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

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January 2013†
Preliminary: please do not cite.

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 show that family planning polices 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, with a smaller effect for the age group 35-39 than for other age groups. The decrease in the young cohort size does not have a significant effect on the number of college graduates during 1990-2000. I find the effect of young cohort size on adult non-college graduates is insignificant from zero in both periods. I further show that the observed increase in adult college graduates is mostly driven by upgrading from non-college graduates who have already been in the local labor markets.

Key Words: adult labor, immigrant.
JEL Classification: I24, J1, J2.

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†This is my job market paper. I am very grateful to my advisors Andrew Foster, Kenneth Chay and Vernon Henderson for all their comments and suggestions. I also thank Anna Aizer, Loren Brandt, Bruce Chapman, Louis Putterman, Xiaobo Zhang, Yaohui Zhao, Xiaodong Zhu, Ang Sun and Nathan Schiff for their very useful comments. Special thanks should go to the participants at Brown Micro Lunch and Brown Applied Microeconomics Seminar. All errors are my own.

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 polices 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.

My research can be linked to the literature on the impact of birth cohort size on wage rate and human capital levels. The research by Card and Lemieux (2001) finds that the rising return to college workers in North American and United Kingdom is caused by the slowdown in the rate of growth of college graduates in birth cohorts born from the early 1950s onward. Other researchers have documented the large influx of young workers from the baby boom has significant impacts on the schooling attainment of those born before and after the baby boom in the US (Stapleton and Young 1988, Wachter and Wascher 1984, Falaris and Peters 1992). However, the potential concern about these studies is that neither the supply of young educated workers nor the birth cohort size of young workers stems from an exogenous source. The fertility change and schooling outcomes could be individuals' behavioral response to the underlying social-economic factors that drive the economic development. The conclusions on the relationship between the supply of young workers and college

return and attainment in these studies could be biased.

This study will contribute to the existing research because it finds a unique quasi-experiment to investigate the impact of birth cohort size. It explores the exogenous source in the young cohort size induced by China's family planning policies. A handful of studies have documented the effects of China's national one-child family planning policies on the total fertility rate in the recent decades (Gu, Wang, Guo, and Zhang 2007, Attane 2002, Short and Zhai 1998). My research examines a longer period of the family planning policies from the initiation in the 1960s. Specifically, I use the variation in the timing of shocks to young cohort size caused by the polices which were adopted at different times across regions in China. Under the general guideline of fertility control by the central government, some provinces had access to contraceptive measures as early as 1964. Many provinces carried out the family planning practices around the mid-70s during the campaign of "Late Long Few". By 1979 fertility polices had reached all provinces in China with the broad principle of "one child per couple". I compare the differential declines in young cohort size in regions where they carried out family planning earlier or later. The strong administrative power to enforce the polices within province allows me to predict the decline in young cohort size sixteen years later, starting from different points of time for different regions.

I use aggregate cohort-province-year level data constructed from China censuses to measure the size of young cohort aged between sixteen and twenty-four. I also use the aggregate data to measure the size of older college and non-college graduates for each age group in the age range between twenty-five and forty-nine. To apply the empirical strategy of a quasi-experiment to the relationship between the young cohort size and the older adults' education levels, I link the cross-regional changes in the number of college/non-college graduates before and after the decline in young cohort size to the cross-regional declines in young cohort size caused by family planning policies. This comparison distinguishes the effect of the young cohort decline due to the policies 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 the timing of the implementation of fertility policies is orthogonal to changes in other confounding factors across

regions and over time.

I also decompose the impact on adult college/non-college graduates by their age to gauge whether the increase is consistent with the cross-age distribution of the migration cost and the cost for older workers to go back to school. Further I distinguish the channel for the increase in adult college graduates via: 1) in-migration of college graduates from the outside of a province that has a decline in the young cohort size versus 2) educational upgrading of non-college graduates already in the province.

My research shows strong impacts of the decline in young cohort size on the educational upgrading for all adult age groups. The empirical results also show that the young cohort size does not have any significant impact on the size of adult non-college graduates. 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 25. The results are consistent with the predictions that older workers have higher costs of migration. Additionally, I show the impact of young cohort decline on educational upgrade becomes insignificant from zero in the period 1990-2000 which is consistent with the relaxation of migration restrictions over time.

As an theoretical 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 resources for education 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, and they might not drop during the time when cohort size was shrinking. The theory predicts that the average level of college

education will be higher for the birth cohort of a smaller size. I show empirical evidence that the young cohort, the post-family-planning cohort, has a greater number of college enrollments compared to their counterpart who was the young cohort prior to the policies. This is consistent with relaxation on the constraint on college education supply. It might be consistent with the quantity-quality trade-off of children at the household level as well.[1]

This paper being the first paper to show the existence of educational upgrading by older adults can broadly contribute to literature in 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 earlier. Through quantifying these results, I contribute to literature on wage 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

[1]In another chapter of my thesis, I will examine the potential mechanisms by which the educational levels of young birth cohort can be affected by the family planning policies. Here I show the reduced empirical results of the impact of family planning policies on the educational attainment of young birth cohort.

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.

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

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.

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

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

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 decease 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 older 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 exploit the geographical variation in the timing 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 adults going back to school and a simultaneously decreasing fertility trend.

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, and/or political favoritism to local educational development can affect the per capita subsidies for higher education. Greater subsides 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 degree of adult educational upgrading to the change in the young cohort size. The reliability of this strategy depends on one underlying assumption. If the unobserved characteristics affecting both education upgrade and changes in 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 tackle the 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 the family planning policies to the change in adult college graduates over time in regions where there is no decrease or a smaller decrease in young cohort size. The key assumption is that the geographical variation in the timing of the initiation of family planning polices in China is exogenous to geographical variations in other confounding factors.

Additionally, all the influences from population density, income level, preferences for more education, labor mobility that would potentially contaminate the association between young cohort size and adult education upgrade will be taken into account by controlling as many characteristics as possible. The key assumption for this identification strategy to be valid is that the changes in young cohort size across geographical regions are not capturing changes due to other unobservable factors. It is hard to imagine a situation where the timing of the family planning policies appointed by the central government in the 1960s will be correlated with the future changes in certain unobserved factors that influence the adult educational upgrading.

Although I can not directly test the last assumption, 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 earliest family planning work was organized by Ministry of Public Health in 1956, but the impact of the early work seemed fairly temporary. The total fertility rate in 1957 was even higher than that before 1955. The concept of reducing population received a lot of debate among top leaders and family planning work was not carried through the Great Famine period (1958-1861). After 1963, the government began to implement stronger policies.

In 1964, the national agency, known as the Family Planning Committee of the State Council, was created to be responsible for making family planning policies and cooperate with local agencies. However, the main function of the committee was to educate people and encourage them to adopt family planning measures; these measures include a recommended later marriage age, technical guidance on birth control methods and surgeries, rewards such as housing benefits associated with family planning

adoption, etc. There was no enforcement of family planning policies. Minority residence areas were completely exempt from family planning policies. Inclusive of other forces that might play a role, the family planning policies were effective. The total fertility rate declined from 7.5 in 1963 to 5.3 in 1967, a near 30 percent decrease. However, the event of Cultural Revolution interrupted the polices and they was resumed after 1970.

After 1970, the main steps in family planning included making birth control pills and other methods and surgeries free in the entire country, ordering local governments to establish family planning agencies, increasing education intensity and media coverage to less dense areas, improving quality of birth control methods, improving health care of women and children at birth, and investing more in research of birth control pills. The family planning programs during the period covered most provinces including some minority areas in case people would have a demand for family planning. However, the minority concentrations still remained the exemption. Meanwhile, the central government decided to increase the intensity of education over family planning. In 1973, the State Council initiated "late long few" family planning program. It encouraged every young couple to adopt a later marriage age, a longer birth spacing and a smaller family size [2].

The family planning work made a great achievement during the 1970s. The total fertility rate declined from 5.8 in 1970 to 2.75 in 1979. From 1979 the government realized that it was difficult to meet the targeted population growth rate because a large cohort born in the late 1950s were facing their primary reproductive stage. Therefore the government developed more forceful measures. New family planning policies, a.k.a., the one-child policy, rewarded new couples with only one child per couple. In 1982, the policies had become that one child was just enough; two children were allowed in certain circumstances; and three children were generally not allowed. Minority areas were ruled by less strict policies. Urban couples can have two children, while rural couple can have three to four children under certain circumstances.

Based on the timing of adopting family planning policies, I divide all provinces into four broad regions. The earliest region includes Beijing, Shanghai, Tianjin and Liaoning. These provinces adopted

[2] "Late" means a marriage age of 25 for men and 23 for women. Some most stringent rules specified age 28 for men and age 25 for women. "Long" means the birth spacing should be more than 3 years. "Few" means that a couple is recommended to have two children or less. In some circumstances, rural couples were encouraged to have three or four.

the policies in 1963-1964. Provinces came in second in adoption are Fujian, Gansu, Guangdong, Hebei, Heilongjiang, Hunan, Inner Mongolia, Jiangsu, Shaanxi, Shanxi, Shandong and Zhejiang. They started family planning work around 1971-1973. Following them, Anhui, Henan, Hubei, Jiangxi, Jilin, Sichuan and Xinjiang came to adopt the policies during 1974-1975. The last group of provinces includes Guangxi, Guizhou, Ningxia, Qinghai and Yunnan, which began to implement the polices from 1979-1983.

The municipalities of Beijing, Tianjin and Shanghai had effective family planning programs in the early 60s. Beijing and Tianjin had provided free birth control methods and surgeries; they had also extended the medical leave and provided goods or monetary compensation for birth control surgeries. Shanghai had birth control surgeries free and started initiating clinical trials of birth control pills. Two kinds of birth control pills for women had been approved in 1967. Some other provinces had provided free birth control surgeries as well, but the policy effectiveness in those provinces was weaker 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 majority of provinces adopted family planning policy before 1979. I divide them into two groups by the criterion whether they had the policies before the program "late long few"(1973) in order to create a clear time cut-off between the two groups. Having implemented family planing policies only since 1979, the latest group of provinces belong to the reference group. This group consists major provinces with minority residents. They were least likely to be affected by family planning policies before 1979 and affected by the least degree after 1979. I will treat them as the control group in the model.

4.2 The Adult Educational System and Educational Upgrading

The Chinese adult education system was initially created in the early 50s and became popular in the late 80s. The development of adult educational system can be divided into three stages: the startup in the early 1950s, the expansion from the late 1970s to the early 1990s, and the further development from the 1993.

The adult educational system 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 belong to this system. I will focus on adult educational progress in the diploma-oriented system, during which the goal is a academic diploma. In this study particularly, it is a diploma at the tertiary level of education.

The diploma-oriented system is to combine with social assistance to help adults achieve academic degrees through self-learning. To meet academic requirements, adult students will normally take an entrance exam and get enrolled on a merit basis in a higher educational institution and earn credits for a diploma just like a young college student. A typical program usually takes two or three years to complete, depending on whether the learning is full-time or part-time. The credit requirement of the degree depends on the academic difficulty set by the programs or schools. 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 public schools like night schools, correspondence schools, or television schools organized by local colleges or universities[3]. College teachers would be available if there was a need from students for authoritative assistance. At the end of the study, candidates are required to take a set of exams and have to pass a minimum of scores to get the diploma. There is no time constraint with respect to the period of study or the period of time it takes to pass all the exams. This "self-study" (zi-kao) regime was introduced as a policy for adults to achieve higher educational levels from 1981.

Although it had existed for a long time, the diploma-oriented adult education started to emerge as a popular tool of achieving higher levels of education for people with some work 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.

[3]Adult 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.

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

5.1 Data Sources

To track educational upgrade of adults and link it to the change in the young cohort size, I need universe data on the geographic and temporal distribution of old and young adults with information over their education levels, migration status and demographic characteristics. I will also use macro-data on economic conditions across regions to control for potential confounding effects.

The universe data that are representative of old and young adults in China are national population censuses in the consecutive survey years 1982, 1990 and 2000. The census data are sampled at the level of household, either domestic household or collective living unit[4]. 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 provide many advantages for purpose of my study. They provide detailed personal information on sex, year of birth, month of birth, ethnicity, hu-kou registration[5], 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, etc[6].

The main variables to construct are the size of college graduates at the cohort-province-year level[7], the size of non-college graduates at the same level, the share of college graduates at the same level, and the size of young cohort between age 16 and 24 at the level of province and year. I define college graduates as those with at least a college degree; non-college graduates as those with no more than a

[4]A 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.

[5]The "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 eligible for grain rations, employer-providing or employer-subsidizing housing benefits, health care benefits, and free school entry of their children. 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.

[6]For detailed information, see the section of data appendix.

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

high school degree.

Second, I construct the size of young cohort aged 16-24 at the province-year level. For example, 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, present in Liaoning province in 1982 from the 1982 census.

Taking advantage of the geographic and temporal variation in the initiation of family planning polices, I group twenty-eight provinces in the sample into four different regions. Region-I includes provinces that initiated the policy measures in 1964. It had a continuous fall in size of births from 1964. This means starting in 1980, when the 1964 birth cohort reached the age of 16 and entered the labor market, the young cohort size started to decline in region-I. Region-II consists of provinces that initiated the policies in 1971, leading to a decrease in young cohort size from 1987. Region-III initiated the policies in 1974 and had a fall in young cohort size in 1990 and Region-IV, being the latest adopter in 1978, had a fall in young cohort size from 1994.

An important challenge for this paper is to distinguish the increase in college educated adults arising from the part of in-migration of the college educated from the part of education upgrading of a high school graduate. 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 that a person lived in five years ago. I will define an individual as a migrant if they lived in a different province five years earlier.

Table 1-1 is the sample statistics for the main variables in my study. The first part of the table lists statistics on the change in the log number of young cohort at the province level and the change in the log number of college and non-college graduates at the province-birth-cohort level during the two periods. The log size of young cohort aged between 16 and 24 on average increased by 0.24 during 1982-1990 and decreased by 0.29 during 1990-2000. The log number of college graduates within a birth cohort on average increased by 0.44 in the first period and increased by 0.28 in the second period. The log number of non-college graduates within a birth cohort did not change much in either period. The second part of the table lists statistics on the same variables by family planing policy regions. The comparison of each region with the national average will illustrate how to exploit the

geographical variation in the young cohort size caused by the timing of the policy implementation. Notice that in the first period, region-I and region-II had a decreased young cohort size relative to the national average, and the young cohort size increased relatively in region-III and region-IV. I also observe that in the same period, the number of older college graduates increased relative to the national average in region-I, region-II and region-III, but decreased relatively in region-IV. This implies that the relationship between the number of older college graduates and the young cohort size is negative. Later in the regression, I will control for other characteristics that might affect adults' educational levels.

To show that the regions are similar to each other in dimensions other than the timing of the initiation of the family planning policies, I test the difference in these controlled variables at the beginning year of the two periods. Results are shown in Table 1-2. Except for region-I, provinces in region-II, region-III and region-IV do not have significant differences in log real GDP per capita, log real value of fixed asset investment per capita, population density and the number of tertiary teachers per capita. Nevertheless, the identification assumption I impost is weaker than the differences in the initial levels of these controlled variables. The identification assumption is that the timing of the implementation of the policies is uncorrelated with the change in the number of college graduates net of the controlled variables.

5.2 Trends in Adult Educational Upgrading Associated with Young Cohort Size

Firstly, I show the pattern of the young cohort size and illustrate the strategy to identify the adult educational upgrade. Figure 1 is the relative annual size of young cohort aged between sixteen and twenty-four in each region. Each dot in these sub-figures is calculated by the ratio of the regional young cohort size to the national size. The three lines of the relative young cohort size in each sub-figure are from three census samples. The lines from the 1982 sample and the 1990 sample match well with each other which implies the internal migration is not important between the period 1982-1990. The migration is more intensive for the period 1990-2000 between region-II and region-III when those migrants are about twenty to forty years old. I also find that the external migration outside the

country is not an issue in my study.[8]

The vertical lines in these sub-figures of Figure 1 represent the different timing of the fall in the size of young cohort resulting from family planning policies. The first substantial fall in the young cohort size starts in 1980 in region-I according to the official year of the initiation of the policies, which is the year of 1964. The fall in the young cohort size in region-II is supposedly from 1987 which is sixteen years later after it adopted the policies in 1971. Region-III approaches the fall of the young cohort size in the year of 1990 and Region-IV in 1994. Figure 4 is the geographic distribution of provinces that are included in these four regions.

To illustrate the impact of the size of young cohort on the average educational level of themselves and on the educational upgrading of the older adults, I plot the change in the size of young cohort aged 16-24 across regions on the x-axis, and the change in college enrollments among the 16-24 year olds and the change of older college graduates among the 25-49 year olds on the y-axis. Figure 2 shows that on the x-axis, the change in the size of young cohort is different across regions. I obtain a significantly negative relationship between the young cohort size and the college enrollments of the young cohort. The magnitude of the slope is greater in the period 1982-1990 than in the period 1990-2000.

Figure 3 plots the change in the older college graduates aged 25-49 on the y-axis. The relationship shows that the decline in the size of young cohort increases the number of older college graduates. The magnitude differs by the age group and by the time period as well. In the following sections I will lay out an econometric model and discuss the results.

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. To illustrate, 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

[8]The figure is available upon request.

will show the econometric method in this study. A simple cross-sectional regression setup is:

$$TC_{jpt} = \alpha ln(YL_{pt}) + \sum_{p} \beta_p Province_p + \sum_{t} \gamma_t Year_t + \lambda X_{pt} + \mu Z_j + \epsilon_{jpt} \tag{4}$$

where j indexes an adult birth cohort, p indexes province and t indexes time. The term TC_{jpt} is the total 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. Here I use $ln(YL_{pt})$ instead of YL_{pt} because the latter is too large in magnitude compared with the change in adult educational upgrading. $ln(YL_{pt})$ also fits better in the regression. $Province_p$, $Year_t$, and Z_j are province fixed effects, time fixed effects, and birth cohort fixed effects. X_{pt} are other characteristics at the province-year level. I use birth cohort fixed effect to separate any affect in the aggregate college graduate number that is from the population compositional change. I use the province fixed effect to capture constant determinants for the size of young cohort and the adult educational upgrading in each province. I use time fixed effect to control for general demand for college workers at the national level. The standard OLS regression will lead to an inconsistent estimate of the relationship between young cohort size and adult college upgrade. 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. Depending on the correlation between the unobserved characteristics and young cohort size, and the effect of unobservable characteristics on adult college upgrade, the bias can be positive or negative.

As described in section 3, my identification strategy 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 the number of adult college graduates in regions where there is no decrease or a smaller decrease in young cohort size. I construct a group of instrumental variables $region \times year_{rt}$[9] for endogenous variable $ln(YL_{pt})$. Calculated from the timing of the initiation of family planning polices in the four different regions, the young cohort aged 16-24 in region-I will be treated by the policy or become smaller from 1980, region-II from 1987, region-III from 1990 and

[9]This is a set of three dummy variables.

region-IV from 1994. I choose region-IV as the reference region, so the term $region \times year_{rt}$ indicates if a given region r has been treated by the polices in the year t and the coefficients on the term mean how much the young cohort size will change in this region relative to the reference region. The identification assumption is $region \times year_{rt}$ is uncorrelated with ϵ_{jpt}.

For the influence of the size of young cohort on their own educational achievement, I run the similar regression on the dependent variable that is the number of college enrollments of the age group 16-24. The only difference in the regression setup is that I omit the birth cohort fixed effect Z_j. Neither does the index j appear in the regression.

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

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

where TNC_{jpt} is the total number of non-college graduates of each birth cohort, in each province and each year. The independent variables are the same as in the equation (4). The identification method uses the same set of instrumental variables $region \times year_{rt}$ for $ln(YL_{pt})$.

7 Results

7.1 The Effect of Young Cohort Size on Educational Attainment of the Young Cohort

The relationship between the size of young cohort and their own educational attainment is important in its own right. Additionally, the results for the young cohort combined with that for the older adults can inform the mechanism for adult educational upgrading, as I formalized it in section 2.

In OLS regression, results suggest the relationship between the size of young cohort aged 16-24 and their college enrollments is positive in the period 1982-1990 and insignificant from zero in the period 1990-2000. Since the OLS estimation does not imply any causal relationship, I use the regional

differences in the timing of the implementation of family planning policies to exploit the exogenous variation in the young cohort size. The estimates from the 2SLS indicate a negative relationship between the cohort size and their college enrollments. A one percent decrease in the size of young cohort increased the number of college enrollments by 68 thousand persons in the first period and by 38 thousand in the second period. The effects are significant in both periods. The OLS bias is positive in two periods, suggesting that the omitted variables can be the supply factors for college education, for instance, the college resources increased for young people.

In all, empirical results show that the post-policy young cohort has a greater number of college enrollments compared to the pre-policy young cohort. This is consistent with relaxation on the constraint on college education supply (cohort crowding). It might be consistent with the quantity-quality trade-off of children within household as well.

7.2 The Effect of Young Cohort Size on Adult Educational Increase

Table 3 presents the OLS results for the relationship between the log number of young cohort size and the number of adult college graduates. Panel A (the period 1982-1990) results show that a one percent increase in young cohort size decreased the number of older college graduates by 1-10 thousand, significantly for the group of age below 40. The secular trend for adult college graduates was increasing over time with exception of the group over 40 for whom there was a negative change. Log real GDP per capita had no significant role in increasing the college graduate number for those below 40, but the effect was significantly positive for those above 40. Log real value of fixed asset per capita had a negative effect on the number of college graduates. Population and population density had a positive effect. The number of tertiary teachers per capita had a positive effect. Panel B (the period 1990-2000) shows a smaller relationship between log number of young cohort size and the number of older college graduates; the effect was insignificant from zero. Over this period, log real GDP per capita had a bigger impact on the number of college graduates. Other controlled variables show similar results as in the previous period.

In all, the OLS results suggest there is a negative relationship between young cohort size and adult college graduate number in the first period 1982-1990, and the relationship is mostly insignificant from

zero in the second period.

Before I proceed to the estimates from 2SLS, I first show the impact of the family planning policies on the log number of young cohort size. In Table 4, the results show that the impact of family planning policies on young cohort size, as indicated by the instrumental variables in the first three rows, is the same across all age groups but different for two decades. In Panel A (1982-1990), controlling for all the characteristics and the fixed effects, the rate of growth of young cohort size in region-II was 12 percent lower than that of the control group region-IV. Other regions did not have a significant difference in the rate of growth of young cohort controlling for all the characteristics.[10]

Panel B of Table 4 lists the first-stage results for the period 1990-2000. Region-I experienced 38 percent less growth in young cohort compared to region-IV. Region-II and region-III had a 34 percent and a 47 percent lower growth rate than region-IV. The year fixed effect indicates that young cohort size declined slightly by 5 percent. GDP per capita was positively associated with the young cohort size increase; fixed asset per capita was negatively associated with it. Population and population density had a reversed sign of the effect on young cohort size in the second period.

Table 5 presents the 2SLS estimates of the effects of the log number of young cohort size on the number of adult college graduates by age group. In the period 1982-1990, a one percent decrease in young cohort size on average increased the number of adult college graduates by 6.6-10 thousand persons. The effects of young cohort size were heterogeneous for adult age groups, with the smallest increase among the age group 35-39. From 1990-2000, the effect of the young cohort size became insignificant.[11]

The 2SLS estimates of the effects of the log number of young cohort size on the number of non-college graduates for all age groups show that these effects are not significant from zero.[12]

Comparing with 2SLS estimates, the OLS results tend to bias the effect of young cohort size on

[10]Without controlling for the number of tertiary teachers per capita (results not shown here), the rate of growth of young cohort size in region-I was 30 percent lower than that of the control group region-IV. Region-II and region-III compared to the control group experienced 15 percent and 5 percent less growth in young cohort size. This suggests that the factor of tertiary teachers channels a large impact from the family planning policies. Indeed, regions that experienced the young cohort shortage did increase the resources of tertiary teachers.

[11]The reason for the insignificant results for the second period might be due to the fact that the migration of young adults becomes easier so that the education levels of younger adults are less affected, or older adults have finished their educational upgrading in the earlier period. This is also confirmed by the result of the number of college enrollments in Table 2. It shows the impact of the size of young cohort is smaller in 1990-2000 than in 1982-1990.

[12]Results are available upon request.

the number of college graduates in different directions for different age groups, suggesting different factors are included in the unobservables for educational upgrading of adults of different age.

In summary, results in 2SLS models suggest that the young cohort size has a negative effect on the number of adult college graduates. The effect is equally strong for all age groups except 35-39. The effect is significant in 1982-1990 and insignificant from zero in 1990-2000. I also find evidence that the young cohort size does not affect the size of adult non-college graduates in both periods.[13]

7.3 Adult Educational Increase: Migration or Upgrading

Having established the negative causal link between young labor supply and the number of older college graduates, I want to address the question that how much of the increase in older college graduate is due to educational upgrade of local non-college graduates and how much is due to migration. If the increase is largely caused by a geographical redistribution of college graduates, it suggests there is no educational upgrade of older adults. This concern is unlikely to persist, since the decline in the young cohort size becomes prevalent in the entire country. The theory of complementarity between college workers of different ages predicts the productivity of older college workers increases widespread, which drives the incentive of adults to acquire college education.

If the decline in young cohort size affects a local non-college graduate and a potential college migrant equally, the chance that an additional college adult is local in a given province or from other provinces should be fixed according the origin composition of college workers in that given province. Therefore, the share of college graduates that are migrants should not be affected by the young cohort size. The effect of young cohort size on the migrant share should be positive if it affects the local non-college graduates more; the effect should be negative if it affects college migrants more.

To examine how much of the increase in adult college graduates is due to migration, I use the econometric model:

$$MigC_{jpt} = \eta ln\left(YL_{pt}\right) + \sum_{p} \beta_p Province_p + \sum_{t} \gamma_t Year_t + \lambda X_{pt} + \mu Z_j + \epsilon_{jpt} \tag{6}$$

[13] Tables of results are available upon request.

where $MigC_{jpt}$ is the share of adult college graduates that are migrants of each birth cohort, in each province and each year; $ln\left(YL_{pt}\right)$ is the young cohort size in each province and each year. As in the previous regression setup, $Province_p$, $Year_t$, and Z_j are province fixed effects, time fixed effects, and birth cohort fixed effects. X_{pt} are other characteristics at the province-year level. The endogenous variable $ln\left(YL_{pt}\right)$ can be potentially correlated with ϵ_{jpt} and is instrumented by indicators of family fertility policies $region \times year_{rt}$ which vary over time and across broad regions. I also run the same setup for the share of non-college graduates that are migrants.

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

where $MigNC_{jpt}$ is the share of the non-college graduates that are migrants.

Using migration information in the 1990 and 2000 census samples[14], results in Table 6 show that the effect on the migrant share is insignificant. It means that the increase in adult college graduates from 1982-1990 is most likely to be through upgrading of local non-college graduates for all the age groups. One interesting finding is that if I omit the number of tertiary teachers per capita in the regression, the results show that the upgrading is more driven by migration of college adults than by upgrading for the age group 25-29. It implies that the channel of increase in young educated migrant workers might be the expansion of the college enrollment.

The results on the migrant share among the adult non-college graduates show that the decline in the young cohort size will decrease the migrant share of non-college graduates. However, the effects are not significant from zero. In the previous section, I have found that the effect of young cohort size on the number of non-college graduates is insignificant from zero, so the implication for the impact on the migrant share of non-college graduates is not important.

In all, the results show that the increase in the number of older college graduates when the young cohort size decreases because of the family planning policies is mostly driven by upgrading from non-college graduates for all adult age groups.

[14]Migration information in not available in the 1982 census samples, so I cannot test the migration part for the period 1982-1990. As shown in Figure 1, the migration issue is not important in the first period. Results obtained here will serve as the upper bound for the impact of young cohort size on the migration intensity of college adults.

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 0-2 percent during 1982-1990. Combined with the fact that the decline in the young cohort size also increases the college enrollment of young cohort aged 16-24, it suggests the complementarity of similarly educated workers of different age in the production function. The young cohort decline does not affect the number of non-college graduates among adults. The increase in the number of adult college graduates resulting from the reduction in the young cohort size is bigger in the 1980s than in the 1990s. This might be due to weaker migration restrictions in the 1990s which lead to more equalized number of both young and older college workers across regions.

The empirical results also show heterogeneous effects on adult educational upgrading. The impact of the young cohort decline on the increase in college graduates is smaller for those aged 35-39 than for other age groups in the first period 1982-1990. I further find that the increase in the number of older college graduates resulting from the reduction in the size of young cohort is mostly 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. The smaller effect for the age group 35-39 might be consistent with the fact there exists higher costs for them to go back to school.

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9 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.

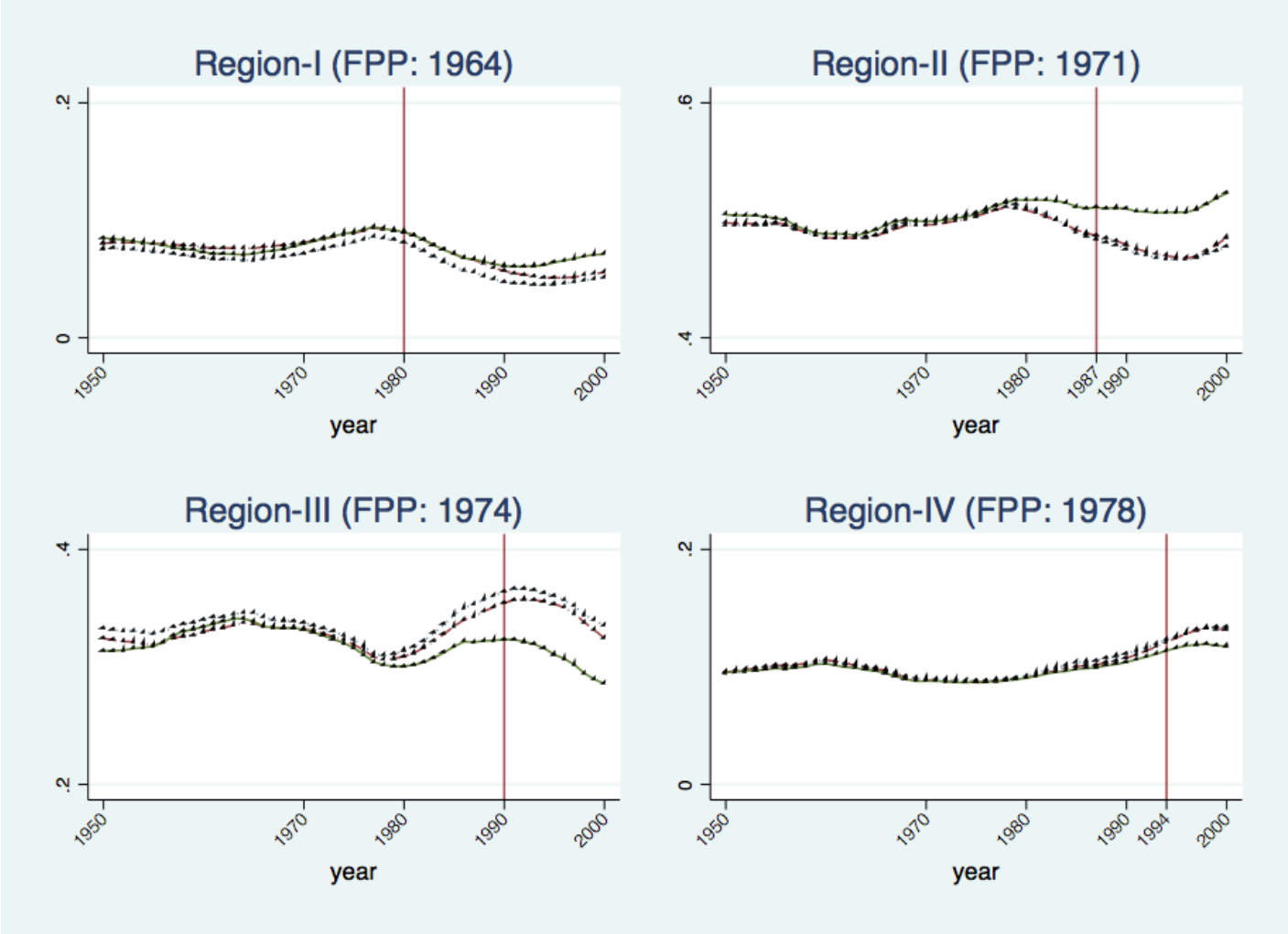
The provinces in censuses include the municipalities, provinces, autonomous regions and special administrative regions in China. They are Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning,

Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong (including Hainan), Guangxi, Sichuan (including Chongqing), Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Hongkong and Macau. Tibet, Hongkong and Macau had not implemented the family planning polices in the period of my study, so they are excluded in my samples.

9.2 Other Yearly Provincial Macro-economy Statistics

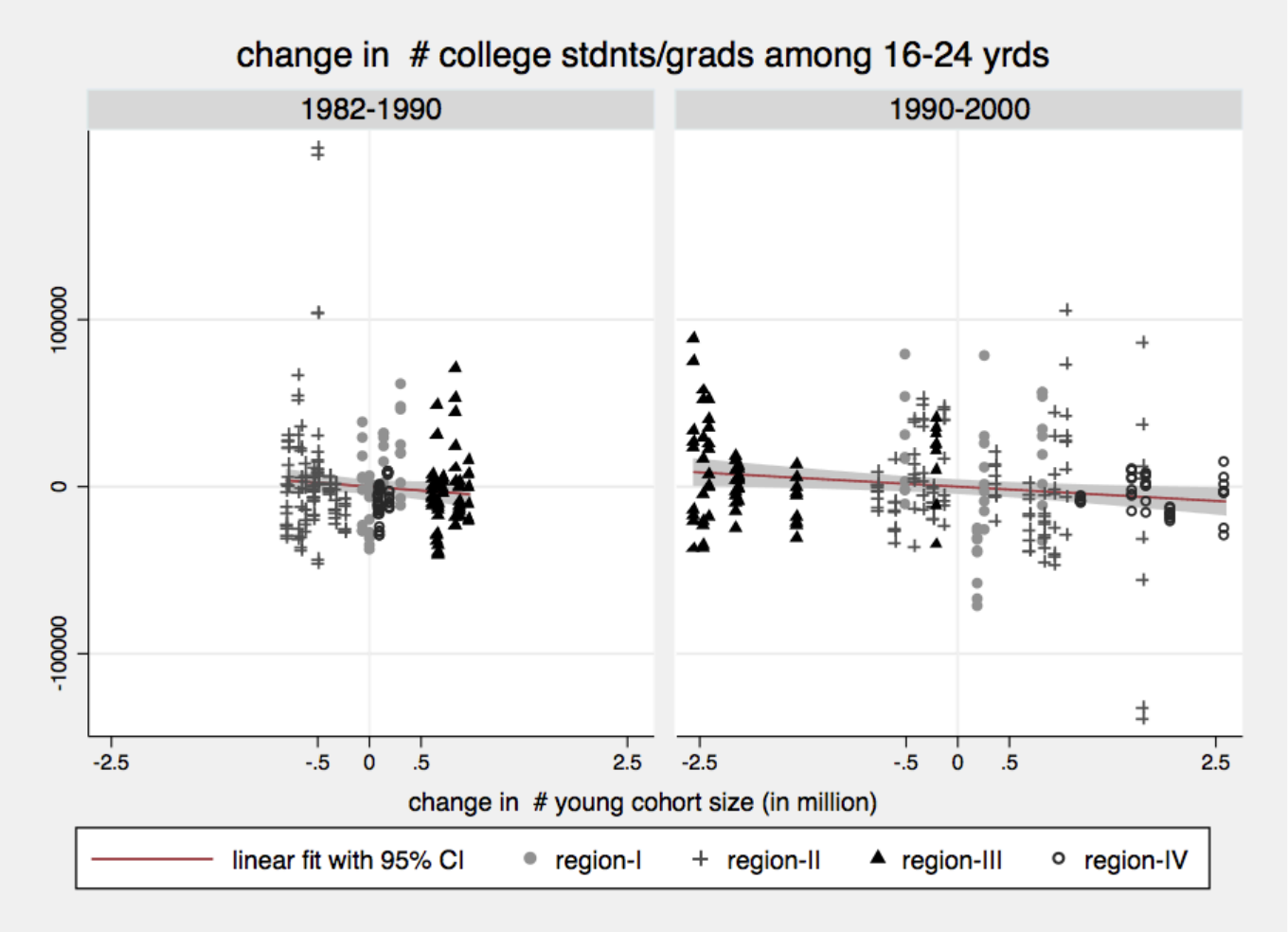
GDP per capita, fixed asset investment per capita, the number of tertiary teachers per 100,000 people, population are collected from China Yearly Provincial Statistical Yearbooks.

Figure 1: Population Distribution by Region



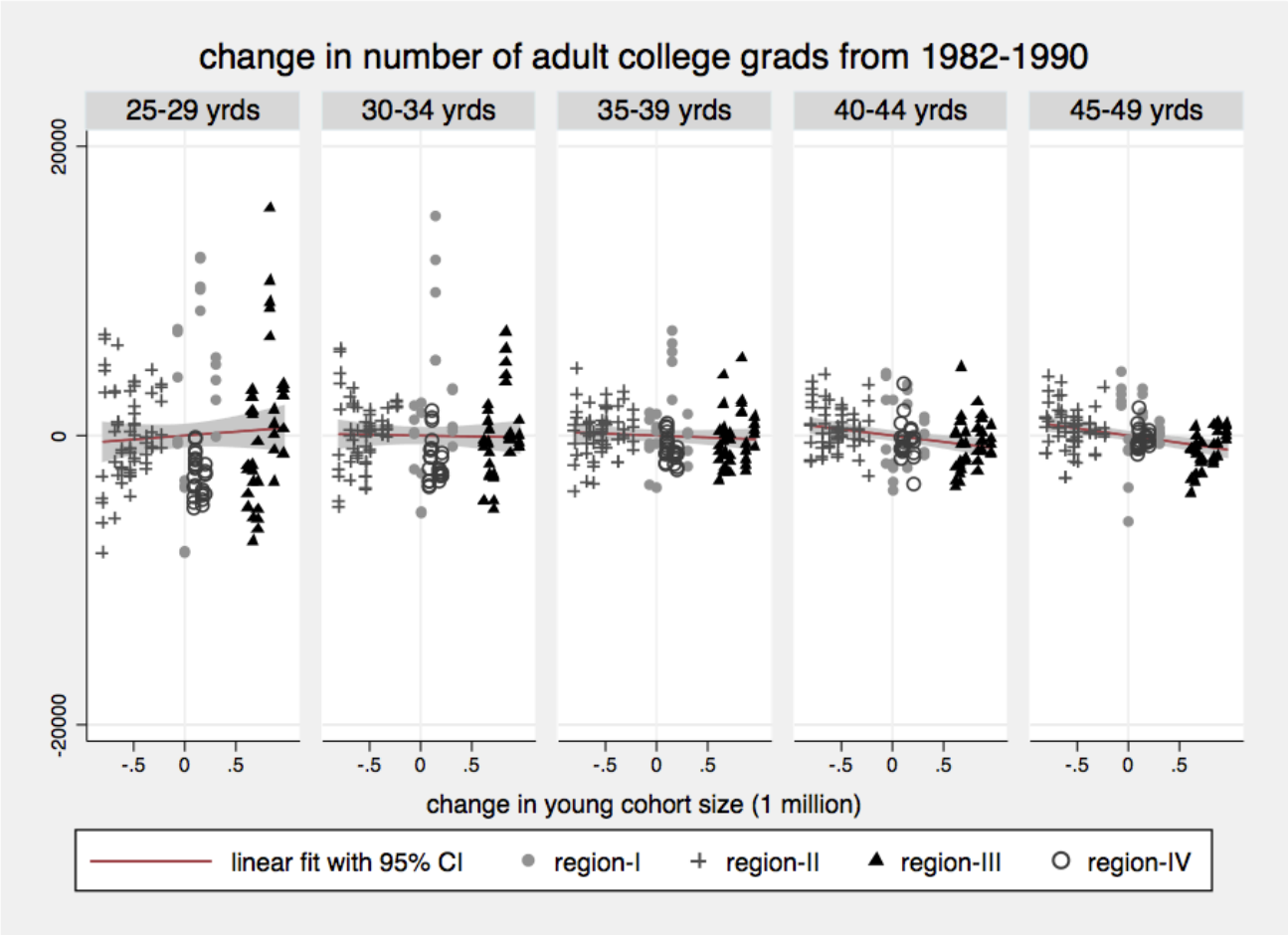
Note: The plotted value is the ratio of young cohort size in each region to the national young cohort size for each year. The young cohort size in each region for each year is calculated by adding up the size of the birth cohorts aged 16-24 within the region and year. The dot line is calculated from the 1982 census sample. The dashed line is calculated from the 1990 census sample. The solid line is calculated from the 2000 census sample. The family planning policies were implemented in 1964 in region-I, 1971 in region-II, 1974 in region-III and 1978 in region-IV. The red lines indicate the year when there should be decline in the young cohort size or the rate of growth of the cohort size.

Figure 2: Change in Educational Levels of Young Cohort Corresponding to Change in Young Cohort Size



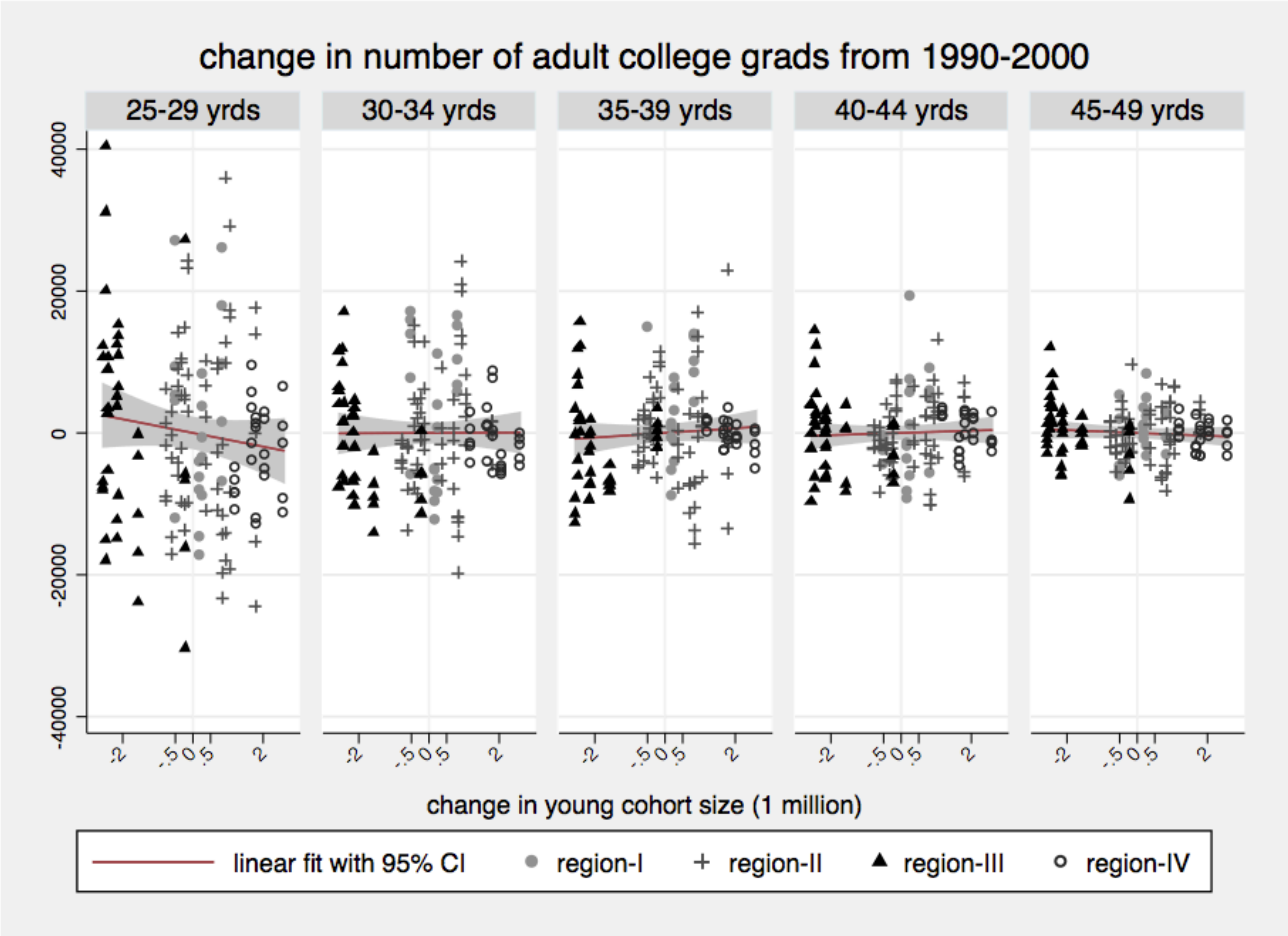
Note: The plot is the relationship between the change in the number of young college graduates of age 16-24 within province and the change in the young cohort size. I control for regional dummies indicating the impact of family planning policies on the young cohort size. I also control for the change in macroeconomic conditions including log real GDP per capita and log real fixed asset investment per capita, density, population and number of tertiary teachers per capita.

Figure 3: Change in Educational Levels of Older Adults Corresponding to Change in Young Cohort Size by Age Group
A: 1982-1990 by Age



Note: This figure *by adult age group* is the relationship between the change in the number of adult college graduates within province and cohort from 1982-1990 and the change in the young cohort size. I control for regional dummies indicating the impact of family planning policies on the young cohort size. I also control for the change in macroeconomic conditions such as log real GDP per capita and log real fixed asset investment per capita, density, population and number of tertiary teachers per capita.

B: 1990-2000 By Age



Note: This figure *by adult age group* is the relationship between the change in the number of adult college graduates within province and cohort from 1990-2000 and the change in the young cohort size. I control for regional dummies indicating the impact of family planning policies on the young cohort size. I also control for the change in macroeconomic conditions such as log real GDP per capita and log real fixed asset investment per capita, density, population and number of tertiary teachers per capita.

Figure 4: Map of Provinces Implementing Family Planning Policies

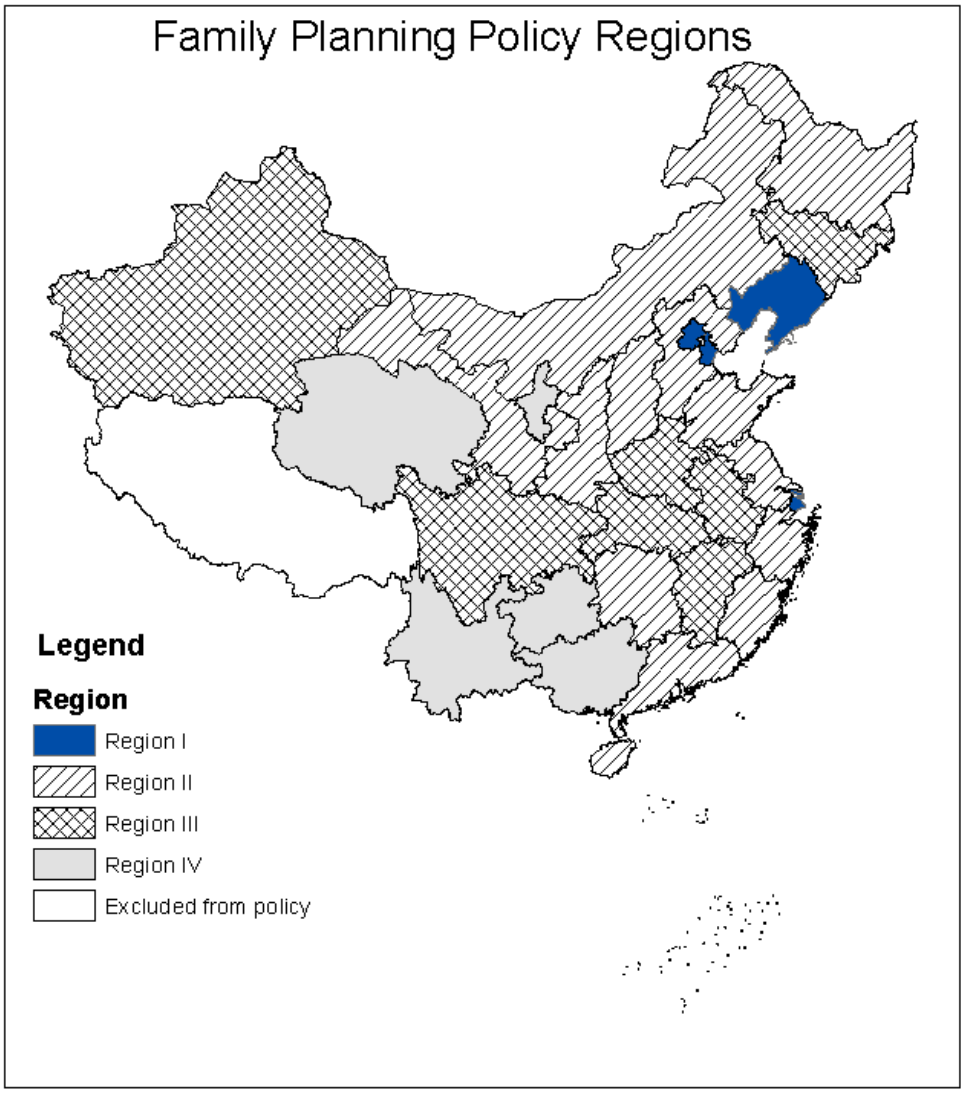


Table 1-1: Sample Statistics

	1982-1990 sample			1990-2000 sample		
	1982	1990	Growth rate	1990	2000	Growth rate
National						
number of provinces	28			28		
# of longitudinal birth cohorts in each province	25			25		
age range	25-49			25-49		
year of birth range	1933-1957			1941-1965		
log population of young labor, age 16-24 (n=28)	15.41 [0.8]	15.65 [0.8]	0.24	15.65 [0.8]	15.36 [0.72]	-0.29
log older population with coll edu /avg. of all birth cohorts (n=700)/	8.37 [1.02]	8.81 [0.95]	0.44	9.09 [0.96]	9.37 [2.42]	0.28
log older population with edu lower than coll /avg. of all birth cohorts (n=700)/	12.69 [0.88]	12.68 [0.85]	-0.01	12.91 [0.86]	12.86 [0.88]	-0.05
Regional (family planning program regions)						
Region-I, number of provinces	4			4		
log population of young labor, age 16-24	14.79 [0.68]	14.81 [0.65]	0.02	14.81 [0.65]	14.75 [0.58]	-0.06
log older pop. with coll edu, all birth cohorts	8.98 [0.48]	9.63 [0.46]	0.65	9.87 [0.51]	10.13 [0.63]	0.26
log older pop. with edu lower than coll, all birth cohorts	12.06 [0.67]	12.18 [0.61]	0.12	12.42 [0.64]	12.33 [0.7]	-0.09
Region-II, number of provinces	12			12		
log population of young labor, age 16-24	15.73 [0.44]	15.95 [0.41]	0.22	15.95 [0.41]	15.64 [0.53]	-0.31
log older pop. with coll edu, all birth cohorts	8.53 [0.48]	8.99 [0.53]	0.46	9.25 [0.62]	9.78 [0.81]	0.53
log older pop. with edu lower than coll, all birth cohorts	13.00 [0.55]	12.98 [0.54]	-0.02	13.23 [0.55]	13.18 [0.59]	-0.05
Region-III, number of provinces	7			7		
log population of young labor, age 16-24	15.75 [0.66]	16.07 [0.70]	0.32	16.07 [0.70]	15.60 [0.52]	-0.47
log older pop. with coll edu, all birth cohorts	8.55 [0.58]	9.03 [0.54]	0.48	9.33 [0.57]	9.81 [0.79]	0.48
log older pop. with edu lower than coll, all birth cohorts	13.05 [0.73]	13.02 [0.73]	-0.03	13.18 [0.59]	13.24 [0.72]	-0.06
Region-IV, baseline region number of provinces	5			5		
log population of young labor, age 16-24	14.64 [1.14]	15.02 [1.11]	0.38	15.02 [1.11]	14.79 [1.08]	-0.23
log older pop. with coll edu, all birth cohorts	7.24 [1.15]	7.44 [1.15]	0.2	7.78 [1.12]	7.20 [4.95]	-0.58
log older pop. with edu lower than coll, all birth cohorts	11.92 [1.07]	11.91 [1.07]	-0.01	12.12 [1.07]	12.06 [1.09]	-0.06

Note: Sample statistics are calculated from China census samples in 1982, 1990 and 2000, and from provincial yearbook data. All the provincial statistics are at the level of province and year; all the birth cohort statistics are at the level of province and year and one-year-of-birth cohort. Sample standard deviations are in brackets. 1982-1990 and 1990-2000 are sub-samples created for the same birth cohort in each province over time. They are birth cohorts aged 25-49 in 1982 and in 1990 respectively. I also divide the whole country into four regions based on the timing of the implementation of family planning program in China.

Table 1-2: Sample Means by Family Planning Program Region in 1982 and 1990

	Family Planning Program Regions				Test of Equal Means (F-Stat)	
	Region-I	Region-II	Region-III	Region-IV	Regions exclusive of region-I	All regions*
1982						
Log (Young Labor Aged 16-24)	14.8[0.7]	15.7[0.5]	15.8[0.7]	14.6[1.1]	5.0	4.57
Log GDP Per Capita (1982RMB)	7.0[0.6]	5.9[0.3]	5.8[0.2]	5.6[0.5]	2.21	12.8
Log Fixed Asset Investment Per Capita (1982RMB)	5.6[0.6]	4.4[0.3]	4.2[0.4]	4.1[1.0]	0.66	6.7
Population density (100 persons per sqaure kilometer)	2.0[1.0]	1.0[0.5]	1.1[0.4]	1.0[0.5]	0.08	3.56
No. Tertiary Teachers/100,000 people	164[116]	25.5[9.2]	26.4[12.0]	19.1[7.5]	0.95	12.64
1990						
Log (Young Labor Aged 16-24)	14.8[0.6]	15.9[0.4]	16.1[0.7]	15.0[1.1]	4.08	5.15
Log GDP Per Capita (1982RMB)	7.3[0.4]	6.4[0.3]	6.3[0.3]	6.1[0.6]	1.79	8.63
Log Fixed Asset Investment Per Capita (1982RMB)	6.1[0.5]	5.0[0.4]	4.7[0.5]	4.5[0.8]	1.15	7.13
Population density (100 persons per sqaure kilometer)	2.4[1.2]	1.1[0.6]	1.2[0.4]	1.2[0.5]	0.05	3.9
No. Tertiary Teachers/100,000 people	184[124]	32.0[11.1]	33.6[16.8]	24.3[9.0]	0.87	13.1

Note: F-statistics for all-region comparison show significance at 5% level at least.

Table 2: OLS/2SLS regression of impact of log number young cohort size on the number of college students/grads among the yong cohort

	Panel A: 1982-1990		Panel B: 1990-2000	
	# (thousand) college students/grads aged 16-24		# (thousand) college students/grads aged 16-24	
	OLS	IV	OLS	IV
VARIABLES				
log # of young cohort	17.09*	-67.51**	-15.12	-37.66**
	(9.91)	(26.82)	(9.29)	(14.98)
year FE=1990	-31.42***	13.34	6.30	-1.88
(or year FE=2000 in Panel B)	(11.41)	(10.99)	(8.32)	(9.39)
lgGDP_percapita_real	21.31*	21.61*	79.15***	80.64***
	(11.81)	(12.44)	(16.67)	(16.17)
lgfasset_percapita_real	-6.77	-12.94	-36.43***	-37.06***
	(6.54)	(8.53)	(12.53)	(12.09)
density	42.75***	19.22***	-19.95*	-18.18*
	(10.12)	(7.29)	(10.24)	(9.67)
population	4.51***	3.47***	-0.34	0.00
	(0.92)	(0.66)	(0.89)	(0.84)
tertiary_teachers_percapta	1.07***	-0.42	-0.07	-0.32
	(0.29)	(0.44)	(0.21)	(0.25)
Age effect	Y	Y	Y	Y
Provnce FE	Y	Y	Y	Y
Observations	504	504	504	504
R-squared	0.49	0.46	0.69	0.68

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Regression results are from census samples. The dependent variable is the number of college students or graduates, in each province in each census year among those aged between 16 and 24. The main independent variable is the provincial supply of young labor, defined as the log number of young people aged 16-24 in each province in each census year; it is instrumented by variables indicating the regional difference in the change of size of young cohort due to family planning policies. I also control for province fixed effect, time fixed effect, age fixed effect, log real GDP per capita and log fixed asset investment per capita, density, population and number of tertiary teachers per capita. I observe 28 provinces or municipality cities, excluding Tibet, Hongkong and Macau. Panel A lists the results during 1982-1990. Panel B lists the results during 1990-2000.

Table 3: OLS regression of impact of provincial supply of young labor on the number (in thoudand) of college grads

	Dependent var: Provincial-year-cohort-level number (in thousand) of college grads									
	Panel A: 1982-1990 sample					Panel B: 1990-2000 sample				
	Age in 1982					Age in 1990				
	25-29	30-34	35-39	40-44	45-49	25-29	30-34	35-39	40-44	45-49
VARIABLES										
log # of young labor	-10.03***	-7.57***	-4.78***	-1.39	-2.17	-3.60	2.09	2.45	1.46	-1.55
	(3.31)	(2.66)	(1.68)	(1.34)	(1.41)	(6.37)	(2.61)	(2.49)	(1.83)	(1.32)
year FE=1990	2.76	3.65**	1.57	-3.57***	-2.60**	9.36	5.94*	0.09	-1.82	-1.44
(or year FE=2000 in Panel B)	(2.30)	(1.72)	(1.10)	(1.19)	(1.15)	(6.51)	(3.55)	(2.87)	(2.41)	(1.59)
lg_GDP_percapita_real	4.07	-0.74	-1.98	5.68***	6.23***	21.47*	22.37***	15.88***	15.46***	4.78*
	(2.70)	(1.99)	(1.52)	(1.51)	(1.45)	(11.58)	(5.72)	(4.65)	(3.42)	(2.58)
lg_fasset_percapita_real	-2.40	-2.34*	-2.11**	-4.24***	-2.52***	-9.41	-8.85**	-3.84	-4.79	-1.03
	(1.88)	(1.33)	(1.01)	(0.78)	(0.86)	(7.96)	(3.91)	(3.64)	(2.94)	(2.00)
density	1.55	3.64**	4.48***	3.38***	0.99	9.00**	3.98*	1.52	-0.98	1.03
	(1.93)	(1.43)	(0.95)	(0.98)	(0.93)	(4.44)	(2.20)	(2.21)	(1.37)	(0.94)
population	0.74***	0.53***	0.42***	0.49***	0.24***	1.65***	0.62***	0.70***	0.21	0.31***
	(0.11)	(0.07)	(0.06)	(0.06)	(0.06)	(0.39)	(0.17)	(0.19)	(0.14)	(0.08)
tertiary_teachers_percapta	0.40***	0.28***	0.25***	0.31***	0.19***	0.41***	0.09	0.00	0.00	0.03
	(0.09)	(0.06)	(0.04)	(0.05)	(0.05)	(0.12)	(0.07)	(0.05)	(0.07)	(0.03)
Cohort FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Provnce FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	280	280	280	280	280	280	280	280	280	280
R-squared	0.86	0.88	0.92	0.94	0.91	0.84	0.85	0.85	0.82	0.85

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Regression results are from census samples. The dependent variable is the number of college graduates in each province in each census year of each one-year-of-birth cohort. The main independent variable is the provincial supply of young labor, defined as the log number of young people aged 16-24 in each province in each census year. I also control for province fixed effect, time fixed effect, birth cohort fixed effect, log real GDP per capita and log fixed asset investment per capita, density and population and tertiary teachers per capita. I observe 28 provinces or municipality cities, excluding Tibet, Hongkong and Macau. Panel A lists the results for a 5-year birth cohort range during 1982-1990. Panel B lists the results during 1990-2000.

Table 4: 1st stage regression of impact of family planning program on provincial supply of young labor

	Dependent var: Provincial-year-level log number of young people aged 16-24									
	Panel A: 1982-1990 sample					Panel B: 1990-2000 sample				
	Age in 1982					Age in 1990				
	25-29	30-34	35-39	40-44	45-49	25-29	30-34	35-39	40-44	45-49
VARIABLES										
region-I#1990	-0.063	-0.063	-0.063	-0.063	-0.063	-0.378***	-0.378***	-0.378***	-0.378***	-0.378***
(or region-I#2000 in Panel B)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.088)	(0.088)	(0.088)	(0.088)	(0.088)
region-II#1990	-0.122***	-0.122***	-0.122***	-0.122***	-0.122***	-0.336***	-0.336***	-0.336***	-0.336***	-0.336***
(or region-II#2000 in Panel B)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.059)	(0.059)	(0.059)	(0.059)	(0.059)
region-III#1990	0.006	0.006	0.006	0.006	0.006	-0.471***	-0.471***	-0.471***	-0.471***	-0.471***
(or region-III#2000 in Panel B)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)
year FE=1990	0.577***	0.577***	0.577***	0.577***	0.577***	-0.047	-0.047	-0.047	-0.047	-0.047
(or year FE=2000 in Panel B)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.108)	(0.108)	(0.108)	(0.108)	(0.108)
lg_GDP_percapita_real	-0.023	-0.023	-0.023	-0.023	-0.023	0.600***	0.600***	0.600***	0.600***	0.600***
	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)	(0.127)	(0.127)	(0.127)	(0.127)	(0.127)
lg_fasset_percapita_real	-0.026	-0.026	-0.026	-0.026	-0.026	-0.385***	-0.385***	-0.385***	-0.385***	-0.385***
	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.102)	(0.102)	(0.102)	(0.102)	(0.102)
density	-0.231***	-0.231***	-0.231***	-0.231***	-0.231***	0.086*	0.086*	0.086*	0.086*	0.086*
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)
population	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	0.022***	0.022***	0.022***	0.022***	0.022***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
tertiary_teachers_percapta	-0.018***	-0.018***	-0.018***	-0.018***	-0.018***	-0.012***	-0.012***	-0.012***	-0.012***	-0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Cohort FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Provnce FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	280	280	280	280	280	280	280	280	280	280
R-squared	0.997	0.997	0.997	0.997	0.997	0.983	0.983	0.983	0.983	0.983

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Regression results are from census samples. I regress the provincial-year-level log number of young people aged 16-24 on instrumental variables indicating whether a region experienced a relative decline of supply of young labor at the end of the period due to family planning program. I also control for province fixed effect, time fixed effect, birth cohort fixed effect, log real GDP per capita and log fixed asset investment per capita, density and population and tertiary teachers per capita. I observe 28 provinces or municipality cities, excluding Tibet, Hongkong and Macau. Panel A lists the results for a 5-year birth cohort range during 1982-1990. Panel B lists the results during 1990-2000.

Table 5: 2SLS regression of impact of provincial supply of young labor on the number (in thoudand) of college grads

	Dependent var: Provincial-year-cohort-level number (in thousand) of college grads									
	Panel A: 1982-1990 sample					Panel B: 1990-2000 sample				
	Age in 1982					Age in 1990				
	25-29	30-34	35-39	40-44	45-49	25-29	30-34	35-39	40-44	45-49
VARIABLES										
log # of young labor	-8.68*	-9.36***	-6.60***	-8.63***	-9.89***	-15.27	-3.88	0.23	1.17	-2.72
	(4.83)	(3.41)	(2.49)	(2.30)	(2.29)	(9.97)	(4.32)	(4.28)	(3.11)	(2.19)
year FE=1990	2.05	4.60**	2.54*	0.26	1.49	5.12	3.77	-0.72	-1.93	-1.86
(or year FE=2000 in Panel B)	(2.82)	(2.03)	(1.39)	(1.50)	(1.44)	(7.03)	(3.36)	(2.88)	(2.40)	(1.68)
lg_GDP_percapita_real	4.07	-0.73	-1.97	5.70***	6.26***	22.24**	22.76***	16.03***	15.48***	4.86**
	(2.49)	(1.88)	(1.44)	(1.49)	(1.42)	(10.94)	(5.40)	(4.29)	(3.14)	(2.34)
lg_fasset_percapita_real	-2.30	-2.47*	-2.25**	-4.77***	-3.08***	-9.73	-9.01**	-3.91	-4.80*	-1.07
	(1.77)	(1.32)	(1.00)	(0.86)	(0.93)	(7.39)	(3.68)	(3.38)	(2.72)	(1.82)
density	1.93	3.14**	3.97***	1.37	-1.16	9.92**	4.45**	1.69	-0.95	1.12
	(2.12)	(1.40)	(0.98)	(1.02)	(0.96)	(4.19)	(2.17)	(2.07)	(1.28)	(0.92)
population	0.75***	0.51***	0.39***	0.40***	0.15**	1.83***	0.72***	0.73***	0.22	0.33***
	(0.11)	(0.07)	(0.05)	(0.06)	(0.06)	(0.38)	(0.16)	(0.18)	(0.13)	(0.08)
tertiary_teachers_percapta	0.43***	0.24***	0.22***	0.18***	0.05	0.29*	0.02	-0.02	-0.00	0.02
	(0.10)	(0.07)	(0.05)	(0.06)	(0.06)	(0.16)	(0.08)	(0.07)	(0.07)	(0.04)
Cohort FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Provnce FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	280	280	280	280	280	280	280	280	280	280
R-squared	0.86	0.88	0.92	0.94	0.90	0.83	0.84	0.85	0.82	0.85

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Regression results are from census samples. The dependent variable is the number of college graduates in each province in each census year of each one-year-of-birth cohort. The main independent variable is the provincial supply of young labor, defined as the log number of young people aged 16-24 in each province in each census year; it is instrumented by variables indicating the regional difference in the change of size of young labor due to family planning program. I also control for province fixed effect, time fixed effect, birth cohort fixed effect, log real GDP per capita and log fixed asset investment per capita, density and population and tertiary teachers per capita. I observe 28 provinces or municipality cities, excluding Tibet, Hongkong and Macau. Panel A lists the results for a 5-year birth cohort range during 1982-1990. Panel B lists the results during 1990-2000.

Table 6: 2SLS regression of impact of provincial supply of young labor on share of college grads who are migrants

Dependent var: Provincial-year-cohort-level share of migrants in college grads

Panel A: 1990-2000 sample

	Age in 1990				
	25-29	30-34	35-39	40-44	45-49
VARIABLES					
log # of young labor	-0.02	-0.02	0.00	-0.02	-0.04
	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)
year FE=2000	-0.08***	-0.03**	0.01	0.02	-0.01
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
lg_GDP_percapita_real	0.04	0.01	-0.02	-0.06	-0.01
	(0.04)	(0.02)	(0.02)	(0.05)	(0.03)
lg_fasset_percapita_real	-0.01	0.00	-0.00	0.01	0.01
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
density	-0.02	-0.02**	-0.00	0.01	-0.01
	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)
population	0.00	-0.00*	-0.00***	-0.00***	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
tertiary_teachers_percapta	0.00***	-0.00	0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Cohort FE	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y
Observations	280	278	278	272	272
R-squared	0.68	0.41	0.41	0.24	0.51

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Regression results are from census samples. The dependent variable is the share of college graduates that are migrants, in each province in each census year of each one-year-of-birth cohort. The main independent variable is the provincial supply of young labor, defined as the log number of young people aged 16-24 in each province in each census year; it is instrumented by variables indicating the regional difference in the change of size of young labor due to family planning program. I also control for province fixed effect, time fixed effect, birth cohort fixed effect, log real GDP per capita and log fixed asset investment per capita, density and population and tertiary teachers per capita. I observe 28 provinces or municipality cities, excluding Tibet, Hongkong and Macau. Panel A lists the results for a 5-year birth cohort range during 1990-2000.