Higher Education Expansion, Economic Reform, and Productivity

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Abstract

This paper advances our understanding of the impact of an educational policy on labor productivity using China’s higher education expansion. In an economy such as China, where allocation distortions widely exist, an educational policy affects average labor productivity not only through its effect on human capital stock, but also through its effect on human capital allocation across sectors. Thus, its impact could be very limited if misallocation becomes more severe following the policy. A two-sector general equilibrium model is constructed. Quantitative analysis shows a slightly negative effect (about 5 percent) of higher education expansion on average labor productivity given distortions, but this effect would be positive if allocation distortions were further reduced by economic reform.

Keywords: Higher education expansion, Economic reform, Human capital, Misallocation, Productivity

JEL Classification: I25, I28, O11, O41

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1 Introduction

Human capital has long been considered the engine of economic growth (Schultz, 1961; Uzawa, 1965; Lucas, 1988; and many others), and government policies that promoted education of a society have thus been valued. Indeed, many countries experienced a government-led education expansion program at some stage of development\(^1\). However, a feature of developing economies is the widely existing factor misallocation, which has caused substantial productivity losses in those economies (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009). Since the working of an educational policy is expected to channel through a production factor – human capital, its effects may be limited if factor misallocation becomes more severe following the policy. In this paper, I examine how an educational policy may affect labor productivity through its effect on the allocation as well as the stock of human capital using China’s higher education expansion, and how an economic reform may influence the effectiveness of the educational policy by triggering more efficient allocation.

While studies have found positive and increasing returns to education in China (Li, 2003; Li and Luo, 2004; Zhang et al., 2005; Fleisher et al., 2011), Pritchett (2006) argues that in many developing countries social returns to education can be well below private returns as an overwhelmingly large share of college graduates were employed by the less-efficient public sector. While sectoral misallocation in China has been well documented, few previous study has examined the impact of the higher education expansion on average labor productivity through its effect on resource allocation across sectors. Moreover, the effect of an education expansion may be masked by the concurrent other institutional changes that improved productivity. In China, the higher education expansion was accompanied by a large-scale economic reform of the state sector and other market-oriented policies. It is therefore interesting to policy makers to understand the isolated effect of the educational policy on labor productivity as well as its interaction with other policies.

\(^1\) For example, Korea and Thailand expanded the tertiary education in the 1980’s. The expansion raised the tertiary enrollment rate from about 10 percent in 1980 for both countries to nearly 100 percent for Korea and over 50 percent for Thailand in recent years. In Taiwan, human capital improvement was given the first policy priority since the 1950’s, followed by growth of higher-educated labor force that far outpaced other educational levels during 1960’s to 1980’s (Tallman and Wang, 1994). Other countries such as China, Japan, Malaysia, Singapore, etc., had similar experience of education expansion.
In order to address these questions, I construct a two-sector general equilibrium model in which households make educational and occupational choices depending on exogenous policies. The key features of the model are as follows. (i) There are two sectors, a state sector and a private sector. State sector firms have lower productivity (or, TFP) than private sector firms, but are subsidized for factor inputs. (ii) Households are heterogeneous in ability. They make an educational choice of whether to acquire college education, and then an occupational choice between the private and the state sector upon graduating. Households’ ability affects both choices. Higher ability not only lowers the disutility of college education, but also lowers the layoff probability of a skilled worker in the private sector, while a skilled worker in the state sector may secure the job perfectly. (iv) The higher education policy enters the model via an exogenous component of the disutility cost of college education, i.e., higher education expansion lowers this disutility.

The model characterizes two main tradeoffs regarding the educational and the occupational choices. For the former, college education enhances one’s future labor income, but incurs a disutility cost. For the latter, private-sector jobs may pay higher wages to skilled workers due to higher productivity, but are less-secured than state-sector jobs. In equilibrium with reasonable parameterizations, households are sorted into three categories by ability: the ablest ones acquire college education and then become skilled workers of the private sector, the least able ones do not go to college and become unskilled workers, and the middle ones enter college and then become skilled workers of the state sector.

The educational policy affects average labor productivity through two channels. One is the “growth” channel. Higher education expansion, by lowering the disutility of college education, encourages more people to enter college. This increases the society’s human capital stock. Since skilled labor complements more productive technology, average labor productivity can be improved. The other is the “reallocation” channel. As more people with lower ability enter college and then become skilled workers under this policy, relatively more of them would prefer working for the state sector to the private sector, since they would have a higher chance to be fired if choosing the latter. This would reallocate relatively more skilled workers to the state sector and hence lower average labor productivity. Furthermore, the reallocation of human capital would magnify misallocation of physical capital due to factor complementarity. As the state sector demands more subsidy for its input, loanable funds market would be tightened, crowding out capital for production use, further lowering labor productivity.
I calibrate the model to match China's data on wage and employment across sectors for years 1990 to 2008, and apply the calibrated model for policy analysis. I find that first, the higher education expansion in China did increase the society's human capital stock significantly (by nearly 50 percent). However, it reallocated more human capital toward the less-productive state sector. Overall, given distortions, the average labor productivity would have increased by about 5 percent had the college enrollment not expanded. Meanwhile, the economic reform of the state sector, by reducing allocation distortions, contributed significantly to labor productivity. Had there been no reform, average labor productivity would have declined by nearly 50 percent. Second, a decomposition of the educational policy shows that the reduction of private-sector share of skilled labor and the reduction of physical capital available for production contribute most to the lowered average labor productivity following college expansion. For the latter, an increase of subsidy to the state sector due to college expansion turns out to be the major factor that crowds out productive capital.

While the negative effect of the educational policy seems striking, it is not to say that higher education expansion in China was wrong. Instead, my analysis suggests that in order to reach the maximal social welfare or average labor productivity, higher education should expand further. However, this must be accompanied with deepened economic reform that further reduces allocation distortion. The effect of higher education expansion on labor productivity would turn positive when distortions are sufficiently small.

This paper is related to the broad literature of the role of human capital in economic growth and development (Schultz, 1961; Uzawa, 1965; Rosen, 1976; Lucas, 1988; Romer, 1990; Caselli, 2005; Hsieh and Klenow, 2010; Galor and Moav, 2004; Goodfriend and McDermott, 1995; Hanushek and Kimko, 2000; Hanushek and Woessmann, 2008; Manuelli and Seshadri, 2014; Erosa, Koreshakova, and Restuccia, 2010; Cubas, Ravikumar and Ventura, 2016; Hanushek and Woessmann, 2012; and many others). Most of these studies, however, focus on the effect of human capital stock, while ignore that of human capital allocation. This paper is also related to the literature on the effect of the allocation of talent on productivity (Pritchett, 2006; Baumol, 1990; Murphy, Shleifer, and Vishny, 1991), which argues that the allocation of talent on productive activity versus unproductive, rent-seeking activity accounts tremendously for cross-country differences in economic growth throughout the history.

This paper is then linked to the misallocation literature (Restuccia and Rogerson,
2008; Hsieh and Klenow, 2009; Alfaro et al., 2008; Bartelsman et al., 2013; Banerjee and Duflo, 2005; Schmitz, 2001), which highlights the role of resource allocation rather than the aggregate level in cross-country income differences. In particular, literature of misallocation in China has documented inefficient capital allocation due to state-dominated financial system (Dollar and Wei, 2007; Dobson and Kashyap, 2006; Allen, Qian and Qian, 2005; Boyrean-Debray and Wei, 2005), and substantial productivity losses resulted from misallocation (Hsieh and Klenow, 2009; Brandt, Tombe and Zhu, 2013; Brandt, Hsieh and Zhu, 2008). While this literature typically focuses on allocation of physical capital and unskilled labor, my paper emphasizes the allocation of human capital, or skilled labor, as a consequence of an educational policy. In his study of efficiency of human capital allocation in developing countries, Vollrath (2014) finds that eliminating wage wedges between sectors has only a small effect on aggregate productivity, but he admits that total productivity gains could be much larger if the model incorporated dynamic physical capital accumulation or if marginal product gaps were all removed.

Finally, this paper is related to the relatively thin literature of China’s higher education expansion. This literature largely focuses on the impact of the college expansion on inequality, rather than productivity (e.g., Meng et al., 2013; Yeung, 2013).

The rest of the paper proceeds as follows. Following a brief introduction of the background, Section 2 provides details of the model economy, followed by a characterization of general equilibrium in Section 3. Section 4 presents a quantitative analysis, and Section 5 concludes.

**Background**

China’s nationwide college enrollment expansion, launched in 1999, was a means of the central government to “stimulate domestic demand, stimulate consumption, promote economic growth, and ease employment pressure”. The policy made college education much more accessible to ordinary people by expanding college admissions substantially. In 1999 alone, the college enrollment number reached nearly 1.6 million, a 48 percent increase from the previous year. The expansion continued throughout the following years and significantly increased China’s skilled labor stock. On average, the annual growth rate of China’s college enrollment reached over 16 percent during 1998-2010, a significant increase from an average of 6.8 percent during
1977-1998. The college enrollment rate, defined as the ratio of the college enrollment number to the number of people who take the college entrance examination, was on average less than a quarter during 1977-1998, but about 60 percent from 1999 to 2010. The college entry number as a share of China’s working-age population was well below 0.15% before 1999, but increased to 0.66% in 2010 following a dramatic upward shift in 1999 (Figure 1). The share of the whole population with college degree also increased from 1.42% in 1990 to 8.93% in 2010 (China Statistical Yearbook).

![Figure 1. College entry number as a share of working-age population (in percentage)](image)

Notes: This figure shows the college enrollment number as a share of working-age population (aged between 15-64) in China during 1990-2010. Data source: China statistical yearbook.

The college enrollment expansion was accompanied by a large-scale economic reform of the state sector. Began in the mid-1990’s, the reform became substantial since 1998. The SOEs, while given priority for access of various resources, were generally regarded as being highly inefficient with redundant employment, and was becoming a barrier to China’s further economic growth. This situation was particularly severe before the 1990’s reform. The reform then cut off subsidies to most SOEs, shut down or privatized the least productive ones, and laid off millions of excessive workers (“Xiagang”).

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21977 is the first year China resumed its college admission since the cultural revolution.

3See Bai et al. (2000) for a review of the SOE reform.
Following the two policies, labor allocation of the private and the state sectors shows a structural change (see Figure 2). For skill-intensive industries, the private-sector employment has been growing very rapidly since 2002, which is the year when the first generation of college students since college enrollment expansion entered the labor market, whereas the state-sector employment has been relatively stable (Figure 2(a)). Differing from that, the labor-intensive industries saw a large drop of state-sector employment around 1998 due to the reform, whereas a roughly linear growth of the private sector throughout the years (Figure 2(b)). These observations illustrate that (i) China’s skill-intensive industries have grown relatively faster than the labor-intensive ones, indicating an increase of skilled labor share, and (ii) although in both skill- and labor-intensive industries, the private-sector share of employment has increased over time, in skill-intensive industries this increase only became significant after 2002, suggesting a reallocation of skilled labor from the state to the private sector after college enrollment expansion. However, the figures do not tell us which policy drives this structural change of labor allocation and what the implications for aggregate labor productivity are. This paper attempts to answer these questions.

(a). Employment of skill-intensive industries (in million)

4The skill-intensive industries are defined as industries in which employment share with college degree above 30 percent in the year 2002, and labor-intensive industries are those in which less than 10 percent of employment had college degree in 2002.
In this model economy, there are two sectors – the private sector and the state sector. State-sector firms have lower productivity but are subsidized for factor inputs. Households, heterogeneous in ability, live for three periods and have perfect foresights about lifetime income. They make educational choices and occupational choices, both depending on ability given policy.

2.1 Production and distortions

Firms of two sectors – the private sector (i.e., private enterprises, or “PE”) and the state sector (i.e., state-owned enterprises, or “SOE”), produce homogeneous goods which are the numeraire, using unskilled labor, skilled labor and physical capital with a CRS technology. Markets are competitive except for factor price distortions. The production functions are:
where $L^i$ ($H^i$) and $K^i$ are the amount of unskilled (skilled) labor and physical capital employed by type $i$ firms, $i \in \{P, S\}$. The unskilled production and the skilled production are separate. The former is linear in unskilled labor and is the same for $PE$ and $SOE$. The latter uses both capital and skilled labor in a Cobb-Douglas form, where $\Psi(\bar{\pi})$ is a function of average ability of skilled workers in type $i$ firms and $\Psi'(\bar{\pi}) > 0$. The two parts of production can be viewed as two types of technology available for firms. One is less productive but does not require higher skill or physical capital to operate with. The other is skill- and capital-augmented and is more productive.\(^5\) A Firm does not know an individual worker’s ability but only knows the average ability of its skilled workers, hence it pays the same wage to all of its skilled workers. I assume $A^P > A^S$ since it is widely documented that private firms have higher TFP than state firms due to better profit incentives. It is also reasonable to think that better incentives matter more for skilled workers than for the unskilled. The capital shares of output are allowed to differ since the two types of firms may specialize in industries with different capital intensities.

Policy distortions on factor price are modeled following Restuccia and Rogerson (2008), and Hsieh and Klenow (2009). Instead of assuming distortions of output or physical capital as in their models, I assume that $SOE$ receives subsidies for both capital and skilled workers. Denote the market rental rate of capital by $R$ and the wage of an $SOE$ skilled worker by $w^S_H$, then what $SOE$ actually pays out of its own pocket is $(1 - \tau_K)R$ and $(1 - \tau_w)w^S_H$ respectively, where $\tau_K$ and $\tau_w$ measure the degree of policy distortions on physical and human capital allocations respectively ($\tau_K \geq 0$, $\tau_w \geq 0$). $PE$ receives no subsidy and hence pays $R$ for capital and $w^P_H$ to its skilled workers. Note that $w^P_H$ may differ from $w^S_H$ in equilibrium. Both firms pay the same wage $w_L = \nu$ to unskilled workers due to linearity of unskilled production.

2.2 The household

Time is discrete. The economy is populated with three-period overlapping generations, in which households make an educational choice – whether to acquire college education when young, and an occupational choice – whether to work for $PE$ or

\(^5\)This production function greatly simplifies the unskilled production and thus allows me to focus on human capital, or skilled labor.
SOE when becoming a skilled worker in the middle age. I assume a household to be equivalent to an individual. Following Fender and Wang (2003), I assume that individuals are identical, except that they differ initially in ability, which is exogenously determined at one’s birth and remains unchanged for her entire life. The ability $a$ follows an $i.i.d.$ distribution with $cdf \ F(a)$. This ability affects one’s disutility cost of acquiring higher education (i.e. going to college), and also her job security if working for $PE$ as a skilled worker. The measure of those born in any particular period is normalized to unity, and individuals have no initial wealth at birth.

All individuals derive utility from the third-period consumption. Apart from this, only the disutility of acquiring higher education affects utility. The disutility cost of education can be thought of as a nonpecuniary cost, e.g., how painful one feels about preparing for the college entrance exam. There is neither endogenous leisure nor altruism. The utility function of a household born at $t$ with ability $a$ is as follows:

$$u_t(a) = c_t^{t+2}(a) - \Omega \frac{\eta}{a}$$

where $c_t^{t+2}$ is her consumption at the third period of life, which is a function of her ability$^6$. $\Omega$ is an indicator function which equals one if the individual chooses to go to college when young, and zero if she does not. The disutility cost of acquiring higher education is $\frac{\eta}{a}$, which consists of two components. $\eta$ is the exogenous disutility cost of education, which can be used to measure an educational policy that rations higher education enrollments, i.e., a larger $\eta$ means more restrictive college admission. The individual’s ability $a$ negatively affects the disutility cost, i.e., people with higher ability feel less painful about going to college.$^7$

$^6$The linear form of utility function greatly simplifies my analysis of household choices without losing any key features needed for modeling.

$^7$An alternative way of modeling the educational policy is to allow the policy to assign a quota of college enrollment, and I will show this way of modeling is equivalent to the way adopted in this paper.

Under the alternative modeling, the quota under the educational policy gives a probability to each individual who attempts to enter college to be admitted into college. This probability depends on the individual’s ability and the quota under policy and will be determined in equilibrium. Let this probability be $p(a; Q)$ for an individual with ability $a$ under an educational policy measured by a college enrollment quota $Q$. $p'_a(a; Q) > 0$ and $p'_Q(a; Q) > 0$, then the expected utility of an individual given that she attempts to enter college is $Eu(a) = p(a; Q)Eu(c_{college}) + (1 - p(a; Q))Eu(c_{noncollege}) = [Eu(c_{noncollege}) + p(a; Q)[Eu(c_{college}) - Eu(c_{noncollege})]]$. This is equivalent to the utility function used in this paper regarding the educational policy: $Eu(a) = Eu(c_{college}) - \frac{\eta}{a} = Eu(c_{college}) + [Eu(c_{college}) - Eu(c_{noncollege})] - \frac{\eta}{a}$, since that the term $Eu(c_{college}) - Eu(c_{noncollege})$ will be linear in skilled wage and that $\eta$ will be written as $\eta = \eta_0 w_H$, where $\eta_0$ is a measure of educational policy relative to skilled wage and will be used in the quantitative analysis. As a result, the whole term $[Eu(c_{college}) - Eu(c_{noncollege})] - \frac{\eta}{a}$ is linear in skilled wage or college premium and is a function of the educational policy, as is in the alternative model.
The timeline of one’s life is as follows.

In the first period, a household decides whether to acquire higher education (i.e., going to college). If she does, she cannot work at this period and needs to pay an education fee $\theta$ by borrowing from the market since she has no initial wealth, but she will become a skilled worker from the next period on and participate in the skilled production\(^8\). If she does not go to college, she can start working immediately but as an unskilled worker and receives unskilled wage for her entire life. Note that the education fee $\theta$ is likely to increase following the college expansion to support resources involved under the policy, such as building new universities or expanding the existing ones, subsidizing new admissions, etc., and this is indeed the case in China.

In the second period, those who went to college when young become skilled workers and make an occupational choice between $PE$ and $SOE$, and would receive skilled wages $w_{H}^{P}$ or $w_{H}^{S}$ accordingly. They also need to repay their loan of education fee at a market interest rate, i.e., $(1 + R)\theta$. Those who did not go to college continue working as unskilled workers. I assume that all middle-aged households are imposed a lump-sum tax $\tau$ by the government to subsidize $SOE$, regardless of her educational level or employer\(^9\).

In the third period, workers cannot change their sector which can be thought of due to frictions of sectoral mobility. Skilled workers of $SOE$ are better-secured at this period than those of $PE$. If the skilled works for $PE$, with a probability $\Phi(a)$ she will be laid off and become unemployed for the rest of her life, where $a$ is her ability and $\Phi'(a) < 0$ – the higher ability she has, the less likely she will be fired. But if she works for $SOE$, she keeps her job whatever\(^10\). This mirrors the reality that

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\(^8\)An alternative way of modeling the education fee is to assume it to be paid by parents (i.e., the middle-aged), then the young cohort need not pay but the middle-aged would pay if their children go to college. This is equivalent to the current model in the steady state but would be more complicated as it requires intergenerational decisions.

\(^9\)This is a simplified way of modeling government budget balance that avoids introducing new distortions.

\(^10\)The layoff function can be viewed as a reduced form of a model in which employers receive a noisy signal about workers’ ability after one period of employment. The higher one’s true ability, the more likely that her employer receives a good signal, and the less likely she would be fired.

An alternative model that needs not the assumption of unemployment is to allow individuals’ ability perfectly observed and hence a skilled worker’s wage increases with ability (and the unskilled wage does not depend on ability). Still, only workers with high enough ability would go to college and sectoral distortions would lead to human capital misallocation. However, in such a model there would be no ability-based sorting into the two sectors as discussed in Section 3.1 as skilled workers would be indifferent between the two sectors, and the implied sectoral wages would be inconsistent with the empirical fact that skilled workers in the private sector earn higher income than those in the state sector on average (China Household Income Project, 2002).
SOEs tend to offer better-secured, “iron-bowl” jobs to the highly educated workers regardless of their ability, as they have a relatively higher motivation of maintaining a highly-educated employment pool instead of making profits. In contrary, private firms have high profit incentives and are more likely to fire the incapable workers even if they had high educational attainment. Moreover, private firms are more likely to shut down and have to dismiss their workers since they are less protected by the government. In this situation, their former employees would find themselves hard to find a new job if their ability is not sufficiently high.

An unskilled worker will be laid off with a probability $\phi_L$ in the last period regardless of the type of firms she works for. Hence, an unskilled worker is indifferent between $PE$ and $SOE$ and thus has no directed occupational choice.

Since only consumption of last period of life matters, a household saves all her income in previous stages of life and receives interest rate $r$ of her saving ($r = R - \delta$, where $\delta$ is depreciation rate of capital). Her consumption when being old under different choices is the following

$$c_{t+2}^{t+2,L} = [w_{L,t}(1 + r_{t+1}) + w_{L,t+1} - \tau_{t+1}] - (1 + r_{t+2}) + (1 - \phi_L)w_{L,t+2}$$

$$c_{t+2}^{t+2,H,S} = [w_{S,t+1}^H - (1 + R_{t+1})\theta - \tau_{t+1}] - (1 + r_{t+2}) + w_{H,t+2}^S$$

$$c_{t+2}^{t+2,H,P}(a) = [w_{P,t+1}^H - (1 + R_{t+1})\theta - \tau_{t+1}] - (1 + r_{t+2}) + [1 - \Phi(a)]w_{H,t+2}$$

$$\text{(4)}$$

### 3 Optimization and Equilibrium

#### 3.1 The Household

With perfect foresights about lifetime income, households’ educational choice and occupational choice can be solved backwardly.

**Occupational choice**

At the second period of life (date $t + 1$), a skilled individual (born at $t$) faces the occupational choice between the private and the state sector, i.e., $o \in \{P, S\}$. She chooses to work for $PE$ if and only if $c_{t+2,H,P}^{t+2} \geq c_{t+2,H,S}^{t+2}$ since the cost of college education has been a sunk cost. By arranging equation (4), we obtain that a household chooses $PE$ if and only if $(w_{P,t+1}^H - w_{H,t+1}^S)(1 + r_{t+2}) + w_{P,t+2}^H - w_{H,t+2}^S \geq a \Phi(a)w_{H,t+2}^P$, that is, when the wage gain of working for $PE$ exceeds the expected loss of being fired at the last period of life. The higher ability she has, the less likely will she be fired.
Under certain conditions, in particular, when the relative TFP of PE over SOE is sufficiently high, and distortions of capital and skilled labor (i.e., $\tau_K, \tau_w$) are not too large, so that $w_{H,t}^P > w_{H,t}^S$, there is a threshold ability $\hat{a}$ such that college graduates with ability above $\hat{a}$ choose to work for PE and those with ability below $\hat{a}$ work for SOE. $\hat{a}$ can be determined by:

$$\Phi(\hat{a}) = \left[ (w_{H,t+1}^P - w_{H,t+1}^S)(1 + r_{t+2}) + w_{H,t+2}^P - w_{H,t+2}^S \right] / w_{H,t+2}^P. \quad (5)$$

In the steady state, the above equation can be simplified as

$$\Phi(\hat{a}) = (2 + r) \left( 1 - \frac{w_{H}^S}{w_{H}^P} \right) \quad (6)$$

Intuitively, there is a trade-off between wage and unemployment risk for the occupational choice. Since PE has higher productivity, it may offer a higher wage than SOE does as long as distortions are not too large. However, the risk of layoff in the third period could be high if the worker’s ability is low. Hence, only those with sufficiently high ability would choose to work for PE, whereas those with low ability would rather give up higher wages to gain an “iron bowl” in SOE. Furthermore, equation (6) shows that the interest rate also affects the threshold ability $\hat{a}$. A higher interest rate increases opportunity costs of working for SOE, and thus lowers $\hat{a}$ and increases the relative PE skilled employment.

**Educational choice**

At the first period, an individual (born at $t$), having perfectly forecasted what she would choose in the next period conditional on her decision at this period, makes the educational choice of whether to go to college, i.e., $e \in \{H, L\}$. She chooses to go to college and become a skilled worker if and only if $\max \{ E[c_{t+2}^{L,H,P}(a)], E[c_{t+2}^{L,H,S}] \} - \frac{a}{\alpha} \geq E[c_{t+2}^{L}]$. The utility function tells us that at this stage a household weighs the higher income she would receive as a skilled worker against the disutility cost of education. The lower ability she has, the more painful would she feel about going to college, and hence the more likely would she choose to become an unskilled worker. Under certain conditions – in particular, when $\eta$ is sufficiently high and the cost of education (disutility and fee) is not too low, there exists another threshold ability $\tilde{a}$ so that a household with ability above $\tilde{a}$ chooses to go to college and become skilled and those
with ability below $\tilde{a}$ become unskilled. $\tilde{a}$ can be determined by

$$
[w_{H,t+1}^S - (1 + r_{t+1})\theta] (1 + r_{t+2}) + w_{H,t+2}^S - \frac{\eta}{\tilde{a}}
= [w_{L,t}(1 + r_{t+1}) + w_{L,t+1}^S] (1 + r_{t+2}) + (1 - \phi_L)w_{L,t+2}
$$

(7)

In the steady state the above equation can be rearranged to

$$
\tilde{a} = \frac{\eta}{\{ w_{H}^S(2 + r) - (1 + R)\theta^2 - w_L [(2 + r)(1 + r) + 1 - \phi_L] \}}
$$

(8)

Intuitively, equation (8) says that the higher the exogenous disutility cost of college education (i.e., higher $\eta$), or the smaller the wage gap between an SOE skilled worker and an unskilled worker, the higher would be $\tilde{a}$. In addition, a higher interest rate would increase opportunity costs of being unskilled when $w_{H}^S$ is sufficiently higher than $w_L$, and would thus lower $\tilde{a}$ and increase skilled share of population; its effect would be opposite when $w_{H}^S$ is not sufficiently high.

**Lifetime choices**

Now we can see that under certain conditions, households self-select into different categories of education and occupation based on ability. This is illustrated in Figure 3, which shows the utility of a household with different ability under different choices. The utility of an unskilled worker ($u_L$) is constant regardless of her ability, since there is neither disutility from education nor layoff risk that are affected by ability. The utility of a skilled worker, however, increases with ability. A PE worker’s utility curve is steeper than an SOE worker’s, because for a PE skilled worker not only disutility from education but also the layoff risk decreases with ability, while for an SOE skilled worker ability only matters for the disutility. Nonetheless, the utility curve of a PE worker starts at a lower point, as the layoff punishment is harsh for those with very low ability. Hence, the two curves of skilled workers in two sectors ($u_{H}^P$ and $u_{H}^S$) intersect at a point which corresponds to $\tilde{a}$. As a result, households self-select, or, “sort” into different skill levels and different types of firms: those with ability in high percentiles acquire college education and then work for PE, those in low percentiles do not go to college and become unskilled workers, and those in the middle go to college and then become skilled SOE workers.
3.2 The Firm

Firms’ problems are standard. They rent capital and hire unskilled and skilled workers in each period, and do not save for the future, thus their problem is static. Firms optimize by equalizing marginal product to marginal cost, taking distortions as given. Their decisions about capital and two types of labor are (subscript \( t \) is skipped)

Capital:

\[
PE: \quad R = \alpha^P A^P \Psi(\bar{a}^P)^{1-\alpha^P}(k^P)^{\alpha^P-1} \\
SOE: \quad (1 - \tau_K)R = \alpha^S A^S \Psi(\bar{a}^S)^{1-\alpha^S}(k^S)^{\alpha^S-1}
\]

Skilled labor:

\[
PE: \quad w_H^P = (1 - \alpha^P)A^P \Psi(\bar{a}^P)^{1-\alpha^P}(k^P)^{\alpha^P} \\
SOE: \quad (1 - \tau_w)w_H^S = (1 - \alpha^S)A^S \Psi(\bar{a}^S)^{1-\alpha^S}(k^S)^{\alpha^S}
\]

where \( k^i \equiv \frac{K^i}{H^i}, i \in \{P, S\} \) is the capital per skilled worker in type \( i \) firm. Unskilled wages are the same for \( PE \) and \( SOE \):

\[
w_L = \nu
\]
3.3 Market clearing conditions

There are three markets in this economy – unskilled labor, skilled labor, and loanable funds markets.

The unskilled labor market clearing condition at time $t$ is

$$L_t^P + L_t^S = F(\tilde{a}_t) + F(\tilde{a}_{t-1}) + F(\tilde{a}_{t-2})(1 - \phi_{L,t})$$ (14)

The subscript $t$ of $\tilde{a}$ indicates the threshold ability of the generation born at $t$.

The skilled labor market clearing condition (for two sectors respectively) at time $t$ is

$$H_t^P = 1 - F(\tilde{a}_{t-1}) + \int_{\tilde{a}_{t-2}}^{\infty} [1 - \Phi_t(a)]dF(a)$$ (15)

$$H_t^S = [F(\tilde{a}_{t-1}) - F(\tilde{a}_{t-1})] + [F(\tilde{a}_{t-2}) - F(\tilde{a}_{t-2})]$$ (16)

The loanable funds market clearing condition at $t$ is

$$K_t^P + K_t^S + \theta_t(h_t^P + h_t^S) + (h_t^P - h_t^S)(1 + R_t)\theta_{t-1} + \tau_t$$

$$= (l_t^P + l_t^S)w_{L,t} + (l_t^P - l_t^S) [(1 + r_t)w_{L,t-1} + w_{L,t}] + h_t^P w_{H,t}^P h_t^S w_{H,t}^S$$ (17)

where $l_t^i$ and $h_t^i$ are the amount of unskilled and skilled workers of the generation born at time $t$ working for sector $i$ ($i \in \{P, S\}$). Equation (17) shows that the demand side of the loanable funds market consists of three parts: productive capital of firms, education loan of young college students and loan repayment of middle-aged skilled workers, and subsidy to SOE (equals tax revenue $\tau$). The supply side of the loanable funds market consists of: wages earned by young unskilled workers, wages earned by middle-aged unskilled workers plus their saving from the last period, and wages earned by middle-aged skilled $PE$ and $SOE$ workers.

The average ability of each type of firm is

$$\bar{a}_t^P = \left[ \int_{\tilde{a}_{t-1}}^{\infty} aF(a) + \int_{\tilde{a}_{t-2}}^{\infty} a(1 - \Phi_t(a))dF(a) \right] / H_t^P$$ (18)

$$\bar{a}_t^S = \left[ \int_{\tilde{a}_{t-1}}^{\tilde{a}_{t-1}} aF(a) + \int_{\tilde{a}_{t-2}}^{\tilde{a}_{t-2}} aF(a) \right] / H_t^S$$ (19)
\( \tau_t \) satisfies the government budget constraint:

\[
\tau_t = \tau_{K,t} R_t K^S_t + \tau_{w,t} w^S_{H,t} H^S_t \\
(20)
\]

that is, it is used to subsidize SOE for renting physical capital and hiring skilled workers.

3.4 Dynamic general equilibrium

**Definition:** A competitive equilibrium is a set of allocations \( \{L^P_t, L^S_t, H^P_t, H^S_t, K^P_t, K^S_t, c(a)\}_t \), and a set of prices \( \{R, w^P_H, w^S_H, w_L\}_t \), such that given prices, distortions \( \{\tau_K, \tau_W\} \) and distribution of ability \( F(a) \),

(i) each household chooses \( e \in \{H, L\}, o \in \{P, S\} \), and consumption to maximize her utility;

(ii) each firm chooses capital and labor \( \{K^i_t, H^i_t, L^i_t\}_t (i \in \{P, S\}) \) to maximize profit (by satisfying equation (9) – (13));

(iii) labor and loanable funds markets clear at each time \( t \), that is, equation (15) – (17) are satisfied at each \( t \).

(iv) government’s budget constraint (equation (20)) is satisfied.

3.5 Characterization of educational policy effects

As mentioned earlier, in the model a higher education expansion policy can be measured by a decrease in the value of the parameter \( \eta \) (or, as is shown in the next section, a relative measure \( \eta_0 \equiv \eta/\bar{w}_H \) will be used). This section characterizes the two channels through which the educational policy affects average labor productivity (see Figure 4).

First, the growth effect. As \( \eta \) decreases, the exogenous cost of acquiring college education decreases, so as the overall disutility cost of education given an individual’s ability. This encourages more individuals to go to college and then become skilled workers, thereby increasing the society’s stock of human capital. Since skilled labor complements more-productive technology, this channel has a positive effect on average labor productivity. Meanwhile, as the supply of skilled labor increases, the average skilled wage decreases in equilibrium, suppressing further increase of skilled labor.

Second, the reallocation effect. Under the model mechanism, only individuals with higher ability choose to go to college. By encouraging more individuals to enter college, the policy brings more less-able individuals to the skilled labor market. Relatively more of these individuals would prefer working for SOE rather than PE,
since their probability of being fired would be higher if choosing $PE$. This may cause relatively more human capital to be allocated to the less-productive $SOE$. Physical capital would then be directed to $SOE$ due to complementarity of the two types of capital. Further, loanable funds market would be tightened as $SOE$ requires more subsidies for its skilled-worker employment and capital renting. This reduces capital per worker and further dampens labor productivity. The relative increase in skilled labor supply to $SOE$ then pushes up relative $PE$ skilled wage and interest rate, reducing the extent of increases in $SOE$ skilled labor supply. This channel has a negative effect on labor productivity since it magnifies misallocation of both human and physical capital.

**Figure 4. The effect of higher education expansion**

### 4 Quantitative analysis

In order to evaluate the effects of policy change, I calibrate two sets of parameters regarding the pre- and post-regimes using China’s data. Then I conduct a number of experiments to examine the impact of policies of interest quantitatively.

#### 4.1 Calibration

I calibrate two sets of parameters regarding pre- and post-regimes, using data of years 1990-1998 (average) for the pre-regime parameters, and data of years 2002-2008 (average) for the post-regime ones. These two sets of parameters are assumed to correspond to the old and the new steady states of the economy respectively. Since
the state sector reform became substantial in 1998, roughly the same period as the college enrollment expansion, I view these two policies as concurrent and thus the old and the new steady state are referred to as the stage before and after both policy changes respectively (they will be called steady state one and two below, or, “ss1” and “ss2” in short). I do not use data between 1999 to 2001 as I consider these years as a transition period under the policy. Data before 1990 is largely missing and after 2008 could be much affected by the global financial crisis and hence are not used.

A caveat of the calibration is that the length of data available is too short compared with the model to reach the new steady state. Assuming an individual makes the college decision at 15 years old and retires at 60, it will take 45 years for the economy to reach the new steady state, for which data is definitely unavailable. Therefore, the data used for calibrating the new steady state actually contains information of a large fraction of old- or middle-aged workers who made decisions in the old regime. Nonetheless, given the lack of data, the current analysis may be the best that can be done so far.

I use employment and wage data of five industries from China labor statistical yearbook (“CLSY”): manufacturing, real estate, finance, information technology, and science and technological service. These are used to represent all of China’s industries in terms of skill composition: manufacturing represents a labor-intensive industry with only 6.3 percent of employment with college degree in 2002, and the rest four are relatively skill-intensive with over 30 percent of employment with college degree in 2002. The data contains information of the average wage of each industry for each of the state sector and the private sector respectively, but has no information about wages of workers with college degrees or not. Thus, I use the average wage of the construction industry to approximate unskilled wage since the college-degree composition in construction is among the lowest of all industries (5 percent in 2002) and remains stable over the years. The construction wage may over-estimate the unskilled wage since some workers in this industry are high-skilled, but may also under-estimate the unskilled wage as a large fraction of construction workers are rural migrants who are usually under-paid. On balance, it can be a reasonable approximation of the unskilled wage. I also calculate the average wage of the private and the state sector using sector-industry wage data, with the state-sector wage adjusted by an increase of 30% for non-wage benefits in the pre-regime. Then

---

11The employment data of information technology is unavailable before 1997, and I assume employment (of both SOE and PE) of 1990-1996 equal that of 1997.

12Liu (1995) estimates that the share of SOE wage bills to excessive workers was about 30 percent before the state sector reform.
I compute the average wage of college graduates in each sector using the average sectoral wages and the fraction of employment with college degree in each sector. All wages used so far are real wages. Finally I normalize the pre-regime unskilled wage to one, and then transform other wages to the form of wage ratios.

The above computation produces a $PE-SOE$ skilled wage ratio of 1.06 for ss1 and 1.29 for ss2. The estimated skill premium (i.e., skilled-unskilled wage ratio) is large, which is 6.8 in ss1 and 3.5 in ss2 (see Table 2)\textsuperscript{13}.

To fit the three-period OLG setting, I assume three cohorts coexist at each period which is twenty years, and population of each cohort is normalized to one. Since the decision of whether to go to college is made roughly at the age 15, I assume only one-fourth population of the young cohort is active and ignore the rest three quarters of this cohort. So although the total population at a period is 3, the “active” population is 2.25.

I assume households’ ability follows Pareto distribution $F(a) = 1 - (a/a_m)^{-t_a}$, where the location parameter $a_m$ (i.e., lower bound of ability) and shape parameter $t_a$ are to be calibrated. I assume that the $PE$ skilled layoff probability in the third period of life takes the form $\Phi(a) = \varepsilon a^{-\gamma}$, where $\varepsilon > 0$ and $\gamma > 0$ are to be calibrated, and the ability function in production is $\Psi(\bar{a}) = \frac{\bar{a}}{a_m}$.

Sixteen parameters or variables need to be determined for each steady state: $r$, $\delta$, $t_a$, $a_m$, $\theta$, $\nu$, $A^P$, $A^S$, $\phi_L$, $\alpha^P$, $\alpha^S$, $\varepsilon$, $\gamma$, $\tau_K$, $\tau_w$, $\eta_0$. Note that instead of calibrating $\eta$ as mentioned in section 3, I calibrate the relative exogenous disutility of education $\eta_0 \equiv \eta/\bar{w}_H$ as a measure of the educational policy. Seven of the parameters or variables are assumed to be identical across the two steady states: $r$, $\delta$, $t_a$, $a_m$, $\alpha^P$, $\alpha^S$, $\gamma$, and the rest can differ. The annual real interest rate is set to be 3% and annual depreciation rate of capital 4%, as is typical in the literature. The tail parameter $t_a$ is assumed to be 2.5 in the benchmark analysis but changing its value would only result in small differences in the quantitative results. College education fee $\theta$ is 10,000 RMB yuan for ss1 and 20,000 RMB yuan for ss2 from data, and are transformed to the ratio over ss1 unskilled wage. Bai et al. (2000) point out that a large number of SOEs maintain their employment of surplus workers only for an obligation to the government and for receiving subsidy, although this situation was largely mitigated by the SOE reform. Before the late 1990’s SOE reform, over one-third of China’s

\textsuperscript{13}These estimates are comparable to those from China’s household/individual level survey (data of most years are unavailable though). For example, the estimates of $PE-SOE$ skilled wage ratio are comparable to the ratio of 1.19 calculated from China Household Income Project (“CHIP”, 2002) for the year 2001, and the ratio of 1.42 calculated from China Family Panel Study (“CFPS”, 2010) for the year 2009. The skill premium is also comparable to 4 estimated from CFPS (2010) for 2009.
SOEs were taking financial losses. The total loss of SOEs was more than double of their total profit in 1998; the loss-profit ratio was reduced to about 1/8 in 2004, but still over one-third SOEs were loss makers (China statistical yearbook). Based on these facts, the skilled wage distortion parameter \( \tau_w \) is set to be 0.68 for ss1 and 0.36 for ss2.

Now ten parameter values remain to be determined: \( a_m, \alpha^P, \alpha^S, \gamma, \varepsilon, \phi_L, A^P, A^S, \tau_K, \eta_0 \), of which the first four have the same value across two steady states. These parameters are then calibrated to match the following targets: (normalized) total number of skilled workers \((H)\) and unskilled workers \((L)\)\(^{14}\), total SOE employment \((N^S)\), total \(PE\) employment \((N^P)\), including domestic private firms and foreign-owned firms), the unemployment rate for the whole population \((u)\) and for skilled workers \((u_H)\)\(^{15}\), fraction of new college graduates that are employed by \(PE\) \((h^P_{fr})\), average wage of \(PE\) and SOE respectively \((w^P \text{ and } w^S)\) with non-wage benefit adjusted for SOE wage \((\kappa)\), and the sectoral capital ratio \((K^P/K^S)\). The target values are shown in Table 1, wage and employment in Table 2, and calibration results in Table 3.

Table 2 shows that besides changes in the wage structure, the allocation of skilled workers across sectors changes substantially from ss1 to ss2. Before the policy change, the vast majority of skilled workers are in the state sector, and less than 1 percent of population are skilled workers in the private sector. But after the policy change, the share of skilled workers in the private and the state sectors are roughly equal, both increase to 8 percent of the population.

Table 3 presents several notable changes in parameter values from ss1 to ss2. First, the measure of college enrollment restrictiveness (i.e., exogenous disutility cost of education) \( \eta_0 \) is reduced by about three quarters, suggesting a large expansion of college enrollment. Second, distortions are largely reduced: in addition to \( \tau_w, \tau_K \) is

---

\(^{14}\)Total labor force \(N\) is computed by adding the number of workers of the five industries under analysis. The estimates of \(H\) depend on the year. \(H\) from 2002 on is obtained using the total number of workers in \(SOE\) and \(PE\) of the five industries and the share of skilled workers (i.e., workers with college or above education) of each industry. As the skilled share data is largely missing before 2002, \(H\) in year \(t\) before 2002 is estimated by multiplying \(H\) in 2002 and the ratio of college entry number in year \(t-3\) to the number in the year 1999. Finally, \(L\) is obtained from the difference between \(N\) and \(H\).

\(^{15}\)The data of unemployment rates from CLSY can be very problematic, but it seems to be the best source of this information. The way I obtain \(u\) and \(u_H\) is as follows. First, I take the unemployment rate of the total labor force from CLSY as \(u\). Then I use this unemployment rate, unskilled share of unemployment, and unskilled share of employment to compute the unemployment rate of unskilled \((u_L)\) and skilled workers \((u_H)\) respectively. I take the average of \(u_H\) and \(u_L\) of 2005-2008 for the values of ss2 as these estimates before 2005 are very volatile. The unskilled share of employment/unemployment data before 1997 is largely missing, so I compute \(u_H\) \((u_L)\) of ss1 using its value of ss2 times the ratio of total unemployment rate of 1990-1998 to the rate of 2005-2008.
about 0.43 in ss1 and 0.08 in ss2, a decrease of about 80%. Third, TFPs of skilled production increase for both types of firms, especially for SOE, which increases by 83%, in line with literature that documents a relatively larger SOE productivity improvement following the reform.

In addition, the multiplier of the skilled layoff probability function $\varepsilon$ changes from 1.8 to 0.01, suggesting a large structural change in the labor market. The decrease in $\varepsilon$ deserves some explanation. It seems unreasonable as the decrease in $\varepsilon$ means that it becomes easier for the skilled workers to keep the job while the number of skilled workers grows significantly, but this can be justified in the following way. First, it turns out that lay-off probabilities of the $PE$ skilled workers at the margin $\hat{a}$ are comparable across the two regimes, which are 0.16 in ss1 and 0.64 in ss2. That the latter is three times larger than the former is indeed aligned with the reality that college graduates are facing an increasingly tough job market. Second, the relative easiness of keeping a private-sector job for a skilled worker given her ability in the post-regime can be attributed to China’s market-oriented policies that create more job opportunities for skilled workers in the private sector, and other factors that are not explicitly modeled, such as directed technological change that increased demand for skilled workers.

Table 1. Target values of calibration

<table>
<thead>
<tr>
<th>target</th>
<th>ss1</th>
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<tr>
<td>$H$</td>
<td>0.10</td>
<td>0.32</td>
</tr>
<tr>
<td>$L$</td>
<td>2.07</td>
<td>1.80</td>
</tr>
<tr>
<td>$N^S$</td>
<td>1.88</td>
<td>0.30</td>
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<tr>
<td>$N^P$</td>
<td>0.64</td>
<td>1.47</td>
</tr>
<tr>
<td>$u$</td>
<td>0.027</td>
<td>0.041</td>
</tr>
<tr>
<td>$u_H$</td>
<td>0.024</td>
<td>0.036</td>
</tr>
<tr>
<td>$h^P_{fr}$</td>
<td>0.15</td>
<td>0.50</td>
</tr>
<tr>
<td>$w^P$</td>
<td>1.28</td>
<td>2.98</td>
</tr>
<tr>
<td>$w^S$</td>
<td>6.76</td>
<td>6.93</td>
</tr>
<tr>
<td>$w_L$</td>
<td>1.00</td>
<td>2.29</td>
</tr>
<tr>
<td>$\kappa$</td>
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<td>1.00</td>
</tr>
<tr>
<td>$K^P/K^S$</td>
<td>0.24</td>
<td>1.46</td>
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Table 2. Wage and Employment

<table>
<thead>
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<th>variables</th>
<th>ss1</th>
<th>ss2</th>
<th>description</th>
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</thead>
<tbody>
<tr>
<td>$w_L$</td>
<td>1.00</td>
<td>2.29</td>
<td>unskilled wage</td>
</tr>
<tr>
<td>$w^P_H$</td>
<td>7.18</td>
<td>8.96</td>
<td>$PE$ skilled wage</td>
</tr>
<tr>
<td>$w^S_H$</td>
<td>6.76</td>
<td>6.93</td>
<td>$SOE$ skilled wage</td>
</tr>
<tr>
<td>$\bar{w}_H/w_L$</td>
<td>6.83</td>
<td>3.47</td>
<td>skill premium</td>
</tr>
<tr>
<td>$w^P_H/w^S_H$</td>
<td>1.06</td>
<td>1.29</td>
<td>$PE$ premium (skilled)</td>
</tr>
<tr>
<td>$%l$</td>
<td>94.7</td>
<td>83.4</td>
<td>share of population who are unskilled workers</td>
</tr>
<tr>
<td>$%h^P$</td>
<td>0.8</td>
<td>8.3</td>
<td>share of population who are $PE$ skilled workers</td>
</tr>
<tr>
<td>$%h^S$</td>
<td>4.5</td>
<td>8.3</td>
<td>share of population who are $SOE$ skilled workers</td>
</tr>
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</table>

Table 3. Calibration results

<table>
<thead>
<tr>
<th>parameters</th>
<th>ss1</th>
<th>ss2</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>0.81</td>
<td>0.81</td>
<td>real interest rate (20 years)</td>
</tr>
<tr>
<td>$\delta$</td>
<td>2.19</td>
<td>2.19</td>
<td>depreciate rate (20 years)</td>
</tr>
<tr>
<td>$t_a$</td>
<td>2.50</td>
<td>2.50</td>
<td>tail of Pareto distribution</td>
</tr>
<tr>
<td>$a_m$</td>
<td>0.20</td>
<td>0.20</td>
<td>location of Pareto distribution</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.17</td>
<td>0.33</td>
<td>college expense</td>
</tr>
<tr>
<td>$\nu$</td>
<td>1.00</td>
<td>2.29</td>
<td>unskilled productivity</td>
</tr>
<tr>
<td>$A^P$</td>
<td>3.51</td>
<td>4.45</td>
<td>skilled TFP of $PE$</td>
</tr>
<tr>
<td>$A^S$</td>
<td>2.19</td>
<td>4.01</td>
<td>skilled TFP of $SOE$</td>
</tr>
<tr>
<td>$\phi_L$</td>
<td>0.06</td>
<td>0.10</td>
<td>unskilled lay-off probability</td>
</tr>
<tr>
<td>$\alpha^P$</td>
<td>0.82</td>
<td>0.82</td>
<td>capital share of $PE$ skilled production</td>
</tr>
<tr>
<td>$\alpha^S$</td>
<td>0.84</td>
<td>0.84</td>
<td>capital share of $SOE$ skilled production</td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>1.79</td>
<td>0.01</td>
<td>multiplier in the $PE$ skilled lay-off probability</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>7.27</td>
<td>7.27</td>
<td>power in the $PE$ skilled lay-off probability</td>
</tr>
<tr>
<td>$\tau_K$</td>
<td>0.43</td>
<td>0.08</td>
<td>policy distortion of capital</td>
</tr>
<tr>
<td>$\tau_W$</td>
<td>0.68</td>
<td>0.36</td>
<td>policy distortion of skilled labor</td>
</tr>
<tr>
<td>$\eta_0$</td>
<td>1.22</td>
<td>0.32</td>
<td>relative exogenous disutility of college</td>
</tr>
</tbody>
</table>

4.2 Comparative statics

With a calibrated model, I am now ready to assess the effect of each specific factor. In this section, I compute comparative statics for each of the two steady states that
correspond to the two regimes. In particular, the parameters under investigation are: \( \eta_0, \tau_K, \tau_w, A^S, A^P, \phi_L, \theta, \) and \( \nu. \) I examine the effects of changes in these parameter values on the following variables: skilled employment and its sectoral share \( (H, H^P, H^S, H^P/H) \), skilled human capital and its sectoral share \( (HC, HC^P, HC^S, HC^P/HC) \), where skilled human capital in sector \( i \) is defined as ability-augmented skilled labor, i.e., \( HC^i \equiv (\pi^i/a_m)H^i, \) and thus total skilled human capital is \( HC \equiv HC^P + HC^S \), the \( PE \) share of skilled production output \( (Y_H^P/Y_H) \), and average labor productivity\( (APL, \) which combines both unskilled and skilled production). Figure 5 shows the comparative statics of \( \eta_0 \) and \( \tau_K \) using the model in the first steady state.\(^{16}\)

Figure 5(a) shows that a decrease in \( \eta_0 \) (the measure of college enrollment expansion) does increase the society’s skilled labor and human capital. However, The \( PE \) share of skilled labor and human capital have a hump-shaped relationship with decreases in \( \eta_0 \) under the current distortions. They tend to increase when \( \eta_0 \) is large, but decrease when \( \eta_0 \) gets smaller. The similar relationship also applies to \( PE \) output share and \( APL. \) The downward side of the \( APL \) curve is mainly caused by the fact that the reallocation effect of the educational policy dominates the growth effect when college restriction is small but allocation distortion is severe.

Figure 5(b) shows that a reduction in distortion of physical capital allocation \( \tau_K \) largely reduces skilled employment and human capital of \( SOE \) and meanwhile increases those of \( PE, \) so as the output share, but its effect on total skilled labor or human capital can either be negative (ss1) or hump-shaped (ss2, not shown here). The intuition is that as distortions favoring \( SOE \) are reduced, the interest rate drops as less subsidy to \( SOE \) loosens the loanable funds market. This may lower opportunity costs of being unskilled if the \( SOE \) skilled wage is sufficiently higher than the unskilled wage. \( APL \) increases as \( \tau_K \) decreases as a result of improved allocation efficiency. The effect of a reduction of \( \tau_w \) is similar to \( \tau_K. \)

Furthermore, though not shown here graphically, an increase in \( A^S \) increases (reduces) skilled labor in \( SOE (PE), \) and increases total skilled labor. It also reduces \( APL \) as relatively more skilled workers go to the (still) less-productive \( SOE. \) An increase in \( A^P \) has the opposite effects.

\(^{16}\) Comparative statics of other parameters and of the second steady state are available upon request. The results of the second steady state is qualitatively similar to that of the first steady state.
(a) Comparative statics of $\eta_0$
4.3 Impacts of policy: counterfactual analysis

In this section, I conduct counterfactual analysis to examine specific policy effects. I focus on the educational policy that expands college enrollment and the state sector reform policy that reduces factor distortions.

First, I look at what would have happened to $PE$ skilled labor share ($H^P/H$), total human capital stock and its $PE$ share ($HC$ and $HC^P/HC$), sectoral output share ($Y^P_H/Y_H$ and $Y^S_H/Y_H$) and average labor productivity ($APL$ and $APL_H$, where the latter is the average labor productivity of skilled production), had there been no higher education expansion (i.e., no changes in $\eta_0$ from ss1 to ss2), no state sector reform (no changes in $\tau_K$ and $\tau_w$ from ss1 to ss2) or no improvement of TFP (no changes in $A^S$ or $A^P$ from ss1 to ss2). The experiment is based on the model in steady state two.

Table 4 shows the results. It can be seen that higher education expansion (i.e., a decrease in $\eta_0$) did increase the society’s total human capital stock significantly,
which would have been reduced by 48 percent had there been no expansion. However, it allocated a larger fraction of skilled labor as well as human capital toward SOE rather than PE – the PE human capital share would have increased by nearly 30 percent had there been no such a policy. As a result, APL would have increased by about 5 percent, as APL\textsubscript{H} would have tripled.

In fact, it is the state sector reform that drove the private sector expansion in skilled employment, as it significantly reduced allocation distortions. Had there been no SOE reform, APL would have been lowered by 47 percent, since almost all skilled labor would have been employed by SOE.

Increases in \( A^P \) and \( A^S \) contribute to the increase of skilled labor and human capital shares of PE and SOE respectively as well as their output share, and have opposite effects on total human capital and labor productivity.

Table 4. Counterfactual analysis: policy

<table>
<thead>
<tr>
<th>variables</th>
<th>ss1</th>
<th>ss2</th>
<th>% inc.</th>
<th>( \eta_0 )</th>
<th>( \tau_K, \tau_W )</th>
<th>( A^P )</th>
<th>( A^S )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( H^P/H )</td>
<td>0.13</td>
<td>0.48</td>
<td>273.0</td>
<td>53.1</td>
<td>-99.9</td>
<td>-96.2</td>
<td>107.8</td>
</tr>
<tr>
<td>( HC )</td>
<td>0.57</td>
<td>1.09</td>
<td>92.4</td>
<td>-47.7</td>
<td>-7.6</td>
<td>34.4</td>
<td>-29.7</td>
</tr>
<tr>
<td>( HC^P/HC )</td>
<td>0.32</td>
<td>0.65</td>
<td>103.9</td>
<td>28.7</td>
<td>-98.5</td>
<td>-86.0</td>
<td>54.5</td>
</tr>
<tr>
<td>( Y^P_H/Y_H )</td>
<td>0.24</td>
<td>0.62</td>
<td>155.8</td>
<td>27.9</td>
<td>-99.8</td>
<td>-96.0</td>
<td>60.3</td>
</tr>
<tr>
<td>( Y^S_H/Y_H )</td>
<td>0.76</td>
<td>0.38</td>
<td>-50.2</td>
<td>-46.2</td>
<td>165.4</td>
<td>159.1</td>
<td>-100.0</td>
</tr>
<tr>
<td>( APL_H )</td>
<td>15.69</td>
<td>38.69</td>
<td>146.6</td>
<td>213.1</td>
<td>-57.4</td>
<td>-30.2</td>
<td>123.7</td>
</tr>
<tr>
<td>( APL )</td>
<td>1.71</td>
<td>7.76</td>
<td>352.9</td>
<td>5.1</td>
<td>-47.1</td>
<td>-19.3</td>
<td>20.3</td>
</tr>
</tbody>
</table>

Second, I decompose the factors that may contribute to the overall impact of educational policy on average labor productivity. Model analysis suggests that several factors may count: total human capital stock and its allocation across sectors, average ability of skilled workers in each sector, and physical capital stock and its allocation. Therefore, in this experiment, I change the value of \( H, H^P/H, \pi^P \) and \( \pi^S, K, \) and \( K^P/K \) in \( ss_2 \), one at a time, to be the same as in the case where there is no college expansion (i.e., no decrease in \( \eta_0 \), as in the first counterfactual experiment), and check how APL would change in each scenario. Table 5 shows the results. Except for the increase of \( H \) following the educational policy which has a large positive effect on APL, all other factors have negative effects on APL, that is, APL in \( ss_2 \) would have decreased if these variable values were equal to those in the no-\( \eta_0 \)-change scenario. The two most important factors are a reduction of total physical capital (\( K \)) and a reduction of PE share of skill labor (\( H^P/H \)). Had values of these two
variables been the same as no-college-expansion scenario, $APL$ would have increased by about 11 percent.

Table 5. Counterfactual: decomposition of educational policy effect

<table>
<thead>
<tr>
<th>variables</th>
<th>E2 (ss2)</th>
<th>E1 ($\eta_0$ as ss1)</th>
<th>$APL_{E2}%$ inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H$</td>
<td>0.32</td>
<td>0.11</td>
<td>-44.4</td>
</tr>
<tr>
<td>$H^P/H$</td>
<td>0.48</td>
<td>0.74</td>
<td>10.8</td>
</tr>
<tr>
<td>$\bar{a}^P$, $\bar{a}^S$</td>
<td>0.93, 0.47</td>
<td>1.23, 0.69</td>
<td>4.2</td>
</tr>
<tr>
<td>$K$</td>
<td>3.52</td>
<td>4.19</td>
<td>11.6</td>
</tr>
<tr>
<td>$K^P/K$</td>
<td>0.60</td>
<td>0.78</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Finally, I pick the most important factor from the experiment above, the physical capital reduction, and investigate its main cause. In particular, I compare both supply and demand sides of loanable funds market in ss2 with that in the no-$\eta_0$-change scenario. Table 6 shows that while a drop of loanable funds supply from unskilled workers and an increase in tuition fees and loan repayment both contribute to the reduction of physical capital used by firms, an increase in subsidies to SOE is the major factor that crowds out physical capital for production. This result suggests that as human capital misallocation becomes more severe following the higher education expansion, it leads to further misallocation of physical capital due to general equilibrium effects. Capital was allocated not only from $PE$ to SOE due to factor complementarity, but also from productive use to unproductive subsidy. Consequently, average labor productivity is further dampened.

Table 6. Counterfactual: effects on the loanable funds market of college expansion

<table>
<thead>
<tr>
<th>loanable funds market</th>
<th>E2 (ss2)</th>
<th>E1 ($\eta_0$ as ss1)</th>
<th>E2-E1</th>
</tr>
</thead>
<tbody>
<tr>
<td>supply</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>unskilled wage and saving</td>
<td>3.24</td>
<td>3.45</td>
<td>-0.21</td>
</tr>
<tr>
<td>skilled wage (middle-aged)</td>
<td>1.33</td>
<td>1.26</td>
<td>0.07</td>
</tr>
<tr>
<td>demand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$K$: capital for production</td>
<td>3.52</td>
<td>4.19</td>
<td>-0.67</td>
</tr>
<tr>
<td>tuition and loan repayment</td>
<td>0.28</td>
<td>0.08</td>
<td>0.19</td>
</tr>
<tr>
<td>subsidy to SOE</td>
<td>0.77</td>
<td>0.43</td>
<td>0.34</td>
</tr>
</tbody>
</table>
4.4 Impacts of educational policy under different distortions

How does the distortion matter for the impact of the educational policy? In this section, I assess the impact of the college enrollment expansion (i.e., changing $\eta_0$ from ss1 value to ss2 value) on human capital stock and allocation, sectoral output share, and average labor productivity, under the assumption of full distortion (i.e., ss1 distortion level) in one scenario, and zero distortion in the other. This experiment is conducted based on the pre-regime economy, and results are shown in Table 7.

It can be seen that when the economy exhibits full distortion, the college enrollment expansion increases human capital stock by 58 percent, but reduces $PE$ human capital share by 25 percent. Its overall impact on $APL$ is again slightly negative (-4 percent) since misallocation is intensified. However, had the economy had no distortion, all skilled labor would have been employed by the private sector and the reallocation effect of the educational policy would have disappeared. It would have increased human capital stock by 9 percent and $APL$ by over 3 percent. The result indicates that the higher education expansion would have a positive effect on productivity by improving human capital in a distortion-free economy, as standard growth theory suggests, but would have a limited or even negative effect if distortions prevailed.

Table 7. Impacts of college enrollment expansion under different distortions

<table>
<thead>
<tr>
<th>variables</th>
<th>full distortion</th>
<th></th>
<th>no distortion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\eta_0 - pre$</td>
<td>$\eta_0 - post$</td>
<td>% inc.</td>
</tr>
<tr>
<td>$H^P/H$</td>
<td>0.13</td>
<td>0.09</td>
<td>-29.5</td>
</tr>
<tr>
<td>$HC$</td>
<td>0.57</td>
<td>0.90</td>
<td>57.6</td>
</tr>
<tr>
<td>$HC^P/HC$</td>
<td>0.32</td>
<td>0.24</td>
<td>-25.1</td>
</tr>
<tr>
<td>$Y^P_H/Y_H$</td>
<td>0.24</td>
<td>0.24</td>
<td>-2.1</td>
</tr>
<tr>
<td>$Y^S_H/Y_H$</td>
<td>0.76</td>
<td>0.76</td>
<td>3.1</td>
</tr>
<tr>
<td>$APL_H$</td>
<td>15.69</td>
<td>7.17</td>
<td>-54.3</td>
</tr>
<tr>
<td>$APL$</td>
<td>1.71</td>
<td>1.64</td>
<td>-4.1</td>
</tr>
</tbody>
</table>

4.5 Social optimal

This section analyzes social welfare optimization with certain constraints. In particular, a social planner is allowed to determine higher education policy ($\eta_0$) and subsidy to $SOE$ for skilled employment ($\tau_W$) to maximize social welfare. Meanwhile, her choice is subject to labor market frictions (i.e., layoff probabilities) and
capital market distortions (i.e., \( \tau_K \)). In addition, a minimum of SOE skilled output share is required out of the concern that keeping a certain level of state sector production may be necessary for many developing countries. The analysis is based on the post-regime economy, with the layoff probabilities \( \Phi(a) \) and \( \phi_L \), and capital market distortions \( \tau_K \) fixed, and the minimum SOE skilled output share is set to be the SOE skilled output share in ss2 as well. Then her problem is

\[
\max_{(\eta_0, \tau_W)} U = u_L F(\tilde{a}) + \int_{\tilde{a}}^{\hat{a}} u_{H,S}(a) dF(a) + \int_{\tilde{a}}^{\infty} u_{H,P}(a) dF(a)
\]

s.t. \( Y_{H}^{P}/Y_{H} \geq 0.376, \tau_K, \Phi(a), \phi_L \) the same as in ss2.

Table 8 shows the results of the social welfare optimization and compares them to ss2. It can be seen that to achieve the optimal welfare, the government should continue expanding higher education, until the exogenous disutility from college education is totally removed. However, allocation distortions of skilled workers should be further reduced at the same time. Under this optimal setting, the human capital share and skilled output share of the private sector would be close to those in ss2, but total human capital stock would improve by 9 percent, and \( APL \) would increase as well\(^{17}\).

A caveat here is that the extent to which the social planner is constrained is somewhat arbitrary. Therefore I would view my results as suggestive rather than definitive, and take the qualitative rather than the quantitative implications.

<table>
<thead>
<tr>
<th></th>
<th>optimal</th>
<th>ss2</th>
</tr>
</thead>
<tbody>
<tr>
<td>( U )</td>
<td>8.50</td>
<td>7.78</td>
</tr>
<tr>
<td>( \eta_0 )</td>
<td>0.00</td>
<td>0.32</td>
</tr>
<tr>
<td>( \tau_W )</td>
<td>0.20</td>
<td>0.36</td>
</tr>
<tr>
<td>( H^P/H )</td>
<td>0.47</td>
<td>0.48</td>
</tr>
<tr>
<td>( HC )</td>
<td>1.19</td>
<td>1.09</td>
</tr>
<tr>
<td>( HC^P/HC )</td>
<td>0.64</td>
<td>0.65</td>
</tr>
<tr>
<td>( Y_{H}^{P}/Y_{H} )</td>
<td>0.62</td>
<td>0.62</td>
</tr>
<tr>
<td>( Y_{H}^{S}/Y_{H} )</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td>( APL_{H} )</td>
<td>33.84</td>
<td>38.69</td>
</tr>
<tr>
<td>( APL )</td>
<td>7.85</td>
<td>7.76</td>
</tr>
</tbody>
</table>

\(^{17}\)The results are the same when the social planner’s objective is to maximize \( APL \) under the same constraints.
5 Conclusion

In this paper, I have investigated the impact of an educational policy on average labor productivity using China’s higher education expansion. I argue that in an economy such as China, where allocation distortions widely exist, an educational policy affects average labor productivity not only through its effect on human capital stock, but also through its effect on human capital allocation. Thus, its impact could be limited if misallocation becomes more severe following the policy. I have constructed a two-sector general equilibrium model in which policy distortions favor the less-productive state sector against the private sector. Households make educational and occupational choices depending on their ability and economic policy. The higher education expansion not only affects the share of population acquiring college education, but also affects the share of employment with college degrees across sectors.

My quantitative results show that the higher education expansion in China overall had a slightly negative effect on its average labor productivity given distortions. Although it did increase China’s human capital stock significantly, the policy had the effect of reallocating relatively more human capital toward the less-productive state sector. This also directed physical capital to the state sector. The intensified factor misallocation increased demand for subsidy by the state sector, crowding out productive capital and further dampening labor productivity. Indeed, it was the concurrent economic reform of the state sector that greatly improved allocation efficiency and complemented educational policy in enhancing productivity.

To this end, I would like to acknowledge the limitations of this study. First, there is no directed technological progress in the model. Though increased skilled labor supply does direct more firms to employ more productive technology, the level of each type of technology is assumed to be independent from the society’s education level, which may cause an underestimate of the positive effect of college expansion. Second, the model assumes all college graduates work in skilled production, while in reality some may end up with unskilled jobs as skilled labor market becomes tougher. This type of misallocation (or, mismatching) is not taken into account, which may cause an overestimate of the effect of college expansion. Finally, it should be noted that the quantitative analysis is based on data of years right before and after policy change. Hence, the results may not be a good indicator of the impact of higher education expansion in the longer run. This impact could be more positive as economic reform was deepened and other market-oriented policy was launched.
References


