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ABSTRACT

Higher Education Expansion, the Hukou System, and Returns to Education in China*

China experienced a near 5-fold increase in annual Higher Education (HE) enrolment in the decade starting in 1999. Using the China Household Finance Survey, we show that the expansion has exacerbated the large pre-existing urban-rural gap in educational attainment underpinned by the hukou (household registration) system. We then instrument years of schooling using the interaction of childhood urban hukou status and the timing of the expansion, which is analogous to a Difference-in-Differences estimator which uses rural students to control for any common time trend. The 2SLS estimates of 17% and 12% for men and women respectively are substantially larger than their OLS counterparts of 5% and 6%, both allowing for county fixed-effects. Our 2SLS results can be interpreted as a Local Average Treatment Effect (LATE), i.e. the average treatment effect of HE attendance on earnings for urban students who enrolled in HE as a result of the higher education expansion.

JEL Classification: I26, I23

Keywords: returns to education, 2SLS, higher education expansion, China

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1. Introduction

Most countries, rich or poor, 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, empirical evidence from the US (see e.g. Card and Lemieux (2001) and Goldin and Katz (2008)), 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 annual enrolment in HE in China grew from 1.08 million in 1998 to 6.08 million in 2008, a near five-fold increase over just a decade. As a result, China's high education participation rate leaped from less than 5% to over 25% within a decade. The most rapid growth occurred at the beginning, with annual growth rates around 40% in both 1999 and 2000 (Wu and Zhao (2010), Che and Zhang (2018)). The scale of the expansion is totally unprecedented, as far as the major economies are concerned.

However, the effect of this massive expansion on labour market outcomes is not very well understood so far. There is even less systemic evidence of the impact of the HE expansion on the equity of educational attainment, in an education system which is underpinned by the unique *hukou* (household registration) system in China. This paper is based on the 2017 China Household Finance Survey (CHFS), conducted by the Survey and Research Centre for China Household Finance at the Southwestern University of Finance and Economics (SWUFE). We start off by showing that the large and unanticipated expansion has exacerbated the pre-existing urban-rural divide in educational attainment, as defined by one's *hukou* status at age 12. To the best of our knowledge, this is the first systemic empirical evidence on the distributional impact of the HE expansion, using large representative data. This finding also motives our identification strategy for estimating the returns to education in China, using the variation across different birth cohorts in the exposure to the 1999 HE expansion interacted with urban *hukou* status at age 12, as instruments for years of schooling.

We show that the benchmark Ordinary Least Squares (OLS) estimates of returns to education are about 5% for men and 6% for women in China, allowing for county/district fixed-effects (district within cities have the same status as counties in the administrative hierarchy of

China). However, once we allow for self-sorting and potential measurement error of education using an IV approach based on the policy induced HE expansion, the Two Stage Least Squares (2SLS) estimates jump to 17% and 12% for men and women respectively. Our estimates satisfy all the diagnostic tests for relevance and exogeneity of instruments, and are also robust to alternative specification of the age profile. While the 2SLS estimates for women are broadly comparable across geographical regions and type of areas of residence, there is significant variation in the returns for men in favour of those living in the more developed Eastern Region and/or major cities. Moreover, for respondents with parental education information, we find that the 2SLS returns for disadvantaged students in terms of fathers' education are at least as high as, if not higher than, their more privileged counterparts for both genders. This is in sharp contrast to OLS estimates of returns which suggest that the returns to both disadvantaged men and women are up to 40% lower than their more privileged counterparts.

Using the same subsample with information on parental education, the alternative 2SLS estimates using either father or mother's education as instruments are still larger than their OLS counterparts, but substantially smaller than the main 2SLS based on the HE expansion and *hukou* status at age 12. Further diagnostic tests suggest that parental education might not be fully exogenous, a plausible scenario if socio-economic background as proxied by parental education exerts a direct effect on one's labour market outcomes over and above the usual education channel.

We contribute to the empirical literature on the returns to education in at least two ways. Firstly, using a large nationally representative survey, we are the first study to show the unanticipated massive HE expansion in China starting in 1999 has exacerbated, at least in the short run, the large pre-existing urban-rural gap in educational attainment in favour of urban residents, due to the *hukou* system. Indeed, it would take more than a decade for rural students to recover their pre-expansion positions in terms of the educational attainment gap with regard to their urban counterparts. Secondly, on the basis of this finding, we develop a novel identification strategy which instruments years of schooling on the interaction of childhood urban *hukou* status and a set of time dummy and time trends which captures the exposure to the expansion. This approach is analogous to a Difference-in-Differences estimator which uses rural students to control for any common time trend such as changes in teaching quality due to the sudden HE expansion or common macro-economic shocks such as China's accession to the WTO (World Trade Organization) at the end of

2001. Our 2SLS results can be interpreted as a Local Average Treatment Effect (LATE), i.e. the average treatment effect of HE attendance on earnings for urban students (as defined at age 12 *hukou* status) who enrolled in HE **only** as a result of the higher education expansion.

Our findings shed new light on the debate regarding whether the expansion was economically justified on the grounds of returns to education and its distributional impacts. First, the fact that the 2SLS estimates of 17% and 12% for men and women respectively are substantially larger than their OLS counterparts of 5% and 6%, both allowing for county fixed-effects, suggest that there are very high returns to education for urban students in China. On the other hand, rural students as a whole have missed out on this historical opportunity due to insufficient investment and poor quality of compulsory and upper secondary education in rural areas. Second, socio-economically disadvantaged students, as measured by father's education level, who are induced to enrol in HE as a result of the expansion, enjoy returns that are at least comparable to their more privileged counterparts, regardless of gender. Moreover, the significantly higher returns for men living in the more developed Eastern Region, and/or major cities indicate substantial returns to geographic mobility in China, which is consistent with the notion that China's *hukou* system has presented a major obstacle to economic development and social mobility.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 presents the data. Section 4 introduces the 1999 Higher Education expansion and studies its distributional impacts, in the context of the unique *hukou* system. Section 5 is devoted to the discussion of the identification strategy for estimating the returns to education. The empirical results are presented and discussed in Section 6. Finally, Section 7 concludes.

2. Literature Review

Due to China's rapidly increasing economic prominence since the reform started in the late 1970s, there has been growing interest in China's education system and its impact on labour market outcomes. Awaworyi and Mishra (2018) conduct a meta-analysis of studies on returns to education in China published in international academic journals and conclude that the returns to education in the post-reform era is around 18% per annum, with higher returns to college degrees than lower levels of education. However, most of the studies surveyed do not go beyond multivariate analyses. Even the few instrumental variables estimations are only based on family characteristics such as parental or spousal education. Therefore, one should be cautious in interpreting these estimates as causal due to the ability biases or remaining endogeneity problems arising from any direct effect of parental/spousal education on own earnings.

Compared to causal studies from elsewhere,[1] there are relatively few studies using Chinese data that have attempted to uncover the causal returns to education using quasi-experimental methods.[2]

A couple of studies have attempted to exploit the introduction of 9-year compulsory schooling in 1986. 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 Regression Discontinuity Design (RDD) approach. Their RDD estimate based on the China Urban Household Survey is 12.8%, which exceeds the 9.6% OLS estimate.[3]

Other studies turn to the large unexpected expansion of the HE sector around 1999 for identification. Using the 2002 Labour Market Survey by the Ministry of Labour and Social Security and the 2005 1% Population Survey, Wu and Zhao (2010) estimate the impact of the 1999 HE expansion on labour market participation and unemployment using the difference-in-differences (DD) and difference-in-difference-in-differences (DDD) strategies. They find an adverse employment effect of the expansion for new graduates. Although new graduates do not fare worse relative to High School graduates in terms of wages, their hourly wage growth rates are more than 10 percentage points lower compared to older graduates. Nevertheless, the estimated return to each

1 For a survey, see e.g. Harmon *et al.* (2003), and Psacharopoulos and Patrinos (2018).

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.* (2018)).

3 Recent studies have also presented descriptive evidence of the impact of the compulsory school reform on assortative marriage and income inequality (Nie and Xing 2019) and intergenerational education mobility (Guo *et al.* 2019 and Cui *et al.* 2019). Liang and Dong (2019) show that the increased education induced by the compulsory education law leads to secularization.

year of university education is still around 14%.[4] 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 at the expense of younger graduates. Their IV estimates of the college premium range from 0.164 for 20-24 year olds to 0.370 for 25-29 year olds. By exploring a fuzzy discontinuity in years of schooling and probability of obtaining HE qualification in the months of births, Dai *et al*. (2018) suggest that each additional year of university education induced by the the HE expansion increases monthly wage income by 21%, compared to an OLS estimate of 8% only.

Kang *et al.* (2019) show that the Random Effects and Inverse Probability Weighted Regression Adjustment (IPWRA) estimates of annual returns to the more selective key universities are higher than ordinary universities or vocational colleges regardless of subjects studied, using the China Family Panel Studies. Moreover, they present suggestive evidence that the mass HE expansion has resulted in lower HE returns across all HE tier and subjects, except for graduates from key universities who studied subjects other than STEM (Science, Technology, Engineering and Mathematics/Medicine) or LEM (Law, Economics and Management). However, IPWRA estimates can only be interpreted as causal if there is no selection on unobservables.

3. Data

This paper is based on the 2017 China Household Finance Survey (CHFS), which was conducted by the Survey and Research Centre for China Household Finance at the Southwestern University of Finance and Economics (SWUFE) of China. CHFS is a large nationally representative survey of over 40,000 households, with detailed information about household income, expenses, assets, liabilities, insurance and securities.

CHFS employs a stratified three-stage probability proportional to size (PPS) random sample design, with the primary sampling units (PSU) covering all counties (including county level cities and districts within cities at the prefectural-level or above in the administrative hierarchy) in

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4 The descriptive analysis by Knight *et al*. (2017) using the 2002 and 2007 China Household Income Project (CHIP) and 2002-2008 Chinese Urban Household Survey, suggest that any adverse effect of the 1999 HE expansion on wages, employment and access to managerial and professional jobs for new graduates is relatively short-lived.

mainland China except Tibet, Xinjiang and Inner Mongolia. The second and third stage of sampling involves selecting residential committees/villages and then households respectively from the sampling units chosen at the previous stages. Every stage of samplings is carried out with PPS method and weighted by its population size.

The sample we use for analysis includes both male and female employees who are aged 23 or above in 2017, and who were born in 1970 or later.[5] We exclude people who work in the Agriculture, Forestry, Fishing or Animal husbandry industries or international organizations. We also exclude people who reported occupation as Agriculture, Forestry, Fishing or Animal husbandry workers or Military Personnel.

After excluding missing values on key variables, such as monthly earnings, years of education and current *hukou* status, we end up with a sample of 20, 966 individuals, of which 11,633 (55.5%) are men.

Table 1: Summary Statistics by gender, weighted

variable	Males	Females	Total
Log total monthly net earnings	8.186	7.925	8.072
Years of schooling	11.39	11.74	11.54
Post-1980 birth	0.618	0.606	0.613
Age	34.8	34.8	34.8
Age squared	1261.3	1268.1	1264.2
Currently rural *hukou*	0.551	0.484	0.522
Rural *hukou* at age 12	0.647	0.606	0.628
Tier 1 cities	0.082	0.098	0.089
Tier 2 cities	0.277	0.311	0.292
Smaller cities and towns	0.359	0.392	0.374
Rural areas	0.282	0.199	0.246
Observations	11,633	9,333	20,966

Note: using adjusted sampling weights based on per capita GDP ranking of the county/district of residence. Table A1 in the Appendix shows the corresponding unweighted means.

[5] We exclude people who were born before 1970, who would be aged 47+ in 2017, for several reasons. First, due to the very generous state retirement age in China (e.g. 50 in the case of blue-collar women) and the prevalence of early retirement, this group is likely to suffer from selective attrition. Second, pre-1970 cohorts started formal education before the end of the Cultural Revolution in 1976, a time when the school system was non-uniform and the quality of education was not a priority. Third, these cohorts would have completed lower secondary education before the 9-year compulsory schooling was introduced in 1986. Moreover, Figures A1-A3 in the Appendix show differential time trend around the 1970 birth cut-off for years of schooling and obtaining 9+ years of education (i.e. lower secondary qualifications), but not for 14+ years of education (i.e. college or above).

Table 1 reports the weighted sample means by gender. On average, women's monthly earnings lag behind their male counterparts by 0.261 log points, despite women having the same age and 0.35 year more schooling. This earnings differential is equivalent to a 23.0% gender gap in monthly earnings. About 55% of men and 48% of women currently hold a rural (formally non-agricultural) *hukou*. More than 60% of men and women are estimated to have a rural *hukou* status before age 12, which is believed to be a key determinant of the educational attainment. Less than 10% of men or women currently live in Tier 1 cities (the 4 metropolises of Beijing, Shanghai, Guangzhou and Shenzhen) while another 30% or so of each gender live in Tier 2 cities (provincial capitals). Together these two types of cities account for most of the major cities in China. While just over one-third of men and nearly 40% of women live in smaller cities or towns, men are clearly over-represented in rural areas, relative to women.

4. The 1999 Higher Education expansion and its distributional impact

The education system in China suffered from severe disruption during the Cultural Revolution (1966-1976), when ideology was stressed over professional or technical competence. It was not until 1978 that the university entrance exam was reintroduced, as China entered the era of reform.

The Law on Nine-Year Compulsory Education was introduced in 1986, making 6 years of primary education and 3 years of Junior High Schools mandatory for all kids. The exit examinations upon completion of compulsory schooling, known as *zhongkao*, are used as the basis to stream students who wish to continue with education into either the academically oriented Senior High Schools or Vocational High Schools, both lasting 3 years (OECD 2016).

After obtaining Senior High School qualifications (or their vocational equivalents) which would normally take 12 years of schooling in total, one can apply to colleges and universities through a centralised admissions system which proceeds sequentially in tiers on the basis of one's performance in standardized National College Entrance Examinations (*gaokao*), with little regard for gender, *hukou* status and family background.[6] Colleges and universities in China can be classified into 2 types in descending order of prestige and entry requirements, i.e. universities, and

6 For details of the Chinese College Admissions system, see Zhu (2014).

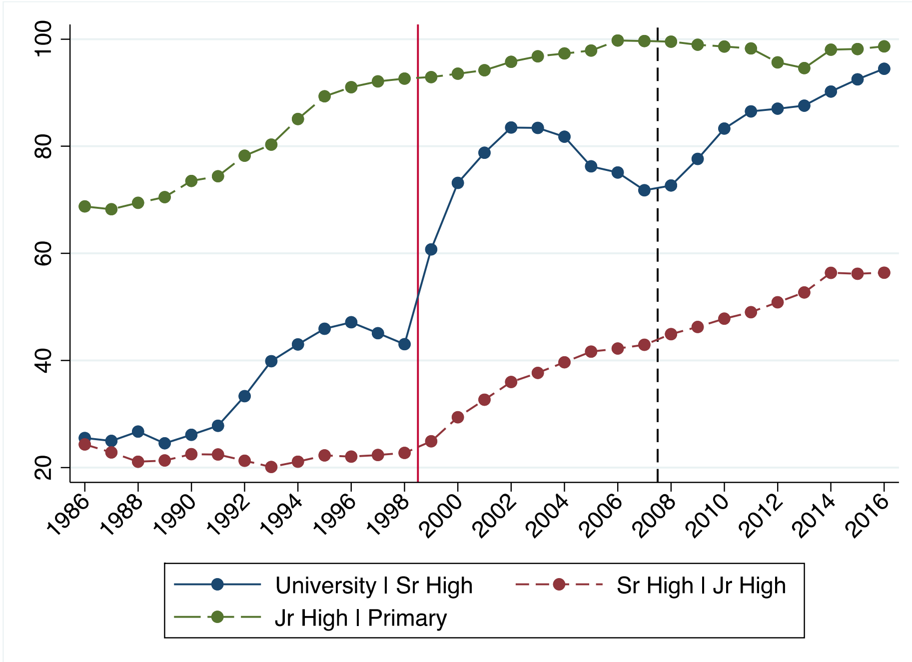
vocationally training colleges. The former takes 4-5 years to complete and leads to a Bachelor's Degree, whereas the latter takes 2-3 years leading to a College Diploma.

Higher Education in China was free of tuition fees but exceedingly elitist till the early 1990s, when modest tuition fees were introduced. 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 2018).

In response to the economic slowdown and rising youth unemployment in the aftermath of the 1997 Asian Financial Crisis, the Ministry of Education suddenly announced a 47% increase in university places. There was virtually no public consultation, and HE institutions around the country were only given a few months to prepare for the surge in intake (Wan (2006), Wu and Zhao (2010) and Li *et al.* (2017)). This was followed by increases of 38% and 22% in 2000 and 2001 respectively, and subsequent more modest but still substantial double-digit growth year on year on average for the next decade (Che and Zhang 2018). This phenomenal growth was only eased off after the Global Financial Crisis in 2008, as the graduate labour market became increasingly challenging. Between 1998 and 2008, annual HE enrolment grew from 1.08 million to 6.08 million.

Figure 1 shows the conditional annual enrolment rate in China, over the period 1986-2016. It is particularly worth noting that, the probability of enrolling in universities and colleges for Senior High School graduates jumped from just over 40% in 1998 to 60% in 1999 and then to almost 80% in 2001.

Figure 1: Conditional enrolment (progression) rate over time, by level of qualifications



Note: data resources: China Statistic Yearbook 2010 and 2017, http://www.stats.gov.cn/tjsj/ndsj/2010/indexch.htm, http://www.stats.gov.cn/tjsj/ndsj/2016/indexch.htm. Data from 1986-2009 is from yearbook 2010, data from 2010-2016 is from yearbook 2017. (same as Figure 2 in Dai *et al*. 2018).

Another important institutional feature of China is the *hukou* (household registration) system, which classifies people as rural and urban status at birth, usually according to the mother's *hukou* status.[7] It is widely known that education resources at primary and secondary level are highly unequal in favour of urban residents in China. For instance, despite the significant improvements in recent years, the public expenditure per Senior High School student in rural areas is only13360 RMB yuan in 2017, lagging behind the national average of 16727 RMB by 25.2% (National Bureau of Statistics 2017a).[8]

As a result, urban *hukou* holders, especially those living in the major cities, enjoy much better access to HE in general. Intuitively, *hukou* status in childhood determines whether the respondent attended an urban or rural secondary school, which are systematically different in quality.

7 See Chan (2009) for a review of the history of the *hukou* system and Meng (2012) for a discussion of the key role of *hukou* in China's labour market reforms in recent decades.

8 In 2016, the Senior High School student-teacher ratios are 12.70, 14.11 and 13.58 in cities, towns and rural areas respectively (National Bureau of Statistics 2017b).

For the purpose of identifying the causal effect of education on earnings, it is the *hukou* status which predates the schooling decision, rather than the current status, that matters. The latter is subject to the endogeneity bias, as it is possible to change one's *hukou* status through migration, marriage, acquirement of properties in cities, and most importantly, through obtaining HE qualifications (Xing, 2013). In this paper, we derive the *hukou* status at age 12 for all sample members, who are all subject to the 9-year compulsory education regime by construction.

Table 2 shows the sample weighted mean log monthly income and key indicators of educational attainment by *hukou* status at age 12 for men and women separately. More than 60% of the both men and women have a rural origin. The urban-rural earnings gaps are approximately 0.17 and 0.25 log points for men and women respectively. Regardless of gender, respondents with urban origins have more than 3 years of extra schooling and are 40 percentage points more (or 3 times as) likely to have a college or above qualification (i.e. at least 14 years of schooling), compared to their rural counterparts. The 10% or so of respondents who have missing or unknown *hukou* status at age 12, seem to have more in common with people with urban origins. Therefore, in the following analyses, they will be grouped into the originally urban group to simplify the model specification and interpretation. However, we will check the robustness of the results to the exclusion of this group.

Table 2: Weighted Earnings and Educational Attainment at age 12 *Hukou* Status and gender

	Men			Women		
variable	Rural	Urban	Missing/ Unknown	Rural	Urban	Missing/ Unknown
Log monthly income	8.127	8.294	8.298	7.832	8.084	8.017
Years of schooling	10.331	13.506	12.789	10.537	13.855	12.746
9+ years of schooling	0.848	0.982	0.969	0.833	0.988	0.931
14+ years of schooling	0.221	0.626	0.516	0.279	0.678	0.535
Observations	7,196	3,303	1,134	5,322	3,017	994
Weighted Share (%)	64.7	26.2	9.1	60.4	29.6	10.0

Note: using adjusted sampling weights based on per capita GDP ranking of the county/district of residence.

Figure 2 shows the share of respondents who hold rural *hukou* status currently and when they were aged 12, by the current type of region of residence and gender. Overall, just over 20% of rural *hukou* holders switched to urban status between age 12 and the time of the survey when they are at least aged 23. For both genders, the gap between current and age 12 rural *hukou* share varies significantly by the current type of region of residence, rising from about 4% in rural areas to 12-

15% in towns and cities of various sizes. This reflects both the large rural to urban migration and an urbanization process which turn non-migrant peasants into urban residents.

Figure 2: Current and historical rural *hukou* status by region of residence and gender

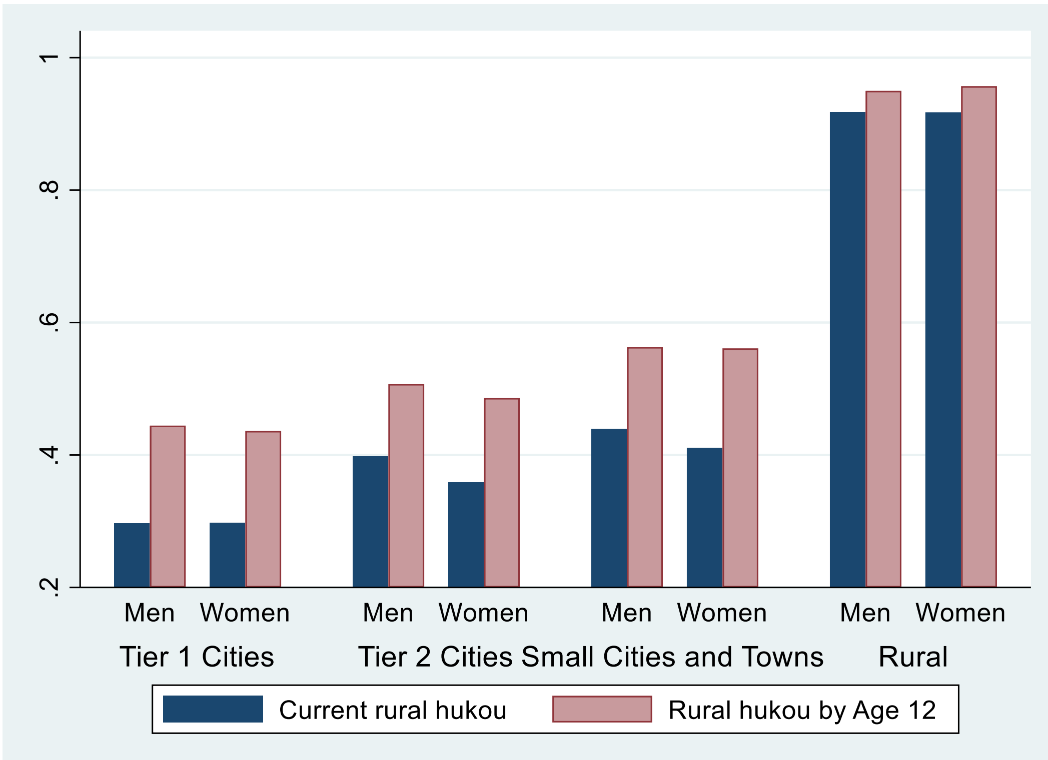
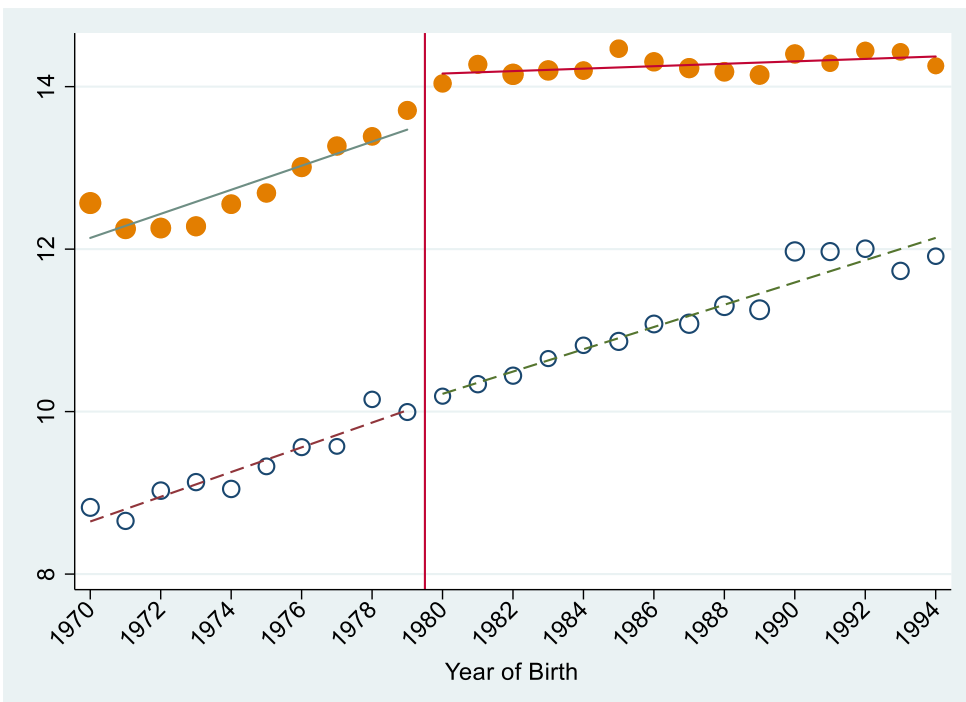


Figure 3 and Figure 4 show the mean years of schooling and the proportion of sample members with at least a college qualification (i.e. 14+ years of schooling), respectively, by year of birth and *hukou* status at age 12. The vertical lines highlight the approximate cut-off points around the birth cohort 1980, which correspond to the great expansion of universities in China starting in 1999.[9] There are two important patterns to note from these figures. First, there is an enormous gap in educational attainment between rural and urban *hukou* holders, as measured by the status before age 12, which is roughly the age when completed primary education. In the decade before the HE expansion, there was a consistent 3-year gap in years of schooling and an even growing gap in college attainment between urban and rural *hukou* holders. Second, the HE expansion has clearly

[9] Dai *et al*. (2018) which uses RDD for identification, uses September 1979 as the optimal birth cut-off. Unfortunately, we only have calendar year of birth but not month of birth in CHFS. A dummy for born 1980 or later effectively treats January 1980 as the cut-off.

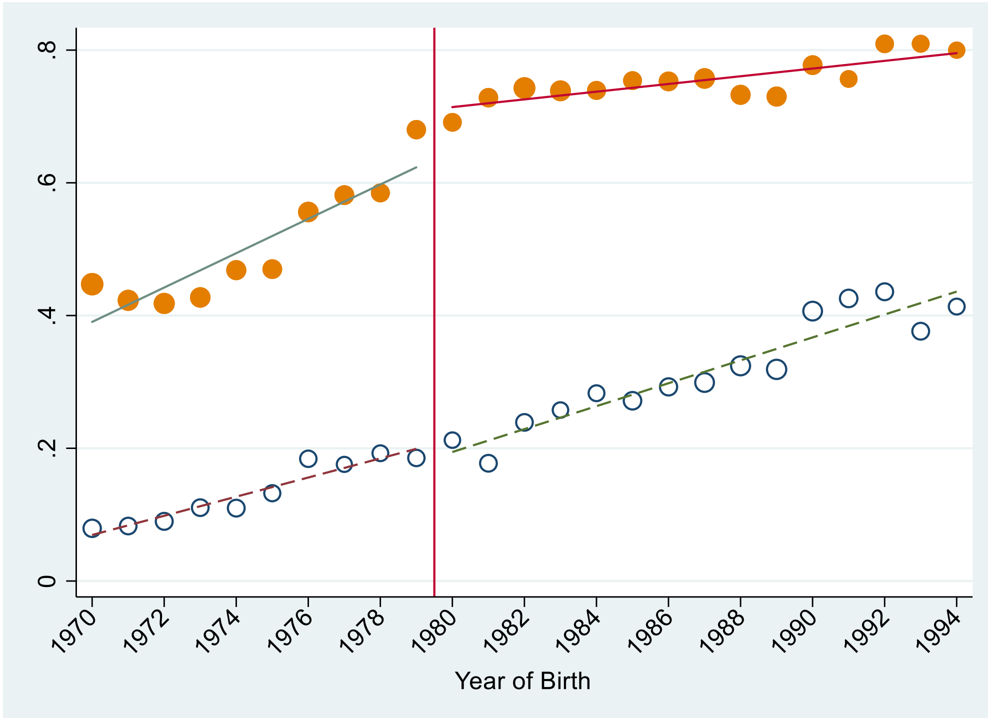
had a differential impact on people of rural versus urban origin, as indicated by the different jumps, if any, around the cut-offs and the different changes, if any, in the slopes before and after the reform. For both outcomes, it appears that the massive HE expansion only induced visible discontinuities for respondents with an urban origin, of the order of about 0.54 in years of schooling and 6.5 percentage points in college attainment. One plausible explanation is that the secondary schools in the cities were much better in quality compared to their rural counterparts, such that the graduates from urban areas benefitted disproportionately from the expansion. On the other hand, while there appears to be no immediate impact of the HE expansion on either outcome for rural students, they manage to catch up over time, as evidenced by the steeper time trends after the expansion for both outcomes, compared to their urban counterparts. Therefore, it is important to allow for the full-interaction of the *hukou* origin with the time trend, the intercept dummy, as well as their interaction terms which captures the change in the trend, in empirical modelling.

Figure 3: Years of Schooling by birth year and *hukou* status at age 12



Note: Solid dots/lines denote urban *hukou* at age 12. Hollowed dots and dashed lines denote rural *hukou* at age 12. Marker size proportional to number of observations.

Figure 4: College attainment (14+ years of schooling) by birth year and *hukou* at age 12



Note: Solid dots/lines denote urban *hukou* at age 12. Hollowed dots and dashed lines denote rural *hukou* at age 12. Marker size proportional to number of observations.

Table 3 present OLS and Linear Probability Model estimates of the effect the impact of the HE expansion on years of schooling and college attainment, allowing for differences in *hukou* status at age 12. This is effectively a parametrisation of Figures 3 and 4, but broken down by gender and allowing for heterogeneity in individual characteristics and county and district fixed-effects. Given China's vast diversity in geography and stages of economic development, it is important to allow for unobservable variation across geographical areas by controlling for 353 county (or city district) fixed-effects.[10]

In order to parameterize the potential change in both the intercept and the slope induced by the HE expansion, one needs to include 3 HE expansion main effect variables in the regressions:

a) *Birth year trend (T)*: a linear time trend before the expansion as the baseline;

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10 A county is the third-level of administrative division of China, under the provincial and prefectural levels. China administers 2,851 county-level divisions, including districts in with city with district-level divisions, at the end of 2017 (NBS 2018).

b) *Post-1980 birth (D)*: a dummy for being born in 1980 or later to capture the instantaneous effect of the HE expansion (on the intercept);

c) *Post-1980 birth year trend (TD)*: an interaction term between the linear *birth year trend* and the *post-1980 birth* dummy to capture the change in the time trend from the pre-expansion baseline.

Moreover, one needs to include a dummy for urban *hukou* at age 12, U, to capture the persistent urban-rural gap before the expansion.

To enable the impact of the HE expansion to differ between rural and urban *hukou* holders, as suggested by Figures 3 and 4, we need to interact an urban *hukou* at age 12 dummy with each of the 3 main HE expansion variables above.

Formally, the OLS wage equation is specified as follows:

$$lnW_{ij} = \alpha + \beta\, S_{ij} + \gamma\, X_{ij} + \delta_0 U_{ij} + \delta_1 T_{ij} + \delta_2 D_{ij} + \delta_3 (TD_{ij}) + \theta C_j + \varepsilon_{ij} \qquad (1)$$

where $\ln W_{ij}$ denotes log monthly earnings for individual i in county j (the dependent variable), S_{ij} is years of schooling (the endogenous variable), X_{ij} is a vector of control variables, C_j is a dummy for county j which captures the county fixed-effect, and ε_{ij} is the error term. U, T, D and TD denote the urban *hukou, Birth year trend, Post-1980 birth and Post-1980 birth year trend* as defined above respectively.

For both educational outcomes and both genders, the first two rows of Table 3 indicate that there is no statistically significant change in either the intercept (captured by the *post-1980 birth* dummy) or the slope (captured by the interaction term *post-1980 birth year trend* which is the product of *post-1980 birth* dummy and the linear birth year trend) relating to the HE expansion, for respondents with rural *hukou* status at age 12 who are taken as the reference category. This is in sharp contrast to men and women with urban *hukou* at age 12, who enjoy a 2.6- and 3.0-year advantage in years of schooling respectively, and more than 20 percentage point advantage in terms of college attainment, before the expansion. Moreover, the urban-rural gaps in years of schoolings widened by 1.2 and 2.3 years after the HE expansion for men and women respectively. In terms of college attainment, the HE expansion increased the urban-rural gaps by 21 and 45 percentage points for men and women respectively in the short-run. The only consolation for rural *hukou* holders is that the HE expansion seems to have induced a catching-up effect, as captured by the negative coefficient of the interaction term between the *post-1980 birth* (i.e. post HE expansion) *trend* and urban *hukou* indicator. But it is important to note that for both outcomes and both genders, resuming their relative pre-expansion positions will take rural students at least a decade. In the case of rural women, the recovery would take 15 years, i.e. 2.302/0.154.

Overall, the parametric estimates are totally consistent with the graphic presentations, and clearly demonstrate that the HE expansion has a large and unintended adverse effect on the pre-existing educational attainment gap that disadvantage rural *hukou* holders.

Table 3: OLS/LPM estimates of educational attainment by gender, with county/district FE

	(1)	(2)	(3)	(4)
	Years of schooling		College attainment	
	Men	Women	Men	Women
Post-1980 birth	0.764	-0.038	0.041	-0.032
	(0.595)	(0.676)	(0.090)	(0.095)
Post-1980 birth year trend	-0.053	0.001	-0.003	0.001
	(0.053)	(0.061)	(0.008)	(0.009)
Urban *hukou* at age 12	2.568***	3.041***	0.232***	0.207***
	(0.183)	(0.208)	(0.027)	(0.028)
Post-1980 birth X Urban *hukou*	1.231***	2.302***	0.207***	0.453***
	(0.346)	(0.383)	(0.054)	(0.056)
Birth year trend X Urban *hukou*	0.012	-0.016	0.009**	0.016***
	(0.030)	(0.033)	(0.004)	(0.005)
Post-1980 birth year trend X Urban *hukou*	-0.106***	-0.154***	-0.016***	-0.034***
	(0.034)	(0.038)	(0.005)	(0.005)
Age	-0.264	-0.335*	-0.025	-0.060**
	(0.165)	(0.187)	(0.026)	(0.028)
Age squared	0.002	0.002	0.000	0.001*
	(0.002)	(0.002)	(0.000)	(0.000)
Constant	16.334***	18.831***	0.768	1.544**
	(3.594)	(4.075)	(0.559)	(0.602)
County/District FE	✓	✓	✓	✓
Observations	11633	9333	11633	9333
R^2	0.370	0.411	0.295	0.341

Note: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Columns 1 and 2 are estimated by OLS. Columns 3 and 4 are estimated by Linear Probability Model (LPM). The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

5. Identification strategy

The results in the previous section motivates our identification strategy for estimating the returns to education. It is well known that the main challenge in estimating the returns to education is the endogeneity of educational attainment, which is subject to self-selection, ability bias and measurement errors. All three factors are relevant in our case. Unlike compulsory education, HE is certainly a matter of individual choice. In CHFS, we also do not have a direct measure of the respondents' ability such as scores in standardized exams or test, or good measures of the quality of the education qualifications they hold. Moreover, the years of schooling variable is imputed from people's self-reported highest qualification obtained or attempted.

In order to overcome the endogeneity and measurement error in self-reported years of schooling (converted from attempted/completed level of qualifications), we will explore the large and unanticipated HE expansion which started in 1999 as a source of exogenous variation in the educational attainment. Moreover, given the strong evidence of differential impact of the HE expansion on educational attainment, it is important to allow the impact of HE expansion to vary according to people's original *hukou* status.

These results in the previous section motivate our identification strategies in the Two-Stage-Least-Squares (2SLS) estimation. As Figures 3 and 4 suggest that the impact of the HE expansion differs for rural and urban *hukou* holders, we need to interact an urban *hukou* at age 12 dummy with each of the 3 main HE expansion variables above. As we include the urban *hukou* dummy and the main effects of the 3 variables capturing the expansion in the second-stage wage equations, the identification of the causal effect of education on earnings only relies on the interactions of the urban *hukou* at age 12 dummy with these variables. In other words, we assume that the interaction effects of the *hukou* system and the HE expansion has no direct effect on earnings over and above their impact on the education attainment. Compared to an instrumental variable strategy which relies on the main effects of HE expansion variables and the urban *hukou* dummy, our identification strategy is much less restrictive. Because our model is over-identified, we will also be able to formally test the exogeneity of our instruments using the over-identification tests. Moreover, if any of the main HE expansion effects above is found to be statistically significant in the second stage, that will lend further support to our identification strategy which only relies on the interaction terms.

Formally, the 2SLS is a two-equation system defined as follows. The first-stage involves estimating an OLS equation of years of schooling on exogenous controls, as well as the instrumental variables $U_{ij}T_{ij,}\ U_{ij}D_{ij,}\ and\ U_{ij}TD_{ij}$, which are known as the excluded variables:

$$S_{ij} = \alpha + \gamma X_{ij} + \delta_0 U_{ij} + \delta_1 T_{ij} + \delta_2 D_{ij} + \delta_3 (TD_{ij})$$
$$+\left[\delta_{10}\left(U_{ij}T_{ij}\right) + \delta_{20}\left(U_{ij}D_{ij}\right) + \delta_{30}\left(U_{ij}TD_{ij}\right)\right] + \theta C_j + \varepsilon_{ij} \tag{2}$$

The second-stage is just equation (1), which is modified by replacing the observed S_{ij} with the fitted value estimated from the first-stage:

$$lnW_{ij} = \alpha + \beta \widehat{S_{ij}} + \gamma X_{ij} + \delta_0 U_{ij} + \delta_1 T_{ij} + \delta_2 D_{ij} + \delta_3 (TD_{ij}) + \theta C_j + \varepsilon_{ij} \tag{3}$$

Technically, our IV estimator is analogous to a Difference-in-differences (DID) estimator that estimates earnings returns to education net of an HE expansion on earnings effect (common for both rural and urban *hukou* holders). The fact that rural *hukou* holders share a common trend in years of schooling with their urban counterparts before the expansion ensures that it can serve as an ideal control group for the urban *hukou* holders.

6. Empirical Results

In this section, we will first present the benchmark Ordinary Least Squares (OLS) estimates of returns to years of schooling by gender, with county/district fixed-effects (FEs). Then we present the main 2SLS estimates, by exploring the 1999 Higher Education expansion. After that, we explore heterogeneous treatment effects, by splitting the sample by the type of area or geographical region of residence. Finally, for sample members living with parents, we check whether the returns to education vary by parental education. For this subsample, we also present evidence that instrumenting on parental education is not a convincing identification strategy in the Chinese context.

6.1. OLS Baseline

Table 4 shows the OLS estimation results of returns to schooling, which serves as the baseline against which the 2SLS results are compared.[11] In Table A2 in the Appendix, we present a more parsimonious specification, which only allows for 4 types of region of residence (with Tier 1 city as the reference). Compared to Table 4, replacing 353 county/district FEs with 3 region-type dummies increase the returns by 0.9% and 0.5% for men and women respectively. Moreover, the R^2 measures also decreased by around 10 percentage points for both genders, suggesting that local labour market conditions account for a significant proportion of the variation in individual earnings.

Apart from urban *hukou* at age 12, our baseline model also controls for a dummy for born in 1980 or later, and their interaction terms (denoted as "Post-1980 birth year trend"). These are intended to capture the main effect of the HE expansion which started in 1999. The (pre-expansion) birth year trend variable is omitted due to perfect multi-collinearity with age in our single cross-sectional data. It is interesting to note that urban *hukou* at age 12 has a negative and significant effect on earnings for men, conditional on years of education and other regressors. Also note that Table 4 is similar in specifications to Table 3, but excluding the interactions between urban *hukou* status at age 12 and the 3 HE expansion main effects.

[11] While all our regression analysis is unweighted, we report robust standard errors throughout. Moreover, allowing for county-FE should capture much of the heterogeneity arising from the multi-stage cluster sampling design.

Table 4: OLS estimates of returns to schooling by gender, with county/district fixed-effects

	(1)	(2)
	Men	Women
Years of schooling	0.049***	0.062***
	(0.002)	(0.002)
Age	0.114***	0.083***
	(0.030)	(0.031)
Age squared	-0.001***	-0.001***
	(0.000)	(0.000)
Post-1980 birth	-0.119	-0.118
	(0.107)	(0.108)
Post-1980 birth year trend	0.012	0.014
	(0.009)	(0.010)
Urban *hukou* at age 12	-0.044***	0.002
	(0.012)	(0.012)
Constant	5.274***	5.485***
	(0.655)	(0.672)
County/District FE	✓	✓
Observations	11,633	9,333
R^2	0.304	0.405

Note: 353 county/district dummies. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

6.2. 2SLS main results

Table 5 presents the corresponding 2SLS estimates by gender. Note the second-stages of the 2SLS for columns (1) and (3) have exactly the same specification as the OLS in Table 4, apart from replacing the observed years of schooling with the corresponding predicted values from the first-stage. Since the full set of the first-stage results are already presented in Table 3, we will only highlight the 3 excluded variables in the bottom panel of the table under the heading "First-stage".

It turns out that allowing for endogeneity and measurement error in years of schooling increases the returns from 4.9% in OLS to 16.5% for men, and from 6.2% in OLS to 12.4% for women. Consistent with Figures 3 and 4, the large positive coefficients of the interaction between post-1980 birth and urban *hukou* origin suggests that the HE expansion itself had significantly widened the urban-rural gap in years of schooling, by approximately 1.2 years for men and 2.3 years for women. On the other hand, the second IV is insignificant, reflecting the parallel time trend between urban and urban *hukou* holders before the HE expansion. Finally, the negative coefficient of the post-1980 birth year trend interacted with urban *hukou* origin indicates that the urban-rural gap in years of schooling is narrowed at an annual rate of 0.1-0.15 year after the initial shock, again fully consistent with Figure 3. It is also worth noting that the main effects of the HE expansion variables as well as the urban *hukou* at age 12 dummy are all included in the second-stage. Because of the perfect multi-collinearity between birth year trend and age in a single cross-section, the birth year time trend variable is omitted from the second-stage wage regression. It turns out that all these main effects are statistically significant individually in Table 5, thus precluding their use as instruments.

Note that for all specifications, our model specifications satisfy all the usual diagnostic tests. The instruments are jointly significant, with the F-statistics with 3 degrees of freedom well above the normal threshold of 10, thus indicating there is no concern for weak instruments. The endogeneity tests for years of schooling are easily rejected with p-values at 0.000. On the other hand, we cannot reject the over-identification tests even at the 50% level of significance across all specifications. This means under the maintained hypothesis that at least one of our 3 instruments (i.e. either the interaction of urban *hukou* with the post-1980 dummy, or the interaction with the birth year trend, or the post-1980 birth year trend) is exogenous, we cannot reject the hypotheses that all 3 instruments are exogenous.[12]

[12] The returns to education estimates are virtually unchanged when using the Limited-Information Maximum Likelihood (LIML) or Generalized Method of Moments (GMM) estimators. These results are not reported but are available upon request.

Table 5: 2SLS estimates of returns to schooling by gender, with county/district FE

	(1)	(2)
	Men	Women
Second-stage		
Years of schooling	0.165***	0.124***
	(0.028)	(0.017)
Age	0.147***	0.106***
	(0.036)	(0.034)
Age squared	-0.002***	-0.001***
	(0.000)	(0.000)
Post-1980 birth	-0.265**	-0.181
	(0.129)	(0.116)
Post-1980 Birth year trend	0.023**	0.019*
	(0.011)	(0.010)
Urban *hukou* at age 12	-0.313***	-0.157***
	(0.065)	(0.045)
Constant	3.303***	4.274***
	(0.887)	(0.794)
County/District FE	✓	✓
First-stage (partial effects of instruments):		
Post-1980 birth * Urban *hukou*	1.231***	2.302***
	(0.346)	(0.383)
Birth year trend * Urban *hukou*	0.012	-0.016
	(0.030)	(0.033)
Post-1980 birth year trend * Urban *hukou*	-0.106***	-0.154***
	(0.034)	(0.038)
Diagnostic Tests:		
Joint significance of IVs: $F_{(3)}$ (p-value)	19.995 (0.000)	41.327 (0.000)
Endogeneity of years of schooling: $\chi^2_{(1)}$ (p-value)	24.124 (0.000)	15.648 (0.000)
Over-identification: $\chi^2_{(2)}$ (p-value)	0.698 (0.706)	0.839 (0.657)
Observations	11,633	9,333

Note: 353 county/district dummies. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

Robustness of 2SLS results

In Table A3 in the Appendix, we check the sensitivity of our headline 2SLS estimates with respect to an alternative specification of the age-earnings profiles. Instead of the conventional

Mincer wage specification with a quadratic in age (Mincer, 1958), we now control for a full set of age dummies. It turns out the estimates for returns to education are virtually identical.

Our 2SLS results are also robust to the exclusion of 10% or so of respondents with unknown or missing age 12 *hukou* status, who are treated as urban in Table 5. Excluding them would only change the headline returns to education estimates marginally to 0.169 and 0.126 for men and women respectively and the model still passes all the diagnostic tests. In the interest of space, we don't report the full set of estimates.

Local Average Treatment effects (LATE)

Our 2SLS estimates are certainly significantly higher than their OLS counterparts. However, they are not out of line with the literature, see Fang *et al*. (2012), Li *et al.* (2017) and Dai *et al*. (2018) who all report higher estimates. Bear in mind that the 2SLS estimates should be interpreted as the Local Average Treatment Effect (LATE), i.e. the returns to (one-year of) schooling for marginal students with urban *hukou* at age 12 who increased their education only because of the HE expansion. This is plausible if these marginal students who won't get college education in the absence of the HE expansion possess favourable characteristics, such as valuable unobservable skills or more social capital as proxied by parental education, which are valued in the labour market. Another explanation is that OLS might be downward biased because of errors in self-reporting, e.g. misclassifying dropouts and non-completions.

We are effectively comparing younger and older birth cohorts with an urban *hukou* at age 12, after controlling for an HE expansion effect which is assumed to be common for all younger birth cohorts regardless of their *hukou* origin. Technically, the IV estimator is analogous to a Difference-in-differences (DID) estimator that estimates earnings returns to education net of an HE expansion on earnings effect (common for both rural and urban *hukou* holders). Compared to a conventional IV, the advantage of our approach is that we can use rural *hukou* holders as a control to net out any common birth cohort related effect (e.g. deterioration in HE quality directly caused by the rapid HE expansion or any common macro-economic shocks such as China's accession to the WTO at the end of 2001).

While it is unfortunate from an equity perspective that the rural origin students largely missed out on the HE expansion, at least in the short run, from an econometric point of view they serve as an ideal control group for urban *hukou* holders in the sense of indicating the potential trend in the absence of the HE expansion.

6.3. Heterogeneous Treatment Effects

We further explore heterogeneous treatment effects, with respect to the type of current area of residence and geographical region. In Table 6, we repeat the analysis by conditioning on the current type of region, by grouping Tier 1 and Tier 2 cities together, and the rest together. Consistent with the pooled sample analysis, 2SLS estimates are significantly higher than their OLS counterparts conditional on the type of area of residence, for both genders. Moreover, while the OLS estimates are significantly higher regardless of gender for residents of major cities, the gap becomes insignificant in 2SLS for women. As for men, the causal estimates of returns for residents of major cities are 9 percentage points higher than (or twice as high as) those living in smaller cities, towns or rural areas.

In Table 7, we rerun OLS and 2SLS regressions for each of the 3 main geographic regions of China, namely Eastern, Central (including Northeast) and Western. Whereas the 2SLS returns for women are similar across the regions, men in the Eastern region enjoy a return of almost 20% which exceeds that for men in other regions by at least 7 percentage points. The Eastern region (excluding the Northeast) is China's most developed area, and also host all 4 Tier 1 cities. So, it is perhaps not surprising that the pattern presented in Table 7 overlaps with that in Table 6.

Table 6: OLS/2SLS estimates of returns to schooling by area type

6A: Tier 1 and Tier 2 cities

	OLS		2SLS	
	Men	Women	Men	Women
	(1)	(2)	(3)	(4)
Second-stage				
Years of schooling	0.069***	0.070***	0.187***	0.133***
	(0.003)	(0.003)	(0.036)	(0.023)
Age	0.123**	0.048	0.132**	0.047
	(0.050)	(0.045)	(0.058)	(0.048)
Age squared	-0.002***	-0.001	-0.001**	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Post-1980 birth	-0.060	0.035	-0.209	0.009
	(0.176)	(0.156)	(0.206)	(0.164)
Post-1980 Birth year trend	0.008	0.003	0.016	0.004
	(0.015)	(0.014)	(0.018)	(0.015)
Urban *hukou* at age 12	-0.067***	0.027	-0.324***	-0.133**
	(0.018)	(0.017)	(0.081)	(0.061)
Constant	4.676***	7.967***	2.974**	4.828***
	(1.068)	(1.221)	(1.323)	(1.073)
County/District FE	✓	✓	✓	✓
First-stage (partial effects of instruments):				
Post-1980 birth * Urban *hukou*			0.549	1.290**
			(0.525)	(0.548)
Birth year trend * Urban *hukou*			-0.012	-0.033
			(0.044)	(0.050)
Post-1980 birth year trend * Urban *hukou*			-0.069	-0.104*
			(0.050)	(0.055)
Diagnostic Tests:				
Joint significance of IVs: $F_{(3)}$ (p-value)			12.862 (0.000)	21.287 (0.000)
Endogeneity of years of schooling: $\chi^2_{(1)}$ (p-value)			15.202 (0.000)	8.994 (0.003)
Over-identification: $\chi^2_{(2)}$ (p-value)			0.191 (0.909)	0.669 (0.716)
Observations	5060	4561	5060	4561
R^2	0.344	0.412	0.086	0.330

Note: 353 county/district dummies. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

6B: Small Cities/towns and rural areas

	OLS		2SLS	
	Men	Women	Men	Women
	(1)	(2)	(3)	(4)
Second-stage				
Years of schooling	0.034***	0.056***	0.093**	0.112***
	(0.002)	(0.003)	(0.041)	(0.024)
Age	0.111***	0.112***	0.134***	0.149***
	(0.037)	(0.042)	(0.042)	(0.049)
Age squared	-0.001***	-0.001***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.001)
Post-1980 birth	-0.192	-0.258*	-0.254*	-0.336**
	(0.130)	(0.150)	(0.143)	(0.164)
Post-1980 Birth year trend	0.018	0.023*	0.024*	0.030**
	(0.012)	(0.013)	(0.013)	(0.014)
Urban *hukou* at age 12	-0.026	-0.031*	-0.172*	-0.181***
	(0.016)	(0.018)	(0.103)	(0.067)
Constant	5.457***	10.399***	4.327***	3.581***
	(0.799)	(1.133)	(1.148)	(1.194)
County/District FE	✓	✓	✓	✓
First-stage (partial effects of instruments):				
Post-1980 birth * Urban *hukou*			1.453***	3.023***
			(0.500)	(0.568)
Birth year trend * Urban *hukou*			0.036	-0.014
			(0.041)	(0.047)
Post-1980 birth year trend * Urban *hukou*			-0.123***	-0.175***
			(0.047)	(0.054)
Diagnostic Tests:				
Joint significance of IVs: $F_{(3)}$ (p-value)			6.072 (0.000)	18.097 (0.000)
Endogeneity of years of schooling: $\chi^2_{(1)}$ (p-value)			2.249 (0.134)	5.917 (0.015)
Over-identification: $\chi^2_{(2)}$ (p-value)			3.109 (0.211)	3.954 (0.139)
Observations	6573	4772	6573	4772
R^2	0.177	0.293	0.076	0.201

Note: 353 county/district dummies. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

Table 7A: OLS/2SLS estimates of returns to schooling by geographical regions, Men

	Eastern		Central & Northeast		Western	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
Second-stage						
Years of schooling	0.060***	0.199***	0.038***	0.100**	0.045***	0.129***
	(0.003)	(0.050)	(0.004)	(0.042)	(0.003)	(0.040)
Age	0.138***	0.163***	-0.006	0.026	0.236***	0.254***
	(0.044)	(0.055)	(0.053)	(0.060)	(0.066)	(0.072)
Age squared	-0.002***	-0.002***	0.000	-0.000	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Post-1980 birth	-0.130	-0.294	0.151	0.066	-0.514**	-0.625**
	(0.156)	(0.196)	(0.185)	(0.202)	(0.239)	(0.264)
Post-1980 Birth year trend	0.015	0.027	-0.014	-0.006	0.048**	0.053**
	(0.014)	(0.017)	(0.017)	(0.018)	(0.021)	(0.023)
Urban *hukou* at age 12	-0.009	-0.304***	-0.100***	-0.248**	-0.042*	-0.268**
	(0.018)	(0.106)	(0.023)	(0.101)	(0.025)	(0.111)
Constant	11.366***	2.292	7.611***	6.543***	2.846**	1.622
	(1.195)	(1.409)	(1.426)	(1.515)	(1.417)	(1.647)
County/District FE	✓	✓	✓	✓	✓	✓
First-stage (partial effects of instruments):						
Post-1980 birth * Urban *hukou*		0.654		1.964***		1.712**
		(0.495)		(0.646)		(0.734)
Birth year trend * Urban *hukou*		-0.049		0.103*		0.020
		(0.044)		(0.052)		(0.061)
Post-1980 birth year trend * Urban *hukou*		-0.027		-0.206***		-0.149**
		(0.049)		(0.061)		(0.070)
Diagnostic Tests:						
Joint significance of IVs: $F_{(3)}$ (p-value)		6.983 (0.000)		6.944 (0.000)		8.241 (0.000)
Endogeneity of years of schooling: $\chi^2_{(1)}$ (p-value)		11.867 (0.000)		2.469 (0.116)		5.218 (0.022)
Over-identification: $\chi^2_{(2)}$ (p-value)		3.103 (0.212)		2.999 (0.223)		0.332 (0.847)
Observations	5,380	5,380	3,526	3,526	2,727	2,727
R^2	0.370	.	0.157	-	0.204	-

Note: 353 county/district dummies. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

Table 7B: OLS/2SLS estimates of returns to schooling by geographical regions, Women

	Eastern		Central & Northeast		Western	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
Second-stage						
Years of schooling	0.070***	0.134***	0.055***	0.122***	0.057***	0.095***
	(0.003)	(0.024)	(0.003)	(0.038)	(0.004)	(0.024)
Age	0.098**	0.118**	0.028	0.068	0.134**	0.144**
	(0.045)	(0.048)	(0.058)	(0.066)	(0.062)	(0.064)
Age squared	-0.001**	-0.001**	-0.000	-0.001	-0.002**	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Post-1980 birth	-0.127	-0.195	0.021	-0.066	-0.323	-0.348
	(0.156)	(0.166)	(0.203)	(0.221)	(0.225)	(0.230)
Post-1980 Birth year trend	0.016	0.021	-0.001	0.006	0.033*	0.034*
	(0.014)	(0.015)	(0.018)	(0.019)	(0.020)	(0.020)
Urban *hukou* at age 12	0.032*	-0.126**	-0.062***	-0.246**	0.014	-0.088
	(0.018)	(0.061)	(0.024)	(0.109)	(0.026)	(0.066)
Constant	5.035***	3.756***	6.810***	5.227***	4.517***	3.896***
	(0.968)	(1.142)	(1.251)	(1.616)	(1.326)	(1.441)
County/District FE	✓	✓	✓	✓	✓	✓
First-stage (partial effects of instruments):						
Post-1980 birth * Urban *hukou*		1.526***		2.835***		3.850***
		(0.528)		(0.711)		(0.890)
Birth year trend * Urban *hukou*		-0.023		0.041		-0.053
		(0.048)		(0.061)		(0.076)
Post-1980 birth year trend * Urban *hukou*		-0.118**		-0.199***		-0.209**
		(0.053)		(0.068)		(0.086)
Diagnostic Tests:						
Joint significance of IVs: $F_{(3)}$ (p-value)		20.925 (0.000)		8.360 (0.000)		15.285 (0.000)
Endogeneity of years of schooling: $\chi^2_{(1)}$ (p-value)		8.133 (0.004)		3.662 (0.056)		3.028 (0.022)
Over-identification: $\chi^2_{(2)}$ (p-value)		0.307 (0.858)		3.983 (0.137)		1.281 (0.527)
Observations	4,615	4,615	2,639	2,639	2,079	2,079
R^2	0.438		0.267		0.303	

Note: 353 county/district dummies. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

One obvious explanation is that the OLS estimates might be contaminated by endogenous migration decisions. In particular, people who expect higher returns to their education may choose to migrate to major cities in order to take advantage of the greater economic opportunities in terms of earnings and career progression.[13] At the equilibrium, the returns to education should be equalized across different area types or geographical regions, in the absence of institutional barriers.

[13] Our estimates might be biased upwards if workers in major cities work longer hours. Unfortunately, we are unable to estimate the returns to education on hourly wages due to lack of information on working hours.

Our finding implies that the *hukou* system has acted as a severe barrier for geographic mobility, even for college graduates who are expected to be the most responsive demographic group to distant labour market opportunities.[14]

6.4. *Heterogenous effect with respect to parental education*

For roughly one-third of the respondents in our sample who live together with their parents, there is information on parental education. This means that for this non-random subsample, we could also test for heterogeneous treatment effect with respect to parental education, which proxies for socio-economic background. Following the literature, we focus on father's education, which turns out to be available for 44.5% of men and 20.8% of women in the original sample. Given this much smaller subsample, we can only distinguish between low and high father's education, depending on whether the father's qualification is beyond Junior High School.

Figures 5A and 5B show the change in the educational qualification distribution of respondents before and after the HE expansion by father's education, and *hukou* status at age 12. From the vast literature on intergenerational mobility (of education), we expect parental education to be a key determinant of child's education. China is clearly no exception. The figures suggest a different pattern in terms of parental socio-economic background between the urban and the rural *hukou* holders: while in urban areas it is the relatively more disadvantaged (i.e. with fathers holding no more than Junior High School qualifications) who benefited more from the expansion, it is the opposite for people with rural origins. In other words, while the HE expansion has widened between-group educational inequality across the urban-rural divide, the within-group inequality has narrowed for urban residents but widened for rural residents.

In Tables 8A and 8B, we report for men and women respectively, the OLS and 2SLS estimates of the returns to schooling for students with low education fathers, high education fathers, as well the large reference group of missing father's education. It is worth mentioning that co-residence with parents in contemporary China is itself a selective outcome. Compared to the main analysis in Tables 4 and 5 using the full sample, it is also no longer feasible to control for

[14] Using 3 decades of census data, Wozniak (2010) shows that US college graduates are several times more responsive in residential location choices to variations in labour market conditions across states than High School graduates.

county/district FEs due to the much smaller sample sizes. Instead, we use a parsimonious specification with dummies for the type of area of residence (tiers of cities) and the geographical regions, a grouping used in Tables 6 and 7 respectively.

Table 8A presents the results for men. While OLS suggests that men from disadvantaged family background have 2.6 percentage points (or 40%) lower returns than their more privileged counterparts, the opposite is true for the 2SLS estimates, even though the causal estimates for students with better educated fathers are statistically insignificant due to weak instruments. On the other hand, the returns for respondents who live independently, and hence having missing parental education information, have the highest returns.

Table 8B reports the corresponding results for women. The fact that traditionally a woman lives with her husband's family after marriage in China largely explains the much smaller sample of women with non-missing information on fathers, compared to men. Nevertheless, we have a similar pattern here. While women with disadvantaged family background appear to have much lower returns to education according to the OLS, the corresponding causal estimates using 2SLS are virtually identical. Moreover, not living with own parents (and hence missing father's education) does not matter for 2SLS estimates of returns for women.

This finding has important policy implications. In contrast to the common belief that better-off children have higher returns to schooling, the causal evidence suggests exactly the opposite: it is those students who are from disadvantaged family background who stand to gain more from the HE expansion.

Figure 5A: Years of schooling by father's education and *hukou* status at age 12

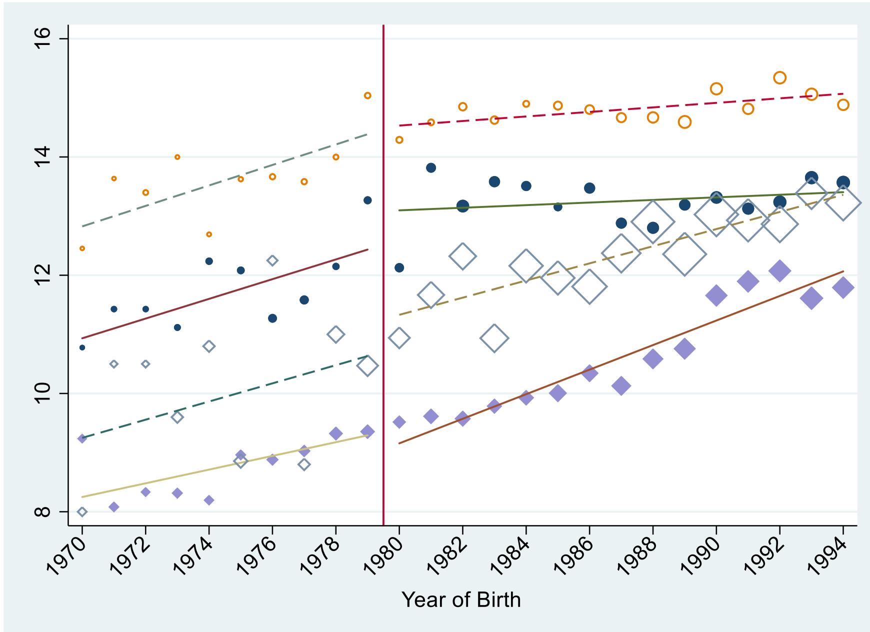
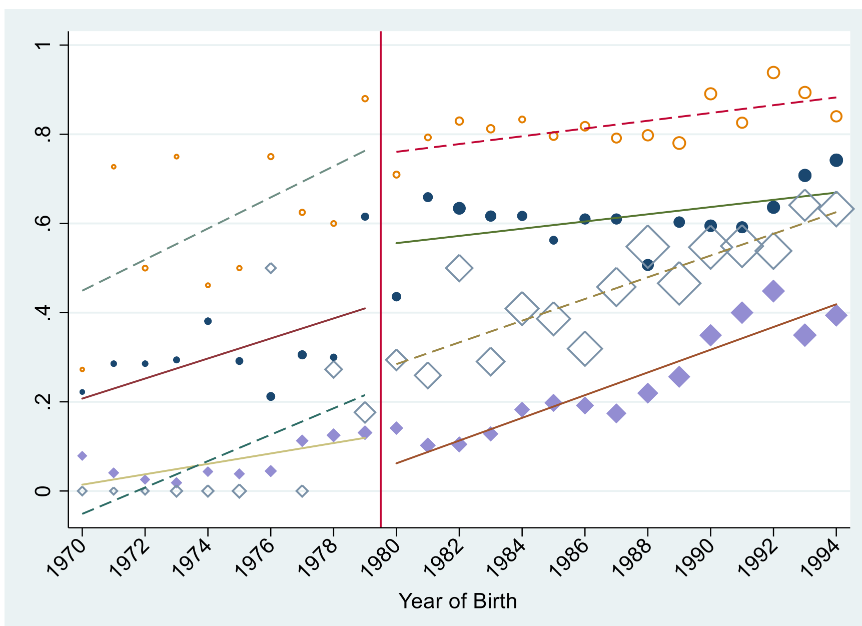


Figure 5B: College attainment by father's education and *hukou* status at age 12



Note: Solid dots denote urban residents whose fathers hold at most Junior High School qualification; Hollow dots denote urban residents whose fathers hold at least Senior High School qualifications; Solid diamonds denote rural residents whose fathers hold at most Junior High School qualifications; hollow diamonds denote rural residents whose fathers hold at least Senior High School qualifications. Marker size proportional to number of observations.

Table 8A: OLS/2SLS estimates of returns to schooling by father's education, Men

	Father Low Education		Father High Education		Father Education Missing	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
Second-stage						
Years of schooling	0.038***	0.095***	0.064***	0.040	0.060***	0.206***
	(0.003)	(0.036)	(0.006)	(0.069)	(0.003)	(0.063)
Age	0.151***	0.164***	0.163**	0.162**	0.088*	0.110*
	(0.047)	(0.050)	(0.080)	(0.080)	(0.050)	(0.064)
Age squared	-0.002***	-0.002***	-0.002**	-0.002**	-0.001*	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Post-1980 birth	-0.338*	-0.360*	-0.339	-0.332	-0.041	-0.258
	(0.178)	(0.185)	(0.304)	(0.308)	(0.161)	(0.223)
Post-1980 Birth year trend	0.032**	0.034**	0.036	0.036	0.007	0.020
	(0.016)	(0.017)	(0.027)	(0.028)	(0.014)	(0.019)
Urban *hukou* at age 12	-0.067***	-0.185**	0.006	0.054	-0.020	-0.400**
	(0.021)	(0.076)	(0.037)	(0.145)	(0.016)	(0.164)
Constant	4.804***	3.780***	4.153**	4.508**	6.306***	3.762**
	(1.021)	(1.272)	(1.743)	(1.981)	(1.056)	(1.697)
City tier FE	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓
First-stage (partial effects of instruments):						
Post-1980 birth * Urban *hukou*		2.905***		0.183		1.123***
		(0.832)		(1.338)		(0.499)
Birth year trend * Urban *hukou*		0.138		-0.011		0.019
		(0.095)		(0.149)		(0.034)
Post-1980 birth year trend * Urban *hukou*		-0.267***		-0.057		-0.099**
		(0.099)		(0.155)		(0.043)
Diagnostic Tests:						
Joint significance of IVs: $F_{(3)}$ (p-value)		8.680 (0.000)		2.883 (0.035)		4.843 (0.002)
Endogeneity of years of schooling: $\chi^2_{(1)}$ (p-value)		2.683 (0.101)		0.122 (0.763)		8.900 (0.003)
Over-identification: $\chi^2_{(2)}$ (p-value)		0.457 (0.796)		0.869 (0.668)		0.158 (0.924)
Observations	3808	3808	1368	1368	6457	6457
R^2	0.086	.	0.175	-	0.264	.

Note: Father low education includes qualification up to Junior High School. Father high education includes qualification at Senior High School or above. Controls for city tier and region dummies. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

Table 8B: OLS/2SLS estimates of returns to schooling by father's education, Women

	Father Low Education		Father High Education		Father Education Missing	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
Second-stage						
Years of schooling	0.048***	0.138***	0.087***	0.144**	0.069***	0.128***
	(0.005)	(0.034)	(0.008)	(0.059)	(0.002)	(0.031)
Age	0.266***	0.223**	0.063	0.048	0.020	0.012
	(0.078)	(0.091)	(0.093)	(0.095)	(0.040)	(0.043)
Age squared	-0.003***	-0.003***	-0.001	-0.001	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Post-1980 birth	-0.694**	-0.483	-0.104	-0.128	0.031	0.020
	(0.309)	(0.367)	(0.377)	(0.387)	(0.132)	(0.141)
Post-1980 Birth year trend	0.053*	0.030	-0.008	-0.005	0.000	-0.000
	(0.029)	(0.034)	(0.036)	(0.037)	(0.012)	(0.013)
Urban *hukou* at age 12	-0.029	-0.193***	0.001	-0.087	0.032**	-0.143
	(0.034)	(0.075)	(0.046)	(0.099)	(0.014)	(0.090)
Constant	2.618	2.370	6.594***	5.910**	7.120***	6.445***
	(1.721)	(1.965)	(2.107)	(2.309)	(0.851)	(0.997)
City tier FE	✓	✓	✓	✓	✓	✓
Region FE	✓	✓	✓	✓	✓	✓
First-stage (partial effects of instruments):						
Post-1980 birth * Urban *hukou*		1.557		1.211		1.806***
		(1.497)		(2.096)		(0.464)
Birth year trend * Urban *hukou*		-0.280		0.257		-0.042
		(0.180)		(0.317)		(0.035)
Post-1980 birth year trend * Urban *hukou*		0.045		-0.387		-0.095**
		(0.185)		(0.322)		(0.043)
Diagnostic Tests:						
Joint significance of IVs: $F_{(3)}$ (p-value)		12.769 (0.000)		6.228 (0.000)		12.726 (0.000)
Endogeneity of years of schooling: $\chi^2_{(1)}$ (p-value)		9.059 (0.003)		0.992 (0.319)		4.382 (0.036)
Over-identification: $\chi^2_{(2)}$ (p-value)		1.100 (0.578)		1.468 (0.480)		0.101 (0.951)
Observations	1218	1218	715	715	7400	7400
R^2	0.183	.	0.353	-	0.330	-

Note: Father low education includes qualification up to Junior High School. Father high education includes qualification at Senior High School or above. Controls for city tier and region dummies. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

It is quite common in the literature to instrument one's education using parental education. So, in Table 9, we present the 2SLS estimates using either father's education (in 9A) or mother's education (in 9B), and compare them to the corresponding OLS estimates using the same subsample. Similar to our main 2SLS results in Table 5, the new 2SLS estimates are larger than their OLS counterparts. Moreover, we find larger 2SLS estimates for men when instrumenting using father's education, and larger 2SLS estimates for women if mother's education is used. However, in all cases, they are smaller in magnitude compared to Table 5, when we instrument on the interaction of urban *hukou* status at age 12 with the 3 indicators capturing the change in level and trend of education induced by the HE expansion.

Further diagnostic tests indicate that the new instruments fail the over-identification tests for women regardless of whether father or mother's education is used as instruments, suggesting that the exogeneity assumption of parental education might not hold. This violation might arise when parental education has a direct effect on children's earning, over and above an indirect effect through the offspring's education. Such a direct effect is not surprising, in a society in which parental background and family social capital (*guanxi*) are expected to play a direct role in the economic success of the child, in addition to its effect through the education channel.

Table 9A: OLS/IV estimates of returns to schooling, by gender (instrumented by father's qualification)

	OLS		2SLS	
	Men	Women	Men	Women
	(1)	(2)	(3)	(4)
Second-stage				
Years of schooling	0.041***	0.045***	0.068***	0.078***
	(0.003)	(0.005)	(0.008)	(0.016)
Age	0.160***	0.209***	0.162***	0.187***
	(0.040)	(0.068)	(0.039)	(0.063)
Age squared	-0.002***	-0.003***	-0.002***	-0.002***
	(0.000)	(0.001)	(0.000)	(0.001)
Urban *hukou* at age 12	-0.040**	-0.002	-0.101***	-0.070*
	(0.019)	(0.031)	(0.026)	(0.041)
Post-1980 Birth year trend	0.034**	0.045*	0.035***	0.035
	(0.014)	(0.025)	(0.013)	(0.023)
Post-1980 birth	-0.386**	-0.587**	-0.392***	-0.506**
	(0.152)	(0.274)	(0.148)	(0.253)
Constant	4.327***	3.496**	3.978***	3.590***
	(0.879)	(1.524)	(0.870)	(1.393)
County/District FE	✓	✓	✓	✓
First-stage (partial effects of instruments):				
Father Primary education			0.686***	1.915***
			(0.186)	(0.536)
Father Jr High School education			1.604***	2.742***
			(0.186)	(0.534)
Father Sr High School education			2.390***	3.336***
			(0.197)	(0.537)
Father College+ education			3.887***	4.150***
			(0.224)	(0.545)
Diagnostic Tests:				
Joint significance of IVs: $F_{(4)}$ (p-value)			127.584 (0.000)	30.039 (0.000)
Endogeneity of years of schooling: $\chi^2_{(1)}$ (p-value)			11.074 (0.001)	4.753 (0.029)
Over-identification: $\chi^2_{(3)}$ (p-value)			0.435 (0.933)	10.979 (0.012)
Observations	5,176	1,933	5,176	1,933
R^2	0.234	0.449	-	-

Note: 353 county/district dummies. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

Table 9B: OLS/IV estimates of returns to schooling, by gender (instrumented by mother's qualification)

	OLS		2SLS	
	Men	Women	Men	Women
	(1)	(2)	(3)	(4)
Second-stage				
Years of schooling	0.044***	0.047***	0.054***	0.115***
	(0.003)	(0.005)	(0.010)	(0.023)
Age	0.160***	0.199***	0.162***	0.142**
	(0.040)	(0.068)	(0.039)	(0.067)
Age squared	-0.002***	-0.003***	-0.002***	-0.002**
	(0.000)	(0.001)	(0.000)	(0.001)
Post-1980 birth	-0.344**	-0.475*	-0.348**	-0.260
	(0.152)	(0.270)	(0.146)	(0.262)
Post-1980 Birth year trend	0.033**	0.031	0.034***	0.007
	(0.013)	(0.024)	(0.013)	(0.024)
Urban *hukou* at age 12	-0.044**	0.010	-0.067**	-0.121**
	(0.019)	(0.031)	(0.028)	(0.053)
Constant	4.339***	3.931***	4.188***	4.362***
	(0.875)	(1.495)	(0.858)	(1.424)
County/District FE	✓	✓	✓	✓
First-stage (partial effects of instruments):				
Father Primary education			0.803***	0.727***
			(0.121)	(0.300)
Father Jr High School education			1.639***	1.270***
			(0.132)	(0.311)
Father Sr High School education			2.377***	1.997***
			(0.156)	(0.332)
Father College+ education			3.268***	2.430***
			(0.201)	(0.380)
Diagnostic Tests:				
Joint significance of IVs: $F_{(4)}$ (p-value)			88.957 (0.000)	15.485 (0.000)
Endogeneity of years of schooling: $\chi^2_{(1)}$ (p-value)			1.140 (0.286)	10.173 (0.001)
Over-identification $\chi^2_{(3)}$ (p-value)			6.332 (0.097)	13.493 (0.004)
Observations	5,172	1,977	5,172	1,977
R^2	0.245	0.450	-	-

Note: 353 county/district dummies. Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

7. Conclusion remarks

This paper is based on the 2017 China Household Finance Survey (CHFS), a nationally representative survey which is sufficiently large for analysis by gender, *hukou* status, type of region, or even county fixed-effects.

To the best of our knowledge, we are the first study to show that the unanticipated massive HE expansion starting in 1999 has had a detrimental effect on the large pre-existing urban-rural gap in educational attainment, using a large nationally representative data. We then build on this finding to develop a novel identification strategy to estimate returns to education which instruments years of schooling using the interaction of childhood urban *hukou* status and the timing of the expansion. This IV estimator is analogous to a Difference-in-Differences estimator which uses rural students to control for any common time trend such as changes in teaching quality due to the HE expansion or common macro-economic shocks such as China's accession to the WTO (World Trade Organization) at the end of 2001. Our 2SLS results can be interpreted as a Local Average Treatment Effect (LATE), i.e. the average treatment effect of HE attendance on earnings for urban students (as defined at age 12 *hukou* status) who enrolled in HE just because of the HE expansion.

The 2SLS estimates of 17% and 12% for men and women respectively are substantially larger than their OLS counterparts of 5% and 6%, both allowing for county fixed-effects. When we employ an alternative identification strategy of instrumenting with parental education using the subsample of respondents living with their parents, the 2SLS estimates are still larger than their OLS counterparts, but substantially smaller than main 2SLS results. However, further diagnostic tests indicate that parental education might not be valid instruments, to the extent that family background directly affect one's labour market outcomes over and above the usual education channel.

We also present evidence of heterogenous returns with regard to the type of residency area and geographical region. After accounting for endogeneity of education using 2SLS, the returns for women are broadly comparable across geographical regions and type of areas of residence, while there is significantly higher returns for men currently living in the more developed Eastern Region and/or major cities. This implies a that the *hukou* system may act as a severe barrier for geographic mobility, even for college graduates who are expected to be the most responsive demographic group to distant labour market opportunities (Wozniak 2010). Moreover, for respondents with parental education information, we find that the 2SLS returns for students from more disadvantaged backgrounds in terms of fathers' education are at least as high as their more advantaged counterparts for both genders.

Our findings have important policy implications, e.g. with regard to whether the massive expansion was justified *ex post*. The estimated substantial returns of 17% and 12% for men and women respectively suggest that overall the massive HE expansion starting in 1999 has resulted in substantive private returns for urban *hukou* holders who would not have had the opportunity to enroll in colleges and universities in the absence of this positive supply shock. Moreover, the 2SLS estimates suggests that students from disadvantaged family background, as proxied by father's education, enjoy returns that are at least as high as their more privileged counterparts. This implies that the strict rationing of HE places under a central planning model before the expansion had resulted in large excess demand for high skills by the rapidly growing economy, regardless of family background.

However, our finding that the rural *hukou* holders as a whole fail to benefit from this massive expansion, at least in the short-run, was a serious cause for concern. A thorough understanding of the underlying causes of this totally unintended consequence of such an important policy is beyond the scope of this study. Here we can only outline some potential contributing factors:

(1) The widening urban-rural gap in access to Senior High School around the time of HE expansion could be a driving factor of the differential response. According to Zhao *et al*. (2017), "In 1990, 2000 and 2010, the transition rates from junior to Senior High School in cities were 40.41%, 66.71% and 88.11% respectively, while in the same years, the transition rates in towns and rural areas were 18.96%. 22.06% and 38.36%, respectively". All else being equal, a low Senior High School enrolment rate means fewer rural students would be able to benefit from a sudden surge in college enrollment rates.

(2) The rising cost of Senior High School and HE faced by rural students around the time of the expansion is another important factor. While the 9-year compulsory education has become largely free, the fees and living expenses for Senior High School could be a substantial burden for an average rural household, whose income per capita is less than half of its urban counterpart and

deteriorating (NBS various years). For rural students who fail to enter colleges, the returns to Senior High School is very low, due to limited job opportunities in the formal sector and the fact that the main purpose of Senior High School is to prepare students for the high-stake university entrance exam (*gaokao*), see e.g. Wu *et al.* 2019. Even if the student manages to enter college, the family still has to provide financial support to cover the university tuition fees and expenses for at least another 3 years.

(3) The rising wages for migrant workers in the urban areas over this period also increase the opportunity cost of staying beyond compulsory education for rural students. Indeed, our analysis of the heterogeneous returns to education suggest that there could be significant returns to geographic mobility in China, especially for men.

Due to the declining fertility rate, new entrants to the labour market in China will come primarily from the rural *hukou* population (Meng 2012). Therefore, reducing the urban-rural educational attainment gap at all levels of education holds the key to China's future economic growth. To the extent that people with rural origin or from less developed areas are held back by the inferior school quality, in addition to the usually more disadvantaged family background, more targeted public investments in primary and secondary education, in rural areas in particular, are needed to increase productivity and to improve social equality in China.

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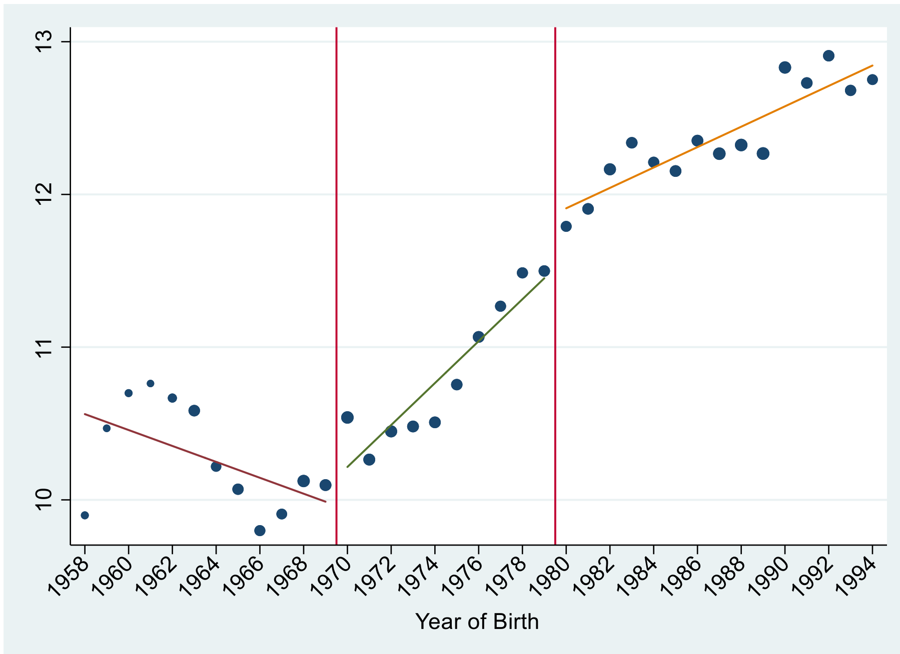
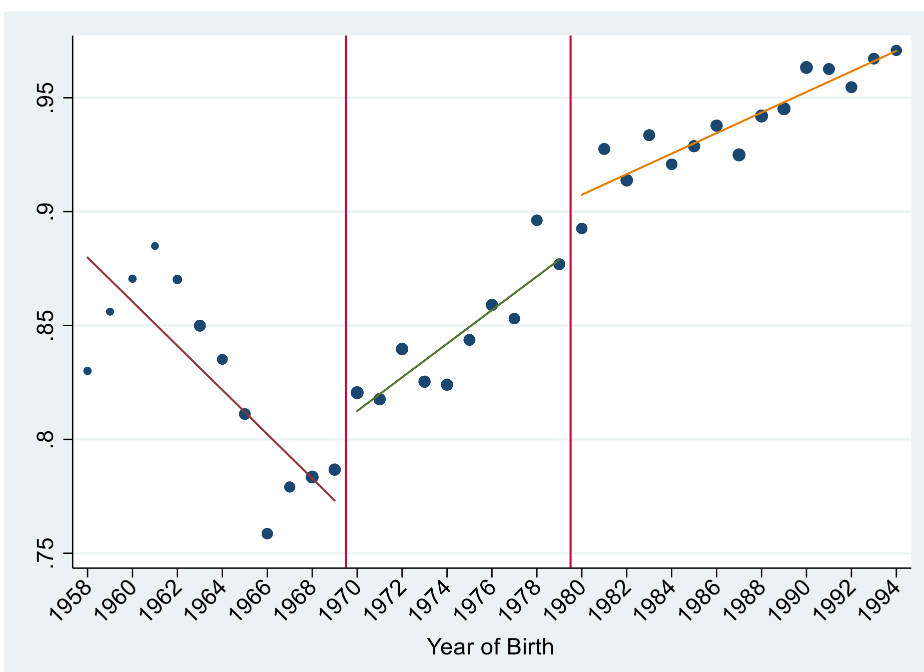
Appendix:

Figure A1: Years of schoolings of sample members, by year of birth



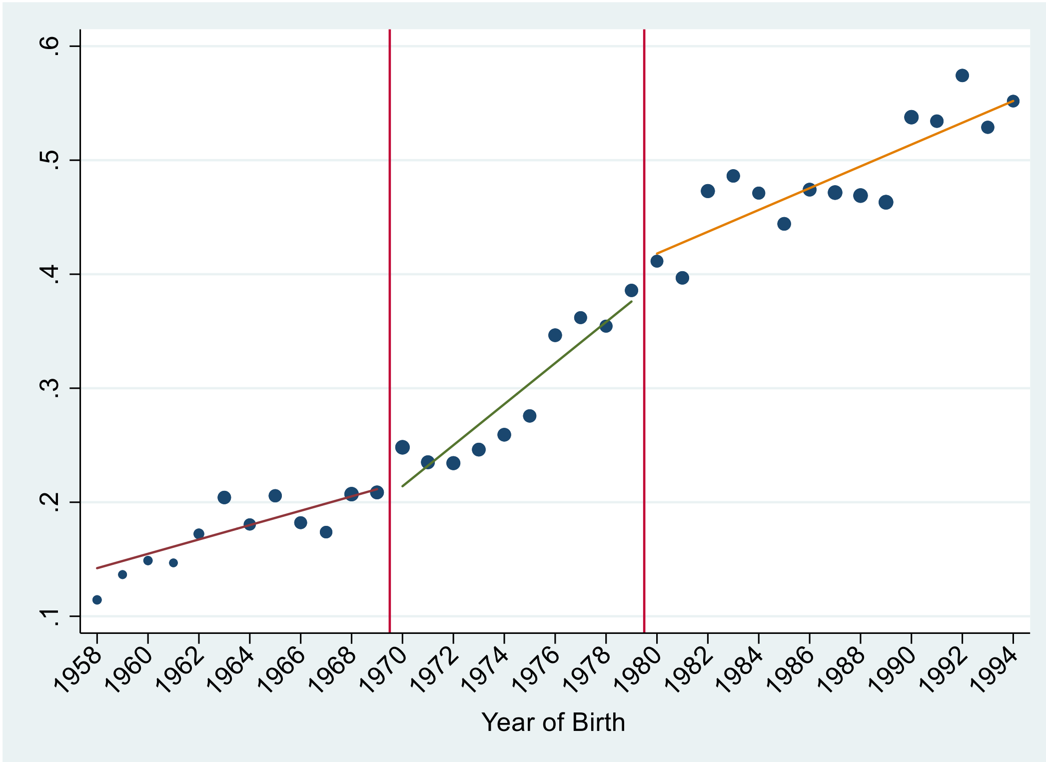
Note: Sample of men aged 23-59 and women aged 23-54. Marker size proportional to number of observations.

Figure A2: Proportion of sample members with 9+ years of schooling, by year of birth



Note: Sample of men aged 23-59 and women aged 23-54. Marker size proportional to number of observations.

Figure A3: Proportion of sample members with 14+ years of schooling, by year of birth



Note: Sample of men aged 23-59 and women aged 23-54. Marker size proportional to number of observations.

Table A1: Summary Statistics by gender, Unweighted

variable	Males	Females	Total
Log total monthly net earnings	8.219	7.981	8.113
Years of schooling	11.61	11.94	11.75
Post-1980 birth	0.611	0.593	0.603
Age	35.0	35.2	35.0
Age squared	1273.9	1288.7	1280.5
Currently rural *hukou*	0.522	0.455	0.492
Rural *hukou* at age 12	0.619	0.570	0.597
Tier 1 cities	0.126	0.149	0.137
Tier 2 cities	0.309	0.339	0.322
Smaller cities and towns	0.333	0.348	0.340
Rural areas	0.232	0.163	0.201
Observations	11,633	9,333	20,966

Table A2: OLS estimates of returns to schooling by gender, with region types instead of county/district fixed-effects (FE)

	(1)	(2)
	Men	Women
Years of schooling	0.058***	0.067***
	(0.002)	(0.002)
Age	0.135***	0.110***
	(0.031)	(0.032)
Age squared	-0.002***	-0.001***
	(0.000)	(0.000)
Post-1980 birth	-0.173	-0.182
	(0.110)	(0.113)
Post-1980 Birth year trend	0.018*	0.020**
	(0.010)	(0.010)
Urban *hukou* at age 12	-0.038***	0.013
	(0.012)	(0.012)
Tier 2 cities	-0.363***	-0.405***
	(0.018)	(0.017)
Other cities and towns	-0.448***	-0.499***
	(0.018)	(0.017)
Rural areas	-0.439***	-0.471***
	(0.019)	(0.020)
Constant	5.204***	5.275***
	(0.665)	(0.684)
Observations	11,633	9,333
R^2	0.215	0.305

Note: Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The baseline (pre-1980) birth year trend is omitted due to perfect multi-collinearity with age in cross-sectional data.

Table A3: Robustness of 2SLS estimates with respect to the age profile

	(1)	(2)
	Men	Women
Second-stage		
Years of schooling	0.166***	0.124***
	(0.028)	(0.017)
Age dummies	✓	✓
Urban *hukou* at age 12	-0.315***	-0.158***
	(0.065)	(0.045)
Constant	5.824***	6.232***
	(0.350)	(0.255)
County/District FE	✓	✓
First-stage (partial effects of instruments):		
Post-1980 birth * Urban *hukou*	1.250***	2.333***
	(0.346)	(0.384)
Birth year trend * Urban *hukou*	0.015	-0.014
	(0.030)	(0.033)
Post-1980 birth year trend * Urban *hukou*	-0.110***	-0.156***
	(0.034)	(0.038)
Diagnostic Tests:		
Joint significance of IVs: $F_{(3)}$ (p-value)	20.158 (0.000)	41.120 (0.000)
Endogeneity of years of schooling: $\chi^2_{(1)}$ (p-value)	24.788 (0.000)	15.730 (0.000)
Over-identification: $\chi^2_{(2)}$ (p-value)	0.601 (0.741)	0.851 (0.654)
Observations	11,633	9,333

Note: Specification same as in Table 5, but replacing age and age squared with a full set of age dummies. The post-1980 birth dummy and all time trend variables are omitted due to perfect multi-collinearity with age in cross-sectional data.