ANNALS OF ECONOMICS AND FINANCE **22-2**, 289–315 (2021)

Diverging College Premiums: A General Equilibrium Framework on China's College Expansion Policy*

Shihui Ma†

In 1999, the Chinese government launched a program to increase enrollment to tertiary education by 42% from the previous year. Following this large inflow of college graduates, college premiums show a diverging trend for workers of different age groups, with premiums decreasing immediately for young workers after the impacted cohort's graduation, then gradually for senior ones in the late 2000s. Assuming imperfect substitutability of workers in different age and education groups, we propose an overlapping-generation model with endogenous educational choices to study the general equilibrium effects of the college expansion. The model successfully accounts for high-school and college graduates' life-cycle earning profiles and is applied to quantify both the long-run and transitional effects of college expansion policies. We find that compared to an alternative mild college expansion, the actual expansion generates overall welfare improvement, benefiting rural residents more than the urban group.

Key Words: College expansion; College wage premium; Higher education; Policy experiments.

JEL Classification Numbers: E24, I21, J24, J31.

1. INTRODUCTION

In June 1999, the State Council of China decided to expand the entry class to tertiary education by 42% from the previous year. In the following decade, China's college admission number increased six-folds, from 1 million in 1998 to 6 million in 2008. Following this large inflow of college graduates, college premiums gradually took a downturn after a prolonged

* I thank an anonymous referee and Yulei Luo (Co-editor) for their helpful comments. I am grateful to advice from Paul Glewwe, Fatih Guvenen, Jonathan Heathcote, Zhen Huo, and Jun Nie. I thank Jing Zhang for his excellent research assistance. I acknowledge financial support of the Fundamental Research Funds for the Central Universities [Grant No. 2016AC008]. Any errors are mine.

† School of Economics, Huazhong University of Science and Technology, 1037 Luoyu Rd, Wuhan 430074, Hubei, China. Email: shihuima@hust.edu.cn.

1529-7373/2021

rising period. However, our empirical analysis shows that the change in college premium is not neutral across different age groups. College premiums for the young workers begin to decrease immediately after 2003 when the first cohorts of the college expansion entered the labor market. On the other hand, college premiums for senior workers keep on growing until the late 2000s.

The diverging college premium trends for workers of different age groups suggest the essential role of age structure in China's labor market. We thus incorporate imperfect substitution of labor in different age and education groups in our production function, and propose an overlapping generation model to study the general equilibrium model with endogenous educational choice. Individuals are heterogeneous in ability and initial asset, have common knowledge of the corresponding distributions, and face the college admission policy that sets a threshold on ability level. Their college enrollment decisions are both exogenously determined by the college admission policy, and endogenously affected by their rational expectation of the college wage premium trend. The government expands tertiary education by decreasing the ability threshold for college entrance. Therefore, in equilibrium, those who satisfy the criterion and willingly enroll in college exactly equals the admission quota.

The model characterizes the general equilibrium effect of the expansion on college wage premiums. College expansion decreases the average ability level of college graduates by lowering the entering threshold, which can be seen as a quality effect.[1] On the other hand, increased supply of college labor shifts down the relative price of college workers through a quantity effect. In the meantime, the shifted college premium trend will change individual's expectation of the college education's benefit, which determines the education structure of the labor market and the corresponding college wage premiums for both young and senior workers.

Treating the college expansion policy as a sharp identification, we are among the first to estimate the demand elasticities of substitution between workers of different age and education groups in China. It took less than half a year from the time when the policy was initially proposed to its action in practice. Therefore the policy serves as a relatively clean-cut tool for the elasticities estimation. Our estimated elasticity of substitution between college and high school labor falls in the range of 1.6 to 1.9, generally comparable to the literature.[2] However, the elasticity of substitution among age groups is between 2.3 to 2.7, substantially lower than the estimates of Card and Lemieux (2001), showing strictly less substitutability

[1] This is different from the quality change that might comes from school quality change in the process of the fierce college expansion, which is not discussed in the current study.

[2] By comparison, Katz and Murphy (1992) report an estimate of elasticity at 1.4, and the estimates from Card and Lemieux (2001) is in the range of 1.1-1.6.

of production between workers of different ages in China. Suppose China's labor substitutability is the same as the U.S., the college premium would be larger for young workers. Therefore, more youth would go to college in the short run, shrinking the long-run college premium by 7.42%.[3]

We calibrate the model to fit the micro-level evidence in China before and after the college expansion in 1999. Our dynamic model accounts for the diverging trends of college premium for both young and old workers. Furthermore, the calibrated model fits well with both the average high-school and college worker's life-cycle earnings profiles. We then apply the calibrated model to an alternative mild expansion policy. Comparing to the mild expansion, the 1999 expansion generates more overall welfare improvement. Calibrating the model to both the rural and urban regions in China, we find that the actual expansion benefits rural residents more than the urban group.

Our study is among the first to examine the impact of China's college expansion on the labor market through a quantitative dynamic general equilibrium framework. The model allows individual educational decisions to respond to changes in admission thresholds and expected wages following the college expansion. By exploring the general equilibrium impact of a massive supply policy change, our study also provides a framework for analyzing social and educational policy in other rapidly developing countries.

Related Literature This paper is closely related to the literature of the labor supply effects on the wage structure, such as the cohort effects in Welch (1979), changes in college education by age groups and cohorts in Katz and Murphy (1992), and Card and Lemieux (2001), and changes in return to experiences in Jeong et al. (2015). However, most of the previous studies are involved with substantial endogenous responses, such as schooling and birth choice, to the underlying social-economic factors. This paper features the dramatic policy change that applies to millions of high-school graduates in China rather abruptly as a sharp identification strategy to estimate the production demand elasticities across different demographic groups. We find that the estimated elasticities between education groups are comparable with previous studies. However, elasticities among different age groups are generally lower in China, implying that the college expansion might affect young graduates and senior workers differently.

Another strand of the literature closely related to this paper include studies on the evolutionary policies of educational institutions, such as empirical studies of Duflo (2001), Lui and Suen (2005), and Wang et al. (2007) as well as estimates of the education returns in China for recent

[3]The steady-state college premium after the college expansion is 0.3839, if we change the age elasticity to 6 as in the U.S., the long-run college premium after expansion falls to 0.3554.

years, as in Zhang et al. (2005), De Brauw and Rozelle (2008), and Ma et al. (2017). Different from the existing empirical literature, our research not only estimates elasticities of substitution by identifying the fluctuations of college premiums driven by the college labor supply, but also studies the general equilibrium effects of the expansion policy, by calibrating the model parameters to fit the empirical trends. Recently, Liao et al. (2017) and Yao (2019) also investigates the effects of the college admission policy revolution in China through a general equilibrium framework.

Finally, the work is motivated by structural models on higher education choice with heterogeneous ability, such as Heckman et al. (1998) and Epple et al. (2006), where students differ in ability and family income, and school enrollment decisions are made with perfect information. Our proposed model builds on the general equilibrium framework and combines it with heterogeneous income profiles (HIP) assumptions, as in Guvenen et al. (2014), where workers with different abilities have various income growth rates. The HIP assumptions of income profiles better fit the life-cycle earnings profile of workers with different education backgrounds.

The rest of the paper is organized as follows. Section 2 describes the data and introduces the background of China's tertiary education system as well as the college expansion policy. Section 3 sets up the two-sector economy and establishes the key variables of elasticities we need to estimate from micro-level data. Section 4 estimates the elasticities and presents calibration. In Section 5, we apply the calibrated model to study the counterfactual effects of an alternative mild expansion. Section 6 concludes.

2. INSTITUTIONAL BACKGROUND, DATA AND STYLIZED FACTS

This section summarizes some stylized facts related to individual education decision that determines the supply of China's college labor. We will start with a brief introduction of the higher education system and the expansion policy in China, explaining their roles in affecting individual educational choices. We then show the sources and construction of the data. Lastly, we review the college premiums trends of different age groups, which motivates our model setup of imperfect substitution between the labor of different age groups and lays the foundation for the elasticity estimation.

2.1. Institutional Background

China's Higher Education China has the largest higher education system in the world. According to the Ministry of Education(MOE),[4] there are over 3,500 higher education institutions, with a total enrollment of 36.5

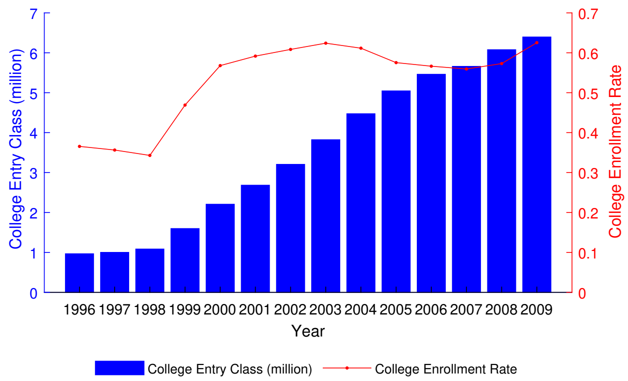
[4]Most recent publicly available data at http://www.moe.edu.cn.

million students. The Ministry of Education controls most higher education institutions through enrollment quota, funding, or evaluation.

Since 1977, a uniformly designed exam, the National College Entrance Examination (NCEE), is required to enter almost any college nationwide.[5] And the exam score is the unique criteria for college admission.[6] Exams are held annually, generally taken by high school students at the end of their third year. After the exam, upon approval by the MOE, each school sets an NCEE threshold score for admission, such that the number of applicants who are above the threshold score generally equals the enrollment quota.

The initial college admission rate[7] was lower than 5% in 1977. Up to 1998, college admission number increased slowly around an annual growth rate of 4%, maintaining a college enrollment rate of around 30%, as shown in Figure 1. This gradual increase in college admission quota ended in 1999 with a fierce college expansion plan.

FIG. 1. College Admission Quotas and Enrollment Rates in China



Data Source: College entrance number is from the China Statistics Yearbooks, and the registration number for the NCEE is from the Educational Statistics Yearbook of China, except for year 2004, where we use the registration data from Li et al. (2011). We calculate the college enrollment rate as the ratio of college entrants over registrants for the exams.

[5]The Ministry of Education allowed the College Enrollment Office of Shanghai and Guangdong to employ an independent exam in 1985. Since 2003, Beijing, Tianjin, Jiangsu, and Zhejiang were allowed to adopt independent propositions. Till now, there have been 16 provinces and municipalities adopting customized exams.

[6]From 2003, some top pilot schools were given autonomy of enrolling no more than 5% of their total entrants.

[7]Calculated as the ratio of college admitted number by the population taking the NCEE in the same year, original data from the Ministry of Education.

The original purpose of the college expansion policy was to combat the effects of the Asian financial crisis in the late 1990s. The rapid growth of college expansion continued at an average annual rate of 21% from 1999 to 2005. After 2006, the government began to control the rapid growth of tertiary education, and the college admission rate settled around 60% thereafter.

College Tuition and Private Expense Higher education was free of charge and heavily subsidized by the government before 1989. The substantial increase in the college entry class would require a broader base of financial support for higher education. However, the college expansion went hand in hand with the transition of the tuition system, from highly subsidized by the government to primarily privately financed. Table 1 displays the rapid growth of tuition per college student from 1997 to 2002, peaking at an annual growth of 37.8% from 1998 to 1999, much higher than CPI growth. During the same time, the average tuition takes more than 50% of the per resident household saving. While a nationwide needed-based financial aid program was initiated in 1999, only very few students received the aid (Yang (2008)). As a result, household wealth plays an important role in college education decisions, considering the very limited loan or debt options before 2000.

TABLE 1.

Per Student Tuition and Residents Saving (in RMB)

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Tuition per student	1824	2145	2922	3464	3928	4324	4562	4857	5071
Saving per resident	3744	4281	4740	5076	5780	6766	8018	9197	10787
Tuition growth (%)	-	17.6	37.8	17.2	13.4	10.1	5.5	6.5	4.4
CPI growth (%)	2.8	−0.8	−1.4	0.4	0.7	−0.8	1.2	3.9	1.8

Data Source: The numbers of the above table are calculated based on the original tuition, colleges student number, residents saving and population data series from the China Statistics Yearbooks.

2.2. Data Sources

Our principal data source is the China Health and Nutrition Survey (CHNS),[8] a longitudinal data set conducted every 2 to 4 years from 1989 to 2011, with a total of 9 survey waves. The surveys were conducted in 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011, each relating to the relevant information of the previous year; therefore, we use the actual year number in the following analysis. In the data appendix, we compare it with

[8]The CHNS is jointly conducted by 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. Please visit http://www.cpc.unc.edu/projects/china for detailed information.

the aggregated data from China Statistical Yearbooks as well as the 1990, 2000, and 2010 Population Census to ensure our sample is representative and general in line with the macro data.

The main advantages of the CHNS compared to other micro-level data sets are that it covers both rural and urban residents and, in the meantime, spans all the relevant years of the college expansion policy.[9] The CHNS survey fits our study well because it provides detailed information on wage, bonus incomes, education level, years of education, employment status, working hours, and all the relevant demographic information. It is an unbalanced longitudinal household survey data that includes 26,000 individuals in nine provinces of China, including Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Liaoning, and Shandong.[10] The provinces sampled are broadly representative of China's regional variation in terms of geography, economic developments, and public resources.

From the CHNS surveys, we create two samples: (1) a wage sample including annual wage incomes;[11] and (2) a working hours count sample that we use to measure the amount of labor supplied. We divide the sample into labor groups, distinguished by gender, education (less than high-school, high-school diploma, college and above), and age (21-30, 31-40, 41-60 years old). Both samples include all individuals aged 21-60 who worked at least 20 hours per week in the preceding year. The wage measure that we use throughout the paper is the average hourly wage, computed as total annual labor income divided by the calculated annual working hours. We use the CPI-weighted wage measures, with the CPI index obtained from the original CHNS datasets, varied across waves, residence status, and provinces.

2.3. College Wage Premiums by Age Groups

Using the wage sample mentioned above,[12] we estimate college premiums by the Mincer regressions separately for every five-year age group in each survey wave. Each regression includes a dummy for college graduates, a quadratic term on experience, and dummies for gender, provinces, and residential status. The estimated college premiums show diverging trend

[9]Chinese Household Income Project survey (CHIP) also includes years before and after the college expansion but lacks a rural sample in 1999. China General Social Survey (CGSS) only includes years after the college expansion. The Urban Household Income and Expenditure Survey (UHIES) and Urban Household Survey (UHS) only include information for urban residents.

[10]The sample in 2011 is expanded by adding Shanghai, Beijing and Chongqing, the three mega municipalities in China.

[11]For the wage sample, I only include employed workers' annual labor income, composed of annual wage income and bonuses. We also include self-employed workers' working hours in the labor supply sample

[12]We only include high-school and college graduates for accuracy, following Card and Lemieux (2001)

across age groups, especially after 2003, when the first cohort of college graduates affected by the expansion policy entered the labor market.

TABLE 2.

College-High School Wage Differentials by Age and Year

	Survey Years					
	1990-96	1999	2003	2005	2008	2010
21-30	0.1453^{*}	0.2209^{*}	0.4615^{***}	0.3424^{**}	0.3785^{**}	0.2776^{***}
	(0.0584)	(0.1086)	(0.1089)	(0.1213)	(0.1216)	(0.0733)
31-45	0.2661^{***}	0.2782^{***}	0.4479^{***}	0.5124^{***}	0.5021^{***}	0.5414^{***}
	(0.0427)	(0.0625)	(0.0703)	(0.0810)	(0.0815)	(0.0561)
46-60	0.1682^{**}	0.3801^{***}	0.5149^{***}	0.6287^{***}	0.7639^{***}	0.5668^{***}
	(0.0639)	(0.0837)	(0.1030)	(0.1005)	(0.0917)	(0.0719)

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3. ECONOMIC MODEL

This section lays out the setup of a general equilibrium life cycle model. In the overlapping generation model, agents differ in their innate ability and their endowed initial wealth. They choose to go to college or not, with full knowledge of their own states as well as the distributions of wealth and ability levels. Their innate ability will affect their chance to enter college and determine their efficiency at work. Aggregate college and high-school labor supply are determined endogenously by each individual educational choice. In the following, we begin by describing the model's demographic structure, preferences, and production technology. Then we outline the life cycle of the agents and define the competitive equilibrium. We summarize the section by discussing the model mechanisms of the college enrollment decisions.

3.1. Environment

The economy is populated by a continuum of individuals, each living for finite periods, with age indexed by $j = 1, \dots, T$. Time is discrete. In each period t, a new cohort of measure one enters the economy, they survive from age j to $j+1$ with probability ζ^j, and die at age T. Since cohort size and survival probabilities are time-invariant, the model age distribution is stationary. We normalized the population measure such that $\int d\mu_{jt} = 1$ for each t, where $\mu_{jt}(e, b, a)$ denotes the share of agents at time t of age j with education status e, innate ability level b, and asset a. In the following analysis, we abstract from time subscript t and keep only the age index j whenever possible for simplicity. We assume a risk-free asset market for simplicity; consumers could borrow at the risk-free interest rate up to a borrowing constraint $\underline{a}$. Workers in different education and age groups are imperfect substitutes in production.

At birth, individuals observe their initial wealth and ability level and choose to attend college or not. If they choose to go to college, they will spend the first four periods in college, living on their initial wealth.[13] If instead, they opt out of college, they will work from period one and earn the high-school wage thereafter. Lifetime is composed of working and retirement periods, $T = T_W + T_R$. The working periods are 1 through T_W for high school workers, 5 through T_W for college labor. In period $T_W + 1$ through T, agents get annual retirement pension as a function of their last period's wage income.

3.2. Agent's Problem

Individuals enter the economy at high-school graduation. They draw their innate ability b and wealth level a at birth, according to a uniform and a log-normal distribution respectively, which is common knowledge across society. Ability level also affects an individual's work efficiency through effective hourly wage. Therefore, agents' college decisions depend on the tradeoff between the educational cost and the college wage premium jointly determined by the whole society. We now spell out the dynamic individual problems at different stages of the life cycle recursively.

Education Decision Individuals make college enrollment decisions at the beginning of their lifetime, observing their initial endowments a, innate ability b, and an ability threshold for college enrollment. The government controls the total college admission quota by choosing the ability threshold $\underline{B}$. The indicator function for the optimal education decision of individual with endowment (b, a) is

$$\eta(b,a) = \begin{cases} 1 & \text{if } \ b \geq \underline{B} \ \text{ and } \ V(1,C,b,a) \geq V(1,H,s,a) \\ 0 & \text{if } \ b < \underline{B} \ \text{ or } \ V(1,C,b,a) < V(1,H,s,a) \end{cases} \tag{1}$$

where $\eta(b, a) = 1$ if the individual goes to college and 0 otherwise. $V(1, e, b, a)$ stands for the value function of educational choice $e \in \{C, H\}$ in the initial period, with C denoting college education, and H high school.

In equilibrium the desired college admission quota E_t^C satisfies:

$$E_t^C = \int_{\underline{B}} \eta(b,a) dG(b,a) \tag{2}$$

Work and Retirement After making the educational decision at the initial period, individuals start working and choose how much to save. The

[13]To abstract from the effects of tuition transition, we assume away the tuition costs in the baseline model for simplicity.

dynamic programming problems for college and high school graduates differ in the first four years when college students study full time and have no labor income.

An individual's efficiency units per hour of market work depend on the history of working experience and a deterministic growth trend on innate ability. Thus, agents of age $j \in \{1, \dots, T_w\}$ with education level e earns an hourly wage $w_j^e \exp(N(j,b,e))$, where w_j^e is the education- and age-specific average wage schedule, and $N(j,b,e)$ is the deterministic efficiency profile. We defer a detailed description of the exact forms of the efficiency profile until the calibration section.

For college students, we assume $y_{col} = 0$ and abstract from the effects of tuition transition in the baseline model. Agents make consumption decision in each period subject to borrowing constraint $\underline{a}$. One unit of savings delivers $1/\zeta^j$ units of assets next period, reflecting the annuity-market survivors' premium. The problem of a working-age individual can thus be written as follows:

$$
\begin{aligned}
V(j,e,b,a) &= \max_{c,a'} \{U(c) + \beta\zeta^j V(j+1,e,b,a')\} \\
c + \zeta^j a' &= (1+r)a + y \\
y &= \begin{cases} w_j^e \exp(N(j,b,e))(1-\tau) & \text{if working} \\ y_{col} & \text{if j=1,}\dots\text{, 4 and e=C} \end{cases} \\
a' &\geq \underline{a}
\end{aligned}
$$

where $V(j,e,b,a)$ defines expected discounted utility for the household problem at age j, and $U(c)$ stands for the current-period utility with consumption level c.

After retiring from period $T_w + 1$ onwards, individuals earn retirement pension $f^r(w_{T_w}^e)$ as a function of their wage income of the last working period:

$$
\begin{aligned}
V(j,e,b,a) &= \max_{c,a'} \{U(c) + \beta\zeta^j V(j+1,e,b,a')\} \\
c + \zeta^j a' &= (1+r)a + f^r(w_{T_w}^e) \\
a' &\geq \underline{a}
\end{aligned}
$$

3.3. Firm's Problem

There is a large number of competitive firms, each subject to a double-layer CES production function that we will discuss in a minute. In each period, the representative firm takes both wages and interest rate as given and chooses its optimal college and high-school labor demand of age group

j, C_j, H_j as well as investment demand i:

$$\Omega(K) = \max_{c_j, h_j, i} F(H, C, K) - \sum_j w_j^c C_j - \sum_j w_j^h H_j - i + \frac{1}{1+r}\Omega(K') \tag{3}$$

$$\text{subject to: } K' = (1-\delta)K + i - \frac{\epsilon}{2}(\frac{i}{K} - \delta)^2 K \tag{4}$$

where K stands for capital, δ denotes the depreciation rate, and ϵ is the investment cost parameter.

For specific production function at time t, we follow the seminal work of Card and Lemieux (2001) in assuming a double-layer CES production technology. Let H_t and C_t denote the aggregate high-school and college educated labor at time t, H_{jt} and C_{jt} stand for the corresponding labor with age j, the production technology is as following:

$$F(H_t, C_t, K_t) = AK_t^{1-\alpha}(\theta_{ct} C_t^{\rho} + \theta_{ht} H_t^{\rho})^{\frac{\alpha}{\rho}} \tag{5}$$

$$H_t = \left(\sum_{j=1}^{T_w} \alpha_j H_{jt}^{\eta}\right)^{\frac{1}{\eta}}, \quad C_t = \left(\sum_{j=1}^{T_w} \beta_j C_{jt}^{\eta}\right)^{\frac{1}{\eta}} \tag{6}$$

$\sigma_E = \frac{1}{1-\rho}$ is the elasticity of substitution between college and high-school labor, and $\sigma_A = \frac{1}{1-\eta}$ is the elasticity of substitution between different age groups with same education level. We assume $\rho < 1$ and $\eta < 1$, so that both groups are imperfect substitutes in production. α_j, β_j and $\{\theta_{ct}, \theta_{ht}\}$ sequences are the relative efficiency parameters between age and education groups. Under the assumption that college and high school equivalents are paid their marginal products, we could derive from the first order conditions:

$$\ln\left(\frac{w_t^C}{w_t^H}\right) = \ln\left(\frac{\theta_{ct}}{\theta_{ht}}\right) - \frac{1}{\sigma_E}\ln\left(\frac{C_t}{H_t}\right) \tag{7}$$

$$\ln\left(\frac{w_{jt}^C}{w_{jt}^H}\right) = \ln\left(\frac{\beta_j}{\alpha_j}\right) + \ln\left(\frac{\theta_{ct}}{\theta_{ht}}\right) - \left(\frac{1}{\sigma_E} - \frac{1}{\sigma_A}\right)\ln\left(\frac{C_t}{H_t}\right) - \frac{1}{\sigma_A}\ln\left(\frac{C_{jt}}{H_{jt}}\right) \tag{8}$$

In the steady state, the first order conditions reduce to:

$$\frac{w_j^C}{w_j^H} = \frac{\beta_j}{\alpha_j}\frac{\theta_c}{\theta_h}\left(\frac{C_j}{H_j}\right)^{\eta-1}\left(\frac{C}{H}\right)^{\rho-\eta}$$

$$r + \delta = \alpha A K^{-\alpha}\left(\theta_c C^{\rho} + \theta_h H^{\rho}\right)^{\frac{\alpha}{\rho}}$$

3.4. Equilibrium Definition

A competitive equilibrium in this economy is a set of household value and policy functions: $\{V_t(j,e,b,a), c_t(j,e,b,a), a_{t+1}(j,e,b,a), \eta_t(b,a)\}$, firms' optimal decision $\{C_t, H_t, C_{tj}, H_{tj}, K_t\}$, the capital rental rate r_t, and the effective wage rate for college and high-school labor, w_{jt}^C, w_{jt}^H, such that, given an initial capital stock K_0 and the survival probability $\{\zeta_j\}$, for each $j = 1, \ldots, T$ and t we have:

1. Given prices, labor tax and retirement pension scheme, V_t solves the Bellman equations in Section 3.2, and $\{a_t, c_t, \eta_t\}$ are the corresponding policy functions.
2. Firms' decisions solve the corresponding problem (3).
3. Asset market clears

$$K_t = \sum_{j=1}^{T} \int a_t(j,e,b,a_{t-1}) d\mu_{jt}$$

4. College labor market for each cohort clears, $j = 5, \ldots, T_w$:

$$C_{jt} = \int \exp(N_t(j,b,C))\eta(b,a) d\mu_{jt}$$

High-school labor market for each cohort clears, $j = 1, \ldots, T_w$:

$$H_j = \int \exp(N_t(j,b,H))(1-\eta(b,a)) d\mu_{jt}$$

The aggregate college and high school labor satisfy the CES functions in (6)

5. The government chooses college entry threshold $\underline{B}$ to satisfy the college admission quota (2), and the budget constraint satisfies

$$\sum_{e=C,H} \sum_{j=T_w+1}^{T} \int f^r(w_{T_w}^e) d\mu_{jt} + \sum_{j=1}^{4} \int_{\underline{B_t}} \eta_t(b,a) y_{col} d\mu_{jt}$$

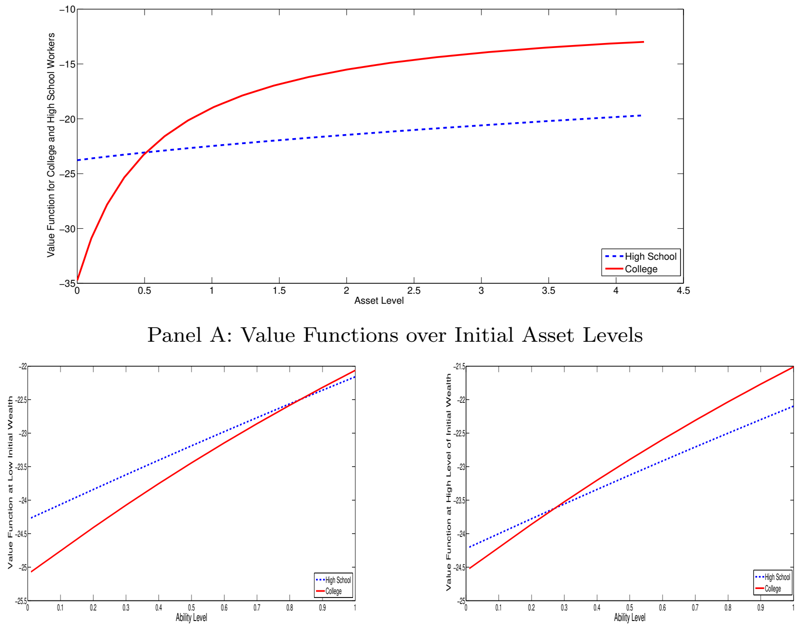
$$= \tau_t \sum_{j=5}^{T_w} \int w_{jt}^C \exp(N(j,b,C))\eta_t(b,a) d\mu_{jt} + \tau_t \sum_{j=1}^{T_w} \int w_{jt}^H \exp(N(j,b,H))(1-\eta_t(b,a)) d\mu_{jt}$$

A stationary equilibrium is a competitive equilibrium in which all individual functions and aggregate variables are constant over time.

3.5. Discussion: College Expansion and Education Decision

This section discusses how the college expansion policy affects the labor market prices through endogenous educational choices. In our model, college enrollment decision is both exogenously affected by the government admission quota and endogenously determined by the individual expectation depending on the individual ability, wealth endowments, and the college wage premium trend. Furthermore, in equilibrium, the individual educational choices aggregate to the labor market structure, ultimately determining the college premiums.

FIG. 2. Value Functions over Initial Asset and Ability Levels



Panel A: Value Functions over Initial Asset Levels

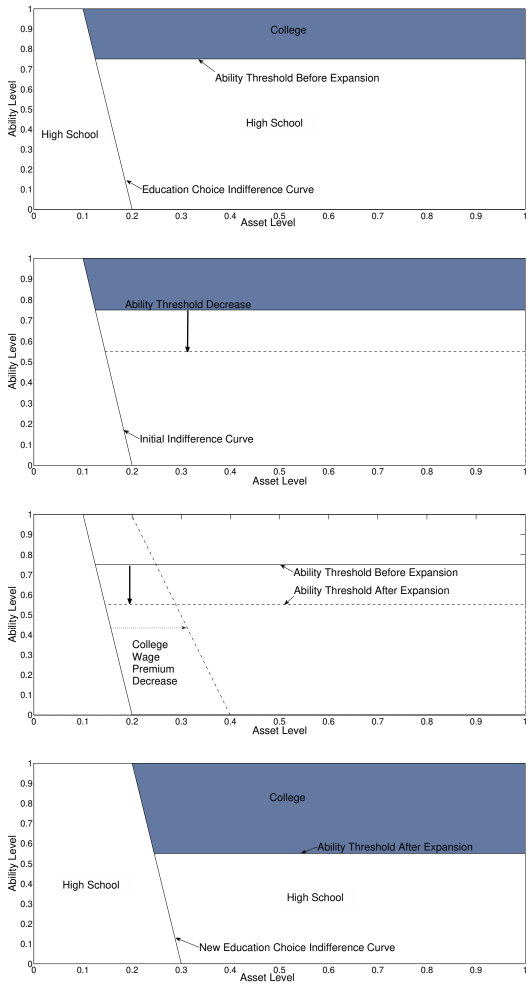
Low Initial Wealth High Initial Wealth

Panel B: Value Functions over Ability Levels

As shown in Figure 2, individuals with minimal initial assets would prefer working directly to starving with a college degree, while rich agents would get a college degree if it pays reasonably well. Given initial wealth, smarter agents are also more likely to enter college since they can reap more benefits from a college education with a higher individual wage growth profile.

Figure 3 displays the effects of a college expansion. When the government sets out to increase the admission quota by lowering the entry threshold on ability levels, agents who were originally denied entrance because of lower

FIG. 3. College enrollment with Ability Thresholds



innate ability could now enter the college. The increased college labor supply will drive down the college wage premium. Given the expected decrease in college wage premium, the composition of college students changes accordingly. Individuals need to be generally wealthier to attend college, but the average ability level of college graduates decreases. This change in the labor force structure will affect the effective relative college labor supply, shifting labor market prices. We plot the effects on individual educational choices in Figure 3, with the top and bottom panel showing the initial and final steady states.

4. CALIBRATION AND ESTIMATION

We now turn to pin down the parameters of the model. We start by specifying the parametric functional forms for the income process and the initial distributions of wealth and ability endowments. Then we move on to estimate the elasticities of substitution between workers of different education and age groups. Finally, we calibrate the parameters to fit the pre-expansion empirical facts. Assuming that the only shock comes from the exogenously determined enrollment quota changes, we present model predictions of college wage premiums for different demographic groups.

4.1. Distributions, Labor productivity Process, and the Pension Scheme

Distributions on Initial Wealth After high school graduation, agents enter the economy with perfect knowledge of their endowments of ability and initial assets. The initial asset is assumed to follow a log-normal distribution. We target the per capita household wealth level and the wealth Gini-coefficients before and after the college expansion, as documented by Li et al. (2005).

Distributions on Innate Ability Individual ability is assumed to be uniformly distributed, with a computationally convenient mean value[14] and the variance σ_b^2. We use the cross-sectional dispersion of wage growth rates to identify the variance of ability distribution.

Labor Efficiency Profile We assume the natural log of the agent's effective labor, $N(j, b, e)$ is composed of a deterministic age trend $f^e(j)$, which is assumed to be a quadratic polynomial; and an individual-specific systematic component bj that fans out the life-cycle wage profiles cross-sectionally.[15] The education-specific polynomial $f^e(j)$ is calibrated to match the life-cycle earnings profile for college and high-school graduates separately. The panel data drawn from the CHNS allows the possibility to identify the life-cycle earnings profiles for high-school and college labor

[14]The mean is just a scaling parameter since a linear growth term has already been defined for function $f(j)$, we assume the ability are uniformly distributed on the interval $[0, U^b]$ where the upper bound U^b is determined by variance.

[15]We follow Guvenen et al. (2014) to assume a heterogeneous income process (HIP), we abstract from the individual transitory shock since the goal of the current paper is to provide a framework to study education choice. We take the initial wealth distribution as given, which is important for agents' education decisions. A model that can endogenously generate a realistic wealth distribution is not the focus of the current paper.

separately.

$$N(j, b, e) = f^e(j) + bj$$
$$f^e(j) = d_0^e + d_1^e j + d_2^e j^2$$

Pension Scheme We model the pension system in China as a defined benefits plan. Following Song et al. (2015), we set the replacement ratio to 60%. This is also general in line with the retirement income (excluding capital income) in the survey data.

4.2. Elasticities of Substitution

Elasticities of substitution between workers of different education and age groups play an essential role in determining individual's expectations for their lifetime labor income. In the meantime, China's fierce college expansion process serves as a sharp identification for us to estimate the corresponding parameters directly. Following the regression framework of Katz and Murphy (1992), we find the education elasticity comparable with estimates in the U.S. However, the elasticity between age groups is generally lower than the estimates of Card and Lemieux (2001), showing strictly less substitutability of production between workers of different ages in China.

We first estimate a version of equation (7), assuming a linear time trend to substitute for the unobserved the demand shifts $\ln(\theta_{ct}/\theta_{ht})$,[16] which can arise from skill biased technology change, nonneutral changes in the relative prices, or quantities of nonlabor inputs, or institutional changes. We find the estimated growth in demand shifts, D_1 is indeed significantly positive at around 2% annually and fits the data well. The estimated education elasticity between college and high school labor is around 1.5, which is roughly in line with the previous estimates of elasticities in the U.S.[17]

$$\text{REG1}: \quad ln\left(\frac{w_t^C}{w_t^H}\right) = D_0 + D_1 t - \frac{1}{\sigma_E}\ln\left(\frac{C_t}{H_t}\right) + \epsilon_t$$

To account for the diverging trend of college premiums of different age groups, we employ the method of Card and Lemieux (2001). Again applying a linear time trend to proxy for demand shocks ($\ln(\theta_{ct}/\theta_{ht})$) and the aggregate supply effect ($(\frac{1}{\sigma_E} - \frac{1}{\sigma_A})\ln(\frac{C_t}{H_t})$), we get the first stage estimates in REG2 belowing. The estimated trend growth, as shown in the second

[16]We follow the approach of Katz and Murphy (1992) for comparison. We also tried to replace the linear trend with dummy years or add quadratic and cubic terms; the results are similar.

[17]Katz and Murphy (1992) report an estimate of elasticity at 1.4 and the estimates from Card and Lemieux (2001) is in the range of 1.1-1.6.

column of Table 3 is 2.5% per annum.

$$\text{REG2}: \quad \log\left(\frac{w_{jt}^C}{w_{jt}^H}\right) = b_j + dt - \frac{1}{\sigma_A}\log\left(\frac{C_{jt}}{H_{jt}}\right) + e_{jt}$$

TABLE 3.

Estimated Models for the College-High School Wage Gap

	REG1	REG2	REG3	REG4
Age-group specific		-0.434^{***}	-0.404^{**}	-0.392^{***}
relative supply		(0.054)	(0.160)	(0.060)
Time Trend	0.015^{***}	0.025^{***}	0.027^{**}	0.026^{***}
	(0.005)	(0.004)	(0.009)	(0.005)
Katz-Murphy aggr.	-0.684^{**}		-0.068	
supply index	(0.168)		(0.158)	
Aggr. supply index				-0.173^{*}
with imperfect substitution				(0.069)
R^2	0.983	0.841	0.841	0.841
pvalue	0.001	0.001	0.001	0.001

TABLE 4.

Elasticity Estimates Comparison

Elasticities	China(CHNS,CGSS)	U.S.(Katz& Murphy)	U.S.(Card& Lemieux)
Age-group (σ_A)	2.3-2.7		4-6
Col-High (σ_E)	1.5-1.9	1.4	1.1-1.6

The last two columns of Table 3 presents the estimates of the second-stage models that include both age-group specific and the aggregate relative college labor supply, as in equation (8). The relative productivity efficiency effect ($\ln(\beta_j/\alpha_j)$) is estimated using the first stage age-group elasticity, and the aggregate supply of college and high school labor time series are constructed assuming perfect (as in REG3) or imperfect (as in REG4) substitution across age groups within the same education group.

We compare the estimated elasticity of substitution between college and high school labor in Table 4. The estimated elasticities of substitution between age groups are in the range of 2.3 to 2.7, generally lower than the corresponding range of 4 to 6 from Card and Lemieux (2001) using U.S. data. This suggests that the substitutability between workers of different ages is substantially lower in China. Therefore simply calculating the average college premiums might be misleading for individuals making educational decisions; the college expansion might affect young college graduates more adversely than senior college workers.

4.3. Parametrization

Externally Determined Parameters A model period corresponds to one year of calendar time. Individuals enter the economy at age 21[18] and retire at age 55, with a total working period $T_w = 35$. Retirement lasts for 15 years, and everyone dies at age 70. The net interest rate, r, is set to equal 2%. Since there is no leisure decision involved, I use the conventional power utility specification of preferences $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, and the risk aversion σ is set to equal 2.0. The labor share of the Cobb-Douglas production technology is set at 0.50, broadly consistent with empirical evidence, as in Bai and Qian (2010) and Chi and Qian (2013). Table 5 shows all the exogenously determined parameters.

TABLE 5.

Externally Determined Parameters

Description	Parameter	Value	Remark
Risk aversion	σ	2.0	Standard practice
Annual risk-free interest rate	r	0.02	Real interest rate between 1990-2010
Discount factor	β	$1/(1+r)$	
Labor Share	α	0.5	Chi and Qian (2013)
Survival Rate from j to $j+1$	ζ^j	—	WHO(2000)
Els of substitution btw age groups	σ_A	2.6	Estimation from data
Els of substitution btw edu groups	σ_E	1.6	Estimation from data
Working periods	T_w	35	years: 21-55
Retirement periods	T_r	15	years: 56-70

Internally Determined Parameters We calibrate the ability thresholds before and after the college expansion to match the college admission rates in 1998 and 1999. We target the per capita household wealth level and the wealth Gini-coefficients as documented by Shi et al. (2005) in 2002. We use the panel data constructed from the CHNS data sets to pin down the life-cycle earnings profile.[19] The standard deviation of the ability distribution is targeted to the cross-sectional dispersion of wage growth rates estimated from our sample. We calibrate the sample mean to match the college admission rate documented by Li et al. (2011) in 1998, immediately before

[18]Age 21 is the median age of entering the labor market in 2000 which is the midpoint of our sample, and it is the lower bound age of college graduates without skipping grades.

[19]We include only the male workers who have been surveyed at least three times between 1991-2009 for this calculation.

the college expansion. There are altogether six parameters to be calibrated for the labor income process:[20]

• the mean log wage growth rate for high school workers (informative about d_1^H)

• the cross-sectional dispersion of log wage for high school workers (informative about d_2^H)

• the mean log wage growth rate for college workers (informative about d_1^C)

• the cross-sectional dispersion of log wage for college workers (informative about d_2^C)

• the average college wage premium (informative about d_0^C)

• the cross-sectional dispersion of the wage growth rate (informative about σ_b^2)

The detailed information of steady state targets and their corresponding parameters are listed in Table 6.

TABLE 6.

Steady-State Targets and Associated Parameters

Description	Parameter	Value	Target	Data
Ability threshold (Before Expansion)	$\underline{B_0}$	0.55	College enrollment rate (1998)	0.35
SD of initial asset distr.	σ_a	30.00	Wealth Gini-Coefficient (2002)	0.55
Mean of initial asset distr.	$E[a]$	20.00	Per capita household wealth (2002)	25897
Variance of ability distr.	σ_b^2	0.16	Cross-sectional SD of wage growth	0.51
Intercept in college worker's income profile	d_0^C	-0.16	Average college premium	62%
Linear term for college workers	d_1^C	$5.0 * 10^{-3}$	College wage growth	1.64%
Square term for college workers	d_2^C	$-1.0 * 10^{-6}$	SD of College wage	0.09
Linear term for high school workers	d_1^H	$8.0 * 10^{-3}$	High-school wage growth	0.55%
Square term for high school workers	d_2^H	$-2.0 * 10^{-4}$	SD of high-school wage	0.10

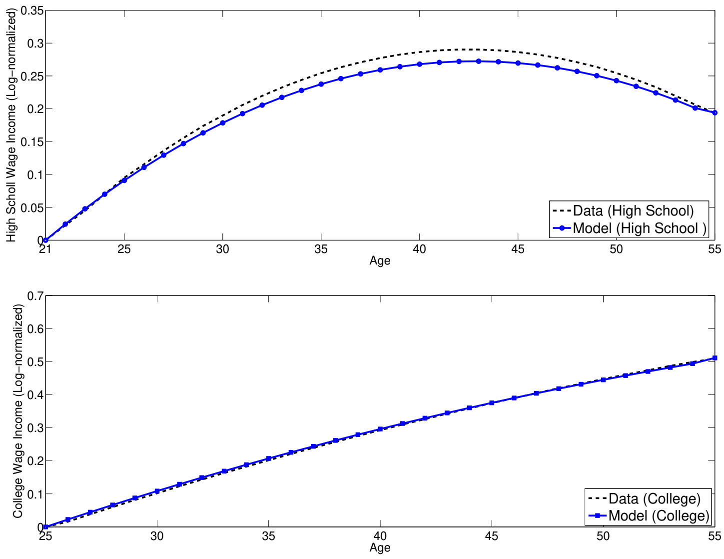
4.4. Model Fits and Simulations

In this section, we begin by presenting model fits, and then proceed to provide the simulation results on the transitional path of the key variables of interest.

The Long-term Impacts of a College Expansion: Steady State Comparison Table 7 compares the long-term impacts by contrasting the two steady states before and after the college expansion. The steady state after the college expansion is simulated with the same set of parameters calibrated in the previous section, except for the ability threshold, which

[20]We normalize the mean log wage for high school workers to 1 and set d_0^H accordingly.

FIG. 4. Life-cycle Earnings Profiles from Model and Data



is targeted to the enrollment rate in 1999. The predicted college wage premium decreased from 0.62 in 1998 to 0.18 after the expansion, accompanied by a massive increase in the relative college labor supply.

TABLE 7.

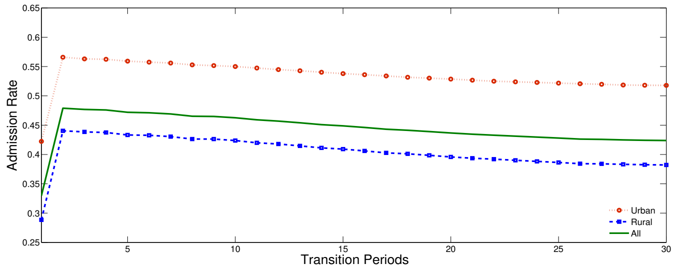
Steady State Comparison

	Average College Wage Premium	Log Relative College Labor Supply	Enrollment Rate
Model(Before)	0.62	-0.78	0.35
Model(After)	0.18	-0.03	0.54

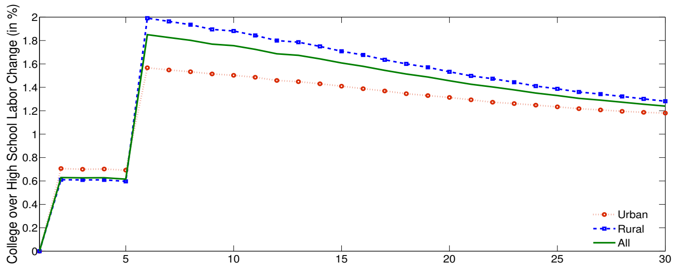
Transitional Dynamics The comparative static exercise above shows the long-term impact of the college expansion. However, in reality, it takes prolonged periods for the economy to shift to a new set of steady state. Moreover, to assess the model's performance in matching the trends since the college expansion, we need to solve the model along a time path. Figure 5 displays the transition path from the initial 1998 steady state towards a final steady state in the far future.

In addition to the baseline results, we explore the trends for both rural and urban individuals, assuming they differ only at the initial asset distri-

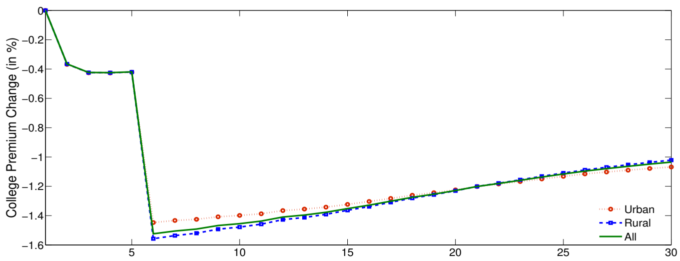
FIG. 5. Transition Path by residential groups



Panel A: College enrollment Rate



Panel B: Effective College over High School Labor Supply



Panel C: College Wage Premium

butions.[21] Panel A displays the college admission rates for urban and rural students. The admission rates rise immediately following the expansion,

[21]Due to lack of direct proof of ability distribution for rural and urban individuals, we shut down this ability channel for the current research. We could use the dispersion of the wage growth for rural and urban workers to calibrate their ability distributions instead. However, since most rural students migrate to urban areas after college graduation, the prediction would be misleading. Per capita household wealth levels and the wealth Gini-coefficients of rural and urban households, from Shi et al. (2005) are targeted for wealth distribution.

then gradually level off for both urban and rural students. Urban students' chance of enrollment is strictly higher than the rural students since they are on average three times wealthier than rural students. Panel B shows the relative college labor supply. It increases immediately after the expansion since more enroll in college and less work directly. The relative college labor supply jumps to a much higher level as the first cohort of expanded admission enter the labor market. Without demand shift, the relative supply of college labor gradually levels off with shrinking college premiums. Panel C presents the percentage change in college wage premiums corresponding to the relative supply change. The general pattern of transitional dynamics is qualitatively in line with the previous empirical trends.

5. COUNTERFACTUAL: MILD COLLEGE EXPANSION POLICY

In Nov 1998, the chief economist Dr. Min Tang, at the Beijing representative office of the Asian development bank, wrote a proposal to the Premier Minister Rongji Zhu on expanding the college admission.[22] The initial proposal was to increase the college entry class by 25% annually and expand the college admission quota by one fold in three to four years. The suggestion was quickly taken into consideration by the Ministry of Education, and the initial target in early 1999 was set to increase the college entry class by 21% from the previous year. However, in June of 1999, the official policy by the State Council increased the college admission quota by 47.4%, which vastly exceeded the initial expansion plan.[23] In this section, we conduct counterfactual analysis using the calibrated model in Section 4. We take an alternative, more conservative expansion policy, resembling the initial proposal by Dr. Min Tang and the original MOE plan in early 1999. Comparisons are made between the actual policy expansion and the alternative policy experiments with welfare analysis on different residential groups.

In the mild college expansion experiment, we increase the college admission quota by 20% each year for three consecutive years and keep the admission rate constant thereafter. We then compare the long-run effects by contrasting the two steady states before and after the alternative expansion with our baseline results. Panel A of Table 8 presents the college enrollment results; with a mild expansion, the overall admission rate is raised less than

[22]Published in the Economic News on Feb. 19th, 1999 under the title of Education to Promote Consumption,
http://finance.sina.com.cn/review/20041023/15201102716.shtml.

[23]The initial target of increasing the gross enrollment ratio in tertiary education to 15% by 2010 was actually surpassed in 2005, with an increment of gross enrollment rate of less than 10% in 1998 to over 20% in 2005.

one third, comparing to an over 50% increase in the baseline expansion. Therefore, college premiums in the alternative mild expansion would be higher compared to the base expansion for both the overall premiums and the premiums in rural and urban regions.

TABLE 8.

Experiment : Mild College Expansion

Panel A: Admission Rates

	All	Urban	Rural
Before Expansion	0.35	0.50	0.21
Base Expansion	0.54	0.70	0.47
Mild Expansion	0.43	0.61	0.32

Panel B: Relative College Labor Supply

Change (log points)	All	Urban	Rural
Base Expansion	66	51	86
Mild Expansion	46	45	57

Panel C: Long-term Welfare Comparison

Change (%)	All	Urban	Rural
Base Expansion	19.10	12.08	22.70
Mild Expansion	11.46	13.81	6.87

It is noted that the welfare improvement is nonlinear in the college expansion scale; the relative college labor increases less by only 20 log points in the mild expansion, but total welfare improvement shrinks by 40%, from 19.10% to 11.46%. This might come from the differential impact of the expansion scale on rural and urban residents. The baseline expansion lowers the ability threshold to the magnitude that many rural students, initially unable to enroll in college, could now attend. While for the urban students, further lowering the ability threshold to the baseline level will not change much of their already high admission rate. Therefore, to augment the college admission quota from the mild expansion to the actual baseline level will substantially raise the relative college labor supply for rural residents but only slightly for urban dwellers.

The long-run impacts are differential for rural and urban residents. The alternative expansion improves the welfare more for urban residents but strictly less for the rural group. Although rural college labor supply grows faster than the urban residents, the overall admission rates are higher in urban regions for both expansions. A long-term welfare comparison in Panel C shows that the overall welfare increases more in the baseline college expansion, which is more phenomenal for the rural group. Nowadays, a lot of discussions focus on whether China should control or reduce the college admission quota. Our research sheds light on this topic from the angle of the heterogeneous impact of expansion scales on rural and urban students. There has been, still is, and in the foreseeable future will be, a substantial gap between the urban and rural residents, in both the asset and human capital accumulation levels. Enabling more students the choice of higher education would potentially mitigate the problem by ensuring talents from rural regions also obtain high-skill jobs and sustain the long-run economic growth.

6. CONCLUSION

This paper develops an empirically grounded dynamic overlapping-generation general equilibrium model. We present the model and its calibration to China to better understand the impacts of the rapid college expansion, allowing individuals to make endogenous education decisions. The model incorporates the imperfect substitutability of workers in different education and age groups estimated from the micro-level data and is applied to quantify both the long run and the transitional effects of the expansion policies.

We estimate college premium by age and the elasticity of substitution among workers different by age and education level. Our empirical analysis shows that the college wage premium trends for workers of different age groups diverged after the college expansion. To account for this fact, we propose a model that incorporates imperfect substitution between different age and education groups. The dramatic exogenous policy change in 1999 serves as a sharp identification strategy to estimate the demand elasticities of substitution for both age and education groups. Our estimated age elasticities are generally lower than the conventional literature in the U.S., showing less substitutability between workers of different ages in China.

We further propose an overlapping generation model to account for the important age structure in China's labor market. We allow for heterogeneity in both ability and initial wealth levels and calibrate the model to fit both the main features of life-cycle wage growth and the wage premium trends. We then apply the calibrated model to an alternative mild college expansion process. Comparing to the actual expansion in 1999, a mild expansion generates less welfare gain overall. The alternative mild college expansion improves urban residents' welfare, at the cost of the rural workers, comparing to the actual, more rapid one. Our research shows the heterogeneous impact of expansion scales on rural and urban residents, which is of reference value for the policy makers regarding college admission policy.

With its rapid execution, the broad range of influence, and varied impacts on different subgroups, China's college expansion policy constitutes a good case study on acceleration in the supply of college educated workers across the developing countries. However, due to the simple structure of demand shocks and the abstraction from the school quality change, the current paper has done a less successful job replicating the entire transitional path quantitatively in data, which poses an interesting question for future research.

APPENDIX: DATA

One potential concern is whether the unweighed panel is representative of the whole China on the key dimensions, including the college enrollment, relative labor supply and wage differentials between rural and urban residents. To allay this concern, in Table 9 we compare the summary statistics from the nine waves of the CHNS in Panel A with that of the census and China Statistical Yearbooks (CSYs) in Panel B. In each survey year, we separate the CHNS sample into cells constructed by four education types and eight age groups,[24] and make sure that the population fraction of each education-age cell is in line with the census data. We use the weighted dataset constructed from the original series, since the aggregated labor supply relies heavily on the fraction of each demographic group.

TABLE 9.

Summary Statistics of CHNS Sample

	A.		CHNS Survey Years						
	1988	1990	1992	1996	1999	2003	2005	2008	2010
Provinces	8	8	8	9	9	9	9	9	11
Full-time workers	3,670	3,128	2,792	2,790	2,842	3,613	3,806	4,197	5,556
Percentage of									
-Male workers	59.62	58.95	60.06	59.17	61.01	56.32	56.57	56.85	56.37
-Urban hukou	69.06	71.14	68.02	64.60	57.30	37.75	37.28	35.62	46.87
-High-school graduates	24.55	26.69	29.48	35.25	37.16	27.48	26.12	23.73	27.27
-College graduates	3.11	4.99	4.19	4.76	7.11	6.64	9.22	8.46	15.59
		B.		National Census Survey Years					
	-	1990	-	1995	2000	-	2005	-	2010
Provinces	31	31	31	31	31	31	31	31	31
Percentage of									
-Male workers	-	55.04	-	54.26	54.66	-	54.58	-	55.46
-High-school graduates	-	15.12	-	12.01	14.60	-	14.02	-	16.24
-College graduates	-	2.92	-	3.23	5.11	-	7.68	-	12.52

[24]Four education types are: primary and below, junior, high school graduates, and college graduates, we separate the 21-60 year old individuals into 8 five-year age groups.

REFERENCES

Bai, C. E. and Z. Qian, 2010. The factor income distribution in China: 1978-2007. *China Economic Review* **21**, 650-670.

Card, D. and T. Lemieux , 2001. Can Falling Supply Explain The Rising Return To College For Younger Men? A Cohort-Based Analysis. *The Quarterly Journal of Economics* **116**, 705-746.

Chi, W. and X. Qian, 2013. Regional disparity of labor's share in China: Evidence and explanation. *China Economic Review* **27**, 277-293.

De Brauw, A. and S. Rozelle, 2008. Reconciling the returns to education in off-farm wage employment in rural China. *Review of Development Economics* **12**, 57-71.

Duflo, E., 2001. Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment. *American Economic Review* **91**, 795-813.

Epple, D., R. Romano, and H. Sieg, 2006. Admission, Tuition, and Financial Aid Policies in the Market for Higher Education. *Econometrica* **74**, 885-928.

Guvenen, F., B. Kuruscu, and S. Ozkan, 2014. Taxation of human capital and wage inequality: A cross-country analysis. *Review of Economic Studies* **81**, 818-850.

Heckman, J., L. Lochner, and C. Taber, 1998. Explaining Rising Wage Inequality: Explanations With A Dynamic General Equilibrium Model of Labor Earnings With Heterogeneous Agents. *Review of Economic Dynamics* **1**, 1-58.

Jeong, H., Y. Kim, and I. Manovskii, 2015. The price of experience. *American Economic Review* **105**, 784-815.

Katz, L.F. and K.M. Murphy, 1992. Changes in Relative Wages, 1963-1987: Supply and Demand Factors. *The Quarterly Journal of Economics* **107**, 35-78.

Li, Y.A., J. Whalley, S. Zhang, and X. Zhao, 2011. The higher educational transformation of China and its global implications. Technical Report 4.

Liao, P.J., P. Wang, Y.C. Wang, and C.K. Yip, 2017. Educational choice, rural-urban migration and economic development. Technical Report. National Bureau of Economic Research.

Lui, H.K. and W. Suen, 2005. The shrinking earnings premium for university graduates in hong kong: The effect of quantity or quality? *Contemporary Economic Policy* **23**, 242–254.

Ma, G., Y. Ji, and J. Xu, 2017. How does college expansion affect college wage premiums? *Management World(Chinese)* **2017**.

Shi, L., W. Zhong, and D. Sai, 2005. Empirical Analysis on the Inequality and the Reason of China Residents' Property Distribution. *Economic Research Journal* **6**, 4-15.

Song, Z., K. Storesletten, Y. Wang, and F. Zilibotti, 2015. Sharing high growth across generations: pensions and demographic transition in China. *American Economic Journal: Macroeconomics* **7**, 1-39.

Wang, X., B.M. Fleisher, H. Li, and S. Li, 2007. Access to Higher Education and Inequality: The Chinese Experiment. IZA Discussion Papers 2823. Institute for the Study of Labor (IZA). Welch, F., 1979. Effects of Cohort Size on Earnings: The Baby Boom Babies' Financial Bust. *Journal of Political Economy* **87**, S65-97.

Yang, D.T., 2008. Public policy changes in China's higher education system. China: Social Sciences Academic Press.

Yao, Y., 2019. Does higher education expansion enhance productivity? *Journal of Macroeconomics* **59**, 169-194.

Zhang, J., Y. Zhao, A. Park, and X. Song, 2005. Economic returns to schooling in urban China, 1988 to 2001. *Journal of Comparative Economics* **33**, 730-752.