Online Appendix
The Expansion of Higher Education and Household Saving in China

A Structural Model

This section derives the results for the structural model that are discussed in the main text. The first sub-section derives Proposition 1 and the related properties of the household's college probability threshold. The second sub-section shows that saving can decrease with college probability for high-saving households.

A.1 Derivation of Proposition 1

We derive the threshold p^t in three steps. First, we calculate lifetime utility for a household (with $Y < 2\tau$) choosing $S < \tau$, at their optimal choice of S. Second, we calculate lifetime utility assuming the household saves enough to pay for college ($S \geq \tau$). However, we note that low income households (with $Y < 2\tau$) will not choose $S > \tau$; at most, they will choose $S = \tau$. These households will be at a 'corner solution'. Finally, we find the p that equalizes the two lifetime utilities (i.e. for $S < \tau$ and $S = \tau$).

Step 1: finding the optimal choice of saving (with $S < \tau$) is straightforward by substituting C and C' from the budget constraints into Equation (2)

$$U = \ln(Y - S) + \ln S.$$

The first order condition is

$$-\frac{1}{Y - S} + \frac{1}{S} = 0. \tag{A.1}$$

Solving for the optimal choice of S gives

$$S^* = \frac{1}{2}Y. \tag{A.2}$$

Lifetime utility then equals

$$U = 2\ln\left(\frac{1}{2}Y\right). \tag{A.3}$$

Call this $U1^*$. Obviously, then, for a household with $Y < 2\tau$, the household cannot send its child to college with this saving choice.

Step 2: finding optimal saving for a household choosing $S \geq \tau$ (and that also has $Y < 2\tau$) requires two parts. First, we consider the constrained or 'corner solution' of $S = \tau$. Second, we argue that, for a low-income household ($Y < 2\tau$), an interior solution ($S > \tau$) always gives lower utility than the corner solution. Hence, a low-income household will save at most $S = \tau$.

First, finding the corner solution only requires setting $S = \tau$. So, the household receives θ in period 2 with probability p and has only its savings τ with probability $1 - p$. The resulting lifetime utility is

$$U = \ln(Y - \tau) + p \cdot \ln\theta + (1 - p) \cdot \ln\tau. \tag{A.4}$$

We call this $U2^*$.

Second, we argue that a low-income household will not choose $S > \tau$. In some sense, this is self-evident because, in the absence of the possibility of college, their utility was maximized by $S < \tau$. Thus, for any $S > \tau$, the household must be on a downward sloping portion of their utility function. For a household (again, with $Y < 2\tau$) choosing $S > \tau$, the utility function is

$$U = \ln(Y - S) + p\ln(\theta + S - \tau) + (1 - p)\ln(S).$$

The marginal utility with respect to additional savings (first order condition) is

$$\frac{\partial U}{\partial S} = \frac{-1}{Y - S} + \frac{p}{\theta + S - \tau} + \frac{1 - p}{S}.$$

Setting this equal to zero and solving for $S > \tau$ (while imposing $Y < 2\tau$) emits no solution for any p from zero to one. The marginal utility from additional savings (above τ) is always negative. Indeed, simple algebra shows that the marginal utility expressed above is only positive if

$$\frac{p}{\theta + S - \tau} + \frac{1 - p}{S} > \frac{1}{Y - S}.$$

Consider, for example, the highest value the left hand side of the inequality can take (i.e. $p = 0$). For the inequality to hold, it must be that $Y > 2S$. But $Y > 2S$ contradicts $Y < 2\tau$ when $S > \tau$. Thus, no interior solution exists (utility is decreasing in S over this range), and the optimal choice is the 'corner solution' $S = \tau$. Utility is given by $U2^*$. Since $p = 0$ is the highest possible value, any $p > 0$ requires an even higher income for the inequality to hold, creating the same contradiction, and

again leading to an optimal choice of $S = \tau$.[1]
Step 3: equating $U1^*$ (A.3) and $U2^*$ (A.4), and solving for p gives

$$\ln\left(\frac{1}{4}Y^2\right) = \ln(Y-\tau) + p \cdot \ln\theta + (1-p) \cdot \ln\tau.$$

Collecting the p terms gives

$$p(\ln\tau - \ln\theta) = \ln(Y-\tau) + \ln\tau - \ln\left(\frac{1}{4}Y^2\right)$$

$$p\ln\frac{\tau}{\theta} = \ln\left(\frac{(Y-\tau)\tau}{\frac{1}{4}Y^2}\right)$$

Hence, the college probability that leaves the household indifferent between saving $S = \tau$ and $S = \frac{1}{2}Y < \tau$ is

$$p^t = \frac{\ln\left[\frac{Y^2}{4(Y-\tau)\tau}\right]}{\ln\frac{\theta}{\tau}}. \tag{A.5}$$

Again, this result relies on the condition that $Y < 2\tau$. Note, a household facing $p > p^t$ will still choose $S = \tau$ because any p larger than p^t only increases the utility from saving at least τ, and, as the derivation implicitly shows, the household will remain at its constrained solution.

In the text following Proposition 1, we claim that p^t is decreasing in the benefits (θ) from college, increasing in the costs (τ), and decreasing in household income (Y) over the relevant set of parameter values. We show each of these in turn.

First, it is straightforward to see that $\partial p^t/\partial\theta < 0$ (as long as p^t is well defined, with $\tau < Y$). Thus, a higher return from college lowers p^t.

Second, applying a simple quotient rule, we find $\partial p^t/\partial\tau$

$$\frac{\partial p^t}{\partial\tau} = \frac{\frac{\partial\ln\left[\frac{Y^2}{4(Y-\tau)\tau}\right]}{\partial\tau} \cdot \ln\left(\frac{\theta}{\tau}\right) - \frac{\partial\ln\left(\frac{\theta}{\tau}\right)}{\partial\tau} \cdot \ln\left[\frac{Y^2}{4(Y-\tau)\tau}\right]}{\left(\ln\frac{\theta}{\tau}\right)^2}.$$

Clearly, $\left(\ln\frac{\theta}{\tau}\right)^2 > 0$ in the denominator. The first term in the numerator is

$$\begin{aligned}\frac{\partial\ln\left[\frac{Y^2}{4(Y-\tau)\tau}\right]}{\partial\tau} &= \frac{1}{4}Y^2\left[-(Y-\tau)^{-2} \times (-1) \times \tau^{-1} + (Y-\tau)^{-1}(-\tau^{-2})\right] \\ &= \frac{1}{4}Y^2\frac{2\tau - Y}{(Y-\tau)^2\tau^2}.\end{aligned}$$

[1]Interestingly, with a high enough p, even some high-income households will be at their corner solution. For example, with $p = 1$, the inequality above becomes $Y > \theta + \tau$. So, households with income $2\tau < Y < \theta + \tau$ will also find it optimal to choose $S = \tau$.

This again is positive, as long as $\tau < Y$. The second term in the numerator is also positive because

$$\frac{\partial \ln\left(\frac{\theta}{\tau}\right)}{\partial \tau} = \frac{\tau}{\theta} \cdot \left(-\frac{\theta}{\tau^2}\right) = -\frac{1}{\tau} < 0.$$

Hence,

$$\frac{\partial p^t}{\partial \tau} > 0.$$

Finally, it is straightforward to show that $\partial p^t / \partial Y < 0$.

$$\begin{aligned}\frac{\partial p^t}{\partial Y} &= \frac{1}{\ln \frac{\theta}{\tau}} \cdot \frac{4(Y-\tau)\tau}{Y^2} \cdot \frac{2Y[4(Y-\tau)\tau] - Y^2(4\tau)}{16(Y-\tau)^2\tau^2} \\ &= \ln \frac{\tau}{\theta} \cdot \frac{1}{Y} \cdot \frac{(Y-2\tau)}{(Y-\tau)} < 0.\end{aligned}$$

The last inequality comes from the assumption that $\frac{1}{2}Y < \tau$. Therefore, p^t is decreasing in household income.

A.2 Saving Response for High-Saving Households

Consider a household saving more than τ, $S > \tau$. For example, a high-income household may have an optimal saving choice that exceeds the cost of college at any value of p, even $p = 0$. Let D be the saving in excess of tuition costs ($D = S - \tau$). Then, the utility function can be written

$$U = \ln(Y - \tau - D) + p \ln(\theta + D) + (1-p)\ln(\tau + D).$$

The first order condition with respect to excess savings D is

$$\frac{\partial U}{\partial D} = \frac{-1}{Y - \tau - D} + \frac{p}{\theta + D} + \frac{1-p}{\tau + D} = 0,$$

We are interested in the response of excess savings D to increasing college opportunities, i.e. $\partial D / \partial p$. Using the implicit function theorem gives

$$\begin{aligned}\frac{\partial D}{\partial p} &= -\frac{\frac{1}{\theta+D} - \frac{1}{\tau+D}}{-\frac{1}{(Y-\tau-D)^2} - \frac{p}{(\theta+D)^2} - \frac{1-p}{(\tau+D)^2}} \\ &= \frac{\frac{\tau-\theta}{(\theta+D)(\tau+D)}}{\frac{1}{(Y-\tau-D)^2} + \frac{p}{(\theta+D)^2} + \frac{1-p}{(\tau+D)^2}} < 0.\end{aligned}$$

The inequality holds because $\tau < \theta$. Therefore, households with excess savings decrease their savings in response to an increase in p .

B Data

Our primary data source is the China Household Income Project (CHIP) 1995 and 2002 urban modules. The data was downloaded from http://www.ciidbnu.org/chip/index.asp. We merge the individual data (that contains earnings for all family members and detailed information on the household head) and household-level data and conduct our analysis at the household level. We also utilize China Yearly Statistical Books to obtain provincial characteristics. Table B.1 lists the definitions for the key variables.

Table B.1: Variable Definitions

Variable	Definition
Saving rate	Household income minus consumption, divided by income - Equation (1)
Child college	Dummy variable indicating a child aged 18 to 23 having attended college
Enrollment ratio	New college enrollees divided by high school graduates, by province
No. kids	Self-reported number of children
No. elderly people	Self-reported number of parents or grandparents of the household head
Private house	Dummy variable indicating private house ownerhsip
Housing accumulation fund	Dummy variable indicating the head has a housing accumulation fund
Head age	Self-reported age of head
Head male	Dummy variable indicating whether the head is a male
Head working	Dummy variable indicating the head's current employment
Head college degree	Dummy variable indicating whether head attended college
Head SOE job	Dummy variable indicating employment at a State-Owned Enterprise for head
Head public health	Dummy variable indicating whether head has health care provided by the state or work unit, or has compulsory medical insurance for serious diseases
Head tenure	Self-reported years of work in current job by head
Head years of schooling	Self-reported years of education for head
Spouse years of schooling	Self-reported years of education for spouse
Annual income	Household income, totaled across family members
Annual expenses	Self-reported household consumption expenditures
Total assets	Self-reported household total assets
Single	Dummy variable, equals 1 if a household has only one dependent child
Population	Provincial population in millions
Urban employment	Urban employment in millions
GDP Growth rate	Growth rate of provincial GDP

Notes: Income, expenses and assets are measured in current price.

C Additional Tables

This section provides supporting evidence for our main analysis.

Table C.1. presents the share of college students from home province. We use the Census 2000 data and keep college-age students (18-22) and calculate the share by dividing number of college students from the province by total number of college students in the province.

Table C.1: Percentage of Local College Students

Province	Share
Beijing	38.65%
Tianjin	59.72%
Hebei	81.59%
Shanxi	83.18%
Inner Mongolia	93.04%
Liaoning	79.55%
Jilin	73.70%
Heilongjiang	78.28%
Shanghai	64.68%
Jiangsu	83.04%
Zhejiang	88.87%
Anhui	85.16%
Fujian	92.11%
Jiangxi	80.37%
Shangdong	90.69%
Henan	85.54%
Hubei	72.26%
Hunan	80.82%
Guangdong	87.31%
Guangxi	89.15%
Hainan	66.96%
Chongqing	56.12%
Sichuan	75.96%
Guizhou	93.81%
Yunnan	86.49%
Tibet	78.38%
Shaanxi	58.51%
Gansu	74.52%
Qinghai	92.54%
Ningxia	83.79%
Xinjiang	97.15%

Notes: This table shows share of college students that are from the same province using the Census 2000 data.

Table C.2 presents the supplemental analysis that examines whether enrollment rates are good indicators for college probabilities. We use the college-age individuals and run the following probit regression:

$$\Pr(College_{ij}) = \Phi(\beta_0 + \beta_1 f(ER_{ij}) + \delta X_j + \gamma_j + u_{ij})$$

where $College_{ij} = 1$ if individual i from province j is a college student and 0 otherwise. X_j are provincial characteristics and γ_j is province fixed effect. ER_{ij} is the enrollment rate.

Table C.2: Probit Regressions of College Attendance Using Census 2000

	(1)	(2)	(3)	(4)	(5)
Enrollment rate	1.068***	4.539***	4.539***	1.385***	2.218*
	(0.391)	(1.613)	(1.613)	(0.448)	(1.218)
Enrollment rate square					-0.323
					(0.338)
Population				-0.002***	-0.002***
				(0.001)	(0.001)
GDP growth rate				2.754***	2.658***
				(0.670)	(0.666)
Urban employment				0.002***	0.002***
				(0.001)	(0.001)
Constant	0.153	-6.355**	-6.355**	0.099	-0.455
	(0.169)	(2.624)	(2.624)	(1.329)	(1.719)
Province FE		✓	✓	✓	✓
Observations	52,790	52,790	52,790	52,790	52,790

Notes: This table reports probit regression results of college attendance using census 2000 dataset.

This next section provides additional details for the probit regressions (Equation 11) used to estimate the changes in college probability.

Table C.3: Probit Estimates for the Probability of Attending College

	(1) 1995	(2) 2002
Enrollment rate	3.529***	-3.743**
	(1.320)	(1.562)
Enrollment rate square	-1.230***	0.393
	(0.404)	(0.337)
No. kids	0.115	0.041
	(0.110)	(0.125)
No. elderly people	0.051	0.114
	(0.185)	(0.153)
Private house	-0.262***	0.199
	(0.080)	(0.145)
Housing accumulation fund	-0.073	0.035
	(0.135)	(0.123)
Head gender	-0.061	-0.122
	(0.141)	(0.135)
Currently working	-0.149	0.002
	(0.188)	(0.126)
Head tenure	-0.008	0.002
	(0.006)	(0.005)
Head age	0.040***	0.035*
	(0.014)	(0.020)
Head with college degree	0.432***	0.569*
	(0.166)	(0.295)
Head years of schooling	0.054***	0.031
	(0.020)	(0.025)
Spouse years of schooling	0.064**	0.014
	(0.028)	(0.017)
SOE job	0.179	-0.024
	(0.281)	(0.099)
Public health	0.170	0.093
	(0.155)	(0.131)
Annual income	-0.023	-0.003
	(0.263)	(0.093)
Annual income square	-0.007	-0.009
	(0.035)	(0.007)
Annual expense	0.106	0.231***
	(0.081)	(0.070)
Total asset	-0.002	0.019*
	(0.013)	(0.011)
Population, millions	-0.075	1.278*
	(0.572)	(0.699)
Urban employment, millions	0.856	-0.686***
	(1.477)	(0.228)
GDP growth rate	-2.101*	-15.742**
	(1.153)	(7.149)
Observations	1,218	973

Notes: This table reports coefficient estimates from the probit regressions. The dependent variable is a dummy variable for whether the college-age child has attended college. Income, expenses, and assets are in 10,000s of yuan and current price. All specifications include province fixed effects. Robust standard errors clustered by province are reported in parentheses.

After obtaining the first stage probit results, we predict each household's probability of having a college child and then average the probabilities across households within each province to obtain the mean probability before and after the expansion. Table C.4 shows the change in probability by province for both the 1995 and 2002 survey samples.

Table C.4: Change in College Probabilities by Province

	1995	2002
Beijing	0.021	0.150
Shanxi	-0.016	0.002
Liaoning	-0.019	0.018
Jiangsu	-0.011	0.034
Anhui	0.004	0.039
Henan	0.004	0.034
Hubei	0.038	0.102
Guangdong	-0.064	-0.014
Sichuan	-0.006	0.031
Yunnan	-0.045	-0.021
Gansu	0.023	0.081
Chongqing		0.154
Observations	2,900	2,357

Notes: This table shows the average change in college probability by province after the first step probit estimation for households surveyed in 1995 and 2002. Provincial variables are not used as we include province fixed effects.

D Triple Difference-in-Difference Estimates

This section reports triple difference-in-difference (DDD) estimates, exploiting the variation due to the other policy reforms and the evolving demographics. The DDD estimates help to further control for confounding trends coming from a third, possibly omitted, dimension. The dependent variable remains the household saving rate, and the below tables report the estimated coefficients for the change in college probability.

Table D.1 reports the estimates when dividing the sample (of households with school age children) based on the variables related to other policy reforms. Looking at panel A, column (3) indicates that the DD estimates for both SOE and non-SOE households are large. The DDD estimate is not tiny, but it is not statistically different from zero. Panel B shows that the DD estimate is large for both households with and without access to public health. Although, we note that the impact on the saving rates of households without public health is markedly larger. The overall pattern remains the same in panel C. As in panels A and B, the coefficient estimate on the change in p is relatively small in 1995 and much larger in 2002. The estimated impact is similar for households with and without privately owned homes.

Table D.1: Triple Difference-in-Difference using Other Reforms

	(1) 1995		(2) 2002		(3) DD	
	Coeff.	Std. Err	Coeff.	Std. Err	Mean	Std. Err
A. SOE job						
No	-0.252	(0.314)	0.359*	(0.195)	0.611	(0.370)
Yes	-0.089	(0.080)	0.867**	(0.408)	0.956	(0.416)
DD	0.163	(0.324)	0.508	(0.452)		
DDD					0.345	
					(0.556)	
B. Public health						
No	-0.341	(0.230)	0.612*	(0.332)	0.953	(0.404)
Yes	-0.049	(0.079)	0.421	(0.273)	0.470	(0.284)
DD	0.292	(0.243)	-0.191	(0.430)		
DDD					-0.483	
					(0.494)	
C. Private house						
No	-0.123	(0.082)	0.670*	(0.405)	0.793	(0.413)
Yes	-0.217	(0.178)	0.451*	(0.262)	0.668	(0.317)
DD	-0.094	(0.196)	-0.219	(0.482)		
DDD					-0.125	
					(0.520)	

Notes: Each cell uses the same specification as Equation (8). The regressions include province fixed effects, and the parentheses report bootstrapped robust standard errors clustered at province level with 50 repetitions.

Table D.2 presents the DDD estimates related to household demographics. Panel A breaks households into two groups based on whether there is a single-dependent child or multiple kids. Panel B leverages the variation from households with differing gender compositions. Panel C is based on the household head's age. For this exercise, we classify households into young households (age 36 and below) and old households (over age 43), based on the bottom and top quartiles of the age distribution.

Table D.2: Triple Difference-in-Difference using Demographics

	(1) 1995		(2) 2002		(3) DD	
	Coeff.	Std. Err	Coeff.	Std. Err	Mean	Std. Err
A. Single-dependent						
No	-0.160	(0.285)	0.708	(0.490)	0.868	(0.567)
Yes	-0.110	(0.084)	0.487*	(0.249)	0.75	(0.263)
DD	0.05	(0.297)	-0.221	(0.550)		
DDD					-0.118	
					(0.625)	
B. Gender						
Female	-0.143	(0.122)	0.538**	(0.215)	0.681	(0.247)
Male	-0.069	(0.102)	0.429	(0.336)	0.498	(0.351)
DD	0.074	(0.159)	-0.109	(0.399)		
DDD					-0.183	
					(0.430)	
C. Age of head						
Young	-0.250	(0.289)	0.432	(0.314)	0.682	(0.533)
Old	-0.188*	(0.097)	0.779***	(0.196)	0.967	(0.219)
DD	0.062	(0.305)	0.347	(0.370)		
DDD					0.285	
					(0.480)	

Notes: Each cell uses the same specification in Equation (8). The regressions include province fixed effects, and the parentheses report bootstrapped robust standard errors clustered at province level with 500 repetitions.

To summarize the DDD section, across the many specifications, the general patterns remain unchanged from our baseline regression results. The estimated change in college probability has only a small correlation with household saving rates within the 1995 sample, and this is true across many different sub-groups. In contrast, the correlation in the 2002 sample is very large for all sub-groups, indicating that the expansion of education opportunities increased household saving rates.

E Additional Figures

In addition, we find evidence that households without dependent children do not alter their saving behavior after the expansion. The age-saving profiles show that there is a parallel shift of saving rates for this type of households while households with children changed dramatically.

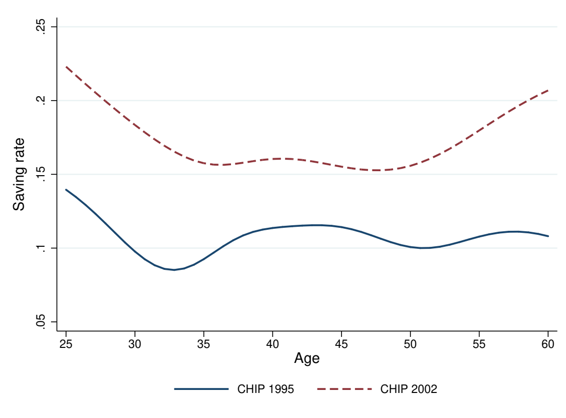

Figure E.1: Age-Saving Profiles for Households without Children

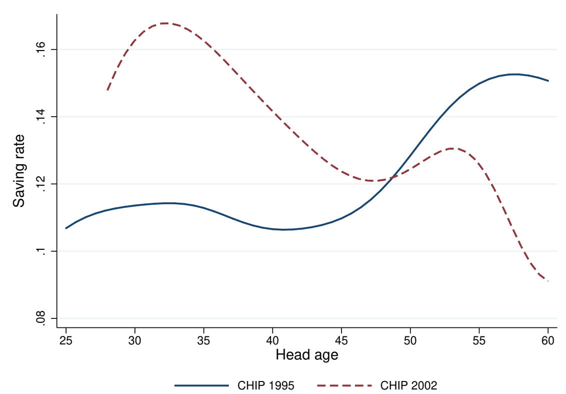

Figure E.2: Age-Saving Profiles for Households with Children