

The Impact of Young Cohort Size on Adult Educational Upgrading: Evidence from Family Planning Policies in China

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Abstract

This paper investigates the effect of the reduction in the young cohort size caused by Chinese family planning policies on the educational upgrading among older cohorts born before the policies. I suggest that family planning policies reduce the size of the young cohorts and increase their educational levels. Through imperfect substitutability of workers with same education but different ages, the incentives for older adults to acquire more education increase. Empirically, I examine the changes in the size of the young cohorts aged 16-24 caused by the family planning policies initiated in 1964 with both geographical and temporal variation. I find heterogeneous effects on the educational upgrading of older cohorts. A one percent decrease in the young cohort size increases the number of college graduates aged 25-49 by 0-2 percent during 1982-1990 and by 0-1 percent during 1990-2000, with bigger effects for the age group below 40. I find the effect of young cohort size on adult non-college graduates is negative but weaker than that for adult college graduates for all age groups. I further show that the observed increase in adult college graduates is more driven by the migration of college graduates for those aged 25-29, but the increase for those aged 30-49 is mostly driven by upgrading from non-college graduates who have already been in the local labor markets.

Key Words: Fertility policies, adult, education.

JEL Classification: I24, J1, J2.

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1 Introduction

The number of college workers in China as of 2000 has more than tripled compared with the level of two decades earlier. A number of empirical studies have documented increasing wage returns to college education over time (Zhang, Zhao, Park, and Song 2005, Maurer-Fazio 1999). It has been found that there is an increase in the number of workers who went back to college to acquire a college degree across adult age groups. Standard models of human capital investment predict low returns to investment during one's adulthood (Carneiro and Heckman 2003) and empirical research has provided some evidence consistent with these models (Silles 2007). Nevertheless, using the China's censuses, I have also found an increase in the number of college graduates across all working-age cohorts over time. In this paper, I provide a simple explanation for the human capital accumulation of adults during the 1980s and 1990s in China. My paper is based on the premise that the dramatic decline in the young cohort size induced by the family planning policies in China increased the return to college education and the relative supply of college workers in the young cohort. In the presence of imperfect substitutability between college workers of different ages, this increase in the relative supply of young college workers can lead to an increase in the productivity of older college workers. This productivity difference may raise the wage differential between older college workers and non-college workers, increasing the incentives for adults without a college education to upgrade.

This paper estimates the increase in the number of college graduates in the working-age population aged 25-49 in China after experiencing a decline in the young cohort size resulting from family planning policies, and decomposes the increase into two parts: 1) in-migration of college graduates from outside a region that has a decline in the young cohort size versus 2) educational upgrading of non-college graduates already in the region. I exploit variation in the timing and intensity of shocks to young cohort size caused by earlier family planning policies implemented differentially across regions in China. Under the family planning policies (PCP), fertility control measures were accessible to some provinces as early as 1964, and spread over to additional provinces during the campaign known as Late Long Few starting in 1973. By 1979 these fertility policies had reached all provinces in China with the broad guideline of one child per couple. The strength of administrative power in the enforcement of the family planning policies in China allows me to predict well the decline of the young cohort size

sixteen years later. I use the cohort-province-year level data constructed from China censuses to examine the impact of a young labor shortage on increases in both college graduates and non-college graduates among adults. I can also gauge whether the decomposition of the increase is consistent with the cross-age distributions of the migration cost and the cost for older workers to go back to school.

As a framework for the empirical analysis, I introduce the model of aggregate production with age-group specific supplies from Card and Lemieux (2001). In their model, under the assumption that college workers across age group are not perfect substitutes, the college premium for a given age group depends on both the aggregate relative supply of college workers in the labor force, and on the age-specific relative supply of college workers. Here, I maintain the assumption of imperfect substitutes of college workers across age group. I interpret the change in the number of college graduates relative to non-college graduates across age group as a response to the change in the age-specific college premium.

I also consider a model of cohort crowding from Bound and Turner (2007), in which a larger cohort that competes for limited public subsidies will end up with a smaller share that become college graduates. Bound and Turner show an inelastic pattern of adjustment that colleges might not increase enrollment when cohort size was increasing, but they might not have dropped much during the time when cohort size was shrinking. In China, colleges are mainly subsidized by the state during the 1980s and the 1990s and the same adjustment pattern applies. The asymmetric adjustment may cause the relative supply of college workers to be particularly low among older adults because of their large birth cohort size. However, the young cohort, the post-PCP cohort, enters the labor market with a higher share of college workers due to the weaker supply constraint on college education. This results in an increase in the productivity of older college workers under the assumption of imperfect substitutability.

Empirically, I employ an instrumental variable strategy to examine the percent change in the size of college and non-college graduates in response to the percent change in the young cohort size. In particular, I compare the cross-regional changes in the number of college/non-college graduates before and after the decline in young cohort with the cross-regional declines in young cohort caused by PCP. This comparison isolates the effect of the young cohort decline due to PCP from other factors

that affect regions more broadly. For example, a region can have a faster education upgrade over time because of factors associated with job specialization and the factors may be correlated with the changes in fertility as well. The empirical strategy will be valid as long as the variation in changes in young cohort size due to fertility policies across regions are orthogonal to the variation in changes in it caused by other confounding factors.

The empirical results show strong impacts of the decline in young cohort size on the educational upgrading for all adult age groups. The impacts on education upgrade are bigger for adults aged below 40 than for older adults. The decomposition of the increase in adult college graduates suggests that migration of college graduates seems to be less important for older adults aged above 30 than for younger adults aged 25-29. The results are consistent with the predictions that older workers have higher costs of migration and higher costs to go back to school. Additionally, I show the impact of young cohort decline on education upgrade becomes smaller over time which is consistent with the relaxation of migration restrictions over time.

The results of this paper contribute to literatures in both demographic transition and wage inequality. My analysis of how fertility decline affects human capital accumulation complements research by Bloom and Canning (2004) and Bloom, Canning, and Malaney (2000), who argue that during the demographic transition when mortality falls down earlier than fertility, it will generate a population age distribution with more working adults and fewer children. A boom of working-age population with low dependency ratio will provide an opportunity of a period of fast income growth and economic development. In this paper, I provide an example of how the decline of young population caused by fertility fall can lead to the human capital accumulation of people born in the boom. Through quantifying these results, I contribute to literature on wage structure and earnings inequality (Autor and Katz 1999), and Mincer's analysis (1996) of economic development and growth of human capital.

2 Impact of Young Cohort Size on Adult Educational Upgrading

I use the model created by Card and Lemieux (2001) to explain how the young cohort size will increase returns to college education for older adults. The model predicts that the increased education level among the young cohort will increase the productivity of older college workers and therefore their returns to college education and further lead to adult college upgrading.

In the Card and Lemieux model, workers with the same education level but of different ages are imperfect substitutes. This is modeled in 1 using CES functions for aggregate labor of each education level, high school and college, where i indicates cohort, t indicates time, η is a parameter defining the elasticity of substitution between workers of the *same* education level, and α and β are efficiency parameters.

$$H_t = \left[\sum_i (\alpha_i H_{it}^\eta) \right]^{1/\eta}, C_t = \left[\sum_i (\beta_i C_{it}^\eta) \right]^{1/\eta} \quad (1)$$

The production function itself, equation 2, is also a CES function with ρ defining the elasticity of substitution between workers of *different* education levels and the θ parameters measure the technological efficiency of each education type at time t . The authors assume that the ratio of marginal wages for different groups is equal to the ratio of their marginal products and thus derive in equation 3 the ratio of wages ("college premium") as a function of efficiency parameters, elasticities of substitution, cohort specific sizes of each worker type, and the aggregate quantities of each worker type.

$$y_t = (\theta_{ht} H_t^\rho + \theta_{ct} C_t^\rho)^{1/\rho} \quad (2)$$

$$\ln \left(\frac{w_{it}^c}{w_{it}^h} \right) = \ln \left(\frac{\theta_{ct}}{\theta_{ht}} \right) + \ln \left(\frac{\alpha_i}{\beta_i} \right) + \left[\frac{1}{\sigma_A} - \frac{1}{\sigma_E} \right] \ln \left(\frac{C_t}{H_t} \right) - \frac{1}{\sigma_A} \ln \left(\frac{C_{it}}{H_{it}} \right) + \epsilon_{it} \quad (3)$$

The key term for this paper is $\left[\frac{1}{\sigma_A} - \frac{1}{\sigma_E} \right] \ln \left(\frac{C_t}{H_t} \right)$, which shows how the aggregate ratio of college workers to high school workers can affect the cohort-specific college premium. The elasticity of substitution of workers of the same education levels but different ages is $\sigma_A = \frac{1}{1-\eta}$ while the elasticity of substitution for workers of different education levels is $\sigma_E = \frac{1}{1-\rho}$. If workers of different education levels are more substitutable than workers of the same education but different ages, $\sigma_E > \sigma_A$, then an

increase in the aggregate ratio of college workers to high school workers can raise the cohort specific college premium. In the case of China, I will argue that regions which initiated fertility policies earlier decreased the cohort size earlier. If these smaller cohorts had access to the same supply of schooling then a greater percentage of the cohort would become college educated and thus the aggregate ratio ($\frac{C_t}{H_t}$) rises. Assuming that $\sigma_E > \sigma_A$, this would raise the education premium for older cohorts, providing an incentive for older high school educated workers to upgrade their education.

However, this result will depend on the supply elasticity of colleges and universities. The study by Bound and Turner (2007) suggests that fixed resources or subsidies allocated to higher education institutions tend to decrease the share of the college educated in a larger birth cohort. Adult workers studied in this paper were born in a larger birth cohort, so limited educational resources can be a constraint to their college enrollment. Even though they have anticipated the increased college premium for them in the near future, they were crowded out of college when they were young and will later undergo the education upgrade. As colleges or adult institutions gradually adjust their cost to provide more seats for adults we should see less educational upgrading.

Finally, a key assumption for this argument is that $\sigma_E > \sigma_A$. Card and Lemieux estimate these elasticities with wage data but I do not have access to appropriate wage data. Without this data I cannot directly estimate these elasticities and therefore just note that this story is consistent with my findings.

3 Research Design for Examining the Relationship Between Young Cohort Size and Adult Educational Upgrading

This study aims to estimate the causal effect of changes to the young cohort size on the educational upgrade of adults. A naive cross-sectional comparison suffers from bias since the young cohort size can be a consequence of adult human capital accumulation or there may be unobserved factors driving both education upgrade and changes to the cohort size. I will exploit an exogenous source that generates variation in the young cohort size. This exogenous variation is caused by the family planning policies carried out in China. I will also exploit the geographical variation in the timing and the intensity of

the policy implementation.

An endogenous change in fertility and human capital investment tends to bias the estimate from a cross-sectional comparison. The estimate is likely to be biased downward, meaning the estimated effect is more negative than the true effect. For example, a shift in preferences for fewer but better educated children could be correlated with a general shift in preferences towards more education, thus we would see a generation going back to school as adults while simultaneously decreasing fertility. Another possible case for a biased effect comes from economic forces correlated with population density or urban congestion. Denser areas could have both greater demand for college educated labor (perhaps as a result of agglomeration economies, foreign trade, or the location of government offices in big cities) and also experience a greater decline in fertility (perhaps as a result of higher housing costs or other costs of raising a child). This correlation could also lead to a downward bias.

An upward bias is also possible. One omitted variable for an upward bias could be the local subsidies for higher education. Local subsidies for higher education could be correlated with many underlying characteristics in that area. The local GDP level, the local financing capacity for education, the existing institutional facilities, or/and political favoritism to local educational development can affect the per capita subsidies for higher education. Greater subsidies per capita allow a bigger proportion of adult that are more educated at any point in time. On the other hand, greater resources will lead to a net inflow of adolescents into that area to enroll in the colleges.

The other variable that could lead to an upward bias in the cross-sectional relationship between young cohort size and adult education upgrade is workforce mobility. If young labor is perfectly mobile, a shortage of young labor leads to an increased relative wage for that type of labor and thus an instantaneous inflow of young labor. This causes no change in education returns for adults, so the estimated effect of young cohort size on education upgrade is zero. A more realistic case is that young labor is not perfectly mobile, which would cause us to see both in-migration and education upgrade.

Since cross-sectional comparison is possibly misleading, a second identification strategy is to link the change in the size of adult college labor to the change in the young cohort size. The reliability of this strategy depends on one underlying assumption. If the unobserved characteristics that are correlated with both education upgrade and young cohort size, as in the previous examples, are

constant over time, doing the pre and post difference in the outcome and the explanatory variable will likely eliminate the potential bias. One obvious critique is that the unobserved characteristics do not stay constant over time.

My identification strategy to deal with confounding effects is to compare the change in the number of adult college graduates over time in regions where there is a large decrease in young cohort size caused by family planning policies to the change in adult college graduates over time in regions where there is no decrease in young cohort size. One advantage this quasi-experimental research design provides is the geographical variation in the timing of the initiation of family planning policies in China. Regions that adopt the policy later will be the control group for regions that adopt it earlier. The secular trend in adult educational improvement in the absence of the fertility decline is captured by the natural growth in the educational level among the control group. More importantly, all the influences from population density, income level, preferences for more education, labor mobility and other unobserved confounders that underlie the association between young cohort size and adult education upgrade will be isolated by the comparison between the treatment and the controlled group. The key assumption in the identification strategy is that the changes in young cohort size across geographical regions that are caused by the fertility policies are orthogonal to changes caused by the potential confounding variables.

The variation in the timing of young cohort declines matches exactly with the variation in the initiation times of the policies across regions. Other factors driving fertility change are unlikely to change so dramatically at a point in time that growth of the young cohort size is reversed abruptly.

4 Background Knowledge in family planning policies and Adult Educational Upgrading in China

4.1 family planning policies

The first campaign for the family planning was organized by Ministry of Public Health in 1956. This first government family planning policy had little impact on population size. Perhaps in response

to the devastating economic and social loss during the Great Famine (1958-1962), the government began to implement stronger policies in 1964. By 1964, almost every province had established a family planning agency, known as Population and Family Planning Commissions. However, the main function of these agencies in most provinces was to provide knowledge and encourage family planning; there was no enforcement of family planning practices and thus no punishment related to extra births. Some provinces were completely exempt from the family planning practice. Inner Mongolia, Ningxia, Tibet are provinces that haven't had family planning agencies by 1964, which means there are no family planning polices for them in 1964.

The municipalities of Beijing, Tianjin and Shanghai had effective fertility policies. Beijing and Tianjin had provided free abortion, birth control surgeries and birth control measures; they had also extended the medical leave and distributed goods or monetary compensation for birth control surgeries. Shanghai had provided birth control surgeries free and started developing and initiating clinical trials of birth control pills. Some other provinces had provided free birth control surgeries as well, but the effectiveness of those policies was substantially weaker in other regions than in the three municipalities. In a strongly planned economy with a system of hierarchical administrative bureaucracies, municipalities may have directly received more support and supervision from the central government.

The second decline in fertility results from the "late long few" birth control policy, which was carried out across the whole country except provinces with minority concentrations in 1973. Here, "late" means that couples are encouraged to marry later. This encouragement varied by region but as an example, the most stringent rule specified that men could not marry until age 28 and women not until age 25. The "long" of the policy intended to increase the birth spacing. Lastly, the "few" of the policy referred to having fewer children. Urban couples were encouraged to have two children while rural couples were encouraged to have three or four. The "late long few" policy led to a great reduction in the total fertility rate. The total fertility rate declined from 5.8 children per woman in 1970 to 2.8 per woman in 1979, a decrease of more than 50 per cent (Xizhe Peng, *Fertility Transition in China Over the Last 30 years*). The reduction in national population size is larger than that from the first wave of family planning policies, and it lasts for several birth years until the initiation of the

one-child policy.

One-child policy started in 1979 and was carried out across the whole country. Later in the year of 1984, rural couples were allowed a second child, subject to province-specific conditions. Policies in provinces with minority concentrations were weaker, allowing a couple to have two children with an exception for a third under some circumstances. According to the 2000 census, the total fertility rates were about 0.86 in urban areas, 1.08 for towns and 1.43 for villages, all below the replacement rate for a population. The one-child policy directly reduced the size of younger age cohorts in China.

4.2 The Adult Educational System and Educational Upgrading

The adult education system was initially started in China in the early 50s and became very popular in the late 80s. The development of adult educational system can be divided into three stages: the early formation in the early 1950s, the expansion from the late 1970s to the early 1990s, and the further development starting from the 1993. In the appendix, I list a couple of policies pertaining to the development of adult education in China that show the policy configurations of the institution.

The adult educational system in China consists of two different tracks: a diploma-oriented system and a non-diploma-oriented system. The non-diploma-oriented system caters to the demand for knowledge or skill improvement related to work or personal interests. Programs such as job training and vocational qualification can be counted in this system. This type of adult education coincides with the usage of "adult education" terminology in the U.S. and many other European countries. I will focus on the diploma-oriented system of adult educational progress where the goal is to get a diploma, particularly for a diploma at the tertiary level of education.

The diploma-oriented system is to help adults achieve academic degrees through self-learning or social assistance. To meet academic requirements, adult students would usually take an entrance exam and get enrolled on a merit basis in a higher educational institution and earn credits for a diploma, as a young college student would normally do. This program usually takes two or three years to complete, depending on whether the student is full or part-time. The credit requirement of the degree depends on the academic difficulty. This form of adult study has existed since the early 1960s. Alternatively, adult students can participate in a self-study program, which provides a concentrated

period of self-studying in the classrooms of local public schools like night schools, correspondence schools, or television schools¹. College teachers would sometimes be available to assist adult students. At the end of the study, candidates are required to pass a certain number of exams and achieve a certain number of points on the exams to get the diploma. There is no time limit with respect to the length of study or the length of time it takes to pass all the examination. Points that candidates have scores on those exams are cumulative. The "self-study" (zi-kao) form was introduced as a policy for adult educational progress to the whole nation since 1981.

Although the system has existed for a long time, diploma-oriented adult education started to emerge as a popular form of achieving a higher level of education for those with some working experience and at least a high school diploma in the late 1980s. In 1999, there were about 80 million adults graduating from adult colleges, which is roughly the same number of college graduates from normal colleges in that year. Another 40 million adults became college graduates through the self-study examination.

5 Date Sources and Trends in Adult Educational Upgrading Associated with Young Cohort Size

5.1 Data Sources

To track educational upgrading of adults in China and link it to the change in the young cohort, I need universe data on the geographic and temporal distribution of old and young labor with information regarding their educational levels, migration information and demographic characteristics. I will also explore data on economic conditions across regions and over time to control for potential confounding effect.

The universe data that are representative of all adults and young people living in China are

¹Adult education at the tertiary level in China can have various forms. Night colleges for adults utilize the time during the night to teach and learn. Correspondence colleges focus on self-study and sometimes provide a concentrated study period. TV colleges use a broadcast system to learn and most often are equivalent to the correspondence colleges. Vocational colleges are special colleges founded by larger enterprises or local trade unions, in which learning is done in spare time and mainly linked to work practice. In recent years, the tuition of correspondence colleges ranges from 700-1500 US dollars per year. The learning experience could be either full-time or spare-time.

national population censuses in the consecutive survey years of 1982, 1990 and 2000. The census data are sampled at the level of household, either domestic household or collective living unit². They are representative sample of all individuals who have Chinese nationality and live in the country at the time of the survey. The sampling rates are 1%, 1% and 0.095% for three years. The census data have great advantages for purpose of this study. They provide detailed personal information on sex, year of birth, month of birth, ethnicity, hu-kou registration³, province of residence, educational levels, educational status, migration history, etc. Censuses also survey characteristics at a household level such as the number of persons living in the household, the number of births and deaths in the previous year, the number of registered persons absent over one year, etc⁴.

The goal is to show the pattern of education upgrade and the change in the size of young cohorts. The main variables to construct are thus the cohort-province-year level⁵ size of college graduates and non-college graduates, the share of college grads, and the province-year size of young cohorts between age 16 and 24. I define college graduates as those with at least a college degree; non-college graduates as those with no more than a high school degree. Taking advantage of the geographic and temporal variation in the initiation of fertility polices, I further divide all provinces in my sample into three separate regions. Region-I includes municipalities that initiated the policies in 1964, and it has a continuous fall in births from 1964. This means starting in 1980, when the 1964 birth cohort reaches the age of 16 and enters the labor market, the young cohort size starts to decline in region-I. Region-II consists of provinces that initiated the policies in 1973, leading to a decreasing young cohort size from 1989. Region-III, being the latest adopter in 1979, has a reduction in the young cohort size from 1995 (see Figure 6 for the map of regions).

Second, I construct the size of young cohort aged 16-24 at the province-year level. For example,

²A domestic household contains a group of individuals who are relatives or non-relatives living in the same household. A collective living unit can be a company's dorm for migrant workers or a university's dorm for college students.

³The "hu-kou" registration is a system adopted by the Chinese government in the 1950s to limit the labor mobility between urban and rural areas. It registers persons in the place of their permanent residency, where they are authorized to work and be eligible for grain rations, employer-providing or employer-subsidizing housing, health care, and schooling enrollment of children in the family. The location of one's hu-kou registration could be identified to the city or county level in 1982 and 1990 censuses, and the street level of residence in 2000 census. The type of one's hu-kou could be agricultural or non-agricultural, which links to the type of occupation.

⁴For detailed information, see the section of data appendix.

⁵A year indexes a census year; a province indexes an administrative division as coded in the place-of-residence in the censuses.

to construct the cohort size in Liaoning province in 1982, I count the number of persons between age 16 and 24, or equivalently born between 1958 and 1966, residing in Liaoning province in 1982 from the census of 1982. I can calculate the young cohort size in a given province in any census year in this way, and likewise I can calculate the young cohort size at the region-year level.

An important challenge for this paper is to distinguish the increase in college educated adults arising from in-migration of educated workers from that caused by education upgrading. To achieve this, I use migration information in censuses to identify migrant labor and native labor to a region. In 1990 and 2000 censuses, the migration variable asks for the province one lived in five years ago. I will define an individual as an immigrant if they lived in a different province five years earlier.

5.2 Trends in Adult Educational Upgrading Associated with Young Cohort Size

Before looking at the regional differences in the young cohort size and the patterns of education upgrade, Figure 1A presents the national birth cohort profile (i.e., birth cohort size in natural log units by year of birth) drawn for three census samples. The birth cohort profiles matched well across censuses suggesting that external (foreign) migration is not an issue in my study⁶. Conditional on being observed in census samples, the birth cohort size increases gradually from 1945-1949 and faster during 1950-1955. The death rate⁷ decreases by almost a half from 20% to 12% in the meantime, so the total population increases dramatically from 1945-1955. Two substantial falls in the birth cohort size appear to be one during the Great Famine (1959-1961) and one in the post-1964 period. The first one is quickly neutralized by compensatory births after the Famine. However, the post-1964 fertility decline due to the initiation of family planning policies in region-I persists. A second significant decline in cohort size starts around 1971-1972 and persists through the 1970s. This decline is a major react to the second wave of family planning policies ("Late Long Few") occurring in both region-I

⁶A small gap in the birth cohort size exists for those born in 1975-1981 between the 1990 and 2000 censuses. It may be caused by missing sampling some of the migrants that neither register at their home county nor at the recipient county in 2000, or due to the emigration to Hongkong, Macau or foreign countries. There also exist a gap in birth cohort size for those born in 1987-1990 possibly due to unreported newly born children. However, this will not affect this study since I only focus on the young cohort size before 2000.

⁷The death rate is units of deaths per 1000 individuals per year. The data on the death rate and the birth rate are from China Population Statistical Yearbooks.

and region-II. The birth rate starts decreasing from 1964, and it changes from 39% to 18% during 1964-1979 with a roughly constant rate of 1.3% per year. Since 1979 almost all regions⁸ have adopted the one-child policy, however, the national birth cohort size becomes larger from 1981-1987, probably due to a large parental cohort.

Figure 1B shows the educational level for each birth cohort over census years, as measured by the share of them that are college graduates. The educational level virtually increases for every birth cohort over the period 1982-2000. Take the 1950 birth cohort as an example, the percentage among them that are college graduates more than doubles from 1982-1990 and almost doubles again over the next period 1990-2000⁹.

To summarize the national trend in the size of young cohort aged 16-24 and adult educational upgrading, Table 1 provides sample statistics at the national level. It presents that young cohort size increases by 24 percent from 1982-1990. Over this period the number of college graduates increases by 60 percent. A positive relationship is suggested between the two. On the other hand, the relationship becomes negative from 1990-2000; 37 percent decrease in young cohort size is associated with 60 percent increase in adult college graduates. The relationship is inconsistent over time.

To illustrate the causal impact of the young cohort size on adult educational upgrade, I break down the population age structure and the adult educational increase by region. Figure 2A, 3A, and Figure 4A show the cohort size (in millions) by year of birth in region-I, region-II and region-III. Notice, for each region there are three birth cohort profiles plotted separately from 1982, 1990 and 2000 census samples. Since one could be sampled in different regions in different censuses¹⁰, the gap between those profiles for a given birth cohort is due to the internal migration of that birth cohort. Comparing all those figures, I first find that: region-I starts to have a continuous decline in the size of birth cohort born after 1964, region-II born after 1972, and region-III born after 1975. Secondly, despite the high mobility of young people across regions, the region-specific pattern of birth cohort

⁸Hongkong, Macau and Tibet are exempted from family planning policies.

⁹One issue raised is whether the large increase in the relative educational levels is due to measurement error, i.e., individuals are more likely to over-report their educational levels over time. I can use another variable in 2000 census to check the consistency in adult education progression. Two thirds of the education upgrade is identified by another variable. Details about this are in data appendix.

¹⁰I use the birth cohort profiles based on region of residence in each census year as shown in Figure 2A, 3A and Figure 4A. I also use the birth cohort profile based on region of birth reported in 2000 census, and the birth cohort profile based on region of residence in 1985 reported in 1990 census.

decline still holds over time.

Next, I construct the size of young cohort aged 16-24 in order to illustrate how it varies by region. By adding up the sizes of birth cohorts born between year $t-24$ to year $t-16$, I derive the young cohort aged 16-24 in year t for a given region. A region can have three birth cohort profiles from sampling in three censuses. I can get three profiles of young cohort size by year for a given region. I will predict the general effect of fertility policies on young cohort size by regressing it on a set of year dummies and an indicator for fertility policies. For instance, region-I will have an impact from fertility policies only after 1980. Figure 5A, 5B and 5C plot the predicted profile of young cohort size for each region.

Figure 5A shows young cohort increases steadily from 1960-1975, becomes constant during 1975-1980, and starts declining in 1981 in region-I. Region-I has a continuing decline in the young cohort size until 1997 when it is increasing again. The year 1980 separates the pre- and post-treatment time of fertility policies. Figure 5B and 5C show region-II and region-III, as the control group, present the same young cohort pattern as in region-I before 1980. Region-II has an increased young cohort in the entire 1980s until it starts falling in 1988 and keeps falling through the 1990s. The post-treatment time is the time after 1989¹¹. Region-III shares the similar pattern of the young cohort size as region-II until 1987; while region-II experiences the decline after 1987, region-III has a slightly increasing young cohort size until it falls in 1995 due to the one-child policy.

The effect of young cohort size on adult education upgrade is displayed in Figure 2B, 3B and Figure 4B. The three figures plot the share of the birth cohort that are college graduates by year of birth and by census year. Clearly, all birth cohorts in all three regions have increased educational levels over time. However, the educational upgrading over 1982-1990 for birth cohorts aged 25-49 in 1982 is much bigger in region-I than in region-II and region-III. This is consistent with the young cohort size changes in the same time. The young cohort size increases by 2 percent in region-I, while they increase by 20 and 30 percent in region-II and region-III respectively (see Table 1). The log number of adult college graduates increases by 0.75 in region-I, while they increase by 0.57 and 0.23 in region-II and region-III. This suggests that, roughly, increasing the young cohort size by 1 percent

¹¹Some provinces in region-II initiated the "late long few" fertility control campaign in 1972, so the post-treatment period should be 1988 for them. That is the reason for region-II to have a decline in the supply in 1988 in Figure 5B.

will decrease the log number of adult college graduates by 0.01-0.02¹². Moving to the next decade 1990-2000, the young cohort size decreases by 2 percent in region-I, and decrease by 39 percent and 26 percent in the other regions; the log number of adult college graduates aged 25-49 in 1990 increases by 0.23 in region-I, and increase by 0.65 and 0.78 in the other regions. Comparing across regions, it implies the effect of young cohort size on the number adult college graduates is negative and between 0.01 and 0.02, exactly the same as the effect in the 1980s.

Having established the link between the decrease in the young cohort size and the increase in the college graduates among adults, I want to further decompose the increase into two parts: 1) in-migration of college graduates versus 2) educational upgrading of adults already in the local labor market. If the first part is more important, the share of college graduates that are immigrants will increase. To deal with the issue of any confounding factors, I compare the change in the share of college graduates that are migrants over time in regions with a large decrease in young cohort size caused by fertility policies to the change in the share in regions with no decrease in young cohort size.

In Figure 7A, 7B and Figure 7C, I plot the share of college graduates that are migrants by year of birth and by census year for each region separately. The cross-sectional share by year of birth show distinct patterns: firstly, birth cohorts aged below 30 or 35 have on average a much higher share that are migrants than those aged above 35; secondly, the immigrant share falls sharply between age 25 and age 30 or 35 and keeps flat after age 35. Looking at a given birth cohort over time, I find that the decline in the share of college graduates that are immigrants over 1990-2000 for birth cohorts aged 25-30 in 1990 is much smaller in region-II and region-III than in region-I, which implies that decreasing young cohort size will increase the share of college graduates that are migrants among those aged 25-30. In other words, the decrease in young cohort size will increase the adult college graduates through the in-migration of college educated labor more importantly than through educational upgrading of local non-college graduates for those aged 25-30. On the contrary, the share of college graduates that are migrants appears to decrease more in region-II and region-III than in region-I for those aged 40-44 in 1990. It means educational upgrading of local non-college graduates is more important to drive the increase in adult college graduates.

¹²Comparing region-I and region-II derives the effect on the log number of college graduates of 0.01, and comparing region-I and region-III derives the effect 0.02.

6 Econometric Specification

In this section, I lay out a simple econometric model to estimate the impact of young cohort size on adult educational upgrading. I assume the impact is homogenous across region and over time. First, I will point out the potential problem with a simple cross-sectional comparison. Then I will show the econometric method in this study. A simple cross-sectional regression model is:

$$\ln(TC_{jpt}) = \alpha \ln(YL_{pt}) + \sum_p \beta_p \text{Province}_p + \sum_t \gamma_t \text{Year}_t + \lambda X_{pt} + \mu Z_j + \epsilon_{jpt} \quad (4)$$

where j indexes an adult birth cohort, p indexes province and t indexes time. The term $\ln(TC_{jpt})$ is the natural logarithm of the number of college graduates in each birth cohort, each province and each year while $\ln(YL_{pt})$ is the natural logarithm of the number of young cohort aged 16-24 in each province in each year. The model also includes the province fixed effects, time fixed effects, other characteristics at the province-year level and characteristics of birth cohort. The standard OLS regression will lead to an inconsistent estimate of the causal relationship between young cohort size and adult college graduates. The unobserved characteristics that are included in ϵ_{jpt} may be correlated with young cohort size ($\ln(YL_{pt})$), such as unobserved factors associated with agglomeration economies, local subsidies for college, or migration of young labor.

My identification strategy is to comparing the change in the log number of college graduates over time in regions where there are large declines in the young cohort size caused by the family planning policies to the change in the log number of college graduates over time in regions where there are smaller or no declines in the young cohort size. I construct instrumental variables named Pop-Effect_{pt} and Pop-Lag-3_{pt} based on the timing of the family planning policies. The way to construct the two instruments is very straightforward. From the timing of the initiation of family planning policies in three regions, the young cohort aged 16-24 in region-I will be treated by the policies from 1980, region-II from 1989, and region-III from 1995. The term Pop-Effect_{pt} indicates if a given province has been treated by the policies in the year t , and Pop-Lag-3_{pt} indicates if a given province has been treated by the policies since the year $t - 3$. My econometric specification is to use Pop-Effect_{pt} and Pop-Lag-3_{pt} as instrumental variables for $\ln(YL_{pt})$ in the econometric model 4.

Similarly, I also examine the impact of young cohort size on adult non-college graduates using family planning policies as instrumental variables for young cohort size. The econometric model is

$$\ln(TNC_{jpt}) = \alpha \ln(YL_{pt}) + \sum_p \beta_p Province_p + \sum_t \gamma_t Year_t + \lambda X_{pt} + \mu Z_j + \epsilon_{jpt} \quad (5)$$

where $\ln(TNC_{jpt})$ is the natural logarithm of the number of non-college graduates in each birth cohort, each province and each year.

7 Results

7.1 The Effect of Young Cohort Size on Adult Educational Increase

Table 3 presents the cross-sectional relationship between the log number of young cohort size and the log number of adult college graduates. Panel A in Table 3 lists the regression results from each age group using 1982 and 1990 census samples. I control for log number of young cohort aged 16-24, a quadratic function of age, log real income per capita, log real fixed asset investment per capita, year fixed effect, and province fixed effects. Cross-sectional comparison shows that 1 percent decrease in young cohort size will increase the number of college graduates by 1 to 2 percent, with a bigger impact on the age group 25-39 than the group 40-49. Other significant relations show that the number of college graduates is increasing over the 1980s for all age groups below 40. Log income per capita is positively correlated with log number of college graduates, while log fixed asset per capita is negatively correlated with log number of college graduates. However, in Panel B, using 1990 and 2000 samples, it shows a positive relationship between log number of young cohort size and log number of college graduates. The switched sign in the correlations between young cohort size and the number of adult college graduates may suggest that the cross-sectional relationship is not causal.

In Table 4, I list the effects of young cohort size on log number of non-college graduates for all adult age groups. The decrease in young cohort size is associated with the declines in the log number of non-college graduates for all adult age groups for two periods, with the effect bigger and more significant in the second period. The log number of non-college graduates increases over the 1980s

and slightly decreases over the 1990s but not significantly. Table 5 combines the previous two tables and provides the impact of young cohort size on adult educational upgrading, i.e., the increase in the share of the birth cohort that are college graduates. The young cohort size is negatively associated with the share of college graduates for all age groups in the 1980s, but positively associated with the share in the 1990s. In all, the estimated cross-sectional impacts of young cohort size on adult educational upgrading in Table 3, 4 and Table 5 may suggest inconsistent estimates of the truth due to confounding factors changing over time or migration of young labor across provinces.

Before moving to the 2SLS estimation of young cohort size on adult educational upgrading using instrumental variables derived from family planning policies (PCP), I list the "first stage" results in Table 6. The impact of PCP, as indicated by the instrumental variables in the first two rows, on young cohort size is the same across age groups but different for two decades. In Panel A, I examine the period of 1982-1990. The result suggests that, compared to region-III that is the control group, being affected by PCP (region-II) will decrease the growth rate of young cohort aged 16-24 by 15 percentage points, while having been affected by PCP for more than three years (region-I) will decrease growth of young cohort by 31 percentage points. The young cohort size increases by 49 percent over the period, which is the change in the control group region-III. Conditional on the PCP's effect, income per capita increases the young cohort size, and the fixed asset per capital decreases the young cohort size. Panel B shows the impact of PCP during 1990-2000. Region-I becomes the control group in this decade and the young cohort size decreases by 33 percent conditional on all other factors equal. Compared to region-I, turning to be affected by PCP (region-III) will decrease growth of young cohort by 20 percentage points, while having been affected by PCP for more than three years (region-II) will decrease growth of young cohort by 34 percentage points. In all, the variation in the young cohort size resulting from PCP is from both the timing and the intensity of PCP, i.e., how long a region has been affected by the policies.

The lower panel in Table 6 presents the proportion of the variation in young cohort size that is explained by the instrumental variables. The instrumental variables together with other control variables explain 47% of the variation in young cohort size in the period 1982-1990, and 16% of the variation in 1990-2000. The reduction in the R-squared value in the second period is consistent with

the fact that migration of young labor is more prevalent in the 1990s compared to the 1980s.

Table 7 presents the 2SLS estimates of the effects of the log number of young cohort size on the log number of adult college graduates. Panel A lists the results for the period 1982-1990. One percent decrease in young cohort size will on average increase the number of adult college graduates by 3.02-0.89 percent. The effects of young cohort declines are heterogeneous for adult age groups, with the biggest increase among the age group 25-29, the second biggest increase among the age group 35-39, and the smallest increase among 40-44. From 1990-2000, the effect of the young cohort size becomes smaller. One percent decrease in young cohort size will on average increase the number of adult college graduates by 1.49-0.42 percent. The effects are bigger for the age group 25-34 than the age group 35-49.

The 2SLS estimates of the effects of the log number of young cohort size on the log number of adult non-college graduates are listed in Table 8. One percent decrease in the young cohort size from 1982-1990 will on average increase the number of adult non-college graduates by 0.05-0.32 percent. The effect is bigger in 1990-2000; one percent decrease in the young cohort size will increase the number of adult non-college graduates by 0.16-0.5 percent. Additionally, the effect on adult non-graduates is much smaller in magnitude than that on adult college-graduates. In total, the decline in young cohort size will raise the college share for all adult groups from 1982-1990, but not raise it as much from 1990-2000.

Comparing with 2SLS estimates, the cross-sectional results overestimate the impact of young cohort size on log number adult college graduates, suggesting that omitted variables are more likely to co-vary with the number of adult college graduates and young cohort size in the same direction, such as factors related to agglomeration economies that lead to more educational upgrading and more inflow of young labor. Migration itself would provide an upward bias of the impact. If young people over-react to the young labor decline in a region, this could potentially drive the young cohort size to increase over time, so we observe a positive correlation between the change in young cohort size and the change in the number of adult college graduates. The bigger bias of cross-sectional results in 1990-2000 is consistent with the more relaxing migration policies in that period.

In summary, results in 2SLS models suggest that the young cohort size has a negative effect on the

number of adult college graduates, and the effect is bigger in 1982-1990 than in 1990-2000. I also find evidence suggesting that the young cohort decline has increased the size of adult non-college graduates as well, although it is smaller in magnitude than the effect on the college graduates. Combining them together, my study suggests that the young cohort decline causes adult to upgrade in educational levels, with strong effects for adults aged 25-39.

7.2 Adult Educational Increase: Migration or Upgrading

In this section, I examine the importance of the contribution of educational upgrading to the increase in the number of adult college graduates shown in the previous section. If the increase is merely due to the geographical redistribution of college graduates, it means there is no educational upgrading. The concern is unlikely to persist, since the decline in the young cohort size becomes prevalent in the country in the 1990s. The hypothesis of imperfect substitution between college workers of different ages predicts the productivity of adult college workers increases eventually, which will drive adults to acquire college education. To examine how much of the increase in adult college graduates is due to educational upgrading, I use the econometric model:

$$MigC_{jpt} = \eta \ln(YL_{pt}) + \sum_p \beta_p Province_p + \sum_t \gamma_t Year_t + \lambda X_{pt} + \mu Z_j + \epsilon_{jpt} \quad (6)$$

where $MigC_{jpt}$ is the share of adult college graduates that are migrants at the cohort-province-year level, and $\ln(YL_{pt})$ is the young cohort size at the province-year level. The term $\ln(YL_{pt})$ is instrumented by indicators of PCP which vary over time and across region. I will also do the same regression for the share of non-college graduates that are migrants.

$$MigNC_{jpt} = \eta \ln(YL_{pt}) + \sum_p \beta_p Province_p + \sum_t \gamma_t Year_t + \lambda X_{pt} + \mu Z_j + \epsilon_{jpt} \quad (7)$$

where $MigNC_{jpt}$ is the share of the non-college graduates that are migrants. If the young cohort decline affects the local non-college graduates and the potential college migrants equally, the share of college graduates that are migrants should not change with respect to the young cohort decline. If it affects the local non-college graduates more, meaning a local non-college graduate is more likely to

upgrade his or her education than it is likely for a college graduate to move to this region, the effect of young cohort size on the migrant share is positive; if it affects the college migrants more, the effect is negative.

Results in Table 10 suggest that the increase in adult college graduates from 1990-2000 is more likely to be through migration than through upgrading for the age group 25-29; 20 percent decrease in the young cohort size will increase the share of college graduates that are migrants by 0.05. The increase is more through the upgrading from non-college graduates for those aged 35-49; 20 percent decrease in the young cohort size will decrease the share by a negligible amount 0.001. The two forces are roughly equal for the age group 30-34.

Table 11 shows the increase in the adult non-college graduates is more likely to be through the increase from the natives for age 35-44. However, this interpretation needs a little more carefulness. The increase in the non-college graduates could only be through migration, since there is no way for college graduates to "downgrade" to high school graduates. The correct interpretation should be that 20 percent decline in the young cohort size decreases the chance of non-college migrants entering the region in the second half of the decade by 0.006-0.008 for the age group 35-44, which means it increases the chance of the entry of non-college migrants earlier in the decade by 0.006-0.008. For other age groups, the change in the timing of migration in response to the young cohort decline is very small.

In all, the results show that the increase in the number of college graduates when the young cohort decreases is more driven by migration of college graduates than by upgrading from non-college graduates for adult aged 25-29. However, for adults aged 30-49, the increase in the number of college graduates is more driven by upgrading from non-college graduates who have already been in the local labor market.

8 Conclusion

In this paper, I examine the effect of the reduction in the young cohort size caused by family planning policies in China on the educational upgrading of older adults born before the policies. I find that

the decline in young cohort size causes the educational upgrading of adults. A one percent decrease in the size of young cohort aged 16-24 increases the number of college graduates of adults aged 25-49 by 0.89-3.02 percent during 1982-1990 and by 0.42-1.49 percent during 1990-2000. The young cohort decline also increases the number of non-college graduates among adults. A one percent decrease in the young cohort size increases the number of non-college graduates by 0.05-0.32 percent during 1982-1990 and by 0.16-0.50 percent during 1990-2000. The increase in the number of college graduates relative to non-college graduates resulting from the reduction in the young cohort size is bigger in the 1980s than in the 1990s, which is consistent with weaker migration restrictions in the 1990s.

The empirical results also show heterogeneous effects on adult educational upgrading. The impacts of the young cohort decline on the increase in college graduates are bigger for those aged 25-39 than for those aged 40-49. I further decompose of the observed increase in adult college graduates into two parts: the in-migration of college graduates to the region with a decline in the young cohort size; the educational upgrading from non-college graduates. The results suggest that the in-migration of college graduates seems to be more important in driving the increase in college graduates for those aged 25-29; the increase in college graduates for those aged 30-49 is largely driven by the educational-upgrading from non-college graduates who have already been in the local labor markets. The results are consistent with the prediction that older workers have higher costs of migration or distastes for migration. They are also consistent with the prediction that there are higher costs for older workers to go back to school.

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9 Data Appendix

9.1 Census data in 1982, 1990 and 2000

The samples I use are from China's national population censuses in 1982, 1990 and 2000. The data are sampled at the household level, either domestic household or collective household living unit, with a sampling rate of 1%, 1% and 0.095%. The data are representative samples of all individuals who have Chinese nationality and live in China.

To examine the effect of the young cohort size on the educational upgrading, I need individual information below to construct the educational composition within each birth-cohort-province-year cell: the number of persons with a college or advanced education (called college graduates) and the number of persons with a high school or lower education (called non-college graduates). The information includes:

1. age: age by July 1st of 1982 (only for 1982 census)
2. year of birth and/or month of birth: available in 1990 and 2000 censuses
3. residential place: the current residential province or county
4. educational level: a discrete variable categorized into six groups: illiterate or semi-literate, primary school, junior high school (7th - 9th grade), senior high school (10th - 12th grade), college or semi-college, or graduate education.
5. educational status: a discrete variable categorized into four groups: graduate, undergraduate, drop-out, or else.
6. adult education: adult education degree (only available in 2000 census)

By tracking the individuals within the birth-cohort-province-year cell over time, I can identify the increase in the number of college graduates over time. One problem about the increase is whether it is because of measurement error in education. Information on (6) adult education helps to illustrate how much of the increase could be potentially caused by measurement error. This variable provides

a second way to count the amount of college graduates who have acquired the college degrees in their adulthood. This amount matches with 67% of the increase calculated from tracking individuals.

I construct the migration percentage for each educational and demographic group, i.e., the fraction of the college graduates or the non-college graduates that are immigrants in each birth-cohort-province-year cell. To identify the migration status, I use the migration information from census data:

7. previous residential place: residential province five years ago (only available in 1990 and 2000 censuses)

The migration share within an education-age group helps to decompose the increase in the group size into a part that is because of migration and a part that is because of the actual upgrading from lower education. If the migration part is more important in response to a decreased young cohort size, we will expect the migrant share within the group to increase.

However, identifying the migration based on a five-year-span comparison is likely to overestimate the part of the increase that is because of the upgrading. For example, a college-educated person had moved to a place six years ago. He is counted in the part of upgrading rather than migration. It can underestimate it as well. If a person was living in another province five years ago temporarily, but was residing in the current province for most of his life, then he should have been counted in the part of upgrading rather than migration had he acquired a college education. Both directions of bias are likely to be mitigated in the cross-region comparison of the changes in the migrant share over time, unless the timing of the migration induced by the young labor shortage, changes dramatically at the cutoff (i.e. five years ago) over time and across region. This kind of bias emerging in the cross-regional comparison of changes over time seems to be less likely.

Another subtle issue is that I cannot know the exact educational level upon one's arrival. They could be college graduates upon arrival or non-college upon arrival but upgrade to college graduates afterwards. Such two scenarios are treated the same as being the contribution of migration to the increase in the number of the college graduates.

The provinces in censuses include the municipalities, provinces, autonomous regions and special administrative regions in China. They are Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning,

Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Sichuan (including Chongqing), Guizhou, Yunnan, Tibet, Shaanxi, Qinghai, Ningxia, Xinjiang, Hongkong and Macau. Tibet, Hongkong and Macau never implement the family planning policies so they are excluded in my samples. Gansu and Hainan are not included in my samples because of data missing for some census years.

9.2 Other Yearly Provincial Macro-economy Statistics

GDP per capita, fixed asset investment per capita, the number of tertiary teachers per 100,000 people, population are collected from China Yearly Provincial Statistical Yearbooks.

The year that each province launches the self-study adult examination program is collected from China Self-Study Examination Online (<http://zikao.eol.cn/>).