Returns to Higher Education in China - Evidence Based on the 1999 Higher Education Expansion using Fuzzy Regression Discontinuity

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Abstract

China experienced a 40% expansion in higher education between 1998 and 1999, and a six-fold expansion in the decade to 2008. In this paper, we explore a fuzzy discontinuity in the months of births induced by the expansion to study the returns to higher education in China. We find that the mean years of education increased by roughly one full year around the cut-off point of the 1999 expansion as defined by months of births. Importantly, each additional year of university education induced by the 1999 higher education expansion increases monthly wage income by 21%, whereas the corresponding OLS estimate is only 8%. Our findings are insensitive to alternative window widths, functional forms, or the exclusion of the self-employed. Moreover, the returns to degrees also appear to vary by gender, with lowers returns to women except when they are the only child in the family.

JEL codes: I23, I26

Keywords: returns to higher education, higher education expansion, regression discontinuity design, China

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Section 1: Introduction

Most economies have experienced significant expansions of the higher education (HE) sector in recent decades. While a simple textbook model would predict a decline in the college premium as a result, the empirical evidence is mixed. Evidence from the US (see Card and Lemieux (2001) and Goldin and Katz (2008) e.g.), and the UK (Blundell et al. (2000, 2016), Walker and Zhu (2008)), suggests that the returns to university degrees are largely constant over time, despite the substantial increase in college enrolment. The usual explanation is *skilled biased technological change (SBTC)* which increases the relative demand for more skilled workers.

The HE sector in China expanded by a factor of six over the decade from 1999, including a 40% or more annual increase in both 1999 and 2000 (Wu and Zhao (2010), Che and Zhang (2017)). The extent of the expansion is unprecedented, at least among major economies. However, the effect of this expansion on labour market outcomes and inequality has not been very well understood so far. In this paper, we take advantage of this massive expansion to study the returns to higher education in China, using the 2005 and 2010 China Urban Labour Force Surveys, conducted by the Chinese Academy of Social Sciences (CASS). Methodologically, we explore the Regression Discontinuity Design (RDD), which relies on less restrictive assumptions for identification than the difference-in-differences (DID) or the Instrumental Variables (IV) approaches. This is important, as there is no regional pilot and the general equilibrium effect arising from the scale of the expansion is too large to ignore.

We find that the mean years of education increased by roughly one full year around the cut-off point of the 1999 expansion as defined by months of births. Importantly, each additional year of university education induced by the 1999 higher education expansion increases monthly wage income by over 20%. Our findings are insensitive to alternative window widths, functional forms, or the exclusion of self-employed. Moreover, the returns to degrees also appear to vary by gender, with lowers returns to women except when they are the only child in the family.

We contribute to the empirical literature on the returns to education in at least two ways. Firstly, we are the first study on the returns to higher education in China using the RDD approach exploiting the massive expansion of the sector that took place around 1999. Secondly, we provide direct evidence to the debate on whether the expansion was economically justified on the grounds of returns to education.

The rest of the paper is organized as follows. Section 2 provides the background of the expansion and reviews the relevant literature. Section 3 introduces the data and describes the sample selection. Section 4 discusses the identification strategy and presents summary statistics. Section 5 presents the empirical analysis and discusses the results. Finally, section 6 concludes.

Section 2: Background and Literature review

China introduced 9-year compulsory education in 1986, consisting of 6 years of primary schools and 3 years of junior high schools. Upon the completion of junior high school, students can choose to go to senior high schools, or vocational schools, both for 3 years, or enter employment directly. High school graduates can apply to universities and colleges, which normally take 4 and 3 years to complete respectively in most cases (OECD 2016).

China's HE sector has always been dominated by public funded universities and colleges. Until the mid 1990s, universities were highly selective but free of tuition fees. University places were highly rationed, and allocated according to the National Higher Education Entrance Examination (*gaokao*) results of applicants, with province-specific score cut-offs regardless of gender, *hukou*[1] status or family resources. The growth of the HE sector was tightly controlled by the Ministry of Education, which sets provincial, university and subject quotas annually (OECD, 2016). Between 1995 and 1998, college enrolment only increased by an average of 4.7% per annum (Che and Zhang 2017).

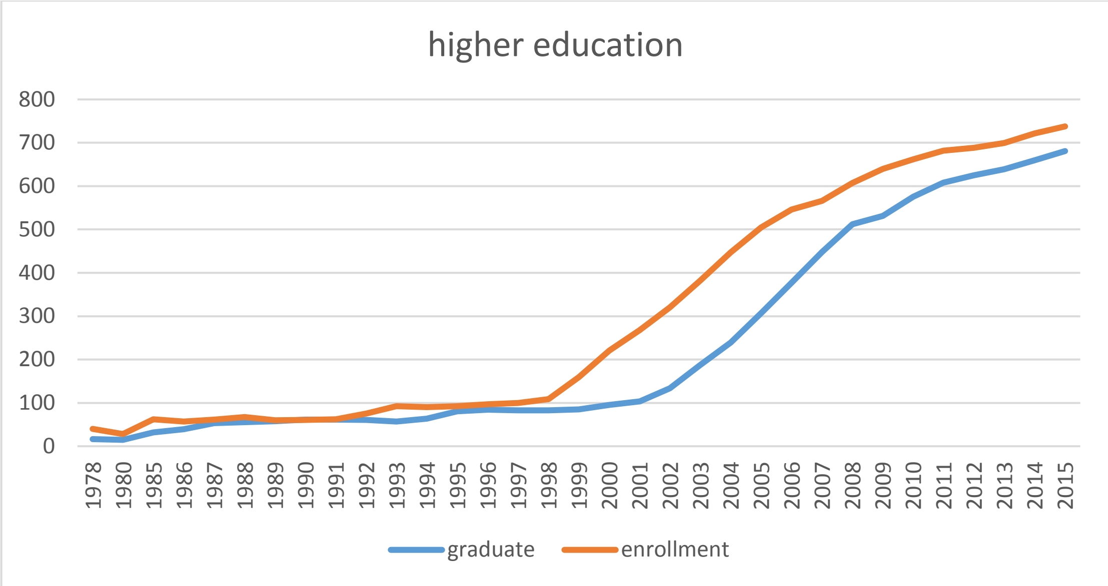
In early 1999, partly as a response to the economic slowdown and rising youth unemployment in the aftermath of the 1997 Asian Financial Crisis, the Ministry of Education announced a sudden 44% increase in university places (Wu and Zhao (2010) and Li et al (2017)). This was followed by another 40% increase in 2000, and subsequent slower but still substantial double-digit growth year on year for the next decade (Che and Zhang 2017). It is only after the Great Recession in 2008 that the government decided to impose a tighter control on the rate of growth. Figure 1 shows the annual higher education enrolment and graduation in China over the period 1978-2015. The decade from 1998 to 2008 witnessed the fastest

[1] China's *hukou (*household registration) system assign people to urban or rural status at the time of birth. Rural hukou holders face substantial disadvantage in terms of access to education, labour market and social welfare, compared to their urban counterparts (OECD 2016).

expansion of the sector, with annual enrolment growing from just over 1 million in 1998 to about 6 million in 2008.

Figure 1: Higher Education Enrolment and Graduation over Time

Unit: 10 thousand



Note: Data resources: China Statistic Yearbook 2010 and 2016, (http://www.stats.gov.cn/tjsj/ndsj/2010/indexch.htm, http://www.stats.gov.cn/tjsj/ndsj/2016/indexch.htm.) Data from 1978-2009 is from yearbook 2010, data from 2010-2015 is from yearbook 2016.

China's education and labour market has drawn increased research interests, due to its growing economic prominence since the reform started in the late 1970s. The meta-analysis by Awaworyi and Mishra (2014) concludes that the returns to education in the post-reform era is around 10.25%. Apart from excluding all studies published in Chinese academic journals, another limitation of the meta-analysis is that it only covers studies using multivariate analyses or instrumental variables estimations typically based on family characteristics such as parent or spousal education. Therefore, one should be cautious in interpreting these estimates as causal due to the ability biases or endogeneity problems.

More recently, a few studies have attempted to uncover the returns to education in China using quasi-experimental methods, in the context of a fast-changing education and labour market.[2]

[2] Other studies using quasi-experimental methods have focused on the effect of HE expansion on the employment of college graduates. They find that while the expansion increased the unemployment of new college graduates in the short-run, this effect mostly vanishes after 5 year (see e.g., Li et al (2014) and Xing et al (2017)).

Using the 2002 Labour Market Survey by the Ministry of Labour and Social Security and the 2005 1% Population Survey, Wu and Zhao (2010) study the effect of the HE expansion in 1999 on labour market participation and unemployment using difference-in-differences (DD) and difference-in-difference-in-differences (DDD) methods. They find that the expansion adversely affects the employment of new graduates. Moreover, new graduates' hourly wages grow by over 10% less than older graduates. However, relative to high school leavers, new graduates' wages are not significantly affected by the expansion, with an implied return to each year of university education around 14%.[3]

By pooling the China Health and Nutrition Survey (CHNS) from 1997, 2000, 2004 and 2006, Fang et al. (2012) estimate the returns to education by instrumenting years of schooling using the variation in the implementation of the 9-year compulsory education across provinces. Their IV estimate is as high as 20%, which is significantly above the OLS estimate. Exploiting the same policy reform starting in 1986, Liu et al. (2016) were the first study on returns to education in China using the RDD approach. Their RDD estimate based on the China Urban Household Survey is 12.8%, which is greater than the OLS estimate of 9.6%.

Section 3: Data and Sample

This paper is based on the China Urban Labour-force Survey (CULS) 2005 and 2010. CULS is a household survey of selected cities undertaken by the Institute of Population and Labour Economics, Chinese Academy of Social Sciences (IPLE-CASS). The survey uses multistage stratified sampling of communities, families and individuals respectively, with interviews undertaken by the local branches of the National Statistical Bureau.

The sampling frame of CULS was based on the 1% sample of the population in the corresponding years in the country. For each city selected, a two-stage sampling method was used to draw samples from the resident population in the main urban area: in the first stage, a predetermined number of neighbourhood committees were selected by the Probability Proportional to Size (PPS) method; in the second phase of resident extraction, a certain number of residential blocks are first drawn from each of the chosen neighborhood committee,

[3] Using the 2002 and 2007 China Household Income Project (CHIP) and 2002-2008 Chinese Urban Household Survey, Knight et al (2017) present descriptive analysis of the 1999 HE expansion on graduate labour market outcomes. They conclude that the adverse effect on relative (to high school leavers) wages, employment and access to managerial and professional jobs is restricted to entry-year or entry-period cohort of graduates.

then within each block a certain number of native and migrant households are selected using random equidistant method.

CULS covers cities at various levels, including municipalities, provincial capitals and mid-sized cities, making it more representative of the urban labour market in contemporary China. The 2005 CULS covers the following cities: Shanghai, Shenzhen (of Guangdong province), Fuzhou and Zhuhai (both of Fujian province), Wuhan and Yichang (both of Hubei province), Xian and Baoji (both of Shaanxi province), Shenyang and Benxi (both of Liaoning province), Daqing (of Heilongjiang province) and Wuxi (of Jiangsu province). On the other hand, the 2010 CULS only covers a subset of major cities from the 2005 survey: Shanghai, Fuzhou, Wuhan, Xian and Shenyang, plus Guangzhou (of Guangdong province). In order to maximize the sample size, we pool the two surveys together, resulting in over 40 thousand individuals in 13 cities from 8 provinces or municipalities. Our analytical sample spans the Eastern, the Central and the Western regions, and covers a mixture of municipalities, provincial capitals and mid-sized cities.

Section 4: Identification strategies: Fuzzy Regression Discontinuity (RD)

The fuzzy Regression Discontinuity Design (fuzzy RDD) is a quasi-experimental design in which the probability of receiving treatment changes discontinuously across the threshold as a function of a continuous running variable. Essentially, RDD compares the treatment group on the right-hand side of the cut-off point to the control group on the left side of the cut-off point, using the latter as the counterfactual (Hahn et al, 2001). The RD strategy can be regarded as a weighted average treatment effect model on all individuals in the presence of heterogeneous treatment effects (Lee and Lemieux, 2009). Compared to more conventional quasi-experimental methods such as the differences-in-differences (DD) approach, RDD is much more robust as it only requires the weaker identifying assumptions of observations being randomly distributed and that the running variable is continuous. Another major merit of RDD is the graphical analysis which shows intuitively and transparently any jumps across the threshold in the running variable.

Critical to our analysis is the identification of the cut-off point in the continuous measure of month of births induced by the higher education expansion policy in 1999. This is an empirical question. According to the Chinese education system, children normally start school between 6 and 8, and are expected to complete 9 years of compulsory education in primary and junior high schools. Another 3 years of education at senior high schools or equivalent is required before one can apply to HE institutions. So, taking into account the minimum 12 years of full-time education required, it works out that people who received the "treatment" of HE expansion in 1999 enrolled in primary schools in 1987 or later. Given that the school year runs between September 1st and August 31st in the following year, we expect the threshold to fall between September 1st 1979 and August 31st 1981.

We choose to define the treatment group as those born on September 1st 1979 or later. This is in line with Wu and Zhao (2010) which show that among full-time students, high school students account for the vast majority of 18-year olds and a small majority of 19-year olds in the various censuses. We will undertake sensitivity checks with respect to alternative cut-off dates in the analysis.

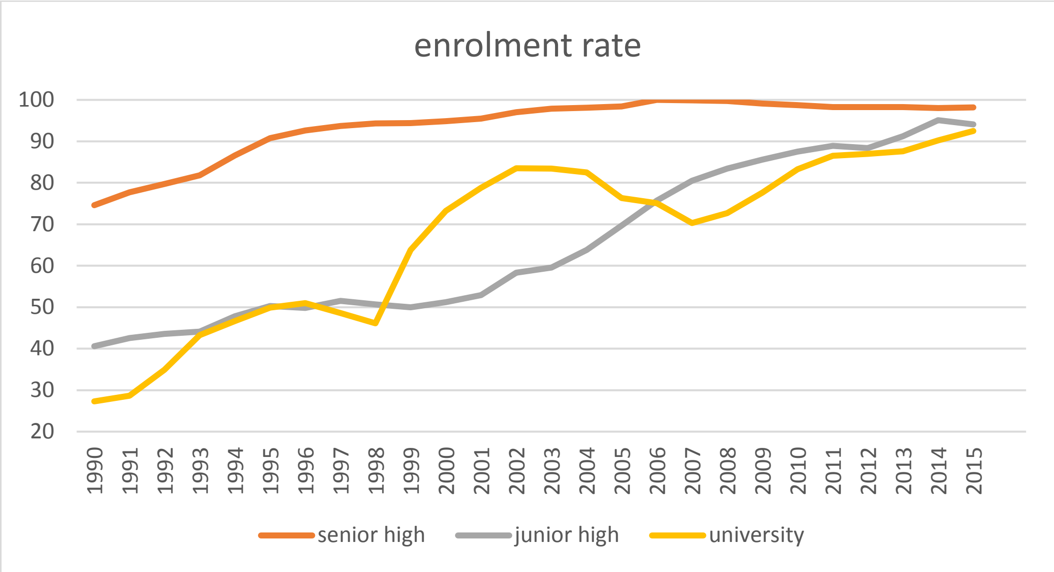
Our preferred control group is people whose highest education is junior high school, the expected qualification at the end of the 9-year compulsory education stage. Note that the 9-year compulsory education had been enforced nationwide for more than a decade by the time of the 1999 HE expansion, and there is no reason to expect the HE expansion to affect attainment of the school-exit qualification. On the other hand, one might expect a positive spill-over effect on the attainment of senior high school qualifications, which are prerequisites for HE studies in China.

Figure 2 shows the graduate enrolment rates into HE, Senior High and Junior High Schools respectively over time. The enrolment of Senior High School graduates into HE jumped from 46.1% in 1998 to 63.8% in 1999, a 38.4% increase which is very close to the 40% increase in HE enrolment.[4] While the enrollment rate of primary school graduates into junior high school stays at over 94% and only increases moderately during the period of higher education expansion of 1998-2008, the enrolment rate of junior high school graduates into senior high schools appears to have experienced a significant expansion, from 50.7% in 1998 to 83.4% in 2008. However, the first significant jump only took place in 2002, from 52.9% in the previous year to 58.3%. The 3-year lag in the expansion of Senior High School suggests not only that the HE expansion in 1999 was indeed unanticipated, but also that it might have a lagged spill-over effect on Senior High completion. This lends strong support to our choice

[4] The small discrepancy might be explained by the increased probability of enrolment of Senior High graduates from previous cohorts. Repeating grades in order to get into (a better) college is a common practice in China, especially in rural areas.

of junior high school graduates as the control group in our research. Including senior high school graduates (in either the treatment or the control group) is likely to lead to biased estimates of returns to higher education.

Figure 2: Graduate enrolment rate over time, by level of qualifications



Note: data resources: China Statistic Yearbook 2010 and 2016, http://www.stats.gov.cn/tjsj/ndsj/2010/indexch.htm, http://www.stats.gov.cn/tjsj/ndsj/2016/indexch.htm. Data from 1990-2009 is from yearbook 2010, data from 2010-2016 is from yearbook 2016.

In practice, we estimate two equations. In the first reduced form equation, the outcome variable is years of education, or a dummy of obtaining an HE qualification.

(1) $$eduyear = \partial_0 + \delta_1 TREAT + \delta_2(a) + \partial_3 * X + \mu$$

where *TREAT* denotes the treatment status (i.e. born after September 1979), $\delta_2(a)$ is a polynomial of the running function in the continuous measure of month of birth which captures the effect of age, and X is a set of control variables. To the extent that $\delta_2(a)$ is a continuous function and the samples before and after the cut-off are randomly assigned, the treatment variable is the only source of discontinuity and hence δ_1 identifies the effect of discontinuity induced by the 1999 HE expansion on years of schooling.

We also estimate the reduced form equation, where the outcome variable is log monthly income:

(2) $$\ln(income) = ß_0 + ß_1 * TREAT + ß_2(a) + ß_3 * X + \nu$$

Using the same reasoning, one can see that β_1 identifies the effect of discontinuity induced by the 1999 HE expansion on earnings. Moreover, the returns to one year of university education is derived by the ratio $ß_1/\delta_1$.[5] Following Calonico et al. (2014, 2017), we choose the optimal fuzzy RDD bandwidth for our sample.[6] Considering the case in China, we include 36 months on either side of the cut-off. Our results are insensitive to choosing alternative bandwidths (windows) of 30 or 42 months. Following Calonico et al. (2014, 2017), we choose the *p-th* order local polynomial estimator with the *q-th* order local polynomial bias correction, and find that local linear regression with quadratic bias correction is optimal for our sample. While our baseline is based on local linear regression with triangular kernel, we report in our robustness analysis that the results are also robust to using 2nd-order polynomials of the running variable.[7]

Table 1 reports the summary statistics for the main analytical sample, with 36 months on each side of the month of birth cut-off. In other words, our main sample consists of all respondents born within 3 years of the September 1979 cut-off in the pooled CULS from 2005 and 2010, who hold either a higher education degree or junior high school diploma as the highest qualification. The sample size is 2995, of which 2540 have non-missing monthly wage incomes. We also report summary statistics by the treatment status (i.e. before or after the cut-off), gender and *hukou* status when the respondent was completing primary education. It is worth noting that the gap in years of schooling between the treatment and the control group is 0.86 years, a remarkable jump for people who are only 3 years apart by birth on average. There are also significant differences in log monthly incomes (in constant 2010 prices) by gender and *hukou* status.

[5] We implement the two-step procedure with the help of the Stata routine *rdrobust*, which reports the right standard errors.

[6] We run bandwidth selection with the help of the Stata command *rdbwselect*, with the option *mserd* for MSE-optimal point estimation using a common bandwidth on both sides of the cutoff.

[7] We do not report results for third and fourth order polynomials. Gelman and Imbens (2017) caution against using higher-order polynomial in RD designs as they tend to inappropriately put large weights on observations further away from the threshold.

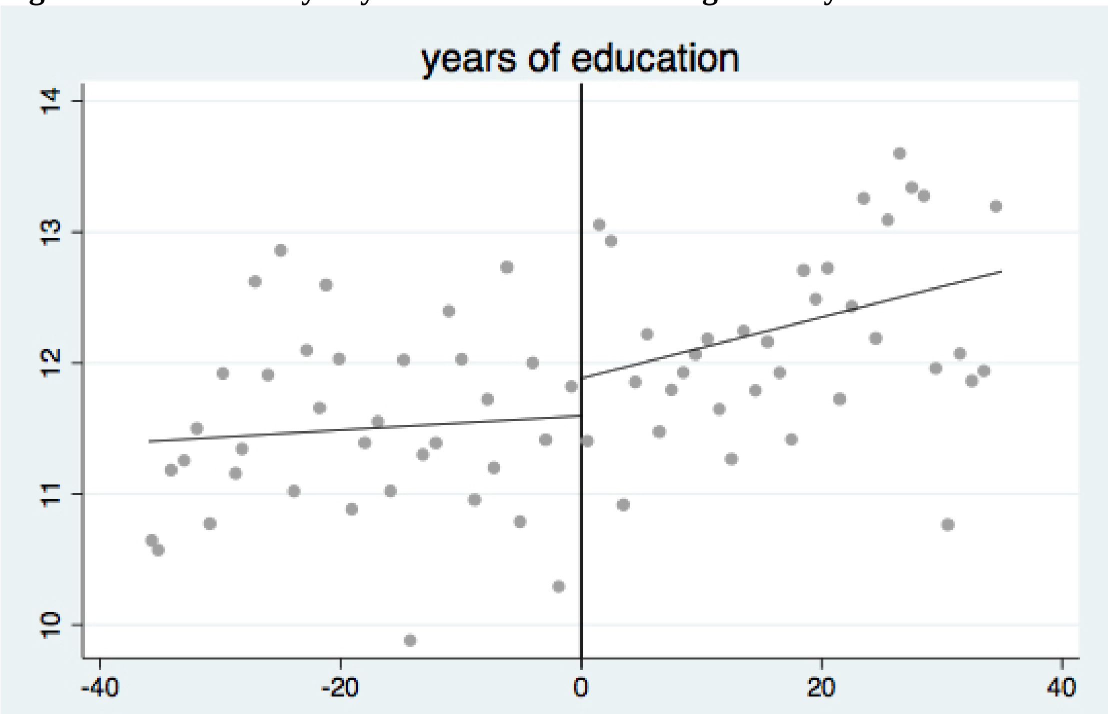
Table 1: Summary Statistics of The Main Sample

	All	By treatment status		By gender		By *hukou* status (primary school)		
		before	after	Female	male	village	town	City
Log monthly income	7.387	7.389	7.385	7.260	7.503	7.186	7.494	7.580
Education years	11.92	11.60	12.46	12.00	12.07	10.18	12.00	14.60
Employed	0.663	0.670	0.760	0.727	0.705	0.558	0.731	0.917
Experience	5.597	6.946	4.245	5.587	5.564	7.393	5.631	3.043
Migrant	0.649	0.664	0.633	0.620	0.674	0.883	0.798	0.221
Gender	0.480	0.552	0.494			0.545	0.524	0.490
Father' years of educ	6.405	6.292	6.575	6.636	6.252	5.982	7.406	6.347
Mother's years of educ	5.082	4.909	5.310	5.364	4.883	4.513	5.728	5.479
Number of siblings	0.837	0.970	0.771	0.918	0.825	1.018	1.057	0.529
Hukou status (location of primary school)								
Village	0.441	0.481	0.399	0.419	0.458	1.000	0.000	0.000
Town	0.233	0.225	0.247	0.235	0.236	0.000	1.000	0.000
City	0.325	0.293	0.354	0.346	0.303	0.000	0.000	1.000
Region of birth:								
Eastern	0.282	0.275	0.321	0.295	0.302	0.210	0.342	0.387
Central	0.161	0.181	0.161	0.183	0.160	0.169	0.165	0.179
Western	0.067	0.067	0.078	0.069	0.076	0.073	0.070	0.074
Current province of residence:								
Shanghai	0.155	0.142	0.183	0.160	0.166	0.122	0.204	0.190
Hubei	0.161	0.177	0.139	0.174	0.142	0.154	0.134	0.180
Liaoning	0.163	0.154	0.164	0.137	0.180	0.167	0.117	0.181
Fujian	0.166	0.171	0.157	0.177	0.152	0.185	0.177	0.125
Shaanxi	0.148	0.140	0.163	0.148	0.155	0.177	0.125	0.136
Heilongjiang	0.032	0.034	0.022	0.028	0.029	0.032	0.042	0.013
Guangdong	0.145	0.148	0.148	0.150	0.146	0.122	0.174	0.163
Observations	2,995	1,251	1,289	1,212	1,328	1,119	599	822

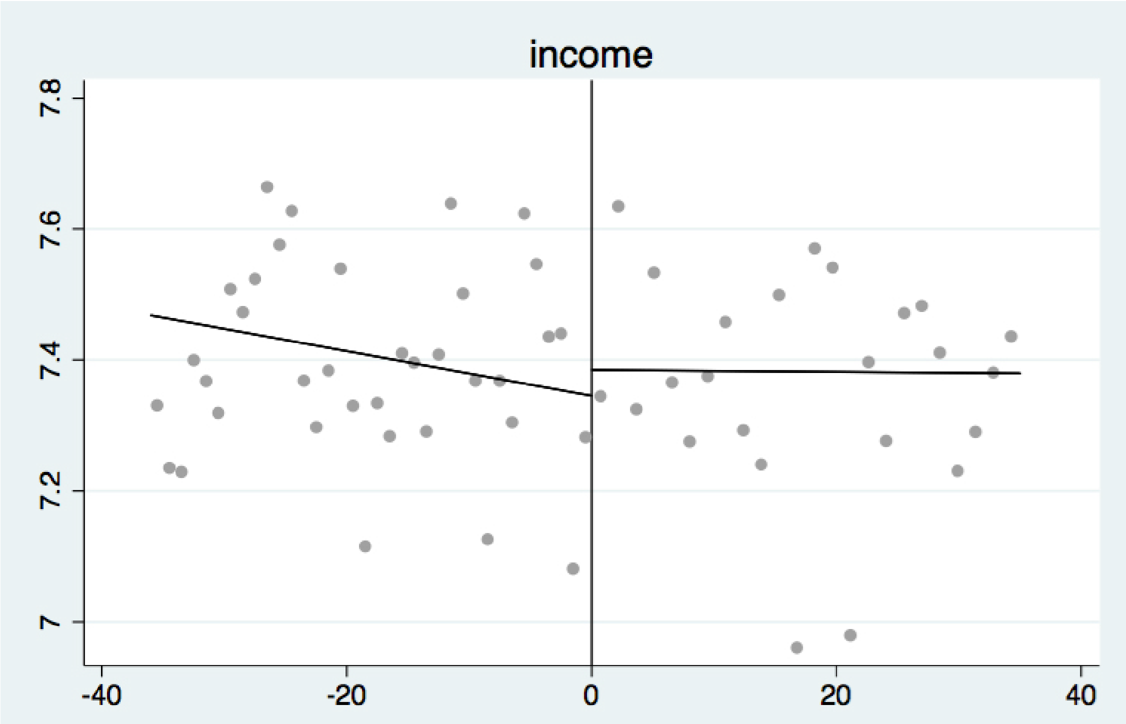
Section 5: Empirical Analysis

Figure 3 highlights the discontinuity in years of education and log monthly income, by months of birth. The top panel clearly indicates a jump of about 0.35 years of education around the cut-off point which corresponds to birth in September 1979. Post the cut-off, the slope also appears to have increased, consistent with the continuous expansion over a decade. In the bottom panel, the polynomial fit suggests an increase of 0.25 log points in monthly income around the cut-off.[8]

Figure 3: Discontinuity in years of education and log monthly income.



[8] Figure A1 in the Appendix shows the frequency counts by month of births (with the cut-off point defined as 0). Figure A2 in the Appendix visually checks the continuity of all covariates. All but gender appears to be continuous around the cut-off point. We will further explore the heterogeneous effect with respect to gender, however it is important to bear in mind that gender is predetermined with respect to the HE expansion.



For the main sample, Table 2 presents the baseline RD results with different set of controls: In column (1) no control is included; column (2) controls for wave of the CULS and province dummies; column (3) additionally controls for gender (ref male), migrant status (ref local) and a quadratic in years of experience; column (4) further controls for region of birth (ref Western region), *hukou* status at primary school (ref urban), interaction of region of birth of *hukou*, education of parents and number of siblings; column (5) further controls for self-employment. Our estimates are reasonably robust across the specifications. Our preferred specification is (3), which is still quite parsimonious yet controls for post-education experience and migration, indicates that the 1999 HE expansion increased the mean years of schooling by 0.91 year. Moreover, for each additional year of education induced by the HE expansion, monthly income increases by 0.19 log point, which is equivalent to about 21%. This is a large effect, which is also statistically significant at the 5% level. The corresponding OLS estimate in Table A2 in the Appendix is about 8.0%.

The bottom panel of Table 2 shows that the 1999 HE expansion increased HE participation by 13.3 percentage points in our preferred specification. The corresponding RDD estimate of the returns to a university degree relative to Junior High School qualification is 1.33 log points, which is equivalent to an annual return of 0.19 log points over a 7-year period (including 3 years of Senior High School).

Our estimate has the interpretation of a Local Average Treatment Effect (LATE), i.e. the returns to one year of university education for a marginal student who would not go to university in the absence of the HE expansion. Compared to the existing quasi-experimental estimates of returns to education in China, our returns to education estimate of 21% is on the high side, and significantly higher than e.g. the 12.8% RDD estimate by Liu et al. (2016), although it is not far off the 20% IV estimate by Fang et al. (2012). Note that both of these studies are based on the variation in time across provinces in the implementation of 9-year compulsory education. There are good reasons to expect a higher estimate in our case:

a) There is a general consensus that the returns to education in China is higher at higher qualification levels, presumably reflecting the relative scarcity of more skilled labour (Awaworyi and Mishra (2014)). So, our LATE estimates on the returns based on higher education expansion should be higher than LATE estimates based on compulsory schooling reforms.
b) There is also consensus that returns to education in China are increasing over time (see also Awaworyi and Mishra (2014)). Since our sample members are interviewed in 2005 and 2010, we would expect higher returns than studies based on older data, including Wu and Zhao (2010).
c) Using potential expansion based on pre-expansion provincial enrolment share as instruments for the supply of young skilled worker, Li et al (2017) find that the 1999 expansion increased the college premium of workers aged 25 or above whereas it decreased the college premium of those aged 20-24. For instance, the IV estimates of the college premium for those aged 20-24 and 25-29 are 0.164 and 0.370 respectively. Since our sample members interviewed in 2005 and 2010 have an mean age of 26 and 31 respectively, we would also expect higher returns than studies such as Wu and Zhao (2010) which is based on samples of younger graduates collected in 2002 and 2005.
d) Compared to Wu and Zhao (2010) who also exploit the HE expansion but uses DD and DDD, it is conceivable that LATE are higher than ATE, e.g. if marginal students are better motivated and/or have higher unobservable skills. Our results are also consistent with Che and Zhang (2017), who suggest that more human-capital intensive industries in China experienced more rapid growth in total factor productivity after 2003 because the HE expansion substantially relaxed the constraint of skilled labour.

On the other hand, one cannot generalise from LATE to the wider population. In particular, our RDD estimate is based on the comparison of up to 3 academic cohorts on either side of the month-of-birth cut-off. With sustained expansion of the HE sector, one might speculate that returns to higher education will eventually decrease. However, a full investigation is beyond the scope of this paper.

Table 2: Baseline Results

	(1)	(2)	(3)	(4)	(5)
A): Treatment = Years of education					
Years of educ	1.125**	1.156**	0.908**	0.672*	0.851**
	(0.547)	(0.502)	(0.391)	(0.344)	(0.351)
Observations	2995	2995	2995	2995	2995
Monthly income	0.178*	0.129**	0.191**	0.250*	0.208**
	(0.095)	(0.061)	(0.091)	(0.137)	(0.096)
Observations	2,540	2,540	2,540	2,540	2,540
B): Treatment = university dummy					
HE participation	0.174**	0.175**	0.133**	0.116**	0.146**
	(0.082)	(0.075)	(0.054)	(0.055)	(0.056)
Observations	2995	2995	2995	2995	2995
Monthly income	1.124*	0.831**	1.330**	1.610*	1.433**
	(0.603)	(0.412)	(0.656)	(0.864)	(0.695)
Observations	2,540	2,540	2,540	2,540	2,540

Note: ***, **, * significant at the 1, 5 and 10 percent level. Sample of Junior High School and University graduates. Standard errors are clustered at province level. (1) with no controls; (2) controls for wave of investigation and province; (3) further controls for gender, dummy of migrant, experience and square of experience; (4) further controls for region of birth, *hukou* status, interaction terms of region of birth and *hukou* status, education of parents, numbers of siblings; (5) further controls the status of self-employed or employed.

Table 3 represents a falsification test using either September 1978 or September 1980 as the cut-off point. As expected, neither specification yields significant results for years of education or monthly income.

Table 4 checks the robustness of the results with respect to alternative window widths: 30 or 42 months, instead of 36 months, on either side of the cut-off points. The patterns are remarkably similar to the baseline estimates in Table 2. This is very reassuring, and suggests that our findings are insensitive to variations in the window widths.

Table 3: Falsification using Alternative Birth Cut-offs

	(1)	(2)	(3)	(4)	(5)
A): Cut-off at 1978.9					
Years of educ.	-0.252	0.128	0.023	-0.193	-0.261
	(0.526)	(0.472)	(0.352)	(0.307)	(0.345)
Monthly income	1.243	-0.741	-2.306	0.32	0.325
	(2.404)	(3.02)	(36.994)	(0.538)	(0.449)
Observations	2,514	2,514	2,514	2,514	2,514
B): Cut-off at 1980.9					
Years of educ.	-0.105	-0.097	0.056	-0.133	-0.035
	(0.504)	(0.443)	(0.388)	(0.322)	(0.305)
Monthly income	0.833	0.795	-1.346	0.700	1.850
	(3.621)	(3.407)	(9.913)	(1.663)	(10.232)
Observations	2,547	2,547	2,547	2,547	2,547

Note: ***, **, * significant at the 1, 5 and 10 percent level. Standard errors are clustered at province level.

Table 4: Robustness w.r.t. Alternative Windows

	(1)	(2)	(3)	(4)	(5)
A): +/-30 months					
Years of educ.	1.37**	1.381***	0.998**	0.783**	0.942**
	(0.595)	(0.510)	(0.409)	(0.392)	(0.375)
Monthly income	0.147*	0.128**	0.188**	0.251*	0.209**
	(0.081)	(0.061)	(0.092)	(0.138)	(0.099)
Observations	2,082	2,082	2,082	2,082	2,082
B): +/-42 months					
Years of educ.	1.282***	1.361***	0.994**	0.902**	0.779**
	(0.499)	(0.489)	(0.408)	(0.423)	(0.326)
Monthly income	0.091	0.120**	0.187**	0.240*	0.199*
	(0.074)	(0.059)	(0.092)	(0.125)	(0.104)
Observations	2,986	2,986	2,986	2,986	2,986

Note: ***, **, * significant at the 1, 5 and 10 percent level. Standard errors are clustered at province level.

Table 5 repeats Table 2, but only using the subsample of employees. While the years of education increases somewhat to 1.3 years, there is virtually no change in the returns to education estimate that remains at 0.19.

Table 6 tests for robustness with respect to higher order polynomials. Again, there is a small increase in the effect on years of education. However, each year of education induced by the HE expansion still increases the monthly income by approximately 0.19 log point.

Table 5: Robustness w.r.t. Alternative Samples

	(1)	(2)	(3)	(4)
Employees only				
Years of educ.	1.665**	1.765**	1.298**	0.0910**
	(0.793)	(0.713)	(0.515)	(0.429)
Monthly income	0.176**	0.136**	0.194**	0.243**
	(0.084)	(0.060)	(0.081)	(0.119)
Observations	1,817	1,817	1,817	1,817

Note: ***, **, * significant at the 1, 5 and 10 percent level. Standard errors are clustered at province level.

Table 6: Robustness w.r.t. Functional Forms (higher order polynomials)

	(1)	(2)	(3)	(4)	(5)
2nd order polynomial					
Years of educ.	1.195	1.515**	1.126**	0.845*	1.015**
	(0.789)	(0.604)	(0.470)	(0.466)	(0.434)
Monthly income	0.251	0.121*	0.185**	0.237	0.200*
	(0.155)	(0.065)	(0.093)	(0.147)	(0.105)
Observations	2,540	2,540	2,540	2,540	2,540

Note: ***, **, * significant at the 1, 5 and 10 percent level. Standard errors are clustered at province level.

Table 7 presents the heterogeneous effect with respect to gender and whether the respondent is the only child. While the effect appears to be weaker for women on average, the effect for the female only child is as strong as the sample as a whole. For men, the estimates are higher but rather imprecisely determined. Note that estimating the returns for men and women separately also gets around the problem of discontinuity in gender around the cut-off point shown in Appendix Figure A2, but the expense of lower statistical precision.

Finally, Table 8 presents the heterogeneous effect by *hukou* status at the time of primary education. We did not use the current *hukou* status which might be contaminated by endogenous migration (see Xing 2013). Unfortunately, the estimates are all poorly determined due to the small cell sizes except for urban residents, for whom the effect on years of schooling are not only large, but also statistically significant. This pattern is consistent with Xing (2013) who finds much lower OLS returns to education in rural areas than in urban areas using the China Household Income Project (CHIP) data from 1995, 2002 and 2007.

Table 7: Robustness w.r.t. Gender and Single-child Status

	(1)	(2)	(3)	(4)	(5)
A): Female					
Years of educ.	1.281	1.208	1.425***	0.538	0.530
	(0.953)	(0.769)	(0.537)	(0.521)	(0.495)
Monthly income	0.175	0.176	0.157*	0.285	0.295
	(0.131)	(0.123)	(0.088)	(0.326)	(0.311)
Observations	1,212	1,212	1,212	1,212	1,212
B): Female Only Child					
Years of educ.	2.853***	2.702***	1.756***	1.096**	1.238***
	(0.994)	(0.749)	(0.585)	(0.485)	(0.448)
Monthly income	0.112*	0.109**	0.208**	0.289*	0.261**
	(0.068)	(0.055)	(0.096)	(0.161)	(0.129)
Observations	705	705	705	705	705
C): Male					
Years of educ.	1.123*	1.204**	0.484	1.307**	1.120**
	(0.596)	(0.599)	(0.553)	(0.633)	(0.556)
Monthly income	0.13	0.127	0.275	0.254*	0.225*
	(0.104)	(0.079)	(0.307)	(0.132)	(0.115)
Observations	1,328	1,328	1,328	1,328	1,328

Note: ***, **, * significant at the 1, 5 and 10 percent level. Standard errors are clustered at province level.

Table 8: Robustness w.r.t. *Hukou* Status

	(1)	(2)	(3)	(4)	(5)
A): Village					
Years of educ.	-0.251	0.213	0.543	0.535	0.662
	(0.645)	(0.520)	(0.437)	(0.437)	(0.444)
Monthly income	-0.001	0.773	0.381	0.425	0.366
	(0.658)	(1.775)	(0.300)	(0.345)	(0.249)
Observations	1,119	1,119	1,119	1,119	1,119
B): Town					
Years of educ.	0.826	-0.229	-0.064	-0.316	-0.192
	(1.052)	(0.864)	(1.117)	(0.640)	(0.845)
Monthly income	0.192	0.697	-0.285	0.427	-0.255
	(0.276)	(1.895)	(6.225)	(0.852)	(1.476)
Observations	599	599	599	599	599
C): City					
Years of educ.	2.276**	2.179***	2.225**	1.417**	1.348**
	(1.046)	(0.795)	(0.917)	(0.676)	(0.633)
Monthly income	0.148*	0.120*	0.104	0.132	0.148
	(0.088)	(0.069)	(0.079)	(0.109)	(0.115)
Observations	822	822	822	822	822

Note: ***, **, * significant at the 1, 5 and 10 percent level. Standard errors are clustered at province level.

Section 6: Conclusions

We take advantage of the substantial HE expansion, which started in 1999 to study the returns to higher education in China. Using pooled China Urban Labour-force Survey (CULS) 2005 and 2010 which contains year and month of birth, we are able to apply fuzzy RDD which relies on less assumptions for identification compared to other quasi-experimental methods such as Difference-in-Differences or Instrumental Variables.

For our sample of people with either HE qualifications or junior high schools and born within 3 years of relevant month-of-birth cut-off, our RDD results indicate that the mean years of education increased by roughly one full year around the cut-off point. Importantly, each additional year of university education induced by the 1999 higher education expansion increases monthly wage income by about 21%, which is much higher than the corresponding OLS estimate of 8%. Our findings are insensitive to alternative window widths, functional forms, or the exclusion of self-employed. Moreover, the returns to degrees also appear to vary by gender, with lowers returns to women except when they are the only child in the family.

Nearly 20 years on, the overall assessment of the massive expansion starting 1999 still remains controversial. Our estimate of such a high return to higher education seems to provide strong ex post justification of the HE expansion, at least from a pure cost-benefit perspective. However, our Local Average Treatment Effect estimate cannot be generalized to more recent graduates, who are exposed to much greater degrees of HE expansion.

References

Awaworyi, S. and Mishra, V. (2014) Returns to education in China: A meta-analysis. *Monash University Department of Economics Discussion Paper* 41/14.

Blundell, R.W., Dearden, L., Goodman, A. and H. Reed. (2000) The returns to higher education in Britain. *Economic Journal,* 110, F82-F99.

Blundell, R.W., Green, D.A. and Jin, W. (2016) The UK wage premium puzzle: how did a large increase in university graduates leave the education premium unchanged? *IFS Working Paper* W16/01.

Calonico, S., Cattaneo, M. D., & Titiunik, R. (2014). Robust nonparametric confidence intervals for regression-discontinuity designs. *Econometrica, 82*(6), 2295–2326.

Calonico, S., M.D. Cattaneo, Farrell, M. H., & Titiunik, R. (2017). Rdrobust: software for regression-discontinuity designs. *Stata Journal, 17*, 372-404.

Card, D. and Lemieux, T. (2001) Can Falling Supply Explain the Rising Return to College for Young Men? *Quarterly Journal of Economics 116*, 705–746.

Che, Y. and Zhang, L. (2017) Human capital, technology adoption and firm performance: Impacts of China's Higher Education expansion in the late 1990s. *Economic Journal* (forthcoming).

National Bureau of Statistics (NBS) of China, China Statistic Yearbook, various years.

Fang, H.，Rizzo, J.A.，Rozelle，S. and Zeckhauser，R.J. (2012) The Returns to Education in China: Evidence from the 1986 Compulsory Education Law, *NBER Working Paper* No. 18189.

Gelman, A., & Imbens, G. (2017). Why high-order polynomials should not be used in regression discontinuity designs. *Journal of Business & Economic Statistics (early view).*

Goldin, C. and Katz, L. (2008) *The Race between Education and Technology*. Harvard University Press, Harvard.

Hahn, J., Todd, P, Van der Klaauw, W. (2001) Identification and estimation of treatment effects a Regression-Discontinuity Design. *Econometrica* 69 (1), 201-209.

Li, H., Ma, Y., Meng, L., Qiao, X and Shi, X. (2017) Skill complementarities and returns to higher education: Evidence from college enrollment expansion in China. *China Economic Review*, 46, C, 10-26.

Li, S., Whalley, J. and Xing, C. (2014) China's higher education expansion and unemployment of college graduates. *China Economic Review*, 30, 567-582.

Liu, S., Zhou, S. and Hu, A. (2016) Compulsory Education Law and economic return to education in urban China: Based on Regression Discontinuity Design. *Economic Research* 2016 (2), 154-167 (in Chinese).

OECD (Organisation for Economic Co-Operation and Development) (2016) Education in China – A Snap Shot. OECD.

Walker, I. and Zhu, Y. (2008) The College Wage Premium and the Expansion of Higher Education in the UK. *Scandinavian Journal of Economics* 110 (4), 695–709.

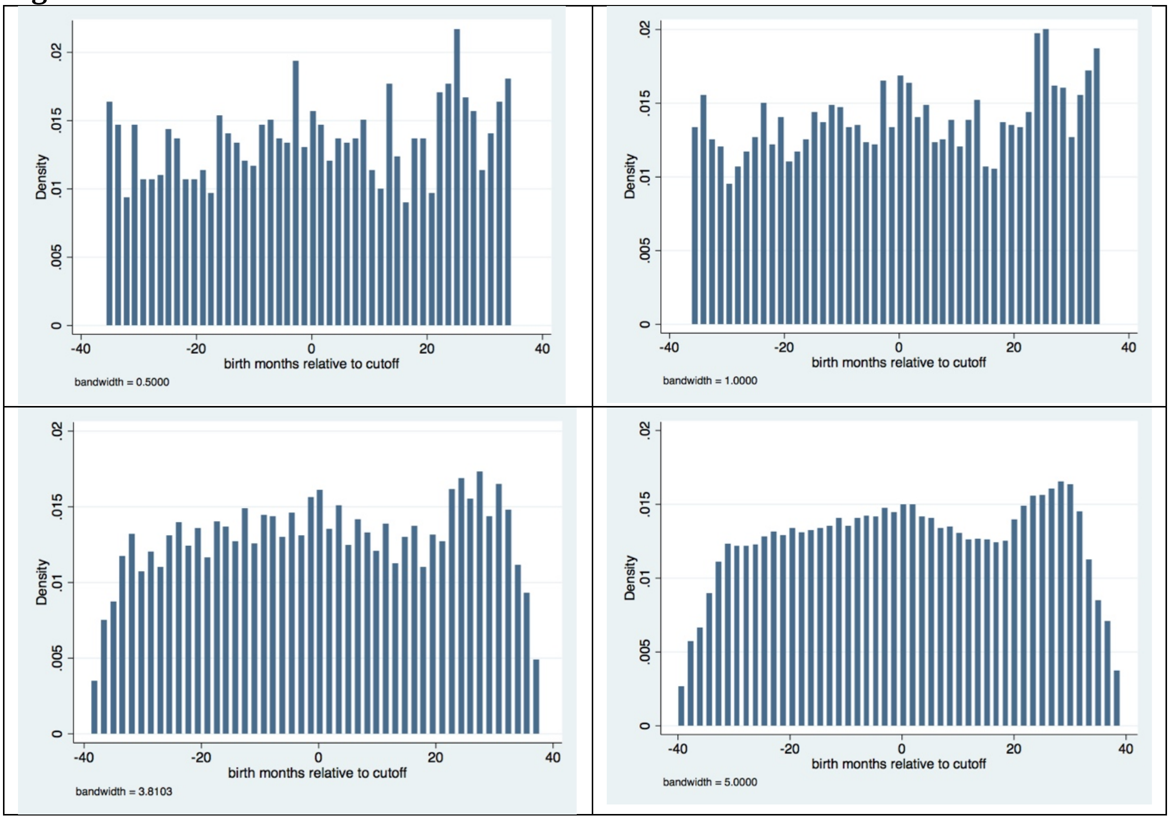
Wu, Y. and Zhao, Q. (2010) Higher Education expansion and employment of university graduates. *Economic Research* 2010 (9), 93-108 (in Chinese).

Xing, C. (2013) Education expansion, migration and rural-urban education gap: A case study on the effect of university expansion. *China Economic Quarterly* 13(1), 207-232 (in Chinese).

Xing, C., Yang, P. and Li, Z. (2017) The medium-run effect of China's higher education expansion on the unemployment of college graduates. *China Economic Review*, forthcoming.

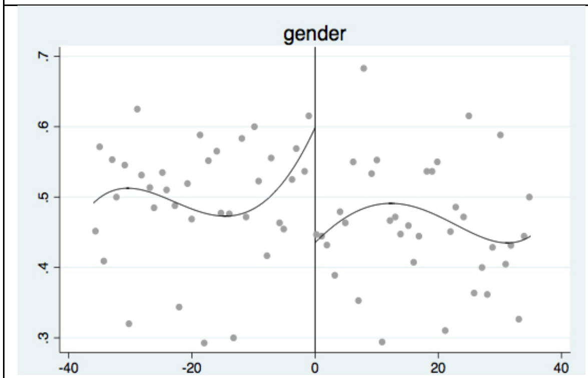
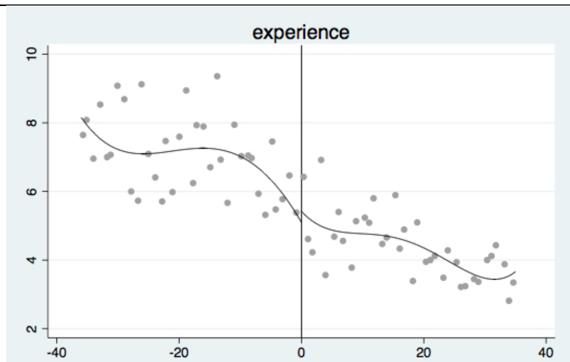
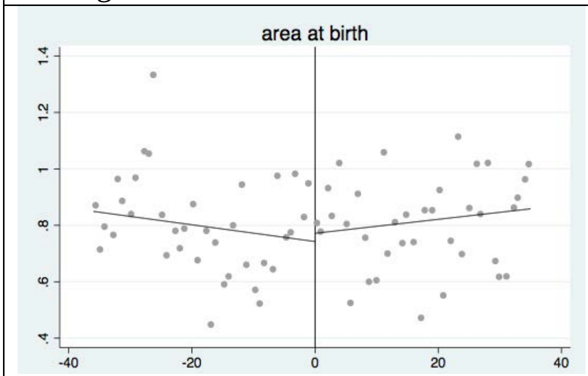
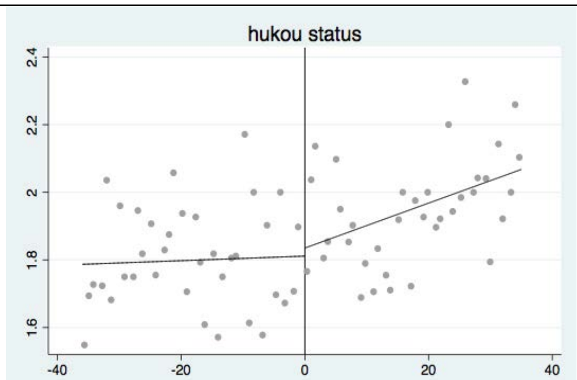
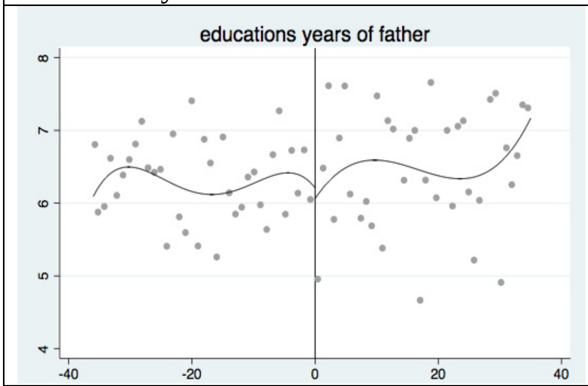
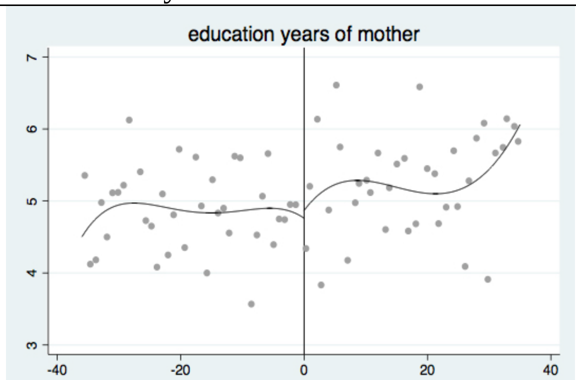
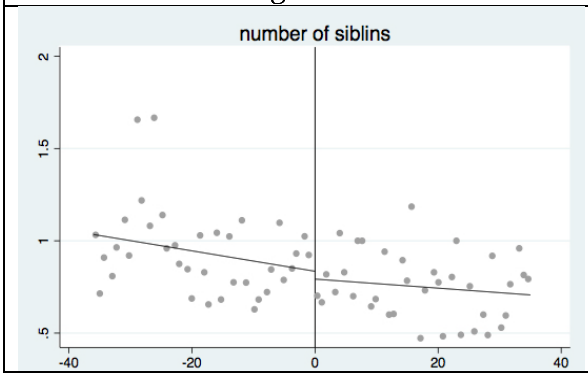
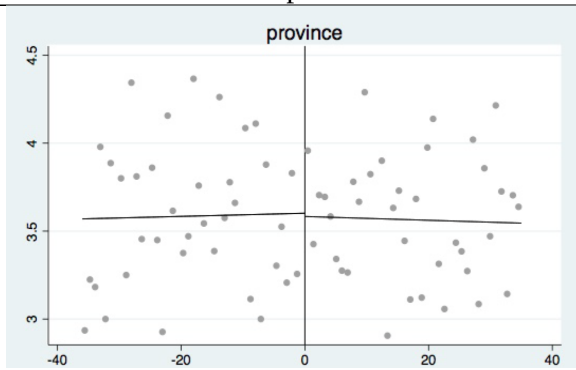
Appendix

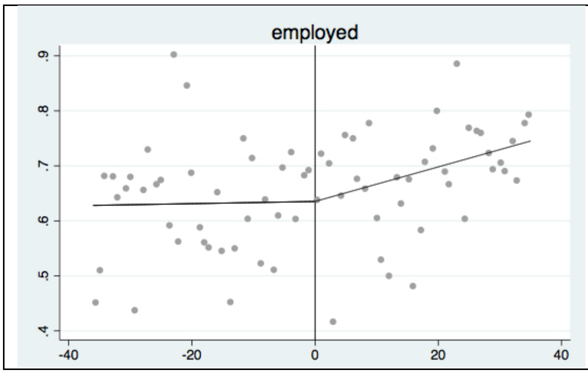
Figure A1: Validation test



Note: we estimate the kernel density of the running variable of months of birth. The graphs indicate a lack of discontinuity around the cutoff in the running variable, thus satisfying the critical RDD assumption of no non-random sorting into treatment status. Our results are insensitive to different bandwidths at 0.5, 1, 3.8 and 5 months.

Figure A2: Continuity test of covariates

A：gender	B：experience
	
C：region of birth	D: *hukou* status (location of primary school)
	
E: father's years of education	F: mother's years of education
	
G: number of siblings	H: current residential province
	
I: employed	



Note: We use the Stata programme *rdrobust* to perform the continuity test of covariates. All the control variables except for gender satisfy the requirement of continuity around the cut-off. Table 7 reports the RDD estimates for men and women separately, at the expense of lower precision.

Table A1: Alternative Samples

	(1)	(2)	(3)	(4)	(5)
A): Junior High and Senior High School graduates					
Years of educ.	0.220	0.346	0.383*	0.351	0.304
	(0.225)	(0.274)	(0.230)	(0.239)	(0.202)
Monthly income	0.173	0.009	0.143	0.166	0.169
	(0.467)	(0.266)	(0.206)	(0.246)	(0.240)
Observations	2,287	2,287	2,287	2,287	2,287
B): Senior High and University graduates					
Years of educ.	0.345	0.610	0.321	0.320	0.318
	(0.364)	(0.264)	(0.248)	(0.235)	(0.224)
Monthly income	0.070	0.160	0.375	0.348	0.349
	(0.399)	(0.145)	(0.346)	(0.331)	(0.320)
Observations	2,137	2,137	2,137	2,137	2,137

Note: ***, **, * significant at the 1, 5 and 10 percent level. Standard errors are clustered at province level.

Table A2: OLS Estimates

	(1)	(2)	(3)	(4)	(5)
Years of educ.	0.103***	0.066***	0.080***	0.074***	0.077***
	(0.013)	(0.011)	(0.011)	(0.010)	(0.010)
Observations	2,540	2,540	2,540	2,540	2,540

Note: ***, **, * significant at the 1, 5 and 10 percent level. Standard errors are clustered at province level.