-0.048
		(0.81)		(0.91)
Tenure		0.016		0.016
		(1.60)		(1.59)
Twin pair	488	488	488	488
Observations	976	976	976	976

Note: $\Delta Z'$ is the difference between the self-reported education of twin 1 and the self-reported education of twin 2. $\Delta Z''$ is the difference between the education of twin 1 as reported by twin 2 and the education of twin 2 as reported by twin 1. ΔZ^* (ΔZ^{**}) is the difference between twin 1's (twin 2's) report of his/her own education and his/her report of the other twin's education. The robust t-statistics are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5: Correlations Between Earnings and the Education Variables

Variable	Y_1	Y_2	Z_1^1	Z_1^2	Z_2^2	Z_2^1	E_F^1	E_F^2	E_M^1	E_M^2
Y_1	1.000									
Y_2	0.506	1.000								
Z_1^1	0.388	0.375	1.000							
Z_1^2	0.397	0.373	0.932	1.000						
Z_2^2	0.366	0.417	0.758	0.720	1.000					
Z_2^1	0.359	0.401	0.739	0.699	0.923	1.000				
Father's education (E_F^1)	0.140	0.159	0.322	0.327	0.394	0.397	1.000			
Father's education (E_F^2)	0.128	0.158	0.315	0.323	0.394	0.396	0.979	1.000		
Mother's education (E_M^1)	0.152	0.120	0.278	0.296	0.341	0.345	0.554	0.539	1.000	
Mother's education (E_M^2)	0.141	0.113	0.278	0.275	0.348	0.346	0.540	0.525	0.986	1.000

Notes: Y_1 and Y_2 represent twin 1's and twin 2's log monthly wage rate, respectively. Z_j^k represents twin k's report of twin j's education, where k = 1, 2 and j = 1, 2. E_F^k (k=1, 2) represents the father's education as reported by twin k, and E_M^k (k = 1, 2) represents the mother's education as reported by twin k.

Table 6: Various Estimates of the Return to High School and College Education for Twins and Non-twins from Urban China

	Dependent variable: log earnings				
Sample	All	Twins	Twins	Twins	Twins
Model	OLS	OLS	FE	IVFE-1	IVFE-2
	(1)	(2)	(3)	(4)	(5)
High school	0.070**	0.105*	-0.003	0.030	0.031
	(2.19)	(1.94)	(0.04)	(0.31)	(0.29)
Technical school	0.324***	0.344***	0.168**	0.218**	0.220*
	(10.40)	(6.72)	(2.09)	(2.22)	(1.89)
College	0.611***	0.623***	0.278**	0.392***	0.400***
	(16.32)	(10.88)	(2.45)	(2.96)	(2.66)
Age	0.022*	0.055***			
	(1.78)	(2.76)			
Age squared	-0.038***	-0.075***			
	(2.70)	(3.03)			
Gender (male)	0.204***	0.189***			
	(8.43)	(4.73)			
Married	-0.049	-0.052	-0.039	-0.035	-0.040
	(1.14)	(0.99)	(0.75)	(0.66)	(0.76)
Tenure	0.016***	0.008	0.014	0.015	0.014
	(4.68)	(1.17)	(1.42)	(1.53)	(1.48)
Twin pairs			488	488	488
Observations	2253	976	976	976	976
R-square	0.18	0.18	0.03		

Note: All of the OLS regressions include city dummies. For model IVFE-1, we use ΔZ' (the difference between the high school and college dummies) as independent variables, which are instrumented by ΔZ''. For model IVFE-2, we use ΔZ* as independent variables, which are instrumented by ΔZ**. The robust t-statistics are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table A1: Estimated Return to Years of Education Using Twins Sample from Different Countries

Study	Sample and Country	OLS (A)	FE (B)	Omitted variable bias (C=A-B)	IVFE (D)
Taubman (1976a)	NAS-NRC Twin Registry sample of white male army veterans, USA	0.079	0.027	0.052	--
Ashenfelter and Krueger (1994)	Twinsburg sample, USA	0.084	0.092	-0.008	0.129
Behrman et al. (1994)	NAS-NRC Twin Registry, Minnesota Twin Registry, USA	--	0.035	--	0.050
Miller et al. (1995)	Australia Twin Registry	0.064	0.025	0.039	0.048
Behrman et al. (1996)	Male twins born in Minnesota, USA	--	0.075	--	--
Ashenfelter and Rouse (1998)	Twinsburg sample, USA	0.110	0.070	0.040	0.088
Behrman and Rosenzweig (1999)	Minnesota Twin Registry, USA	--	--	--	0.104
Rouse (1999)	Twinsburg sample, USA	0.105	0.075	0.030	0.110
Isacsson (1999)	Sweden Twin Registry	0.049	0.023	0.026	0.024
Bonjour et al. (2003)	Twins Research Unit, St., Thomas' Hospital (female only), London, UK	0.077	0.039	0.038	0.077
This study	Chinese Twins Survey, China	0.084	0.027	0.057	0.038