Picking Up the Losses: The Impact of the Cultural Revolution on Human Capital Reinvestment in Urban China

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This paper uses the Cultural Revolution in China as a quasi-experiment to analyze the long-term impact of interrupted education during an economic transition with many opportunities that reward educational qualifications. We focus on the remedial human capital investment decisions taken by individuals whose education was interrupted by the Cultural Revolution. We find substantial increases in schooling levels among the adult cohorts as they invest in continuous education to compensate for their interrupted schooling and to take advantage of new opportunities afforded by the economic transition. The initial lower level of education caused by the institutional shock can be largely remedied.

I. Introduction

Measuring the long-term impact of large-scale disruptions brought about by war or institutional shocks has been the subject of much recent eco-

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nomic research. Davis and Weinstein (2002) and Brakman, Garretsen, and Schramm (2004) study the effects of World War II bombing on city growth in Japan and Germany, respectively, and find that long-term growth of cities is generally robust to large temporary shocks. Miguel and Roland (2006) study the effects of Vietnam War bombing at a fine geographical level and do not find any significant effects on population density, poverty rates, infrastructure, or illiteracy. Studies also consider the effects of large shocks on human capital investment and returns to education. Ichino and Winter-Ebmer (2004) examine the schooling of German and Austrian children during World War II, Maurin and McNally (2008) 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 1959–64.

In China, the Cultural Revolution in 1966–76 upset the educational system for almost an entire decade, and its effects on human capital investments and returns are considered by Deng and Treiman (1997), Meng and Gregory (2002), Cai and Du (2003), Zhang, Liu, and Yung (2007), and Li, Rosenzweig, and Zhang (2010). These studies on human capital investments generally find a larger negative impact of temporary disruptions than studies based on city growth data. Presumably, restoring human capital investments takes a more protracted period than the recovery of physical infrastructure. In this paper, we focus on the decision of adults to reinvest in human capital following large disruptions in schooling opportunities when they were younger. Using the institutional shocks brought about by the Cultural Revolution in China, we provide evidence on how individuals recovered by reinvesting in schooling in the aftermath of the disruption. Such reinvestment decisions have received little attention in the literature, and we hope our contribution will provide suggestive evidence on how individuals recover from large temporary disasters when there are incentives to do so.

During the Cultural Revolution, schools were largely closed, and many people were prevented from pursuing their primary, secondary, or tertiary 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 for labor outcomes such as wages and unemployment. At the same time, educational opportunities were enhanced. Many adults decided to reinvest in their lost schooling years. Thus, the Chinese experience provides a quasi-experiment to test education reinvestment for adults who want to compensate for their educational loss due to unexpected interruption.

Rather than a one-time shock, the Cultural Revolution deeply influenced an entire generation and perhaps more. This movement not only disrupted

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the schooling of the youth but also forged their ideological beliefs. The Cultural Revolution promoted a strong anti-intellectual ideology. One may imagine that the students who beat their teachers are reluctant to go back to school. However, this ideological influence tends to reduce reschooling and bias the estimates downward. The main purpose of this study is to look at the effect of the Cultural Revolution on reschooling.

Many studies examine human capital investment on children (e.g., Chiswick 1988; Blau 1999; Plug 2004; Black, Devereux, and Salvanes 2005; Banerjee et al. 2007). Most human capital decisions for children are made by their parents. Studies have paid little attention to adult human capital investment through reschooling. This paper tries to fill this void. From a different perspective, Banerjee et al. (2007) use the field experiment of a remedial educational program to analyze whether the program helps students lagging in basic literacy and numeracy skills. We use the natural experiment of the Cultural Revolution to examine whether there are human capital increases (demanded and financed by the people themselves) for those whose education had been interrupted.

The main difference between this and existing studies is that we focus on the reschooling behavior after institutional shocks, while other studies measure the loss in education caused by such shocks (Ichino and Winter-Ebmer 2004; Meng and Gregory 2002; Heaton 2008). We study the decisions of adults to reinvest in schooling following loss and investigate whether interrupted education increases the likelihood that they will reinvest in schooling during adulthood. Thus, we provide a possibility that previous studies may understate the true negative effects of these aforementioned shocks, as individuals may have made up for their educational losses by the time researchers measure their educational attainment.

Educational policy has changed greatly during the economic transition in China. Educational qualifications have become essential requirements for promotion in government posts. At the same time, the rapid economic development has created great demand for higher skills.[1] Employees in many industries and occupations are pressured to pursue "self-increment," by studying for higher degrees and qualifications. The term "self-increment" has become popular in newspapers and magazines, which encourage individuals to participate in reschooling and training programs. We mainly focus on formal reschooling by adults (aged at least 25) in this study. We discuss how educational policy can be a catalyst in the decision on human capital reinvestment and how it may affect educational attainment in two ways: through the channel of the educational supply, such

[1] Anti-intellectual and antieducation sentiments circulated during the 1980s. In the beginning of economic transformation, relatively less educated people earned high income from the free market, and educated people received limited wages under the planned-economy system. People may have been less likely to reinvest in education during these years. Nevertheless, many individuals chose to study abroad during the same period. Many senior officials and executives pursued higher degrees to achieve promotion, which is the driving force behind reschooling. In addition, reschooling has become popular since the early 1990s, after Deng Xiaoping's Southern Tour, which covers most of our sample period.

as college and evening-class expansion, and through the channel that affects demand, by influencing relative benefit and cost of reschooling.

We use two data sets in our analysis. We can directly observe the reschooling behavior of individuals through longitudinal data. We remove cohort trends, obtain the treatment effect based on a discontinuity structure (see, e.g., Almond 2006), and identify the long-term reschooling behavior of treated cohorts from adjacent cohorts. However, the panel data do not cover yearly information, and the sample size is relatively small. Therefore, we also use another large-scale, repeated, cross-sectional data set to study the different reschooling behaviors between the treatment and comparison groups. This data set does not provide information on individual schooling history (we have only the schooling level as of the survey date). To examine reschooling for adults, 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) explains some virtues of synthetic-cohort data relative to panel data.

Previous studies typically assumed that education is completed by age 25. One purpose of this study is to determine whether education is actually completed by this age during special periods of institutional shocks and subsequent economic transition. This paper contributes to four areas. First, it presents new evidence on human capital reinvestment by adults, which has rarely been analyzed in the literature. Second, we provide an interesting explanation why such reinvestment occurs, namely, to make up for opportunities lost as a result of the Cultural Revolution. We also use the subsequent economic transition to test how cost and benefit considerations affect these decisions. Third, using the educational interruption and missing years of schooling as instrumental variables, we analyze the impact of initial education on reschooling to determine whether a lower level of initial education due to the Cultural Revolution can be remedied and to what extent. Fourth, we analyze why reschooling is important to the literature on the educational loss due to the Cultural Revolution. Ignoring remedial actions by individuals to recover would result in downward biases in the estimates of educational losses caused by that tragic event.

This study looks at reschooling in terms of schooling years. China adopts a separate education system for adults, which makes reschooling easy, but the value of adults' degrees and certificates are discounted. Taking college degrees as an example, if a student passes the college entrance test (CET), attends a four-year college, and graduates, then this college degree is considered genuine. Adults can take another separate CET. Those who pass this test go to an adult program, and the college degree obtained in this program is not as valuable as a genuine college degree. Before 1985, adults could take the CET, but they were not allowed to take the CET between 1985 and 2001 and were required to take the adult program. The four-year education in an adult program may not be as valuable as a genuine college program. The mitigation effect of reschooling should be smaller than estimated if we consider the lower value of the adult degree. The schooling quality of such adult reschooling may be quite different from that of normal schooling by younger adults. Thus, one should exercise caution in interpreting the value of such reschooling. However, our study is focused on schooling years rather than schooling quality. In addition, we seldom touch upon wages, which are highly correlated with schooling quality. Thus, the main conclusion of our study is unaffected. If we obtain specific data on education quality in the future, we can analyze the reschooling quality.

II. Theoretical Framework

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

Because of liquidity constraints or institutional shocks, some individuals could have been deprived of education opportunities when they were young. During adulthood, these setbacks may have been removed or the economic environment may have changed such that these adults may decide to reinvest 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 $g(A, E)$, with $g_A \geq 0$ and $g_E \geq 0$. We interpret such costs as tuition fees and disutility from learning. The ability to acquire new knowledge declines with age, and thus we assume that the psychic costs of learning increases with age. Furthermore, we assume that the explicit cost of education rises with the level of education being pursued. For every year of reschooling, the cost for a junior high school student to study in a technical school is typically lower than that for a high school graduate to pursue a college 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 or she starts to obtain L more years of schooling at age A_0 is given by

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

The marginal gain from reinvestment in education is

$$\begin{aligned}\Delta'(L) = &\int_L^{T-A_0} e^{-rt} f_E(A_0 + t, E_0 + L)\, dt \\ &- e^{-rL}[f(A_0 + L, E_0 + L) + g(A_0 + L, E_0 + L)].\end{aligned} \quad (2)$$

The first term is the benefit from human capital reinvestment, and the second term is the cost. At a higher age A_0, the length of the period to collect 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, individuals are less likely to reinvest in schooling as they grow older.

Turning now to the effect of initial education E_0 on the gains from reschooling, we have

$$\frac{\partial \Delta'(L)}{\partial E_0} = \int_L^{T-A_0} e^{-rt} f_{EE}(A_0 + t, E_0 + L)\, dt - e^{-rL}[f_E(A_0 + L, E_0 + L) + g_E(A_0 + L, E_0 + L)]. \tag{3}$$

If $f_{EE} = 0$, then $\partial\Delta'(L)/\partial E_0 < 0$. People with lower initial education have a greater incentive to reinvest in education because both the opportunity cost and the explicit reschooling costs are low. According to the standard human capital earnings function, however, the logarithm of earnings is a linear function of years of schooling. If this is the case, then $f_{EE} > 0$, and $\partial\Delta'(L)/\partial E_0$ becomes indeterminate in sign. For example, suppose $\log f(A, E) = c_0 + c_1 A + c_2 A^2 + c_3 E$, and suppose $g_E(A, E)$ is equal to a constant γ. Then, $\partial\Delta'(L)/\partial E_0 = ke^{c_3 E} - \gamma$ for some constant k. Thus, we can have $\partial\Delta'(L)/\partial E_0 < 0$ for small E_0, but the sign of $\partial\Delta'(L)/\partial E_0$ reverses for large E_0 as the consideration for increasing marginal returns to education becomes dominant.

To summarize the discussion, we have the following results.

1. Younger individuals are more likely to reinvest in education.
2. People with low initial education tend to face a lower cost of reinvesting in education. The effective initial education level E_0 of those whose education was interrupted during the Cultural Revolution is lower if they experienced greater education disruption. Our analysis therefore suggests that people more affected by the Cultural Revolution during their schooling years are more likely to reinvest in education once the opportunity arrives.
3. In the case of $f_{EE} > 0$, it is possible that $\partial\Delta'(L)/\partial E_0 < 0$ for people with low initial education but $\partial\Delta'(L)/\partial E_0 > 0$ for people with high initial education. Since the returns to college education are substantially above the returns to high school education in China, the rising returns to education over time may prompt people with high initial education to reinvest more in schooling.

III. Increases in Educational Attainment among the Adult Population

Economic transition and education development in China have provided many opportunities for people whose education had been interrupted or for those who were deprived. After the Cultural Revolution, China began implementing a series of policies to enhance the education system. First, in 1977, the government restored the CET, 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 a centrally planned economy. Only since the early 1990s have university courses been updated to levels comparable with international norms. Second, universities and colleges began to set up a two-track system: those with higher scores in the CET would pay lower fees, while those with lower scores would pay higher fees. This provided an avenue for people with the incentives but not the qualifications to attain higher education. Third, a college expansion began in the late 1990s, and postgraduate education expanded in the early 2000s. The number of new enrollments among college students and postgraduates increased at an annual rate of around 30 percent in 1998–2001 (National Bureau of Statistics in China 2007). Fourth, private schools have been set up, many of which hire experienced teachers, provide high-quality educational facilities, and charge market-level tuition fees. There has been a substantial improvement in education opportunities since the mid-1980s, and much of the educational reform that may affect adult reschooling has been present since the 1990s. Therefore, we believe that our data beginning in 1988 or 1989 cover the major reschooling period.

We follow Meng and Gregory (2002) and separate those affected by the Cultural Revolution into five subgroups. The Cultural Revolution started in 1966–68, when education at all levels was stopped. In 1968–69, 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 on political attitudes or family background rather than academic merit. The Cultural Revolution ended in 1977. We classify cohorts whose education was interrupted by the Cultural Revolution into five subgroups: (1) those whose university study was delayed (born in 1947); (2) those whose senior high school education was interrupted (born 1948–50); (3) those whose senior and junior high school education were both interrupted (born 1951–55); (4) those whose junior high and primary education were interrupted (born 1956–57); and (5) those whose primary education was interrupted (born 1958–61). See table A1. From 1972 onward, senior high schools began admitting junior high school graduates directly as new students, and those whose education was interrupted at the senior and junior high school levels before 1972 (i.e., group 3 above) were not provided a further opportunity to return to senior high school. This has caused the greatest loss for those whose education was interrupted at both senior and junior high schools, and there is marked increase in the missed schooling years for this subgroup. Therefore, we expect to see a larger make-up effect for this subgroup on the basis of our theoretical results. We define dummy variables CR_g ($g = 1-5$) for these five groups in the empirical work. These five subgroups 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 in the sample (data) constitute the control group.

We use two data sets to analyze reschooling: the China Health and Nutrition Survey (CHNS) and the Urban Household Survey (UHS). We describe the data sets and analyze the reschooling patterns using these two data sets in turn.

A. *Reschooling of Individuals: CHNS Data*

The CHNS was designed to examine the effects of the health, nutrition, and family planning policies and programs implemented by national and local governments and to track how the social and economic transformation of Chinese society is affecting the health and nutritional status of its population.[2] 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 CHNS was collected in 1989. Six additional panels were collected in 1991, 1993, 1997, 2000, 2004, and 2006.

We restrict the CHNS sample to individuals aged over 25, so that the sample consists of those who would have finished their education under normal circumstances. In addition, we include only those born between 1930 and 1980, for the sample cohorts to be close to those whose education was interrupted during the Cultural Revolution. We track the changes in educational level of each cohort in 1989–2006. To reduce the noise of sample attrition, we exclude those who appeared in the data set infrequently. For example, those who appear in the panel data only once (one year) or twice (two consecutive panels) are excluded. The main empirical results presented in this paper pertain to individuals who remained in the CHNS for at least 10 years. All our empirical results are robust to the choice of this cutoff. If we select individuals who remained in the survey for an interval of at least 7, 9, 11, 13, or 15 years, the basic patterns are not affected as long as this cutoff interval is not too short.

It should be noted that potential sample selection/attrition problems exist in the CHNS data. Table A2, which uses the whole panel data set of CHNS to compare the overall sample and our sample, shows that those who left the sample are younger and more highly educated, with slightly

[2] The CHNS is 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.

TABLE 1
Distribution of the Reschooling Years of Treatment Group (Interrupted-Education Cohorts) and Comparison Group Using CHNS Data

	Treatment Group (1947–61)		Comparison Group (Before 1947)		Comparison Group (After 1961)	
Reschooling Years	Frequency	Percent	Frequency	Percent	Frequency	Percent
0	1,303	49.06	1,008	57.50	2,129	73.52
1	533	20.07	218	12.44	322	11.12
2	179	6.74	146	8.33	104	3.59
3	261	9.83	140	7.99	165	5.70
4	143	5.38	78	4.45	77	2.66
5	96	3.61	64	3.65	34	1.17
6	67	2.52	55	3.14	37	1.28
7	25	.94	12	.68	11	.38
8	15	.56	8	.46	3	.10
9	27	1.02	16	.91	8	.28
10	2	.08	2	.11	0	.00
11	2	.08	3	.17	3	.10
12	1	.04	2	.11	3	.10
13	1	.04	0	.00	0	.00
14	0	.00	1	.06	0	.00
15	1	.04	0	.00	0	.00
Total	2,656	100	1,753	100	2,896	100

lower reschooling. However, the lower reschooling mainly arises from the fact that we cannot observe the sample throughout our sample period. The reason lies in either leaving the region to study for a higher degree or changing jobs. If the reason is the former, then it is positively correlated with reschooling. If the reason is the latter, then we cannot assume whether they will conduct reschooling. Given the small difference, our results may not be biased to a large extent.

Table 1 lists the distribution of reschooling years for the treatment group and the comparison group. Over 50 percent of the treatment group (those whose education was interrupted during the Cultural Revolution) have reinvested in education, but the proportion in the comparison group is only about 42 percent for those born before 1947 and 26 percent for those born after 1961. Among those who have reinvested in schooling, the bulk have taken one to five additional schooling years. In terms of average reschooling years, people in the treatment group have invested in 1.4 years, while those in the comparison group have invested in 0.9 years.

B. *Reschooling of Cohorts: UHS Data*

We use data from the UHS, conducted by the National Bureau of Statistics of China from 1988 to 2003, for the synthetic-cohort analysis. The sample frame of UHS covers households in all urban areas, including cities of all scales, in China. It is designed to be representative of conditions at both provincial and national levels.[3] 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 different regions in China. Beijing is the capital city of China. Guangdong and Zhejiang are dynamic economic provinces in the south- and east-coastal areas, respectively. Liaoning is a province in the northeast with a concentration of heavy industries. Shaanxi and Sichuan are relatively less developed provinces in the northwest and southwest, respectively.

We restrict the UHS sample to include individuals aged 25–60, so that the sample consists of those who would have finished their education under normal circumstances. We construct synthetic-cohort data according to the year of birth and track the changes in educational level of each cohort in 1988–2003, using repeated cross-sectional data.

The UHS reports only information on the level of schooling attained. To measure years of schooling, as in Zhang et al. (2005), we converted 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 been used in related studies on schooling in China.[4] Figure 1 shows the mean years of schooling for each cohort (averaged over all observations) in the pooled data of 1988–2003. 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 was not uniform across successive cohorts. In particular, educational attainment between successive cohorts actually fell for those born during 1940–50, 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 1940–60, which reflects a more serious effect of the Cultural Revolution on higher education.[5]

We use the synthetic-cohort data to analyze how the education attainment of a specific cohort changes through the years. We regress educational attainment (mean schooling years) on cohort and year variables to determine the precise magnitude of intercohort differentials in education and the changes in education of any given cohort of over time. The coefficient of the cohort variable is 0.078, while that of the year variable is

[3] 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.

[4] When converting the level of schooling into schooling years, a potential misreporting problem exists. Schooling may be underreported if respondents perceive education level as the finished degree, but it can also be overreported if respondents consider finishing a particular level of schooling as attaining that level of schooling. However, we conduct synthetic-cohort analysis only when using the UHS. Without systematic underreporting or overreporting for cohorts, the mean schooling years can be close to the true values.

[5] Those born during 1950–60 could not be affected by World War II and the Chinese Civil War; the dip in their educational attainment is attributable to the Cultural Revolution.

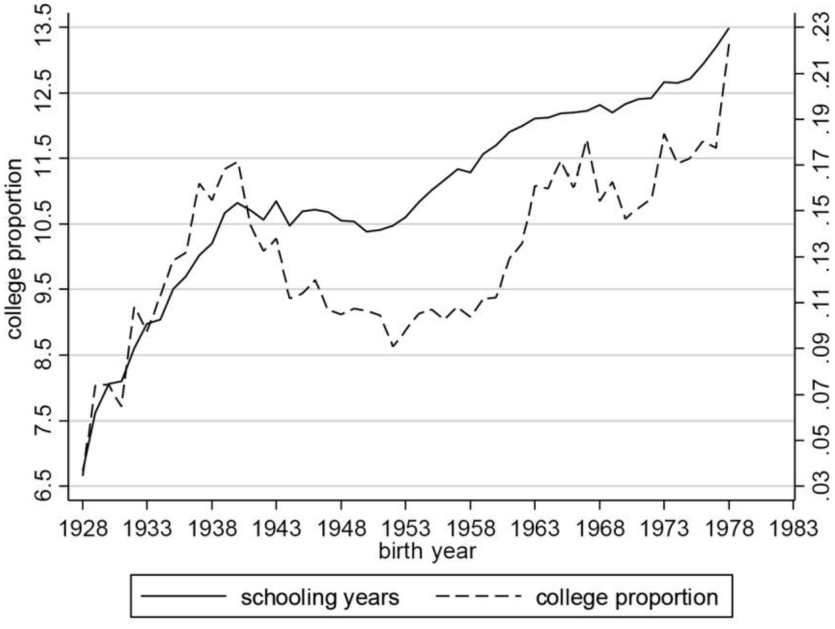

Figure 1.—Schooling years and college proportion across cohorts.

0.019. The coefficient of the cohort variable indicates that educational attainment greatly increased across successive cohorts. The coefficient of the year variable indicates the rise in educational attainment with years. Since we focus on individuals aged 25 or above, the within-cohort rise in education reflects their reinvestment in schooling of 0.019 schooling years per year for each cohort. We also regress the proportion of college and above in each cohort (in percentage points) on cohort and year variables and find that the coefficient of the cohort variable is 0.4 percentage points, the same as that of the year variable. These results reflect the sharp increases in higher education in the adult population. This preliminary evidence suggests a substantial amount of reschooling in urban China.

We can also depict the overall reschooling behavior across birth cohorts using the UHS. Reschooling 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, 1989, and 1990) for each cohort. Figure 2 shows that most cohorts have positive levels of reschooling. In addition, the highest level of reschooling is taken by those born in the 1950s.

Before we proceed further, we address the concern that migration, which was quite widespread in the 1990s, would cause a composition change in the data of cohorts if migrants have different education levels,

Figure 2.—Reschooling between 1988–90 and 2001–03 by birth cohorts.

compared with local residents. Migrants from rural to urban areas do not have urban household registration (*hukou*), and they are not included in the UHS data. We used panel data from the CHNS to calculate the proportion of individuals who chose reschooling and found that the proportion is similar to that in the present data set: about 2–3 percent per year. We ran a similar regression of educational attainment on age and year variables using the 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 reschooling between the two data sets adds confidence to our findings.

IV. Impact of School Interruption on Human Capital Reinvestment

This section analyzes the impact of the exogenous shock (the Cultural Revolution) on the choice of human capital reinvestment.

A. Discontinuities in Cohort Reschooling Trends: CHNS Data

We depict the average schooling years for the same individuals before (1989) and after (2006) reschooling in figure A1, using the CHNS panel data set. There is a trough in educational attainment for those born in the 1950s; specifically, the difference between the two lines is largest for those born in the 1950s. However, there is almost no difference between the

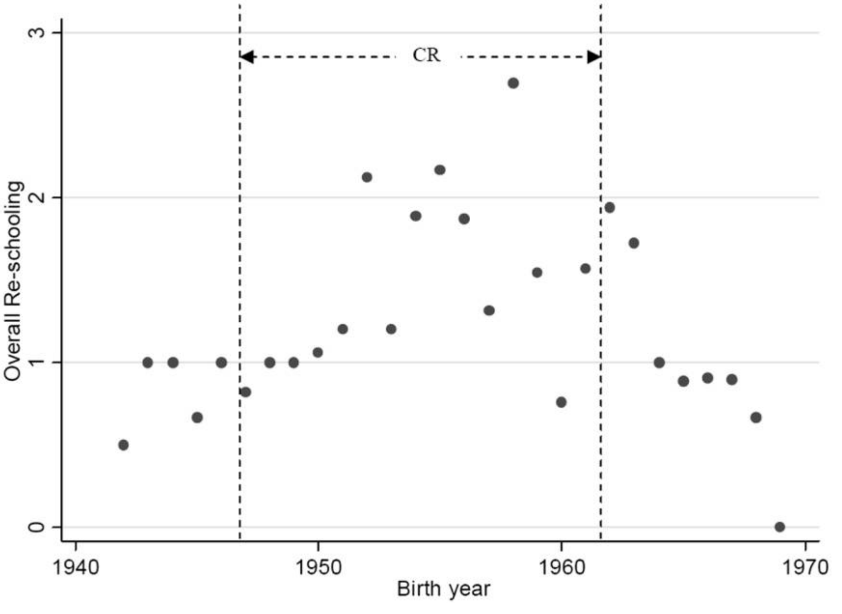

Figure 3.—Scatter points of reschooling years across birth cohorts. CR: Cultural Revolution.

two lines for those born before 1945 and those born after 1965. Therefore, reschooling was chosen mostly by those whose education was interrupted during the Cultural Revolution. We further depict the scatter points of reschooling across birth cohorts in figure 3. Reschooling years showed a marked increase for those born in the 1950s. We follow Almond (2006) to isolate the cohort effect, using the discontinuity in reschooling to identify the treatment effect from adjacent cohorts. Cohorts who finished schooling before the Cultural Revolution began and those who were not enrolled in primary school after the Cultural Revolution ended are relatively unaffected by the education interruption, therefore providing the comparison group based on the discontinuity design. The identification assumption is that the different cohorts differ only in the presence or duration of the Cultural Revolution. Naturally, one might be concerned with differences in labor market entry conditions for different cohorts. We come back to this issue in Section IV.E. It is important to control for the cohort trend, which is measured by the (polynomial) birth year variables, to identify our treatment effect cleanly. Deviations of reschooling behaviors from smooth cohort trends are estimated as follows:

$$\Delta \mathrm{Edu}_i = \beta_0 + \sum_g \alpha_g \mathrm{CR}_g + \beta_1 \mathrm{Birthyear} + \beta_2 \mathrm{Birthyear}^2 + \beta_3\ \mathrm{Birthyear}^3 + \gamma X_i + \varepsilon_i. \quad (4)$$

TABLE 2
Reschooling Outcomes of Interrupted Education: CHNS

Interrupted-education variables	(1)	(2)	(3)
Dummy for IEG	.482***	.171***	.171***
	(.045)	(.059)	(.060)
Birthyear and quadratic of Birthyear	No	Yes	No
Birthyear and quadratic and cubic of Birthyear	No	No	Yes
Gender and region variables	Yes	Yes	Yes
Observations	7,305	7,305	7,305
R^2	.03	.04	.05

Note.—Robust standard errors clustered at cohort level are in parentheses.
*** Significant at the 1 percent level.

The dependent variable ΔEdu_{ct} is the change in educational attainment for every individual i between the beginning and the ending years. The five dummy variables CR_g are defined as the five subgroups whose education was interrupted by the Cultural Revolution. Alternatively, these five subgroups are grouped together under one dummy variable IEG. The variable Birthyear is calculated as year of birth minus 1950. We include the polynomial quadratic and cubic terms of the variable Birthyear in the independent variable set. The variable X includes some control variables, including gender and region variables.

Table 2 presents the results of the regression based on equation (4). There is a positive coefficient for the treatment group (col. 1) without removing the cohort trend. We then look at the discontinuity prediction for the treatment effect after removing the cohort trend in columns 2 and 3. The coefficient falls after the cohort trend is removed, and the departure of the reschooling years of interrupted cohorts from the cohort trend is 0.17, with or without the cubic term. Our model reveals a jump in reschooling years for the treatment group, and the corresponding graph using the polynomial cubic results (eq. [4]) is depicted in figure 4, which shows the different reschooling behaviors for the treatment group and the comparison group. The discontinuity is the make-up effect.[6] Note also that reschooling for the treatment group slopes down across the year of birth, which indicates that later cohorts who were interrupted at lower education levels had lower reinvestment in education.

We also estimate the discontinuity in reinvestment behavior with a piecewise linear model:

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

[6] This methodology is akin to a recent application of regression discontinuity to analyze the long-run effects of the *mita*, a forced mining labor system in Peru and Bolivia between 1573 and 1812 (see Dell 2010).

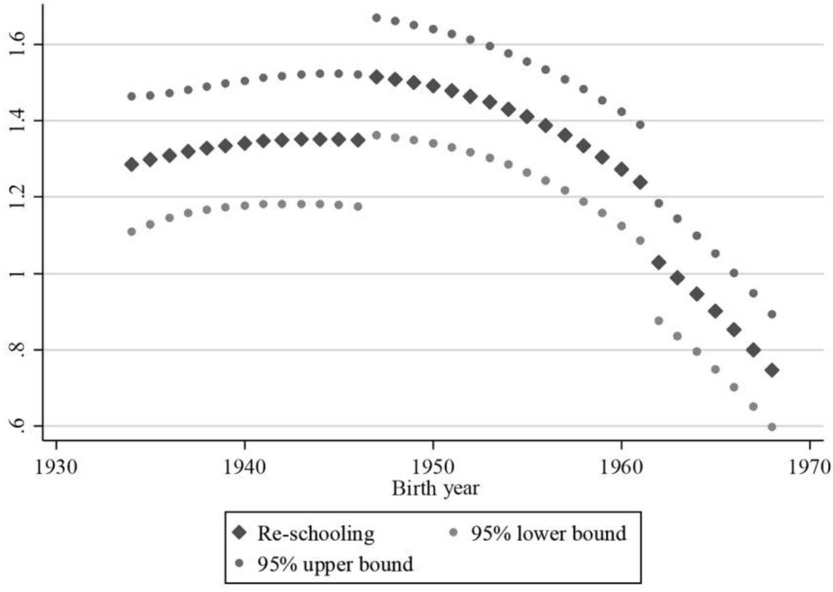

Figure 4.—Reschooling by birth year: polynomial cubic estimation using CHNS data.

The years 1947 and 1961 are the two cutoff points for individuals whose education was interrupted by the Cultural Revolution. We have three linear sections separated by the two cutoffs: those born before the treatment group, the treatment group, and those born after, corresponding to the variables Before, Between, and After, respectively, in equation (5). Column 1 of table 3 presents the results, and the estimated model is depicted graphically in figure 5. Similar to figure 4, the linear estimation also shows a discontinuity indicating the pickup effect. As a robustness check, we include a smaller sample with only those born closer to the cutoff points (born between 1935 and 1975, rather than born between 1930 and 1980 in col. 1), with results in column 2, and a larger sample that does not exclude those who appear infrequently (rather than just those with staying in the survey for at least 10 years in col. 1), with results in column 3. The results are similar to those in column 1, but the coefficients are smaller to some extent.

The school entry age rule was never strictly implemented until the late 1990s. A child may start first grade at age 8, 7, 6, or as early as 5. The treatment might not be accurately limited in the birth cohort 1947–61. Thus, we conduct a robustness check by removing the births near the cutoff years, for example, removing 1946–48 and 1960–62. We find results similar to those of table 2, with even higher coefficients. Therefore, our results are not influenced by the different entry age.

B. *Determinants of Human Capital Reinvestment: UHS Data*

In this subsection, we use repeated cross-section data from the UHS to compare the reschooling behavior between the treatment group and

TABLE 3
Reschooling Outcomes of Interrupted Education by Linear Estimation: CHNS

Interrupted-Education Variables	Original Sample (1)	Smaller Sample (2)	Larger Sample (3)
Dummy for IEG	.210**	.169*	.141**
	(.092)	(.096)	(.068)
Before	.007	.004	.007
	(.006)	(.010)	(.005)
Between	−.004	−.004	−.005
	(.009)	(.009)	(.006)
After	−.073***	−.084***	−.053***
	(.006)	(.008)	(.004)
Gender and region variables	Yes	Yes	Yes
Observations	7,305	6,576	13,277
R^2	.05	.05	.04

Note.—The years 1947 and 1961 are the cutoff points for individuals whose education was interrupted by the Cultural Revolution. We have three linear sections separated by the two cutoffs: those born before the treatment group, the treatment group, and those born after, corresponding to the variables "Before," "Between," and "After," respectively. We include a smaller sample with only those born closer to the cutoff points (born between 1935 and 1975, rather than between 1930 and 1980 as in the original sample) and a larger sample that does not exclude those who appear infrequently (rather than just those staying in the survey for at least 10 years as in the original sample). Robust standard errors clustered at cohort level are in parentheses.
* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

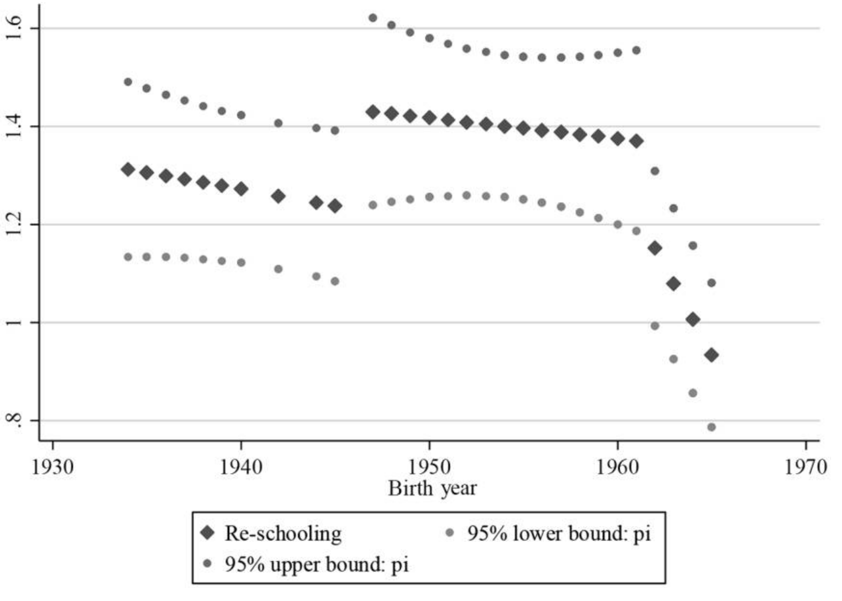

Figure 5.—Reschooling by birth year: linear estimation using CHNS data.

the comparison group. In the empirical model, we also control for the cohort size[7] and the gender composition of the cohorts. The estimating equation is as follows:

$$\Delta \text{Edu}_{ct} = \beta_0 + \alpha_0 \text{Age}_{ct} + \sum_g \alpha_g \text{CR}_g + \beta_1 \text{Cohortsize}_c + \beta_2 \text{Male}_c + \sum_t \gamma_t T_t + \varepsilon_{ct}. \tag{6}$$

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. Educational attainment can be measured by the average number of schooling years or proportion of college graduates. The dependent variable ΔEdu_{ct} is the change in educational attainment for gender-cohort cell c between years t and $t + 1$. It measures the extent of reinvestment in human capital of that cohort. The five dummy variables CR_g, which are grouped together under one dummy variable IEG, are the same as those defined in equation (4). The variable T_t refers to year dummies. Year dummies are not directly collinear with the CR variables, as they include some birth-year cohorts. Section II discusses how age affects the decision to reinvest in schooling. We therefore include age in the regression as an independent variable. The summary statistics for these and other control variables are reported in table A3. We use weighted least squares to 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 4 shows the results when the dependent variable is the change in mean schooling years.[8] The age effect is significantly negative, which confirms our theoretical findings in Section II that reschooling should be conducted as early as possible to achieve greater potential benefits. The coefficient for the interrupted-education group is insignificantly positive in column 1 of table 4. When the interrupted-education group is divided into five subgroups, most of these subgroups have insignificantly positive coefficients (col. 2). Only the first, second, and third subgroups have invested in reschooling, but the coefficients are insignificant at a traditional level. We also 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 reinvestment is negative, and the subgroup with delayed university studies tends to invest more in reschooling than other cohorts. The

[7] 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 1959–61 because of the sudden reduction in agricultural output (Lin and Yang 2000), leading to small cohort sizes for these years.

[8] We also analyzed the results of logarithm change in schooling years, in accordance with tables 2 and 4. We find that all results are similar in statistical significance, but with a lower coefficient as a result of the lower changes in the logarithm of schooling years.

TABLE 4
EFFECT OF THE INTERRUPTED EDUCATION ON REEDUCATION
(Increase in Schooling Years): UHS

	(1)	(2)	(3)	(4)	(5)
Age	−.003***	−.003***	−.004***	−.004***	−.007**
	(.001)	(.001)	(.001)	(.001)	(.003)
Interrupted-education variables:					
Dummy for IEG	.007		.028**		
	(.009)		(.013)		
Delayed university		.009		.028**	.074**
		(.010)		(.013)	(.031)
Interrupted senior high		.000		.019	.056*
		(.012)		(.017)	(.031)
Interrupted junior and senior high		.013		.048***	.065***
		(.010)		(.014)	(.019)
Interrupted primary and junior high		.009		.021	.023
		(.015)		(.014)	(.014)
Interrupted primary school		−.003		.010	
		(.013)		(.015)	
Cohort variables:					
Cohort size	−2.522*	−1.800	−1.581	.780	1.465
	(1.472)	(1.972)	(1.412)	(1.896)	(.995)
Male	.007	.007	.028**	.031***	.009
	(.008)	(.008)	(.011)	(.011)	(.011)
Economic-transition variables:					
Log education premium			.085**	.089**	.050
			(.035)	(.035)	(.056)
Unemployment of college graduates			.309	.332	.549
			(.496)	(.512)	(1.508)
Unemployment of high school graduates			.135	.199	.087
			(.258)	(.269)	(.447)
Earning uncertainty of college graduates			−.005	−.005	−.010
			(.012)	(.012)	(.020)
Earning uncertainty of high school graduates			−.006	−.006	−.007
			(.014)	(.014)	(.023)
Year dummies	Yes	Yes	Yes	Yes	Yes
Observations	926	926	925	925	449
R^2	.09	.09	.09	.09	.10

Note.—Weight is used according to the cell size. Robust standard errors clustered at cohort level are in parentheses.
* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

latter result confirms our prediction that those interrupted at higher educational levels may have greater intention to reinvest in education.

Cohort size has a negative effect on reschooling in almost all specifications, which seems to agree with the negative effect of cohort size on educational attainment (rather than reschooling in our analysis) 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 reinvestment 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 labor market uncertainties inherent in a modern economy have also risen. The literature has advanced three important factors that may affect the costs or benefits of human capital investment.

Education premium.—It is not very surprising that returns to education will affect decisions on education investments (e.g., Haveman and Wolfe 1995; Charles and Luoh 2003; Jensen 2010). A higher education premium tends to encourage individuals to pursue higher educational attainment. We measure the education premium by the logarithmic wage differential between college (and above) graduates and high school graduates. It is calculated as $\log W_{\mathrm{u}ct-1} - \log W_{\mathrm{h}ct-1}$, where W means wages, "u" refers to college and above, "h" means high school, and c and t are defined as in previous equations. The college premium increased from about 15 percent in 1988 to nearly 40 percent in 2003, although the rate of increase has slowed since the 2000s.[9] Such large increases in the returns to higher education are expected to encourage individuals with interrupted education to reinvest 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 pursuing higher educational levels. Earnings uncertainty in China has increased greatly as a result of the decentralization of wage setting. It is calculated as $\log W_{90c(t-1)} - \log W_{10c(t-1)}$, with 90 meaning the 90th percentile of wages, 10 referring to the 10th percentile of wages, and other variables defined as above. Measured as the 90th − 10th 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.

[9] Zhang et al. (2005) use the same data set (UHS) to estimate the college premium, obtaining a similar result at around 40 percent, and the returns to years of schooling, at approximately 8–9 percent. Li, Liu, and Zhang (2012) use a twins data set to deal with the potential endogeneity problem and find that the college premium lies in the range 28–40 percent and the returns to years of schooling to be roughly 3 percent, after controlling for twin fixed effects. Thus, the college premium of the estimation may be modestly overstated. In addition, the estimation of the college premium has included those individuals with reschooling in the adult program, which may understate the true college premium because of the lower quality of the adult program.

Employment opportunities.—There are few studies (Fredriksson 1997; Rice 1999) 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. Better employment opportunities are associated with lower unemployment possibilities. Thus, they are evaluated as the difference in unemployment rate between education groups: $UN_{uc(t-1)} - UN_{hc(t-1)}$, with UN meaning unemployment rate and the other variables defined as above. 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 in the lower education groups. The incentive for investment in education may be expected to increase with a higher unemployment rate because the risk of unemployment is lower among the more educated and the opportunity cost of education is reduced.

We augment the empirical model of equation (6) to include the above factors. The results are presented in columns 3–5 in table 4. Table 4 shows that the education premium has a significant positive impact on human capital reinvestment: a 10 percent higher education premium increases reschooling by 0.009 years per year (see cols. 3 and 4), which implies an impact of 0.135 years over the entire sample period. In regressions using the change in proportion of college graduates as a dependent variable (not reported here because of space constraint), the education premium has a positive, albeit statistically insignificant, effect on college attainment. The coefficients on the earnings uncertainty and employment opportunities variables are statistically insignificant in table 4. We conclude that, among the three economic variables considered, the size of the education premium has the greatest effect on human capital reinvestment. We also test this result by including only the education premium in our regressions and find that it continues to have significantly positive effects on reschooling.

The effect of age on reschooling continues to be significantly negative when the factors related to economic transition are added to the regressions. The average investment of a cohort in reschooling years decreases as the cohort grows older, and the probability of receiving college or higher degrees also decreases. This is consistent with our prediction that reinvestment decisions are typically made early in adult life to ensure a longer period of education returns.

In column 3 of table 4, the average education increase for the interrupted-education group is 0.028 years per year more than that for the comparison group (all other cohorts), and it is statistically significant at the 5 percent level.[10]

[10] The accumulated reschooling is estimated to be about $0.028 \times 15 = 0.420$ years over our sample period 1988–2003. This effect is larger than the estimated effect of 0.17 years using the discontinuity approach on CHNS data. One possible explanation is that the

In column 5 of table 4, we use only data from cohorts in the treatment group and compare the differences in reschooling behaviors among the five subgroups, using those interrupted at the primary school level as the base. The differences are more pronounced, compared to those shown in columns 2 and 4. Column 5 of table 4 shows a significant and positive reschooling effect for those interrupted at higher education levels. Similar patterns are seen in the proportion of college and above, and only those with delayed university education or interrupted senior high school education have significant and positive coefficients.

C. *Sensitivity to the Choice of Treatment Span*

One could be concerned that the treatment span in question may be too wide to generate a convincing discontinuity analysis. Therefore, we attempt to shorten the treatment span and compare the results with the previous ones (e.g., tables 2, 3). We now conduct two experiments to examine whether the length of the treatment span can affect our results to a large extent.

The first experiment uses a fixed reference group (those born before 1947 or after 1961) and analyzes the treatment effect of a narrower treatment group. The second experiment takes other subgroups not included in the narrower treatment group as the reference group. Therefore, some subgroups in the first experiment may not be included in either the treatment group or the reference group. However, all subgroups are included in the second experiment (as either the treatment group or the reference group). The treatment group consists of five subgroups. Within each experiment, a narrower treatment span is defined in two ways. In the first way, a narrower treatment group (IEG1, IEG2, or IEG3) is based on the combination of three continuous subgroups.[11] In the second way, we define an even narrower treatment span, using only one subgroup at a time (altogether five subgroups).

We first use the CHNS data to conduct the two experiments. In the first definition of the first experiment, IEG1, IEG2, or IEG3 belongs to the treatment group, whereas the reference group is fixed. The results of the narrower treatment group are shown in table 5. Compared with the corresponding estimate of 0.17 in column 3 of table 2, the estimates seem to be similar in table 5: 0.15, 0.22, and 0.23 in columns 2, 4, and 6, respectively. This result supports the robustness of our findings. The coefficient of IEG1 is significant and positive in column 1, while it is less significant in

UHS covers only urban areas and samples wealthier regions in China, compared to the CHNS.

[11] Thus, IEG1 consists of three subgroups: delayed university, interrupted senior high, and interrupted junior and senior high. IEG2 consists of three subgroups: interrupted senior high, interrupted junior and senior high, and interrupted primary and junior high. IEG3 consists of three subgroups: interrupted junior and senior high, interrupted primary and junior high, and interrupted primary school.

TABLE 5
Reschooling Outcomes of Narrower Interrupted-Education Groups: CHNS

Interrupted-Education Variables	(1)	(2)	(3)	(4)	(5)	(6)
Dummy for IEG1	.512***	.148*				
	(.076)	(.081)				
Dummy for IEG2			.556***	.224***		
			(.075)	(.079)		
Dummy for IEG3					.517***	.234***
					(.073)	(.069)
Birthyear and quadratic and cubic of Birthyear	No	Yes	No	Yes	No	Yes
Gender and region variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,305	7,305	7,305	7,305	7,305	7,305
R^2	.02	.05	.02	.05	.02	.06

Note.—IEG1 consists of the three subgroups: delayed university, interrupted senior high, and interrupted junior and senior high. IEG2 consists of the three subgroups: interrupted senior high, interrupted junior and senior high, and interrupted primary and junior high. IEG3 consists of the three subgroups: interrupted junior and senior high, interrupted primary and junior high, and interrupted primary school. Robust standard errors clustered at cohort level are in parentheses.
* Significant at the 10 percent level.
*** Significant at the 1 percent level.

the result after removal of the cohort trend, shown in column 2. All results in the remaining four columns are significant and positive, while the coefficients decline after we remove the cohort trend. These results corroborate the previous findings, which supports our finding that the pickup effect exists. The smaller and less significant result in column 2 arises from the lower reschooling of those who were delayed in attending the university and those who were interrupted at senior high school. As those subgroups whose education has been affected seriously during the Cultural Revolution mostly appear in IEG2 and IEG3, the results are significant and positive in columns 4 and 6.[12]

We also conduct the second definition of the first experiment and find that the coefficients are similar, which confirms the robustness of our findings. It follows that, even with the second definition of the narrower treatment span, the pickup effect still exists for the subgroups who suffered the largest loss during the Cultural Revolution.

Finally, we conduct the second experiment by narrowing the treatment span while including all of the others in the reference group. For example, if IEG1 is the treatment group, then those interrupted at primary and junior high or interrupted at primary school belong to the reference group. As we know, the treatment group in the preceding subsections consists of all five subgroups, and thus taking a subgroup as a treatment group while taking the others as the reference group would make results less signifi-

[12] The first experiment narrows the treatment group and keeps a fixed reference group. We also narrow the reference group to 1935–75. Compared with coefficients in table 5, those from the first experiment are similar, with lower coefficients. It indicates that our results still hold with both a narrower treatment group and a narrower control group.

cant. If there are significant results for some subgroups from doing so, it would indicate that the pickup effect really exists. Results seem to be similar, without showing them here to save space. The main difference is that almost all coefficients are smaller in the second experiment than those in the first experiment, which is consistent with our expectation.

We also conduct the two experiments using the UHS data and find that results become weaker for the narrower treatment span. The results are not provided here to save space. All coefficients become smaller after we shorten the treatment span. Most of the coefficients are insignificant because of the smaller sample size of the cohort analysis. However, those who suffered the largest losses (interrupted at senior and junior high) during the Cultural Revolution still make up for the educational losses significantly, supporting the existence of the pickup effect.

Finally, we cut the data into two experiments: for experiment 1, the control group is those born before 1947 and the treated group those born in 1947–55; for experiment 2, the treated group is those born 1955–61 and the control group those born after 1961. We can observe a discontinuity or a slope change for these two experiments, without controlling for birth-year effects. However, it becomes less significant after we control for birth-year effects. The main reason may be that the number of cohorts of every experiment has been quite low. In order to show the validity of our results, we conduct two more experiments: for experiment 3, the control group is those born before 1947 and the treated group those born 1947–61; for experiment 4, the treated group is those born 1947–61 and the control group those born after 1961. We find that the treatment effects are still significant.

In summary, all of the experiments support that the proposed discontinuity analysis is robust to the treatment span. All of our results show that those whose education had suffered the greatest loss tend to make up for the educational loss.

D. Discussion

Individuals and birth cohorts whose education was disrupted during the Cultural Revolution chose to make up for their lost education, regardless of which data set or methodology we use. Sharp institutional shock can deprive people of education, but individuals have incentives to recover from lost education when educational opportunities arise and when benefits exceed costs of reschooling.

Those who suffered the greatest losses during the Cultural Revolution, that is, those interrupted at both senior and junior high schools, have a high incentive to make up for the missed schooling years. This is in accordance with our theoretical result that $\partial\Delta'(L)/\partial E_0 < 0$. As shown in tables A1 and A4, subgroups who suffer higher educational losses have lower initial education in both data sets, and these subgroups have higher incentives for reschooling. Our theoretical findings also show that those who have very high initial education can also have great incentives to reinvest in education, that is, $\partial\Delta'(L)/\partial E_0 > 0$ for large E_0. Those who had delayed university had high initial education E_0, and this subgroup should also have a strong incentive to reinvest in education. Our result shows that only the subgroups that experienced delayed university and senior high school studies chose to reinvest in university degrees, while all other subgroups in the interrupted-education group did not show a significant reinvestment, although they were all largely deprived of advanced education. We believe that reschooling cost is an important explanation of this finding. The cost of reschooling to obtain advanced degrees is particularly high for those interrupted at lower educational levels, not only in terms of the opportunity cost of a longer time to finish these degrees but also in terms of the higher psychic cost of learning as a result of inadequate preparation. Those interrupted at a lower educational level reinvest in schooling years but seldom reinvest in advanced education. 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 completing an advanced degree is relatively high for these individuals. For some of those who had been interrupted at a low educational level, the educational loss may persist throughout their lives. This situation can be considered a low-education trap: the less educated had their schooling disrupted at an early stage, and they remained with their low educational attainment even when subsequent reschooling became possible. This loss is a scar, which is a long-term effect of institutional shocks that are difficult to remedy.

We conduct a brief counterfactual analysis based on the synthetic-cohort analysis to study the relative importance of the Cultural Revolution and its resulting economic transition in adult reschooling decisions. We remove the estimated effects of each set of factors, using the empirical model shown in column 4 of table 4, and compare how the amount of reschooling would have been affected. Figure 6 depicts the counterfactual results.[13] Reschooling is significantly positive across all birth cohorts, and removing the Cultural Revolution variables (CR_g) or the economic-transition variables reduces the predicted amount of reschooling. The estimated amount of reschooling after the Cultural Revolution variables are removed declines sharply for those whose education was interrupted during the Cultural Revolution but, as expected, does not change much for more recent birth cohorts. The line overlaps with the original line of "schooling increase" for the most recent cohorts (those born after 1962), whose education was not interrupted by the Cultural Revolution. In comparison, the curve showing the estimated amount of reschooling after the economic-transition variables are removed declines only a little for the interrupted-education group but lies far below the other two curves for

[13] We use regressions to calculate counterfactual results and ignore other variables such as age, and thus it is possible to have negative reschooling estimates. The focus here is to compare relative magnitudes rather than the absolute values of the estimates.

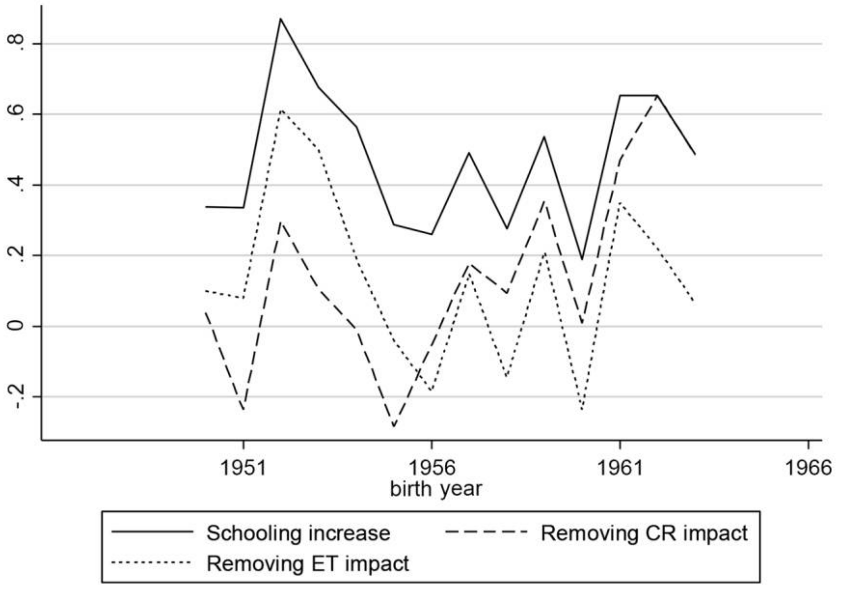

Figure 6.—Counterfactual reeducation after removal of Cultural Revolution (CR) or economic-transition (ET) impacts.

more recent cohorts. The comparison of these results shows that recovering from the losses is the dominant consideration for those whose education was interrupted in the Cultural Revolution, while responses to the economic transition are the major consideration for the more recent cohorts. Both factors are important in explaining the reschooling decision, and the relative importance of these two effects is different across different birth cohorts.

E. *Effect of Missing Years of Schooling*

We have analyzed the effect of education disruption, measured by the birth cohort dummies, on reschooling. We can infer the number of potential years of schooling missed for each cohort according to the time the school reopened during the Cultural Revolution. In this subsection, we go one step farther by looking at the effect of years of schooling missed and the age at which the disruption occurred.

Table A1 lists the missing years of schooling for the five subgroups, assuming that individuals finish senior high school (col. 3) or college (col. 4).[14] The former are referred to as MY1 and the latter as MY2. Some

[14] The missing years of education consist of the actual losses during the school and university closures and the predicted potential losses after the school and university reopened. Positive predicted potential educational losses exist for those interrupted during junior and senior high schools after the schools and universities reopened, as they were not allowed to return to senior high school even when the opportunity arose. The other subgroups had only actual educational losses (without predicted losses).

birth cohorts suffered greater losses, while others suffered less. Those whose education was interrupted at senior or junior high school suffered the greatest losses, and our results in the previous subsections show that this subgroup has the highest reschooling. The primary and middle schools reopened for those born after 1955, and they continued their education very quickly. They did not miss further years of higher education (e.g., college and above), as the CET resumed in 1977. However, older cohorts totally missed the college years. For example, those interrupted at junior or senior high schools could not attend senior high school during the Cultural Revolution and therefore missed years of college and above. After 1977, only a trivial proportion of these cohorts had opportunities to go to college by self-learning through their own efforts.

We test the effect of the missing years of schooling on reschooling, with results reported in tables 6 and 7, using CHNS and UHS data, respectively. Consider table 6, using the CHNS. Column 1, using MY1, shows a significant and positive effect of the missing years of schooling on reschooling. This suggests that the pickup effect exists and that higher educational losses engender higher reschooling. The coefficient estimate suggests that for every missing year of schooling, reschooling is 0.049 years higher. Adding the age at disruption in column 2 shows that the variable of missing years of schooling still has a significant and positive impact. The age at disruption has an insignificant and negative effect. This result supports the proposition that disruption at higher age results in higher cost of, and therefore lower incentive for, reschooling. In addition, the inclusion of age at disruption does not remove the pickup effect. Using the alternative measure MY2 in columns 3 and 4 shows that results are similar to those using MY1 in columns 1 and 2.

TABLE 6
Effect of Schooling Years Missed on Reschooling: CHNS

	MY1		MY2	
	(1)	(2)	(3)	(4)
Schooling years missed during the Cultural Revolution	.049***	.060***	.022***	.037***
	(.011)	(.013)	(.007)	(.011)
Initial age during interruption		−.007		−.011*
		(.005)		(.007)
Birthyear and quadratic and cubic of Birthyear	Yes	Yes	Yes	Yes
Gender and region variables	Yes	Yes	Yes	Yes
Observations	7,305	7,305	7,305	7,305
R^2	.05	.05	.05	.05

Note.—MY1 consists of missing years of primary and high school, while MY2 consists of missing years of primary, high school, and college. Robust standard errors clustered at cohort level are in parentheses.
* Significant at the 10 percent level.
*** Significant at the 1 percent level.

TABLE 7
EFFECT OF SCHOOLING YEARS MISSED ON RESCHOOLING: UHS

	MY1		MY2	
	(1)	(2)	(3)	(4)
Schooling years missed during the Cultural Revolution	.007***	.005***	.005***	.006***
	(.002)	(.002)	(.001)	(.002)
Initial age during interruption		.001		.001
		(.001)		(.001)
Cohort, gender, year, and age	Yes	Yes	Yes	Yes
Economic-transition variables	Yes	Yes	Yes	Yes
Observations	925	925	925	925
R^2	.09	.09	.09	.09

Note.—MY1 consists of missing years of primary and high school, while MY2 consists of missing years of primary, high school, and college. Robust standard errors clustered at cohort level are in parentheses.
*** Significant at the 1 percent level.

Table 7 reports results using the UHS. The effects of missing years of schooling are similar to those in table 6, but the initial age at interruption has no effect. Since synthetic-cohort data are used and the average reschooling per year is analyzed, the coefficients of MY1 and MY2 are smaller than those in table 6. However, if we multiply the coefficients of missing years of schooling by years of changes, they will be comparable with those of table 6.

As noted above, there may exist some differences across cohorts in the entry labor market environments. However, if the entry labor market environment were the main reason for the later reschooling, we should not have found the significant and positive effect of the missing years of schooling on reschooling (tables 6, 7). Indeed, there are two sources of variation that help identify the reschooling effect: first, of course, the differences between the Cultural Revolution cohorts and the non–Cultural Revolution cohorts and, second, the differences in the lost years of schooling among the Cultural Revolution cohorts. For the latter, the entry labor market environments are rather comparable (e.g., similar entry years but very different missed years of schooling for those born in 1954, 1955, and 1956, based on table A1). Therefore, considering both variations together, the missing education during the Cultural Revolution appears to be the main driving force for reschooling.

V. Recovered to What Extent?

Our theoretical model shows that initial education before reschooling tends to have a negative effect on reschooling. In this section, we test this point and determine the size of the make-up effect. If the coefficient of initial education is −1, then reschooling remedies the initial lower education entirely. If it lies between 0 and −1, then the initial low education is only partially remedied.

The problem of endogeneity can arise if we directly regress years of reschooling on the level of initial education. People who experienced greater education disruption have a lower effective initial education level E_0. Suppose their education at the time of disruption is S_0. Their initial education measured at the beginning of our sample period E_0 may be different from S_0 because some students returned to schools when schools reopened during the Cultural Revolution, and some managed to enter college or university when the CET resumed. Suppose $E_0 = h(S_0, u)$, where u denotes unobserved factors such as ability and determination. We have $\partial h/\partial S_0 > 0$ and $\partial h/\partial u > 0$. This means that higher education at disruption, higher ability, and higher determination to study engender higher initial education level E_0. We know S_0 but cannot observe u. Therefore, the effect of E_0 on reschooling would suffer from the problem of potential endogeneity, since unobserved ability and determination will affect both E_0 and reschooling. After the temporary shock of the Cultural Revolution, primary schools reopened, and then high schools also recovered. Some students continued their education after the recovery of schools, while others dropped out permanently. In addition, the CET since 1977 provided good opportunities for those interrupted at different education levels to continue their college and university study. Therefore, the initial education of our sample period is the outcome of self-selection. Individuals with higher ability and interests to study usually chose to return to school after the schools reopened, while those with lower ability tended to stay away. The positive selection will cause our estimation results to be biased.

Fortunately, we have a good instrumental variable: the Cultural Revolution, which is an exogenous shock that engendered a uniform effect on individuals of the same birth cohort. Thus, we can use the Cultural Revolution as the instrument for initial education. Even within the treatment group, we can identify the initial education for different cohorts with different educational losses during the Cultural Revolution. We employ two sets of instrumental variables. The first set consists of IEG and its five subgroups, and the second set includes the missing years of schooling, age at disruption, and the interaction term of these two. Both sets of instrumental variables can be used to evaluate the impact of the initial education on reschooling.

To determine how the Cultural Revolution is related to the initial education level, we examine the initial education level across the five subgroups, as shown in table A4. In accordance with our classification of the five subgroups, those with the most missing years of schooling (interrupted at senior and junior high school) have the lowest initial education level. The relationship is clear, although the two segments are not necessarily negatively related to missing years of schooling for all subgroups. In addition, the choice of regions in the sample is different between the CHNS and the UHS. The UHS contains a larger proportion of regions with higher-quality education. Thus, we can observe higher initial education levels in the UHS than in the CHNS.

Table 8 presents results using the CHNS. The first column does not use instrumental variables, and the coefficient is −0.14. This means that for every 1-year reduction in initial schooling years, the reschooling is about 0.14 years higher. If we use IEG as the instrumental variable, the coefficient is much higher (in absolute value), at −0.36. This indicates that the initial low education is partially remedied, but the make-up effect is higher when we use the instrumental variable. Using different sets of instrumental variables results in estimates that range between −0.14 and −0.44 (cols. 3–7). All results show that individuals have partially made up for the initial lower education caused by the educational losses.

Table 9, based on UHS data, shows results similar to those of table 8. Note that the dependent variable is reschooling per year, and thus the coefficients are smaller in absolute value. Results using instrumental variables are larger than those not doing so, but they do not change much whether we use MY1 or MY2 in evaluating missing years of schooling.

The endogeneity problem arises from unobservable factors such as ability and determination, which are positively related to selectivity into schools after they reopened. Unobservable ability has also a positive relationship with reschooling, in that higher ability indicates higher potential benefits and lower costs to study. Therefore, the problem of potential endogeneity engenders an upward bias in the estimated coefficient. Using instrumental variables eliminates such bias and produces more negative coefficient estimates.

VI. Role of Reschooling in Estimating Educational Loss

A common practice in estimating educational loss due to large-scale disruptions uses data from a period long after the disruption occurred. In this paper, the incentive to recover from losses by reschooling is strong for those whose education was 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 sample period. Data from earlier years may reveal true educational losses directly caused by the Cultural Revolution. On the other hand, data from later years (i.e., after 1992) may obscure the true educational losses because part of those losses have been offset by subsequent reschooling.[15]

We run a regression estimating educational loss caused by the Cultural Revolution, replacing the change in educational attainment by the level of educational attainment as the dependent variable in equations (4) and (6). The results, using CHNS data, are reported in table 10 for the interrupted-education group. The first three columns report the different specifications of results before reschooling in 1989, and the remaining three columns show the results after reschooling in 2006. Based on the cubic specification,

15 As discussed above, most reschooling occurred in the early 1990s, when education reform and economic transition accelerated.

TABLE 8
EFFECT OF INITIAL EDUCATION ON RESCHOOLING: CHNS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Initial education	−.140***	−.361**	−.141**	−.440***	−.220***	−.243***	−.203***
	(.006)	(.141)	(.062)	(.111)	(.078)	(.076)	(.074)
Instrumental variable(s)	No	IEG	5 IEG subgroups	MY1	MY1, initial age	MY2	MY2, initial age
Birthyear and quadratic and cubic of Birthyear	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gender and region variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,305	7,305	7,305	7,305	7,305	7,305	7,305

Note.—MY1 consists of missing years of primary and high school, while MY2 consists of missing years of primary, high school, and college. Robust standard errors clustered at cohort level are in parentheses.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

TABLE 9
EFFECT OF INITIAL EDUCATION ON RESCHOOLING: UHS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Initial education	−.025**	−.070**	−.057***	−.078***	−.063***	−.055***	−.055***
	(.012)	(.029)	(.018)	(.025)	(.022)	(.014)	(.014)
Instrumental variable(s)	No	IEG	5 IEG subgroups	MY1	MY1, initial age	MY2	MY2, initial age
Cohort, gender, year, and age	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic-transition variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	925	925	925	925	925	925	925

Note.—MY1 consists of missing years of primary and high school, while MY2 consists of missing years of primary, high school, and college. Weight is used according to the cell size. Robust standard errors clustered at cohort level are in parentheses.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

TABLE 10

Effect of the Interrupted Education in the Cultural Revolution on Education Attainment: Individual Analysis Using CHNS

	Before Reschooling			After Reschooling		
Interrupted-Education Variables	(1)	(2)	(3)	(4)	(5)	(6)
Dummy for IEG	−.525***	−.437***	−.426***	−.114	−.338***	−.307***
	(.097)	(.113)	(.115)	(.094)	(.112)	(.115)
Birthyear and quadratic of Birthyear	No	Yes	No	No	Yes	No
Birthyear and quadratic and cubic of Birthyear	No	No	Yes	No	No	Yes
Gender and region variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,305	7,305	7,305	7,305	7,305	7,305
R^2	.09	.31	.31	.10	.28	.28

Note.—Robust standard errors clustered at cohort level are in parentheses.
*** Significant at the 1 percent level.

for example, the estimated effect of the Cultural Revolution on the treatment group is to reduce their schooling by 0.43 years, using education level data in 1989 (col. 3 of table 10). With the same specification but data in 2006, the estimated effect diminishes to a reduction of 0.31 years (col. 6). The difference between the estimation results for the two periods shows that reschooling has made up for a portion of the losses caused by the education interruption.[16] The results for the five treatment subgroups, which are not reported here because of space constraint, are similar, although some are not very significant at conventional significance levels.

Using UHS data in table 11, we report separate regression results from the beginning period 1988–90 and the ending period 2001–03. Column 1 shows that the reduction in education caused by the Cultural Revolution is estimated to be 0.79 years, based on 1988–90 data, but shrinks to 0.10 years for 2001–03 data. In other words, about 87 percent of the initial decline in schooling years has been compensated for by the end of the sample period. Therefore, the estimation of educational loss that ignores reschooling would be highly biased if subsequent reschooling is popular. We believe that the value of 0.79 years of lost schooling 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 reschooling was rare. A 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, and 0.07 in Sweden, and there was even a beneficial (positive result in the regression) effect at 0.11 in Switzerland.[17] However, our result indicates that the educational loss caused by the Cultural Revolution is 0.79 years, much higher than that caused by World War II.

Similar results are found for the treatment subgroups. A comparison of column 3 and column 4 shows that the largest difference arises from two subgroups: those delayed at university and those interrupted at junior and high senior schools. This confirms our theoretical prediction of the make-up effect. The estimated schooling loss for those with delayed university studies fell from 0.60 to 0.27 years when we change the sample period from 1988–90 to 2001–03. The latter estimate is statistically insignificant at conventional levels. For those disrupted at junior and senior high schools, the two estimates are −1.14 and −0.53, respectively, both significant at a traditional level. In addition, the true educational loss

[16] We compare this result with the result in table 2. The reschooling in tables 2 and 3 is 0.17–0.21. Now, the estimation gap in the educational loss between the beginning and ending periods is about 0.13. The results are comparable.

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

TABLE 11
INTERRUPTED SCHOOLING YEARS IN THE CULTURAL REVOLUTION: SYNTHETIC COHORT ANALYSIS USING UHS

Interrupted-Education Variables	Beginning Period (1)	Ending Period (2)	Beginning Period (3)	Ending Period (4)
Dummy for IEG	−.792***	−.100		
	(.139)	(.103)		
Delayed university			−.600***	−.272
			(.093)	(.181)
Interrupted senior high			−.793***	−.627***
			(.204)	(.159)
Interrupted junior and senior high			−1.137***	−.525***
			(.148)	(.156)
Interrupted primary and junior high			−.237	−.277***
			(.142)	(.072)
Interrupted primary school			−.029	−.119
			(.143)	(.086)
Year dummies	Yes	Yes	Yes	Yes
Age, cohort, and economic variables	Yes	Yes	Yes	Yes
Observations	184	186	184	186
R^2	.79	.93	.85	.94

Note.—Weight is used according to the cell size. Robust standard errors clustered at cohort level are in parentheses.
*** Significant at the 1 percent level.

for all other subgroups in the earlier sample period is higher than the estimated educational loss when data from the more recent sample period are used.

VII. Concluding Remarks

This study fills a gap in the human capital literature by explicitly looking at human capital reinvestment decisions among adults. China experienced two critical periods that affected education: 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 incentives to compensate for lost education through reschooling. Using a simple theoretical framework, we find that reinvestment in education should be made as early as possible. Those who suffered greater losses would have higher incentive to compensate for the educational losses. These predictions are tested and confirmed in our empirical analysis.

The average reschooling for the interrupted-education group is 0.17 years (CHNS data) or 0.42 years (UHS data), higher than that for the comparison group (all other cohorts). This make-up effect is quite strong for these adults, regardless of the data set or methodology used.

Economic transition (specifically, the large increase in the education premium) is important in explaining the demand for reschooling. Using a counterfactual analysis, we find that the make-up effect is strong for those whose education was interrupted (particularly for the subgroup who 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 large for more recent cohorts. Both factors have had important impacts on the reschooling decision.

One lower initial schooling year results in 0.2–0.44 reschooling years, implying that a large proportion of the losses due to institutional shocks can be compensated for. The instrumental-variable estimates have larger magnitude than those without instrumental variables, which reflects a positive selection of higher-ability individuals to return to schools after they reopened. This finding is important in analyzing human capital recovery after a temporary disruption.

The subject of human capital investment has been an important focus for economic researchers. Similar to the studies on economic and demographic recovery from temporary shocks (Davis and Weinstein 2002; Brakman, Garretsen, and Schramm 2004), we analyze the issue of schooling interruption and find an encouraging policy implication, that reschooling 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, the pickup incentives of affected individuals seem strong, and they choose a substantial amount of reschooling. This study looks at reschooling in terms of schooling years. China adopts a separate education system for adults, which makes reschooling easy, but the value of adults' degrees and certificates should be discounted. As discussed above, the schooling quality of such adult reschooling may be quite different from that of normal schooling by younger adults. Hence, the four-year education and degree obtained in the adult program may not be as valuable as a genuine college program and degree. The mitigation effect of reschooling should be smaller than estimated if we consider the lower value of the adult degree. Thus, one should exercise caution in interpreting the value of such reschooling.

Appendix

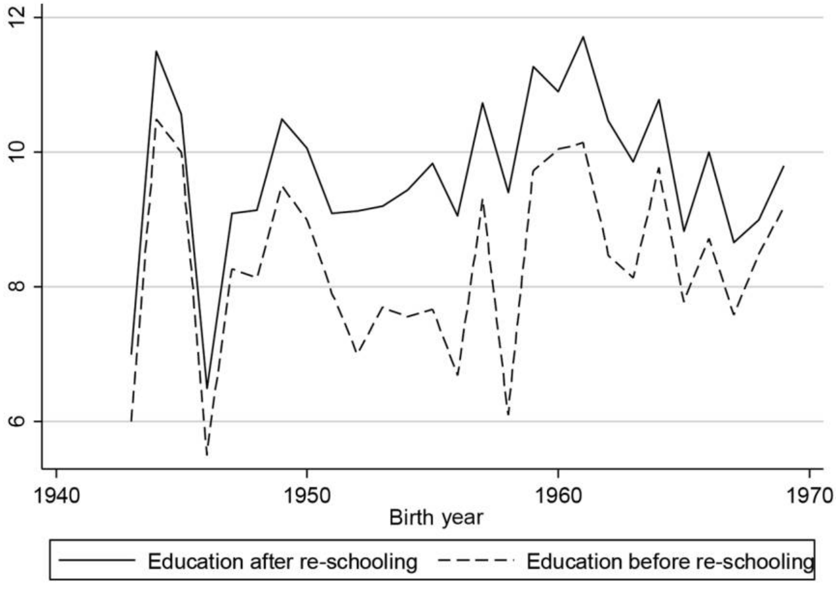

Figure A1.—Average schooling years before (1989) and after (2006) reschooling.

TABLE A1
Classification of Subgroups

Educational Disruption, Birth Year	Missing Years of Schooling (at Primary and High School)	Missing Years of Schooling (at Primary, High School, and College)	Age at Disruption
Interrupted primary school:			
1961	1	1	5
1960	2	2	6
1959	3	3	7
1958	3	3	8
Interrupted primary and junior high:			
1957	4	4	9
1956	5	5	10
Interrupted junior and senior high:			
1955	8	12	11
1954	7	11	12
1953	6	10	13
1952	5	9	14
1951	4	8	15

TABLE A1 (*Continued*)

Educational Disruption, Birth Year	Missing Years of Schooling (at Primary and High School)	Missing Years of Schooling (at Primary, High School, and College)	Age at Disruption
Interrupted senior high:			
1950	3	7	16
1949	2	6	17
1948	1	5	18
Delayed university:			
1947	0	4	19

Note.—The two columns of data on missing years of schooling are extended from Meng and Gregory (2002).

TABLE A2
Overall Sample and Our Sample: CHNS

Variable	Mean	Standard Deviation	Minimum	Maximum
Overall sample ($N = 48{,}838$):				
Reschooling	1.14	1.88	0	15
Schooling Years	7.25	4.22	0	19
Age	41.43	9.70	25	60
Our sample ($N = 33{,}524$):				
Reschooling	1.27	1.95	0	15
Schooling years	6.66	4.14	0	19
Age	41.91	9.57	25	60

TABLE A3
Sample Characteristics of the Synthetic Cohort Data

	Mean	Standard Deviation	Minimum	Maximum
Age (years)	42.5	10.393	25	60
Interrupted-education variables:				
Dummy for IEG	.533	.499	0	1
Delayed university	.027	.161	0	1
Interrupted senior high	.097	.296	0	1
Interrupted junior and senior high	.209	.406	0	1
Interrupted primary and junior high	.081	.273	0	1
Interrupted primary school	.119	.324	0	1
Cohort variables:				
Cohort size	.015	.004	.007	.023
Cohort birth year: 1928	25	11.370	0	50
Male	.5	.5	0	1
Economic-transition variables:				
Log education premium	.572	.590	−2.129	4.431
Unemployment of college graduates	.008	.023	0	.188
Unemployment of high school graduates	.034	.056	0	.299
Earning uncertainty of college graduates	1.654	1.264	0	7.666
Earning uncertainty of high school graduates	2.377	1.501	.589	6.642

TABLE A4
Initial Education

Educational Disruption	CHNS	UHS
Interrupted primary school	9.356	10.809
Interrupted primary and junior high	8.450	10.786
Interrupted junior and senior high	8.375	10.240
Interrupted senior high	8.546	10.580
Delayed university	8.885	10.843

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