Picking up the Losses: the Impact of the Cultural Revolution on Human Capital Re-investment in Urban China[*]

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Abstract: Using the Cultural Revolution of China as a quasi-experiment, this paper analyzes the long-term impact of interrupted education in the midst of economic transition with booming opportunities that highly reward educational qualifications. We focus on the remedial human capital investment decisions taken by individuals whose education has been interrupted by this shock. We find substantial increases in schooling levels among the adult cohorts as they invest in continuous education to make up for their interrupted schooling and take advantage of new opportunities afforded by the economic transition. Estimates of the educational loss caused by the Cultural Revolution that ignore subsequent re-investments would not accurately measure the true losses inflicted by this event.

Keywords: Cultural Revolution, economic transition, interrupted education, human capital re-investment.

JEL codes: I21, J24, P36.

1. Introduction

Measuring the long-term impact of large scale disruptions brought about by war or institutional shocks has been the subject of much recent economic research. Davis and Weinstein (2002) and Brakman, Garretsen and Schramm (2004) study the impacts of World War II bombing on city growth in Japan and Germany, respectively. They find that long-term growth of cities is generally robust to large temporary shocks. Miguel and Roland (2006) study the effect of Vietnam War bombing at a much finer geographical level, and do not find any significant impacts on population density, poverty rates, infrastructure, or illiteracy. The literature has also considered the effects of large shocks on human capital investment and the returns to education. Ichino and Winter-Ebmer (2004) examine the schooling of German and Austrian children during World War II; Maurin and McNally (2007) investigate the educational disruptions caused by the 1968 student demonstrations in France; and Heaton (2008) looks at a unique episode of childhood schooling disruption in Prince Edward Island during 1959–1964.

In China, the Cultural Revolution during 1966–1976 upset the educational system for almost an entire decade, and its impacts on human capital investments and returns are considered by Deng and Treiman (1997), Meng and Gregory (2002; 2007), Giles, Park and Wang (2007), and Zhang, Liu and Yung (2007). These studies on human capital investments generally find a larger negative impact of temporary disruptions than studies based on city growth data. Presumably, pick-up in human capital investments takes a much more protracted period of time than the recovery of physical infrastructure. In this paper, we focus on the decision to re-invest in human capital among adults following large disruptions in schooling opportunities in their earlier lives. Using the institutional shocks brought about by the Cultural Revolution in China, we provide evidence about how individuals picked up their losses by re-investing in schooling in the aftermath of the disruption. Such re-investment decisions have received little attention in the literature, and we hope our contribution will provide suggestive evidence concerning the mechanism of how individuals involved recover

from large temporary disasters when there are incentives to do so.

During the Cultural Revolution, schools were largely closed and a great number of individuals were interrupted from pursuing their primary school, high school, or university education. Formal education was gradually reinstated later according to specific education levels. Following the end of the Cultural Revolution, China entered a period of economic reform, and education became much more important than it was in the past for labor outcomes such as wages and unemployment. At the same time, educational opportunities were enhanced to a large extent. Many adults decided to re-invest in their lost schooling years. Thus, the Chinese experience provides a quasi-experiment for testing education re-investment for adults who want to make up for their educational loss due to an unexpected interruption.

There is abundant literature which examines human capital investment on the part of children (e.g., Chiswick 1988; Blau 1999; Plug 2004; Black, Devereux and Salvanes 2005; Banerjee, Cole, Duflo and Linden 2007). Most human capital decisions for children are made by their parents. The extant literature has paid little attention to adult human capital investment through re-schooling. This paper tries to fill this void. From a different perspective, Banerjee, Cole, Duflo and Linden (2007) use the field experiment of a remedial educational program to analyze whether the program provides help to students lagging in basic literacy and numeracy skills. We use the natural experiment of the Cultural Revolution to examine whether there is human capital pick-up (required and conducted by the people themselves) for those whose education had been interrupted.

Educational policy has changed greatly during the economic transition in China. Educational qualifications have become essential parts of requirements for promotion in government posts. At the same time, the particularly rapid economic development has caused a great demand for skills. Employees in many industries and occupations have been put under pressure to find "self-incrementing" ways through studying for higher degrees and qualifications. The word "self-increment" has become very popular in newspapers and magazines, which urge individuals to participate in re-schooling and training programs. We mainly focus on

formal re-schooling for adults in this study. Educational policy can be a catalyst in the decision on human capital re-investment. It may affect educational attainment in two ways: through the channel of the educational supply, such as college and evening class expansion; and through the channel which affects demand, by influencing relative benefit and cost of re-schooling. We will discuss these in our analysis.

We use two datasets in our analysis. In the longitudinal data we will use, we can observe the re-schooling behaviors of every individual directly. We remove the cohort trend and get the treatment effect based on discontinuity structure (see also e.g., Almond 2006), and identify the long-run re-schooling behaviors of treated cohorts from adjacent cohorts. However, the panel data do not cover information for every year, and the sample size is relatively small. Therefore, we also use another large-scale repeated cross-sectional dataset to study the different re-schooling behaviors between treatment group and comparison group. This dataset does not provide information on an individual's schooling history (we only have the schooling level as of the survey date). To examine re-schooling for adults, therefore, we look at educational attainment of successive cohorts over time. Cohort analysis is widely used in the literature (e.g., Card and Lemieux 2001, 2002; Charles and Luoh 2003). A common theme in cohort analysis is that unobserved cohort-specific factors can be controlled for with synthetic cohort data. Moffitt (1993) points out some virtues of synthetic cohort data relative to panel data.

The contribution of this paper lies in three areas. First, it presents new evidence on human capital re-investment, which has rarely been analyzed in the literature. Using the Cultural Revolution as a quasi-experiment, we analyze interrupted human capital investment and its resumption when new educational and economic opportunities arise. Second, we provide some interesting explanations. The most interesting explanation is the make-up effect for lost education due to the Cultural Revolution. We also test some interesting explanations related to economic transition. Third, we analyze why re-schooling is important to the literature on the educational loss due to the Cultural Revolution. Ignoring remedial

actions by individuals to pick up the losses would result in downward biases in the estimates of educational losses caused by that tragic event.

2. Theoretical Framework

The classic paper on human capital investment in a life-cycle setting is Ben-Porath (1967). The literature establishes that human capital investment diminishes over time as a person ages because the returns from investment fall. In this section, we modify the standard treatment slightly to accommodate human capital re-investment decisions.

Because of liquidity constraints or institutional shocks, some individuals could have been deprived of education opportunities when they were young. When they grow up, these setbacks may have been removed or the economic environment may have changed such that these adults may decide to re-invest in their education. Let the benefit from education for a person of age A and education level E be captured by its monetary return: $f(A, E)$. The (flow) cost of further education is $g(A)$, with $g_A > 0$. We interpret such cost as the psychic cost of learning. As one becomes older, the ability to acquire new knowledge declines. On the other hand, learning new knowledge is easier with a higher level of prior education.

Let T be the retirement age and r be the rate of interest. For an individual with education level E_0, the net change in lifetime income if he starts to obtain L more years of schooling at age A_0 is given by:

$$\Delta(L) = \int_L^{T-L-A_0} e^{-rt}[f(A_0+t, E_0+L) - f(A_0+t, E_0)]dt - \int_0^L e^{-rt}[g(A_0+t) + f(A_0+t, E_0)]dt. \tag{1}$$

The marginal gain from re-investment in education is:

$$\Delta'(0) = \int_0^{T-A_0} e^{-rt} f_E(A_0 + t, E_0)dt - (f(A_0, E_0) + g(A_0, E_0)). \tag{2}$$

The first term is the benefit from human-capital re-investment and the second term is the cost. At a higher age A_0, the length of the period for collecting the human capital returns is

shorter, and hence the benefit is smaller. At the same time, the opportunity cost as well as the direct cost of education increases with age. Therefore, people are less likely to re-invest in schooling as they grow older.

Turning now to the effect of initial education E_0 on the gains from re-schooling, we have:

$$\frac{\partial \Delta'(0)}{\partial E_0} = \int_0^{T-A_0} e^{-rt} f_{EE}(A_0 + t, E_0) dt - f_E(A_0, E_0). \tag{3}$$

If there are diminishing returns from education ($f_{EE} < 0$), then the above term is negative. For people with the same years of schooling, their effective initial education level E_0 is lower if they experience greater education disruption during the Cultural Revolution. Our analysis therefore suggests that people who are more greater affected by the Cultural Revolution during their schooling years are also more likely to re-invest in education once the opportunity resumes.

3. Increases in Educational Attainment among the Adult Population

The economic transition and education development have provided a very good opportunity for those whose education had been interrupted or deprived. After the Cultural Revolution, China has employed a series of policies to enhance the education system. First, in 1977, the government restored the college entrance examination, which ensured the fairness of educational opportunity for students. However, the education system in the 1980s was still quite outdated for a modern economy. During that period, many courses (particularly in management and social sciences) were designed to meet the demands of centrally-planned economy. Only since the early 1990s have university courses been revamped to a level more comparable with international norms. Second, universities and colleges began to set up a two-track system: those with higher scores in the entrance examination would pay lower fees, while those with lower scores would pay much higher fees. This provided an avenue for people with the incentives but not the qualifications to attain higher education. Third, there has been a college expansion since the late 1990s, and an expansion in postgraduate

education since the early 2000s. The number of new enrollments in college students and postgraduates had increased at an annual rate of around 30 percent in the period covering 1998–2001 (National Bureau of Statistics in China 2007). Fourth, private schools have appeared, many of which hire experienced teachers, provide high-quality educational facilities, and charge market level tuition fees. From the above description, we know that there has been substantial improvement in education opportunities since the mid-1980s, and that much of the educational reform which may affect adult re-schooling has been present since the 1990s. Therefore, we believe that our sample period since 1988 or 1989 has covered the major re-schooling period.

We use two datasets to analyze the re-schooling: China Health and Nutrition Survey (CHNS), and Urban Household Survey (UHS). We will describe the datasets and analyze the re-schooling patterns using these two datasets in turn.

3.1. Re-schooling of Individuals: CHNS Data

CHNS, an ongoing international collaborative project between the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention, was designed to examine the effects of the health, nutrition, and family planning policies and programs implemented by national and local governments and to see how the social and economic transformation of Chinese society is affecting the health and nutritional status of its population. The survey covers nine provinces that vary substantially in geography, economic development, public resources, and health indicators. A multistage, random cluster process was used to draw the sample surveyed in each of the provinces. Currently there are about 4,400 households in the overall survey, covering some 19,000 individuals. The first round of the CHNS, including household, community, and health/family planning facility data, was collected in 1989. Six additional panels were collected in 1991, 1993, 1997, 2000, 2004, and 2006.

We restrict the CHNS sample to include individuals with average ages between twenty-

two and sixty (inclusive), so that the sample consists of those who would have finished their education under normal circumstances. In addition, we only include those born between 1930 and 1975 (inclusive), in order that the sample cohorts are very close to those whose education was interrupted during the Cultural Revolution. We track the changes in educational level of each cohort in the period covering 1989–2006.

Table 1A lists the distribution of re-schooling years for the overall group, the treatment group, and the comparison group, respectively, using CHNS. Over 50 percent of the treatment group (those those education had been interrupted during the Cultural Revolution) have reinvested in education, but the proportion of the comparison group is about 36 percent. In Table 1B, the average re-schooling years of the treatment group if about 1.41, while that of the comparison group is 1.04. The former is much larger than the latter. It indicates that the treatment group have higher incentives to make up for their lost education.

3.2. Re-schooling of Cohorts: UHS Data

For the synthetic cohort analysis, we use data from the Urban Household Surveys conducted by the National Bureau of Statistics of China from 1988 to 2003. The sample frame of the Urban Household Survey covers households in all urban areas, including cities of all scales in China. It is designed to be representative of conditions at both the provincial and national levels.[1] The data set we use in this paper includes five provinces and one municipality: Guangdong, Liaoning, Shaanxi, Sichuan, Zhejiang, and Beijing. They are roughly representative of China's different regions. Beijing is a rapidly growing municipality in North-Central China. Guangdong and Zhejiang are dynamic economic provinces, standing in the East-Coastal and South-Coastal areas. Liaoning is a heavy-industry province in the Northeast. Shaanxi and Sichuan are relatively less developed provinces in the Northwest and Southwest, respectively.

We restrict the UHS sample to include individuals with ages between twenty-five and sixty (inclusive), so that the sample consists of those who would have finished their education

[1] Zhang et al. (2005) and Han (2006) show that the sample averages of the main variables in this survey are close to those reported in the official statistical yearbooks.

under normal circumstances. From the repeated cross-sectional data, we construct synthetic cohort data according to year of birth, and track the changes in educational level of each cohort in the period covering 1988–2003.

Figure 1 shows the mean years of schooling for each cohort (averaged over all observations) in the pooled data of 1988–2003.[2] Mean schooling increased from 6.7 years for the 1928 cohort to 13.5 years for those born in 1978. However, the rise in educational attainment has not been uniform across successive cohorts. In particular, educational attainment between successive cohorts actually fell for those born during 1940–1950, possibly as a result of the disruptions brought by World War II, the Chinese Civil War and the Cultural Revolution. A similar pattern is observed if we focus on the proportion of college graduates in a cohort, with a deeper education trough for those born during 1940–1960, which reflects a more serious effect of the Cultural Revolution on higher education.[3]

Previous studies have typically assumed that a person's formal education is completed by age twenty-five. One purpose of this study is to find whether education is really completed by that age during a special period of institutional shocks and subsequent economic transition. Therefore, instead of looking at the overall patterns of education by cohorts (as in Figure 1), we will use the synthetic cohort data to analyze how the education attainment of a specific cohort changes through the years. Figure 2 plots the average schooling of selected cohorts over time. Although the graph seems to be noisy to some extent, we can still observe that the curves are generally sloping upward. This means that their education attainment continues to rise beyond age twenty-five, generally considered to be an age when formal schooling should have been completed.

In order to know the precise magnitude of inter-cohort differentials in education and

[2]The Urban Household Surveys report only information on the level of schooling attained. To measure years of schooling, as in Zhang et al. (2005), we convert different levels of education to years of schooling as follows: primary school–6 years, middle school–9 years, high school–12 years, technical school–15 years, and college and above–16 years. Such conversion has also been used in other related studies on schooling in China.

[3]Those born during 1950–1960 only experienced the Cultural Revolution, and therefore could not be affected by World War II and the Chinese Civil War.

intra-cohort changes in education over time, we regressed the educational attainment (mean schooling years) on cohort and year variables. The coefficient of the cohort variable is 0.078, and that of the year variable is 0.019. The coefficient of the cohort variable indicates that educational attainment has increased greatly across successive cohorts. The coefficient of the year variable indicates the rise in educational attainment for each cohort. Since we focus on individuals aged twenty-five or above, the within-cohort rise in education reflects their re-investment in schooling of 0.019 schooling years per year for each cohort. We also regressed the proportion of college and above in each cohort (in percentage point) on cohort and year variables, and find that the coefficient of the cohort variable is 0.4 percentage point, and that of the year variable is 0.4 percentage point. These results reflect the sharp increases in higher education among the adult population. This preliminary evidence suggests a substantial amount of re-schooling in urban China.

we can also depict the overall re-schooling behavior across birth cohorts using UHS. Re-schooling is calculated as the logarithmic increase in mean schooling years for each cohort across the overall sample period 1988–2003. In order to reduce sampling noise, we use the logarithm of the average schooling years for the last three years (2001, 2002 and 2003) minus that for the first three years (1988, 1990, and 1991) for each cohort. In Figure 3, we find that most of the cohorts have positive amounts of re-schooling. In addition, the highest level of re-schooling is taken by those born in the 1950s. Does it arise from the interruptions caused by the Cultural Revolution? We will take up this question in the following analysis.

Before we proceed further, there is a concern that migration, which had been quite widespread in the 1990s, would cause a composition change in the data of cohort if migrants have different education levels compared to local residents. Nevertheless, migrants from rural to urban areas do not have urban household registration (*hukou*), and they are not contained in the data. Another important class of migrants are individuals who go to urban colleges and stay in that city or move to another city to work, which may affect the cohort composition of young people. Most of these individuals are young people under age 25,

because the usual college and university graduation age is around 22. We only analyze the re-schooling behavior for those over age 25, and therefore even those who remain in the city will not affect the cohort composition of those aged over 25. In a related study (Giles, Park and Wang 2007), the educational levels across birth cohorts are compared between residents born in the local area and those born in other areas using the 2000 Chinese census data. The main finding is that there is no substantial difference in educational attainment between these groups of individuals. We have also used panel data from the CHNS to calculate the proportion of individuals who have chosen re-schooling, and find that the proportion is similar to what we find in the present data set: about two to three percent per year. We ran a similar regression of the educational attainment on age and year variables using CHNS, and found the coefficient on the year variable to be about 2–3 percent. In our UHS results, the coefficient on the year variable is about 2 percent. The similarity in the estimated amount of re-schooling from the two datasets adds robustness to our findings.

4. The Impact of Interrupted Education on Human Capital Re-investment

This section analyzes the impact of the exogenous shock (the Cultural Revolution) on the choice of human capital re-investment. The existing literature only focuses on measuring the loss in education caused by the World War II, the Cultural Revolution or school closings (Ichino and Winter-Ebmer 2004; Meng and Gregory 2007; Heaton 2008), but we study people's decisions to re-invest in schooling following the loss: Does interrupted education increase the likelihood that people re-invest in schooling in their adult lives? It is an interesting and important question that can shed light on the theory of human capital investment. Furthermore the education of different cohorts was interrupted to different extents. Do these different groups of individuals respond to the interrupted education with similar re-schooling decisions?

We follow Meng and Gregory (2007) and separate those affected by the Cultural Revolution into five sub-groups. The Cultural Revolution was most fervent during 1966–1968, when education at all levels were stopped. In 1968–1969, primary and junior high school

education recommenced. From 1972 onward, senior high schools began admitting new students directly from junior high schools. Colleges and universities also began restricted and small-scale admission, based upon political attitudes or family background rather than on academic merit. By 1977, the the Cultural Revolution had come to an end. We classify cohorts whose education was interrupted by the Cultural Revolution into five sub-groups: (1) those whose university study was delayed (born in 1947); (2) those whose senior high was interrupted (born 1948–50); (3) those whose senior and junior high were both interrupted (born 1951–55); (4) those whose junior high and primary were interrupted (born 1956–57); and (5) those whose primary education was interrupted (born 1958–61). As noted earlier, from 1972 onward, senior high schools began admitting new students directly from junior high school graduates, and all those who were interrupted in education levels at senior high and junior high before 1972 could not get a further opportunity to return to senior high school. This has caused the greatest loss for those whose education had been interrupted at both senior high and junior high schools, and there is a discontinuous jump in the missed schooling years for this subgroup. Therefore, we predict that there is a larger make-up effect for this subgroup based on our theoretical findings. We define dummy variables CR_g ($g = 1, \ldots, 5$) for these five groups in the empirical work. All these five sub-groups together form what we call the "interrupted education group," and we define a dummy variable IEG to indicate this group. The "interrupted education group" is the treatment group, and all other cohorts constitute the comparison group.

4.1. Discontinuities in Cohort Re-schooling Trends: CHNS Data

With the CHNS panel dataset, we depict the average schooling years for the same individuals before (1989) and after (2006) re-schooling in Figure 4. This figure tells us that there is a trough in educational attainment for those born during 1950s. In particular, the difference between the two lines is the largest for those born during 1950s. However, there is almost no difference between the two lines for those born before 1945 and those born after 1965. Therefore, Figure 4 indicates that re-schooling mostly happened for those whose education

had been interrupted during the Cultural Revolution. We further depict the scatter points of re-schooling across birth cohorts in Figure 5. Again, we find an obvious jump in re-schooling years for those born in the 1950s. We follow Almond (2006) to isolate the cohort effect, that is, the discontinuity characteristic in the re-schooling enables us to identify the treatment effect from adjacent cohorts. Cohorts who have finished schooling before the Cultural Revolution began and cohorts who have not been enrolled into primary schools after the Cultural Revolution ended are relatively unaffected by the education interruption, therefore providing the comparison group based on the discontinuity design. It is important to control for the cohort effect to identify our treatment effect cleanly. Deviations of re-schooling behaviors from smooth cohort trends are estimations as follows:

$$\Delta Edu_i = \beta_0 + \sum_g \alpha_g CR_g + \beta_1 Birthyear + \beta_2 Birthyear^2 + \beta_3 Birthyear^3 + \gamma X_i + \varepsilon_i. \quad (4)$$

The dependent variable ΔEdu_{ct} is the change in educational attainment for every individual i between the beginning year and the ending year. The five dummy variables CR_g are defined as the five sub-groups whose education was interrupted by the Cultural Revolution. Alternatively, these five sub-groups are grouped together under one dummy variable IEG. Variable $Birthyear$ is calculated as year of birth minus 1950. We include the polynomial quadratic or cubic terms of the variable $Birthyear$ in the independent variable set.

Table 2A presents the results of regression based on Equation (4). Even without removing cohort trend, there is a positive result for the treatment group in the urban area (column 1). However, in the rural area (column 2), re-schooling behavior is much smaller due to the limited opportunities, and the pick-up effect is also quite trivial. Then we take a look at the discontinuity prediction for the treatment effect after removing cohort trend in columns 4 and 5. We find that the coefficient increases after removing cohort trend, and the departure of the re-schooling years of interrupted education cohorts from cohort trend is 0.55–0.74, using polynomial quadratic and cubic, respectively. If follows that there exists a jump in re-

schooling years for the treatment group, and the corresponding graph using the polynomial cubic results is depicted as Figure 6. We can observe the different re-schooling behaviors for the treatment group and comparison group. Similar as our theoretical prediction, there is a jump which can interpreted as the make-up effect. In addition, it slopes down across the year of birth for the treatment group, which indicates that those later cohorts who were interrupted at lower education had less re-investment in education.

We also estimate the discontinuity in re-investment behavior with a piecewise linear model:

$$\begin{aligned} \Delta Edu_i &= \beta_0 + \sum_g \alpha_g CR_g + \beta_1(1946 - Birthyear)Before + \beta_2(Birthyear - 1946)Between \\ &+ \beta_3(Birthyear - 1961)After + \gamma X_i + \varepsilon_i. \end{aligned} \tag{5}$$

Because 1947 and 1961 are the two cutoff points for individuals whose education was interrupted by the Cultural Revolution, we use the distance from each cutoff to the birth-year interacted with the section that every individual belongs to. We have three sections here according to the two cutoffs: those born before the treatment group, the treatment group, and those born after, corresponding to the variables of $Before$, $Between$, and $After$ in equation (5). Table 2B presents the results, and the estimated model is depicted graphically in Figure 7. Similar to Figure 6, the linear estimation has also shown a pick-up effect and the pick-up effect is larger for the sub-group who were born earlier (who experienced more severe disruption). Then as a robustness check, we include only those born closer to the cutoff points with results in column 2, and a larger sample which includes those who do not appear in recent investigation with results in column 3. We find the results are similar to those in column 1.

Table 2C provides a look at the treatment effect for each subgroup. Without removing cohort trend, most of the subgroups do not have a significant effect in column 1, but we find most become significant using the discontinuity prediction for the treatment effects on the

five subgroups in column 2. The coefficients decline with the education interrupted at lower levels on the average. However, we find that those interrupted at junior and senior high have almost similar coefficient as those interrupted at college. It arises from the fact that those interrupted at junior and senior high suffer the highest loss in educational attainment from the Cultural Revolution (Meng and Gregory 2007). Therefore, they have the highest incentive to reinvest in education because of the pick-up effect.

4.2. Determinants of Human Capital Re-investment: UHS Data

In this section we use the repeated cross section data from the UHS to compare the re-schooling behavior between treatment group and comparison group. In the empirical model, we also control for cohort size,[4] and the gender composition of the cohorts. The estimating equation is of the following form:

$$\Delta Edu_{ct} = \beta_0 + \alpha_0 Age_{ct} + \sum_g \alpha_g CR_g + \beta_1 Cohortsize_c + \beta_2 Male_c + \sum_t \gamma_t T_t + \varepsilon_{ct}. \quad (6)$$

In this equation, each unit of observation c is a cohort-gender cell. Every cohort is classified as those individuals born in the same year, and we have 51 cohorts born between 1928 and 1978 (inclusive). Educational attainment is measured in two alternative ways: average number of schooling years and proportion of college graduates. The dependent variable ΔEdu_{ct} is the change in educational attainment for gender-cohort cell c between year t and year $t+1$. It measures the extent of re-investment in human capital of that cohort. The five dummy variables CR_g, which are grouped together under one dummy variable IEG, are all the same as those defined in Equation (4). T_t refers to year dummies. Section 2 discusses how the age of an individual affects his decision to re-invest in schooling. We therefore include age in the regression as an independent variable. The summary statistics for these variables and the other control variables are reported in Appendix Table 1. We use weighted least squares to

[4]Cohort size is defined as the fraction of that cohort in the population. Changes in the population structure in China have been quite dramatic. For example, the birth rate declined sharply and mortality rose during the Great Famine of 1959–1961 due to the sudden reduction in agricultural output (Lin and Yang 2000), leading to small cohort sizes for these years.

estimate the equation, with weights based on the cell size of each cohort in every year. We report robust standard errors in the results.

Table 3A shows the results when the dependent variable is the change in mean schooling years. The age effect is significantly negative, which confirms our theoretical findings in Section 2 that re-schooling should be conducted as earlier as possible in order to achieve greater potential benefits. We find that the coefficient for the "interrupted education group" is insignificantly positive in column 1 of Table 3A. When the "interrupted education group" is divided into five sub-groups, we find that most of these sub-groups have insignificantly positive coefficients (column 2). Only the first, third and fourth sub-groups have invested in re-schooling, but with an insignificant traditional level. In Table 3B, we use the change in proportion of college graduates within a cohort as the dependent variable and find similar results: the effect of age on human-capital re-investment is negative, and the sub-group with delayed university studies tend to invest more in re-schooling relative to other cohorts. This latter result confirms our prediction that those interrupted at higher educational levels will have greater intention to re-invest in education.

Regarding the effect of cohort size, we find that it has a negative effect on re-schooling in almost all specifications, which seems to be in accordance with the negative effect found in the literature (Charles and Luoh 2003). The results on interrupted education variables are robust to the inclusion of cohort variables.

We further examine the factors that may affect the demand for re-investment in education. China went through a period of rapid economic transition following its economic reforms from a centrally-planned economy to a market-oriented economy. The demand for skills has increased, but the labor market uncertainties inherent in a modern economy also loom large. The literature has advanced three important factors that may affect the costs or benefits of human capital investment.

Education Premium. It is perhaps not very surprising that returns to education will affect decisions on education investments (e.g., Haveman and Wolfe 1995; Charles and Luoh 2003).

A higher education premium tends to encourage individuals to pursue higher educational attainment. We measure education premium by the logarithmic wage differential between college (and above) graduates and high school graduates. We find that the college premium increased from about 15 percent in 1988 to nearly 40 percent in 2003, though the rate of increase has slowed down since the 2000s. Such large increases in the returns to higher education are expected to induce individuals with interrupted education to re-invest in a college degree.

Earnings Uncertainty. Charles and Luoh (2003) advance the importance of earnings uncertainty in education investment. Greater earnings uncertainty will prevent risk-averse individuals from fulfilling higher educational levels. Earnings uncertainty in China has increased greatly due to the decentralization of wage-setting. Measured as the 90–10 percentile wage differential within an education group, earnings uncertainty among college graduates has nearly doubled between 1998 and 2003. The same is true for other education groups. Therefore, it will be interesting to test whether this greater uncertainty in the economic transition has a negative effect on human capital investment among adults.

Employment Opportunities. There is a sparse literature (Fredriksson 1997; Rice 1999) that touches on the effect of employment opportunities on human capital investment. Unemployment is not evenly distributed across skill groups; it tends to be concentrated toward lower-skilled groups. The unemployment rate increased sharply when China turned from a centrally planned to a market-oriented economy. However, the rise in unemployment among the college-educated was much slower than that among the lower education groups. With a higher unemployment rate, the incentive for investment in education may be expected to increase because the risk of unemployment is lower among the more educated and because the opportunity cost of education is also depressed.

We augment the empirical model of equation (6) to include the factors due to economic transition discussed above. Let EP_{ct} be the education premium, defined as the relative wage of college graduates to high-school graduates, for the gender-cohort cell c at year t. Let

EU_{ctk} be the variables that measure earnings uncertainty, defined as the within-group wage dispersion of group k within cell c at time t. We use two groups here: college and high school. Finally, let PU_{ctk} refer to potential unemployment, calculated as the unemployment rate for group k in cell c at year t. Again, we use the same two groups (college and high school) for k.

We present the results after controlling for economic transition variables in columns 3, 4, and 5 in Tables 3A and 3B. In Table 3A, we find that education premium has a significant positive impact on human capital re-investment: a ten percent higher education premium (EP) increases re-schooling by 0.0085 year. In regressions using the change in proportion of college graduates as a dependent variable (Table 3B, columns 3, 4, and 5), we find that EP has a positive, albeit statistically insignificant, effect on college attainment. The coefficients on the earnings uncertainty and employment opportunities variables (EU and PU) are statistically insignificant in both Tables 3A and 3B. We conclude that, among the three economic variables considered, the size of education premium has the greatest effect on human capital re-investment. We also test this result by including only EP in our regressions, and find that it continues to have significantly positive effects on re-schooling.

The effect of age on re-schooling continues to be significantly negative when the economic transition variables EP, EU and PU are added to the regressions. The results show that a cohort's average investment in re-schooling years is reduced by 0.14 year as the cohort grows older by ten years, and the probability of receiving college or above degrees is reduced by 1 percent. This is consistent with our prediction that re-investment decisions are typically made early in adult life to ensure a longer period of education returns.

In column 3 of Table 3A, the average education increase for the "interrupted education group" is 0.028 year per year more than the comparison group (all other cohorts), and is statistically significant at the five percent level.[5] Similarly, if we divide this cohort into sub-

[5]This is the re-schooling per year, and therefore we estimate the accumulated re-schooling to be about $0.028 \times 15 = 0.420$ year across our sample period 1988–2003. This number is quite close to our discontinuity prediction of 0.55 in Table 2A and 0.52 in Table 2B.

groups, we find that there is one more variable becoming more significant after controlling for economic transition factors (column 4). In columns 3 and 4 of Table 3B, we show the results for advanced education after controlling for economic transition variables. Column 3 indicates that the "interrupted education group" did not re-invest significantly more in college degrees than the comparison group. However, when we divide this cohort into sub-groups (column 4), we again find a significant re-investment in advanced education among the sub-group whose university studies had been delayed.

In column 5 of Tables 3A and 3B, we use the sample of only the treatment group, and compare the different re-schooling behaviors within the treatment group, using those interrupted at the primary school as the base. We find that the difference seems to be more obvious than columns 2 and 4. In column 5 of Table 3A, we can observe the declining trend of re-schooling years for those interrupted at lower education levels. Regarding the proportion of college and above, we find similar patterns, and only those delayed university and interrupted senior high school have significant and positive coefficients.

4.3. Discussions of Results Using CHNS and UHS

We find that individuals and birth cohorts whose education had been disrupted during the Cultural Revolution have both chosen to make up for their lost education, regardless of which dataset or methodology we use. It follows that a sharp institutional shock can deprive people of education, but individuals have a high incentive to pick up the lost education when educational opportunities arise and benefits overtake costs of re-schooling.

Those who suffered the greatest losses during the Cultural Revolution, i.e., those interrupted at both senior and junior high schools, have a high incentive to make up for the missed schooling years. In Table 3B, we observe that only the sub-groups that experienced delayed university studies and senior high school have chosen to re-invest in university degrees while all other sub-groups in the "interrupted education group" have not done so significantly although they had all been deprived of advanced education to a large extent. We believe that the re-schooling cost is a very important explanation to this finding. For those who have

been interrupted in lower educational levels, the cost of re-schooling to advanced degrees is particularly high: not only the opportunity cost of longer time to finish these degrees, but also a higher psychic cost of learning as a result of inadequate preparation. For those who had been interrupted at a low educational level, the educational loss may persist throughout their life. This situation can be considered a low-education trap: the low-educated had their schooling disrupted at an early stage and were stuck with their low educational attainment even when subsequent re-schooling became possible. This loss is a scar, which is the long-term effect of institutional shocks that cannot be remedied.

Some of those who re-invest in education may not have chosen to fulfill advanced educational degrees, but just make up for some of their middle or high school years. The difference between Tables 2A and 2C, 3A and 3B tells us that for those interrupted at a lower educational level, they re-invest in schooling years while seldom re-investing in advanced education. It follows that these individuals conduct "self-increment" by making up for the lost basic education, rather than finishing more advanced degrees. This result also suggests that the cost of these individuals to complete advanced degrees is relatively high.

Regarding the relative importance of the Cultural Revolution and the economic transition in adult re-schooling decisions, we conduct a brief counter-factual analysis based on the synthetic cohort analysis. We remove the estimated effects of each set of factors using the empirical model shown in column 4 of Table 3A, and compare how the amount of re-schooling would have been affected. Figure 8 depicts counter-factual results.[6] We find that re-schooling is significantly positive across all birth cohorts, and removing the Cultural Revolution variables (CR_g) or the economic transition variables (EP, EU and PU) each reduces the predicted amount of re-schooling. The estimated amount of re-schooling after removing the Cultural Revolution variables declines sharply for those whose education had been interrupted in the Cultural Revolution period, but, as expected, does not change much

[6]Because we use regressions to calculate counter-factual results and ignore other variables such as age, it is possible to get some re-schooling estimates that are negative. The focus here is to compare relative magnitudes rather than the absolute values of the estimates.

for more recent birth cohorts. The line overlaps with the original line of "Schooling increase" for the most recent cohorts whose education had not been interrupted by the Cultural Revolution. In comparison, we find that the curve showing the estimated amount of re-schooling after removing the economic transition variables only declines a little for the "interrupted education group," but lies far below the other two curves for the more recent cohorts. The comparison of these results shows that picking up the losses is the dominant consideration for those whose education had been interrupted in the Cultural Revolution, while conventional cost-benefit calculations in response to the economic transition are the major consideration for the more recent cohorts. Both factors are important in the explanation of the re-schooling decision, and the relative importance of these two effects are different across different birth cohorts.

5. The Role of Re-schooling in the Estimation of Educational Loss

A common practice in the estimation of educational loss due to large scale disruptions uses data from a period long after the disruption occurred. In this paper, we find that the incentive to pick up the losses by re-schooling is quite strong for those whose education had been interrupted by the Cultural Revolution. Therefore, we believe that the estimation results for educational loss due to the Cultural Revolution are sensitive to the choice of the sample period. When using a sample from earlier years, the estimation results may reveal the true educational losses directly caused by the Cultural Revolution. When using a sample from later years (i.e., after 1992), the estimated educational loss might be mixed up with subsequent re-schooling that offsets the direct educational loss to some extent.[7]

We run a regression estimating the educational loss due to the Cultural Revolution, replacing the dependent variable in equations (4) and (6) with the level of educational

[7]As discussed earlier, almost all re-schooling behaviors have taken place since the early 1990s when education reform and economic transition accelerated.

attainment. The estimating equations are of the following forms:

$$Edu_i = \beta_0 + \sum_g \alpha_g CR_g + \beta_1 Birthyear + \beta_2 Birthyear^2 + \beta_3 Birthyear^3 + \gamma X_i + \varepsilon_i. \quad (7)$$

$$Edu_{ct} = \beta_0 + \alpha_0 Age_{ct} + \sum_g \alpha_g CR_g + \beta_1 Cohortsize_c + \beta_2 Male_c + \sum_t \gamma_t T_t + \varepsilon_{ct}. \quad (8)$$

Equations (7) and (8) correspond to the empirical models using CHNS and UHS, respectively. All variables are defined the same as those in equations (4) and (6). The results using CHNS are reported in Tables 4A and 4B, for the treatment group and five subgroups, respectively. The beginning three columns report the different specifications of results before re-schooling at 1989, and the remaining three columns for the results after re-schooling at 2006. We can find that without removing cohort trend the educational loss is very trivial. However, the discontinuity prediction for the educational loss of the treatment group turns out to be about 0.37–0.58. The remaining three columns indicate that the educational loss is very small or even positive, which means that there are benefits for the treatment group. The difference between the estimation results for the two periods shows that re-schooling has made up for most of the losses due to the education interruption.[8] The results for the five subgroups in Table 4B are quite similar, although most of results are not very significant at traditional significance levels.

Using UHS, we can have results with every two columns showing results for three periods, respectively: the overall period 1988–2003, the beginning period 1988–1990, and the ending period 2001–2003. Regarding the two columns in each period, the first column displays results for the entire "interrupted education group," and the second column displays coefficient estimates for each of the five sub-groups of the large group IEG.

We find that re-schooling offsets the educational loss to a large extent, as shown in Table 5. The amount of lost schooling for the "interrupted education group" is estimated to be 0.567,

[8]We compare this result with the previous result in Table 2A. The re-schooling in Table 2A is 0.55–0.74. Now, the estimation gap in the educational loss between the beginning period and ending period is about 0.58–0.78. The two results are very similar and comparable.

0.792, and 0.100 for the overall, beginning, and ending periods, respectively.[9] It follows that re-schooling has served to reduce the gap in the schooling years between treatment group ("interrupted education group") and comparison group (other cohorts) greatly: about 87 percent of the initial decline in schooling years is made up for by the end of the sample period. Therefore, the estimation of educational loss that ignores re-schooling would be highly biased if subsequent re-schooling has been very popular. We believe that the figure of 0.792 year of lost schooling years is a more convincing estimate of the true educational loss directly caused by the Cultural Revolution, as this figure is based on an earlier sample period when re-schooling had been quite rare, as discussed in Section 3.[10] A brief comparison of our result with the educational loss due to the World War II (Ichino and Winter-Ebmer 2004) shows that the Cultural Revolution had a more destructive impact on education. The educational loss in schooling years caused by the World War II was about 0.16 in Germany, 0.11 in Austria, 0.07 in Sweden, and even had a beneficial (positive result in the regression) effect at 0.11 in Switzerland.[11] However, our result indicates that the educational loss due to the Cultural Revolution is 0.792, much higher than that due to World War II. Even with the compensation of re-schooling, the educational loss is still about 0.1, similar to that due to the World War II. The Cultural Revolution has a more destructive effect on education because schools were largely closed during the shock period.

For the sub-groups of the "interrupted education group," we find similar results. If we compare column (5) with column (6), we can find that the largest difference arises from two subgroups: those delayed university and those interrupted at junior and high senior schools. It confirms our theoretical prediction of the make-up effect. For those with delayed university

[9] We compare this result with the previous result in Table 3A. The re-schooling year per year in Table 3A is 0.028, and therefore the accumulated re-schooling year is 0.420. Now, the estimation gap in the educational loss between the beginning period and ending period is about $0.792 - 0.1 = 0.692$. The two results are similar and comparable.

[10] The under-estimation is very large whether or not re-schooling has been taken into account. As we show in Section 4, the re-schooling is about 0.028 schooling year per year, and therefore the accumulated re-schooling over the transitional period has been large enough to offset the educational loss to a great extent.

[11] The latter two coefficients are insignificant at a traditional significance level, as shown in Table 1 of Ichino and Winter-Ebmer (2004). The authors provide explanations that Austria and Germany were seriously involved in the World War II, while Sweden and Switzerland were away from the conflict.

studies, the estimated schooling loss fell from 0.6 year to 0.27 year as we change the sample period from 1988–1990 to 2001–2003, and the latter estimate is statistically insignificant at conventional levels. For those disrupted at junior and senior high schools, the two figures correspond to 1.14 and 0.53, respectively, both significant at traditional level. We also find that the true educational loss for all other sub-groups in the earlier sample period are higher than the estimated educational loss using data from the more recent sample period.

If we compare our results in Tables 4A and 4B with those in Tables 2A and 2C, or compare results in Table 5 with those in Table 3A, we can reach a preliminary conclusion: the sub-groups interrupted most severely (see column 5 of Table 5) did take more human capital re-investment. This is in accordance with our theoretical predictions. Those interrupted at junior and senior high school also have significantly higher re-schooling, which indicates that the make-up effect is very important in the re-investment decision for this subgroup.

6. Concluding Remarks

This study fills a gap in the human capital literature by explicitly looking at human capital re-investment decisions among adults. China experienced two critical periods which affected education to a large extent: the Cultural Revolution, which interrupted the education of school-age children, and the subsequent economic transition which stimulated great demand for education and expanded the supply of higher education for adults. This study uses these two unique historical episodes to analyze the incentive to make up for lost education through re-schooling. Using a brief theoretical framework, we find that the re-investment in education should be made as early as possible. Those who had suffered the greater loss would have higher incentive to make up for the educational losses. These predictions are tested and confirmed in our empirical analysis.

The average education increase for the "interrupted education group" is 0.52–0.55 year (using CHNS data) or 0.42 year (using UHS data) higher than that for the comparison group (all other cohorts). This make-up effect is quite strong for those adults, regardless of which dataset or methodology we use. We also find that economic transition (in particular, the

large increase in the education premium) has been very important in the demand for re-schooling. Using a brief counter-factual analysis, we find that the make-up effect is strong for those whose education had been interrupted (particularly high for the subgroup who had suffered the greatest educational loss, e.g., the subgroup disrupted at both senior and high schools) during the Cultural Revolution, and the effect of a higher education premium during the economic transition is very sharp for the more recent cohorts. Both factors have had important impacts on the re-schooling decision.

The subject of human capital investment has been an important focus for economic researchers. Similar to the studies of economic and demographic recovery from temporary shocks (Davis and Weinstein 2002; Brakman, Garretsen and Schramm 2004), our findings suggest a human capital pick-up from the destructive shock of the Cultural Revolution. The pick-up has made up for the educational loss greatly, in particular for those whose education had been interrupted at a higher educational level. This study has analyzed the issue of human capital interruption with an encouraging policy implication that human capital investment can be conducted even at a late stage as long as new educational opportunities become available and economic environments provide appropriate incentives. Although subject to the huge shock of the Cultural Revolution (much more serious than World War II), the pick-up ability of affected individuals is so strong that most of the educational losses have been remedied.

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Table 1A. Distribution of the Re-schooling Yeas of Treatment Group (Interrupted Education Cohorts) and Comparison Group in Urban Area using CHNS data

	All groups		Treatment group		Comparison group	
Re-schooling years	Freq.	Percent	Freq.	Percent	Freq.	Percent
0	833	58.25	258	48.59	575	63.96
1	225	15.73	115	21.66	110	12.24
2	64	4.48	22	4.14	42	4.67
3	134	9.37	54	10.17	80	8.9
4	77	5.38	41	7.72	36	4
5	27	1.89	15	2.82	12	1.33
6	40	2.8	14	2.64	26	2.89
7	13	0.91	4	0.75	9	1
8	3	0.21	0	0	3	0.33
9	10	0.7	6	1.13	4	0.44
10	2	0.14	1	0.19	1	0.11
11	2	0.14	1	0.19	1	0.11
Total	1430	100	531	100	899	100

Table 1B. Average Re-schooling Yeas of Treatment Group (Interrupted Education Cohorts) and Comparison Group in Urban Area using CHNS data

Re-schooling Years	Observation	Mean	Standard Deviation	Minimum	Maximum
All groups	1430	1.178	1.895	0	11
Treatment group	531	1.407	1.979	0	11
Comparison group	899	1.043	1.831	0	11

Table 2A. Re-schooling Outcomes of Interrupted Education by Regions: CHNS

	(1)	(2)	(3)	(4)	(5)
	Urban	Rural	Urban and rural	Urban	Urban
Interrupted Education Variables					
Dummy for IEG	0.360***	-0.035	0.070	0.739***	0.552***
	(0.104)	(0.074)	(0.048)	(0.150)	(0.157)
BY and BY square	No	No	No	Yes	No
BY , BY square and BY cubic	No	No	No	No	Yes
Gender and region variables	Yes	Yes	Yes	Yes	Yes
Observations	1430	2219	5819	1430	1430
R-squared	0.02	0.01	0.01	0.03	0.04

Note: Robust standard errors in parentheses:* significant at 10%; ** significant at 5%; *** significant at 1%. Weight is used according to the cell size.

Table 2B. Re-schooling Outcomes of Interrupted Education by Linear Estimation: CHNS

	(1)	(2)	(3)
	Urban	Urban smaller sample	Urban larger sample
Interrupted Education Variables			
Dummy for IEG	0.517**	0.576**	0.468***
	(0.223)	(0.236)	(0.180)
Before	-0.005	0.028	0.009
	(0.007)	(0.021)	(0.016)
Between	-0.014	-0.013	-0.027*
	(0.021)	(0.021)	(0.016)
After	0.020	-0.007	-0.026
	(0.017)	(0.023)	(0.016)
Gender and region variables	Yes	Yes	Yes
Observations	1841	1437	2424
R-squared	0.02	0.03	0.02

Note: Robust standard errors in parentheses:* significant at 10%; ** significant at 5%; *** significant at 1%. Weight is used according to the cell size.

Table 2C. Re-schooling Outcomes of Interrupted Education by Different Subgroups of the IEG: CHNS

	(1)	(2)
Interrupted Education Variables		
Delayed University	0.612	0.771*
	(0.418)	(0.428)
Interrupted Senior High	0.030	0.257
	(0.233)	(0.255)
Interrupted Junior and Senior High	0.488***	0.779***
	(0.153)	(0.189)
Interrupted Primary and Junior High	0.231	0.534**
	(0.220)	(0.245)
Interrupted Primary School	0.146	0.422**
	(0.171)	(0.195)
BY and BY square	No	Yes
Gender and region variables	Yes	Yes
Observations	1423	1423
R-squared	0.02	0.03

Note: Robust standard errors in parentheses:* significant at 10%; ** significant at 5%; *** significant at 1%. Weight is used according to the cell size.

Table 3A. The Effect of the Interrupted Education in the Cultural on Reeducation (Increase in Schooling Years)

	(1)	(2)	(3)	(4)	(5)
Age	-0.003***	-0.003***	-0.004***	-0.004***	-0.007**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)
Interrupted Education Variables					
Dummy for IEG	0.007		0.028**		
	(0.009)		(0.013)		
Delayed University		0.009		0.028**	0.074**
		(0.010)		(0.013)	(0.031)
Interrupted Senior High		0.000		0.019	0.056*
		(0.012)		(0.017)	(0.031)
Interrupted Junior and Senior High		0.013		0.048***	0.065***
		(0.010)		(0.014)	(0.019)
Interrupted Primary and Junior High		0.009		0.021	0.023
		(0.015)		(0.014)	(0.014)
Interrupted Primary School		-0.003		0.010	
		(0.013)		(0.015)	

Cohort Variables					
Cohort Size	-2.522*	-1.800	-1.581	0.780	1.465
	(1.472)	(1.972)	(1.412)	(1.896)	(0.995)
Male	0.007	0.007	0.028**	0.031***	0.009
	(0.008)	(0.008)	(0.011)	(0.011)	(0.011)
Economic Transition Variables					
Log Education Premium			0.085**	0.089**	0.050
			(0.035)	(0.035)	(0.056)
Unemployment of College			0.309	0.332	0.549
			(0.496)	(0.512)	(1.508)
Unemployment of High School			0.135	0.199	0.087
			(0.258)	(0.269)	(0.447)
Earning Uncertainty of College			-0.005	-0.005	-0.010
			(0.012)	(0.012)	(0.020)
Earning Uncertainty of High School			-0.006	-0.006	-0.007
			(0.014)	(0.014)	(0.023)
Year dummies	Yes	Yes	Yes	Yes	Yes
Observations	926	926	925	925	449
R-squared	0.09	0.09	0.09	0.09	0.10

Note: Robust standard errors in parentheses:* significant at 10%; ** significant at 5%; *** significant at 1%. Weight is used according to the cell size.

Table 3B. The Effect of the Interrupted Education in the Cultural on Reeducation (Increase in Proportion of College and Above)

	(1)	(2)	(3)	(4)	(5)
Age	-0.001***	-0.001***	-0.001***	-0.001**	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Interrupted Education Variables					
Dummy for IEG	-0.000		0.000		
	(0.001)		(0.001)		
Delayed University		0.003**		0.003	0.011*
		(0.001)		(0.002)	(0.006)
Interrupted Senior High		0.002		0.002	0.008*
		(0.001)		(0.002)	(0.005)
Interrupted Junior and Senior High		-0.001		0.000	0.005
		(0.002)		(0.002)	(0.004)
Interrupted Primary and Junior High		-0.002		-0.002	-0.000
		(0.001)		(0.001)	(0.002)
Interrupted Primary School		-0.001		-0.001	
		(0.002)		(0.002)	

Cohort Variables					
Cohort Size	-0.283	-0.279	-0.147	-0.087	0.170
	(0.221)	(0.287)	(0.212)	(0.277)	(0.167)
Male	0.002**	0.002**	0.003	0.003	0.000
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Economic Transition Variables					
Log Education Premium			0.004	0.005	-0.002
			(0.004)	(0.004)	(0.008)
Unemployment of College			0.120	0.116	0.043
			(0.082)	(0.084)	(0.165)
Unemployment of High School			-0.000	-0.000	0.028
			(0.042)	(0.044)	(0.063)
Earning Uncertainty of College			0.001	0.001	0.001
			(0.002)	(0.002)	(0.003)
Earning Uncertainty of High School			-0.002	-0.002	-0.001
			(0.002)	(0.002)	(0.003)
Year dummies	Yes	Yes	Yes	Yes	Yes
Observations	926	926	925	925	449
R-squared	0.07	0.07	0.07	0.07	0.07

Note: Robust standard errors in parentheses:* significant at 10%; ** significant at 5%; *** significant at 1%. Weight is used according to the cell size.

Table 4A. The Effect of the Interrupted Education in the Cultural Revolution on Education Attainment: Individual Analysis Using CHNS

	(1)	(2)	(3)	(4)	(5)	(6)
	Before Reschooling in 1989			After Reschlooling in 2006		
Interrupted Education Variables						
Dummy for IEG	0.044	-0.583*	-0.373	0.325	0.197	0.209
	(0.210)	(0.300)	(0.331)	(0.204)	(0.294)	(0.325)
BY and BY square	No	Yes	No	No	Yes	No
BY , BY square and BY cubic	No	No	Yes	No	No	Yes
Gender and region variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1283	1283	1283	1283	1283	1283
R-squared	0.09	0.16	0.17	0.09	0.15	0.15

Note: Robust standard errors in parentheses:* significant at 10%; ** significant at 5%; *** significant at 1%. Weight is used according to the cell size.

Table 4B. The Effect of the Interrupted Education on Education Attainment: Different Subgroups of the IEG Using CHNS

	(1)	(2)	(3)	(4)	(5)	(6)
	Before Reschooling at 1989			After Reschlooling at 2006		
Interrupted Education Variables						
Delayed University	-0.374	0.069	0.447	0.239	0.880	0.838
	(0.814)	(0.806)	(0.838)	(0.792)	(0.790)	(0.822)
Interrupted Senior High	-0.480	-0.416	-0.039	-0.595	-0.245	-0.288
	(0.455)	(0.484)	(0.535)	(0.443)	(0.474)	(0.525)
Interrupted Junior and Senior High	-0.158	-0.655*	-0.379	0.286	0.167	0.136
	(0.303)	(0.365)	(0.401)	(0.294)	(0.358)	(0.394)
Interrupted Primary and Junior High	0.154	-0.646	-0.500	0.360	-0.042	-0.058
	(0.435)	(0.471)	(0.479)	(0.423)	(0.462)	(0.470)
Interrupted Primary School	0.831**	-0.113	-0.095	0.801**	0.226	0.223
	(0.350)	(0.387)	(0.387)	(0.340)	(0.380)	(0.380)
BY and BY square	No	Yes	No	No	Yes	No
BY , BY square and BY cubic	No	No	Yes	No	No	Yes
Gender and region variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1283	1283	1283	1283	1283	1283
R-squared	0.10	0.16	0.17	0.09	0.15	0.15

Note: Robust standard errors in parentheses:* significant at 10%; ** significant at 5%; *** significant at 1%. Weight is used according to the cell size.

Table 5. The Interrupted Schooling Years in the Cultural Revolution: Synthetic Cohort Analysis Using UHS

	(1)	(2)	(3)	(4)	(5)	(6)
	Effect on the overall group IEG			Effect on the five subgroups of IEG		
	Pooled sample	Beginning period	Ending period	Pooled sample	Beginning period	Ending period
Age	-0.044***	-0.050***	-0.083***	-0.045***	-0.060***	-0.061***
	(0.007)	(0.012)	(0.009)	(0.006)	(0.012)	(0.009)
Interrupted Education Variables						
Dummy for IEG	-0.567***	-0.792***	-0.100			
	(0.076)	(0.139)	(0.103)			
Delayed University				-0.352***	-0.600***	-0.272
				(0.058)	(0.093)	(0.181)
Interrupted Senior High				-0.735***	-0.793***	-0.627***
				(0.103)	(0.204)	(0.159)
Interrupted Junior and Senior High				-0.838***	-1.137***	-0.525***
				(0.088)	(0.148)	(0.156)

Interrupted Primary and Junior High				-0.422***	-0.237	-0.277***
				(0.063)	(0.142)	(0.072)
Interrupted Primary School				-0.241**	-0.029	-0.119
				(0.099)	(0.143)	(0.086)
Cohort Variables						
Cohort Size	28.842***	15.792	32.931***	-2.092	-52.780**	10.440
	(8.851)	(19.425)	(6.667)	(9.516)	(21.806)	(9.848)
Male	0.787***	1.023***	0.641***	0.750***	0.956***	0.657***
	(0.043)	(0.078)	(0.072)	(0.046)	(0.082)	(0.069)
Economic Transition Variables						
Log Education Premium	-0.336***	-0.503**	-0.379***	-0.396***	-0.683***	-0.409***
	(0.093)	(0.230)	(0.137)	(0.096)	(0.178)	(0.129)
Unemployment of College	-0.107	0.000	-0.139	-0.337	0.000	0.470
	(0.692)	(0.000)	(0.884)	(0.703)	(0.000)	(0.857)
Unemployment of High School	1.892***	-8.829*	0.574	1.341**	-6.005	0.848
	(0.620)	(4.768)	(0.678)	(0.622)	(3.653)	(0.676)
Earning Uncertainty of College	-0.000	0.036	-0.056**	-0.006	0.060	-0.052*
	(0.018)	(0.090)	(0.027)	(0.019)	(0.079)	(0.029)

Earning Uncertainty of High School	-0.069**	-0.280***	0.043	-0.082***	-0.294***	0.046
	(0.028)	(0.099)	(0.035)	(0.029)	(0.083)	(0.030)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	987	184	186	987	184	186
R-squared	0.84	0.79	0.93	0.87	0.85	0.94

Note: Robust standard errors in parentheses:* significant at 10%; ** significant at 5%; *** significant at 1%. Weight is used according to the cell size.

Appendix Table 1. Sample Characteristics of the Synthetic Cohort Data

	Mean	Standard Deviation	Minimum	Maximum
Age	42.5	10.393	25	60
Interrupted Education Variables				
Dummy for IEG	0.528	0.499	0	1
Delayed University	0.139	0.346	0	1
Interrupted Senior High	0.083	0.277	0	1
Interrupted Junior and Senior High	0.139	0.346	0	1
Interrupted Primary and Junior High	0.056	0.229	0	1
Interrupted Primary School	0.111	0.314	0	1
Cohort Variables				
Cohort Size	0.015	0.004	0.007	0.023
Cohort Birthyear - 1928	25	11.370	0	50
Male	0.5	0.5	0	1
Economic Transition Variables				
Log education Premium	0.572	0.590	-2.129	4.431
Unemployment of College	0.008	0.023	0	0.188
Unemployment of High School	0.034	0.056	0	0.299
Earning Uncertainty of College	1.654	1.264	0	7.666
Earning Uncertainty of High School	2.377	1.501	0.589	6.642

Figure 1. Schooling Years and College Proportion across Cohorts

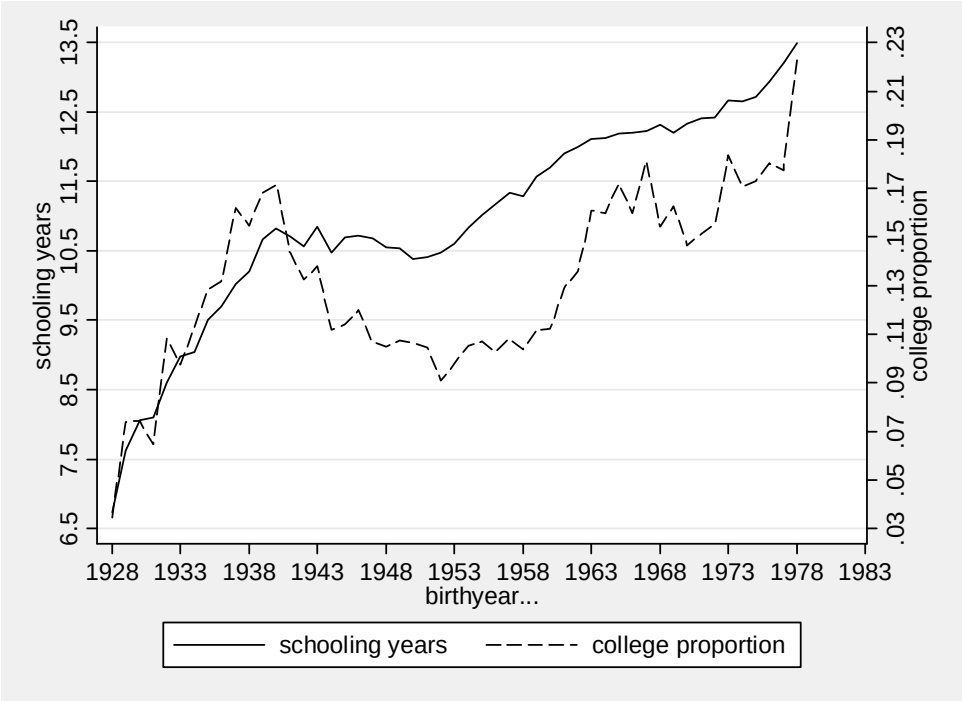

Figure 2. The Education Attainment across Cohorts through Years

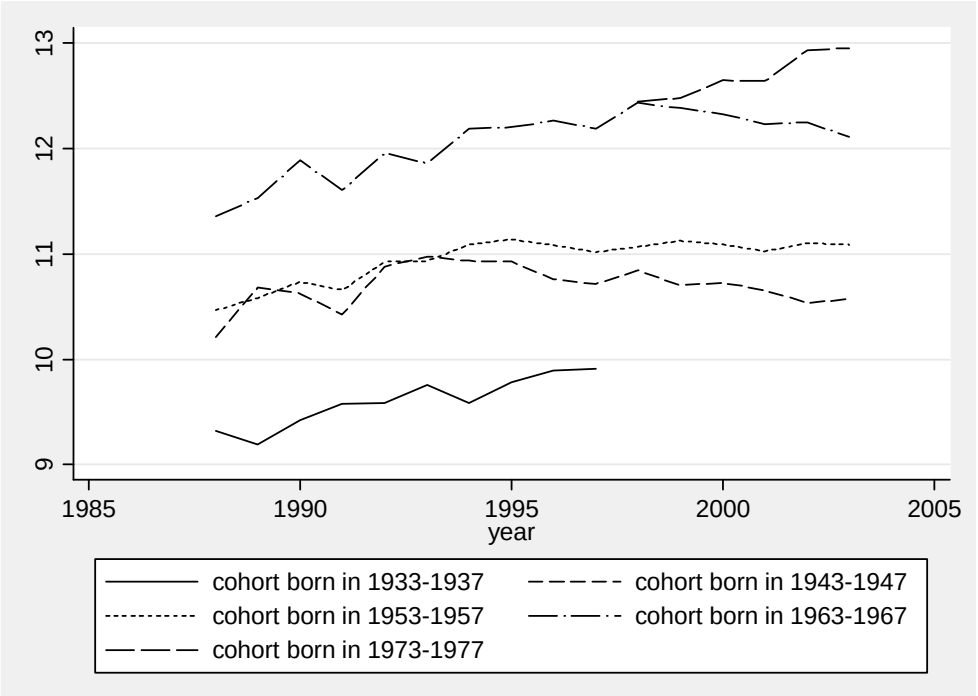

Figure 3. The Re-schooling Between 1988-90 and 2001-03 by Birth Cohorts

Figure 4. Average Schooling Years Before (1989) and After (2006) Re-schooling

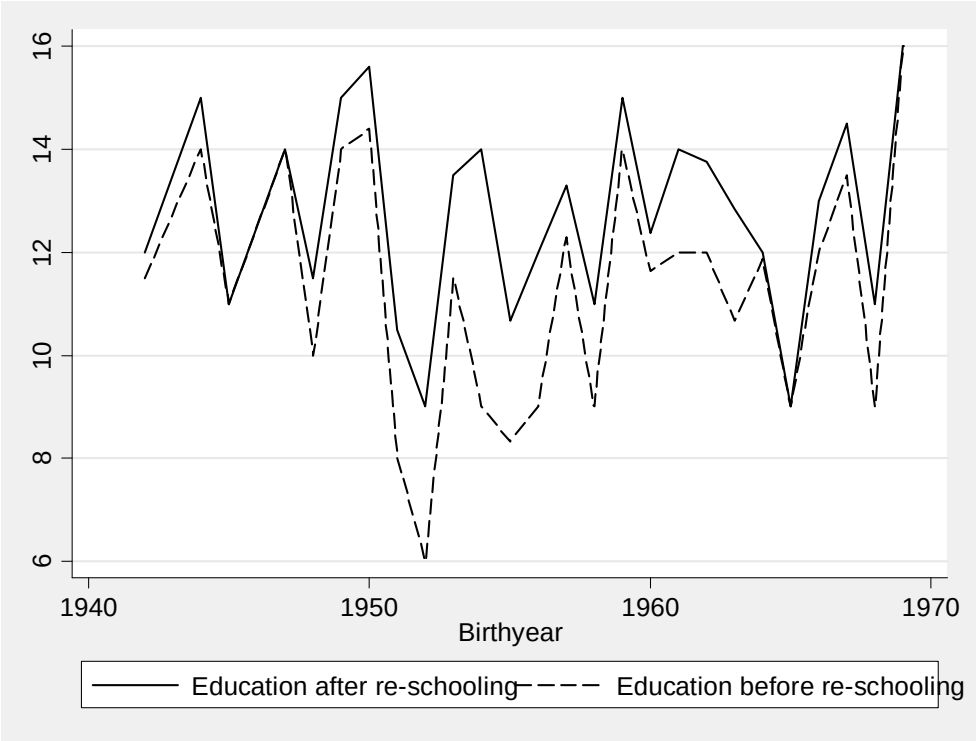

Figure 5. Scatter Points of Re-Schooling Years across Birth Cohorts

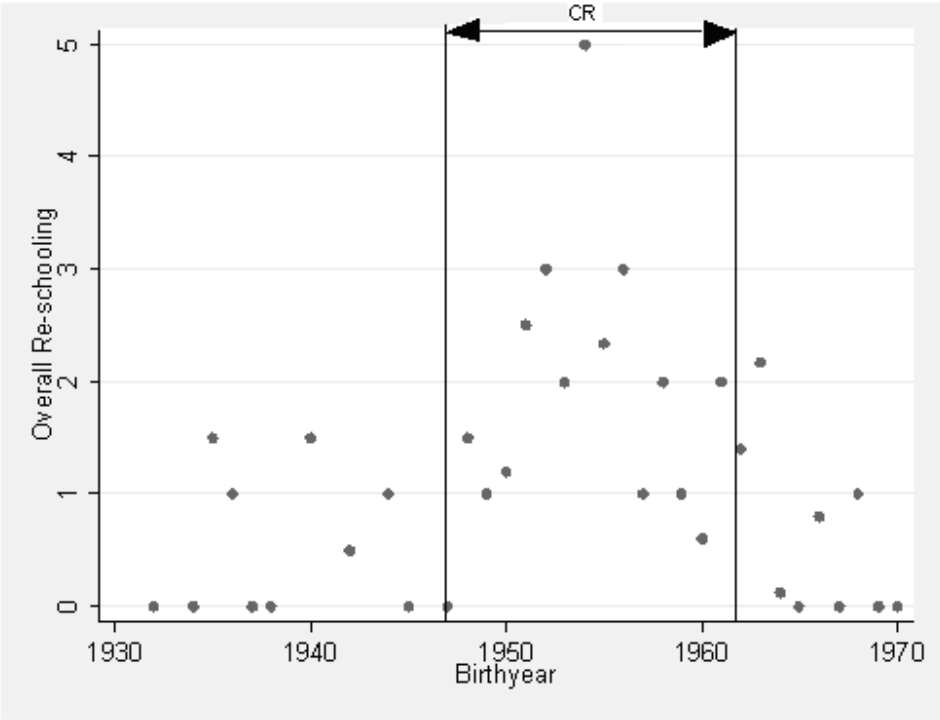

Figure 6. Re-Schooling by Birthyear: Polynomial Cubic Estimation Using CHNS

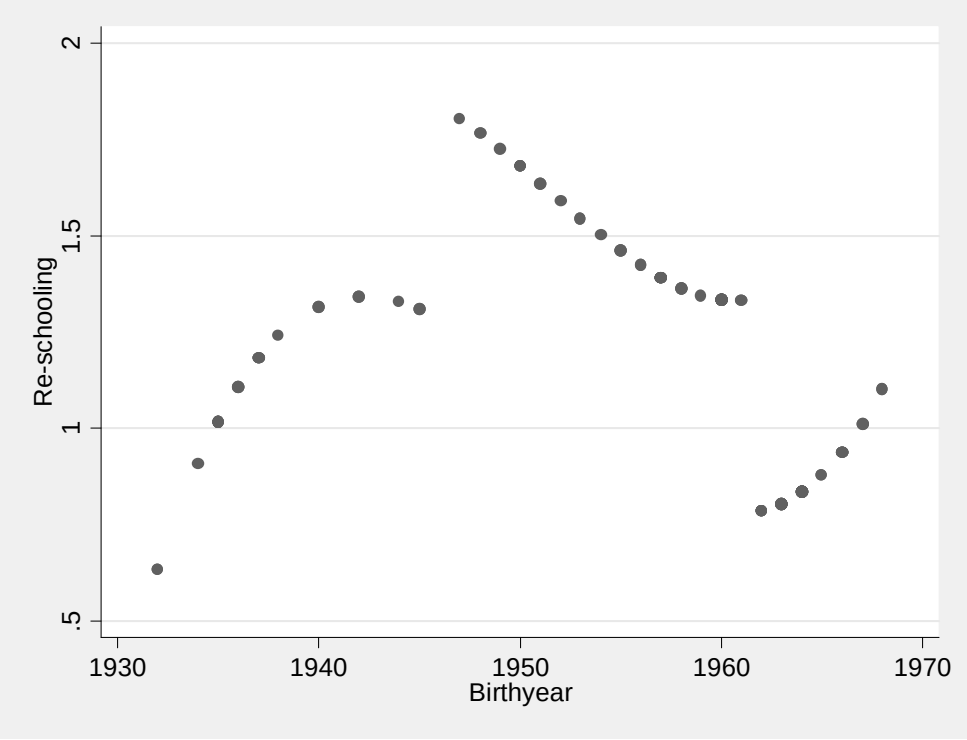

Figure 7 . Re-Schooling by Birthyear: Linear Estimation Using CHNS

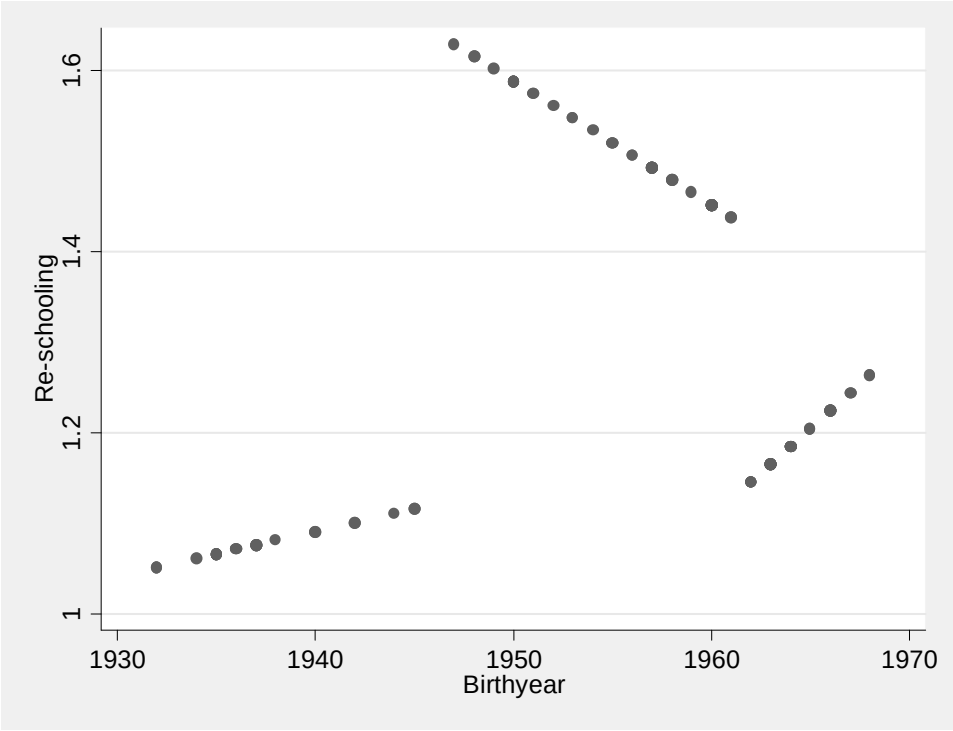

Figure 8. Counterfactual Reeducation after Removing CR or ET Impacts