Higher Education Expansion, Economic Reform, and Productivity

Yao Yao*

School of Economics and Finance, Victoria University of Wellington, 216 Railway West Wing, Pipitea Campus, Wellington 6140, New Zealand

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 (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

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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 the level of education of a society have thus been valued\(^1\). Indeed, many countries experienced a government-led education expansion program at some stage of development\(^2\). 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 real effect of an education expansion alone 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

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\(^1\)See, for example, Tallman and Wang (1994) for a study of government policies that improved human capital stock in Taiwan.

\(^2\)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, and the growth of higher-educated labor force then far outpaced other educational levels during 1960’s to 1980’s. Other countries such as China, Japan, Malaysia, Singapore, etc., had similar experience of education expansion.
educational policy on labor productivity as well as its interaction with other policies.

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 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 effect” 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 effect” 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.
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 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 effect shows that the reduction of physical capital available for production and the reduction of private-sector share of skilled labor contribute most to the lowered average labor productivity following college expansion. For the former, an increase of subsidy to the state sector 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.

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; Li and Xing, 2010; Yeung, 2013).

**Background**

China’s nationwide college enrollment expansion, launched in 1999, was a means of the central government to “stimulate domestic demand, promote economic growth, and alleviate 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 (see Figure 1). On average, the annual growth rate of China’s college enrollment reached over 16 percent during 1998-2010, a significant increase from 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 less than a quarter before 1999, but nearly 60 percent after 1999.

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 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

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31977 is the first year China resumed its college admission since the cultural revolution.
or privatized the least productive ones, and laid off millions of excessive workers ("Xiagang") \(^4\).

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 rapidly since 2002\(^5\), whereas the state-sector employment has been relatively stable (see Figure 2(a)). This is in contrast to the labor-intensive industries (see Figure 2(b)), where the state-sector employment dropped dramatically around 1998 due to the reform, while the private-sector employment had a roughly linear growth. These observations illustrate that (i) China’s skill-intensive industries has grown relatively faster than the labor-intensive ones, and that (ii) within skill-intensive industries, the private sector has expanded more quickly than the state sector since 2002. While the former indicates an increase of skilled labor share, the latter suggests a reallocation of skilled labor from the state sector to the private. 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.

The rest of the paper proceeds as follows. 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.

### 2 The Model

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 and 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

\(^4\)For more references of the SOE reform, see Bai et al. (2000).
\(^5\)2002 is the year when the first generation of college students since college enrollment expansion entered the labor market.
with a CRS technology. Markets are competitive except for factor price distortions. The production functions are:

\[ PE : \quad Y^P(K^P, H^P, L^P) = vL^P + A^P(K^P)^{\alpha^P}(\Psi(\bar{\pi}^P)H^P)^{1-\alpha^P} \]  
\[ SOE : \quad Y^S(K^S, H^S, L^S) = vL^S + A^S(K^S)^{\alpha^S}(\Psi(\bar{\pi}^S)H^S)^{1-\alpha^S} \]

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 \( \Psi(\bar{\pi}^i) \) is a function of average ability of skilled workers in type \( i \) firms and \( \Psi(\bar{\pi}^i) > 0 \). 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. 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 \( \alpha^P \) and \( \alpha^S \) 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 \( w_H^S \), then what \( SOE \) actually pays out of its own pocket is \((1 - \tau_K)R\) and \((1 - \tau_w)w_H^S\) 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 \( w_H^P \) to its skilled workers. Note that \( w_H^P \) may differ from \( w_H^S \) in equilibrium. Both firms pay the same wage \( w_L = \nu \) to unskilled workers due to the linear form of unskilled production.

2.2 The household

Time is discrete. The economy is populated with three-period overlapping genera-

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6These production functions allow me to focus on human capital (or skilled labor) by greatly simplifying the unskilled production to be identical across types of firms.
tions, in which households make an educational choice – whether to acquire college education when young, and an occupational choice – whether to work for PE or 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, i.e., 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:

$$u_t(a) = c_t^{a+2} - \frac{a}{c_t^a},$$

where $c_t^{a+2}$ is her consumption at the third period of life, which is a function of her ability$^7$. $\Omega$ 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 $\frac{a}{c_t^a}$, 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.

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 join in the skilled production. 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.

In the second period, those who went to college when young become skilled work-

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$^7$ The linear form of utility function greatly simplifies my analysis of household choices.
ers and make an occupational choice between \( PE \) and \( SOE \), and would receive skilled wages \( w^P_H \) or \( w^S_H \) 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.

In the third period, workers cannot change their sector. This can be thought of as 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\(^8\). But if she works for \( SOE \), she keeps her job whatever. This mirrors the reality that SOEs tend to offer better-secured, “iron-bowl” jobs to the highly educated workers regardless of their ability, since they have a 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 would be indifferent between working for \( PE \) or \( SOE \) and 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 old under different choices is the following

\[
\begin{align*}
\hat{c}_{t,L}^{t+2} &= [w_{L,t}(1 + r_{t+1}) + w_{L,t+1} - \tau_{t+1}](1 + r_{t+2}) + (1 - \phi_L)w_{L,t+2} \\
\hat{c}_{t,H,S}^{t+2} &= [w_{H,S,t+1} - (1 + R_{t+1})\theta - \tau_{t+1}](1 + r_{t+2}) + w_{H,S,t+2} \\
\hat{c}_{t,H,P}^{t+2} &+ (a) = [w_{H,P,t+1} - (1 + R_{t+1})\theta - \tau_{t+1}](1 + r_{t+2}) + [1 - \Phi(a)]w_{H,P,t+2}
\end{align*}
\]  

\(^8\)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.
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 \( o \in \{ P, S \} \). She chooses to work for \( PE \) if and only if \( c_{t,H,P}^{t+2} \geq c_{t,H,S}^{t+2} \) 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 \( (w_{H,t+1}^P - w_{H,t+1}^S)(1 + r_{t+2}) + w_{H,t+2}^P - w_{H,t+2}^S \geq \Phi(a)w_{H,t+2}^P \), 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 (i.e., lower \( \Phi(a) \)), and hence the more appealing is \( PE \) to her.

Under certain conditions, in particular, when relative TFP of \( PE \) to \( SOE \) is sufficiently high, and distortions of capital and skilled labor (i.e., \( \tau_K, \tau_w \)) are not too large, so that \( w_H^P > w_H^S \), 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:

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

(5)

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

\[
\Phi(\hat{a}) = (2 + r) \left( 1 - \frac{w_H^S}{w_H^P} \right) 
\]

(6)

Intuitively, there is a trade-off between wage and layoff 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 \( SOE \).

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 \( e \in \{H,L\} \). She chooses to go to college and become skilled if and only if \( \max\{E[c_{t+2}^{H,HP}(a)], E[c_{t+2}^{H,SP}]\} - \frac{\eta}{a} \geq E[c_{t+2}^{L}] \). 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

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

In the steady state the above equation can be rearranged to

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

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 \( \tilde{a} \).

**Lifetime choices by ability**

Now we can see that under certain conditions, households sort into different categories of education and occupation by 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 is constant regardless of her ability, while utility of a skilled worker increases with ability. A PE worker’s utility curve is steeper than an SOE worker’s but starts at a lower point. As a result, households 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 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:**

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

where $k^i \equiv \frac{K^i}{P^i}, i \in \{P, S\}$ 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

\[
L^P_t + L^S_t = F(\bar{a}_t) + F(\bar{a}_{t-1}) + F(\bar{a}_{t-2})(1 - \phi_{L,t})
\]

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

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

\[
H^P_t = 1 - F(\bar{a}_{t-1}) + \int_{\bar{a}_{t-2}}^{\infty} [1 - \Phi_t(a)]dF(a) \\
H^S_t = [F(\bar{a}_{t-1}) - F(\bar{a}_{t-2})] + [F(\bar{a}_{t-2}) - F(\bar{a}_{t-2})]
\]
The loanable funds market clearing condition at $t$ is

$$K^P_t + K^S_t + \theta_t(h^P_t + h^S_t) + (h^P_{t-1} + h^S_{t-1})(1 + R_t)\theta_{t-1} + \tau_t$$

$$= (l^P_t + l^S_t)w_{L,t} + (l^P_{t-1} + l^S_{t-1})[(1 + r_t)w_{L,t-1} + w_{L,t}] + h^P_{t-1}w^P_{H,t}h^S_{t-1}w^S_{H,t} \tag{17}$$

where $l^i_t$ and $h^i_t$ 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 loanable funds demand side consists of: productive capital of firms, education loan of young college students and loan repayment of middle-aged skilled workers, and subsidy to SOE (equals to tax revenue $\tau$). The loanable funds supply side 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

$$\bar{a}^P_t = \left[ \int_{\hat{a}_{t-1}}^{\infty} adF(a) + \int_{\hat{a}_{t-2}}^{\infty} a(1 - \Phi_t(a))dF(a) \right] / H^P_t \tag{18}$$

$$\bar{a}^S_t = \left[ \int_{\hat{a}_{t-1}}^{\infty} adF(a) + \int_{\hat{a}_{t-2}}^{\infty} a(1 - \Phi_t(a))dF(a) \right] / H^S_t \tag{19}$$

$\tau_t$ satisfies the government budget constraint:

$$\tau_t = \tau_{K,t}R_tK^S_t + \tau_{w,t}w^S_{H,t}H^S_t \tag{20}$$

that is, it is used to subsidize SOE for physical capital and skilled labor.

### 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 \( \eta \). This section characterizes the two channels through which the educational policy affects average labor productivity (see Figure 4).

**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 later, 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, average skilled wage decreases in equilibrium, suppressing further increase of skilled labor.

**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 enlarges misallocation of both human and physical capital.

### 4 Quantitative analysis

I calibrate two sets of parameters regarding the pre- and post-policy-change regimes using China’s data of years 1990-2008. 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-policy-change regimes, using the average of 1990-1998 data for the first set, and the average of 2002-2008 data for the second. I assume that these two sets correspond to the old and the new steady states (i.e., steady state 1 and 2, or, “ss1” and “ss2” hereafter) of the economy respectively\(^9\). 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 affected by the global financial crisis\(^10\).

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\(^11\). Manufacturing is a labor-intensive industry with only 6.3 percent of employment with college or above degree in 2002. The rest four are skill-intensive industries with over 30 percent of employment with college or above degree in the same year. I use the average wage of the construction industry as unskilled wage since the higher-education composition in construction is among the lowest of all industries (5 percent in 2002) and remains stable over the years. Then I compute the wage of college graduates in two sectors using the mean sectoral wage and the fraction of employment with college degree in each sector. I normalize the pre-regime unskilled wage to one, and then transform other wages to wage ratios. The above computation generates a \(PE\) to \(SOE\) skilled wage ratio of 1.06 for ss1 and 1.29 for ss2\(^12\). The estimated skilled premium (i.e., skilled-to-unskilled wage ratio) is large, which is 6.8 in ss1 and 3.5 in ss2 (see Table 2)\(^13\).

\(^9\)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 steady state corresponds to the stage before both policy changes, and the new one corresponds to after both policy changes.

\(^10\)A caveat of the calibration is that the length of data available may be too short to reach the new steady state, i.e., data spans for less than 20 years, while one life period of a generation in the model takes about 20 years. So in the second calibrated steady state, a large fraction of workers are the old or middle-aged living through the first steady state and are not able to make choices as modeled. This makes the quantitative results less convincible. Nonetheless, due to the lack of data, the present analysis may be the best that can be done so far.

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

\(^12\)While it is difficult to find China household income survey data for most years, my estimates of \(PE\) to \(SOE\) skilled wage ratio are comparable with China Household Income Project (“CHIP”, 2002) from which this ratio is 1.19 for year 2001.

\(^13\)There could be an underestimate of unskilled wage by using construction wage as the proxy while ignoring sectoral wage differences. However, considering that college graduates were rare in China especially before the college expansion, and that a large share of population (typically
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 happens roughly at age 15, I assume only one-fourth population of the young cohort is active and ignore the rest three quarters of the young cohort. So although the whole 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 lay-off 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 $\phi_i(a) = a/a_m$.

Sixteen parameters or variables need to be determined for each steady state: $r, \delta, t_a, a_m, \theta, \nu, A^P, A^S, \phi_L, \alpha^P, \alpha^S, \varepsilon, \gamma, \tau_K, \tau_w, \eta_0$. Seven of them 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. Annual real interest rate is assumed to be 3% and annual depreciation rate of capital is 4% which 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 not make a significant difference to my quantitative results. Education fee $\theta$ is 10,000 RMB yuan for ss1 and 20,000 RMB yuan for ss2 from data, and are normalized to the ratio over ss1 unskilled wage. $\tau_w$ is assumed to be 0.68 for ss1 and 0.36 for ss2.

Now ten parameter values remain to be determined: $a_m, \alpha^P, \alpha^S, \gamma, \varepsilon, \phi_L, A^P, A^S, \tau_K, \eta_0$, the first four of which have the same value for two steady states. I calibrate these parameters to match the following targets: (normalized) total number of skilled workers ($H$) and unskilled workers ($L$), total SOE employment ($N^S$), total PE unskilled) lived in poverty, especially before economic reform, these estimates may be reasonable.

Instead of calibrating $\eta$ as mentioned in section 3, I calibrate the relative exogenous disutility cost of education $\eta_0 \equiv \eta/\bar{w}_H$.

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 meanwhile receive subsidy for the employment. This was largely mitigated by the SOE reform though still lasts. The parameter values about skill wage subsidy are picked to allow calibration results reasonable, and these values are reasonable since before the late 1990’s SOE reform, over one-third of China’s SOEs were taking financial losses. The total loss of SOEs is more than double of their total profit in 1998, and total-loss-to-total-profit ratio became about 1/8 in 2004, whereas still over one-third SOEs are loss makers.

Total labor force $N$ is computed by adding the number of workers of the five industries under analysis. The estimate of $H$ depends 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 with the ratio of college entry number of the year $t - 3$ to the year 1999. Finally, $L$ is obtained from the difference between $N$ and $H$. 
employment ($N^P$, including domestic private firms and foreign-owned firms), total unemployment rate ($u$) and unemployment rate of the skilled ($u_H$) (computed using the unemployment rate, unskilled share of unemployment, and unskilled share of employment)$^{17}$, fraction of new college graduates that are employed by PE ($h^P_{fr}$), average wage of PE and SOE respectively ($w^P$ and $w^S$) with non-wage benefit adjusted for SOE wage ($\kappa$)$^{18}$, and the sectoral physical 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 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 about 0.43 in ss1 and 0.08 in ss2, decreasing by 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 the relatively larger SOE productivity improvement following the reform. In addition, the multiplier of the skilled lay-off probability function $\varepsilon$ also changes from 1.8 to 0.01, suggesting a structural change in the labor market. The decrease in $\varepsilon$ seems unreasonable since it means that it becomes easier for the skilled workers to keep the job while the number of them grows dramatically, but this can be justified by the following points. For one thing, it turns out that lay-off probabilities of the PE skilled workers with lowest ability $\hat{a}$ are comparable across the two regimes, which are 0.16 in ss1 and 0.64 in ss2. That the latter is much larger than the former indeed fits the reality that college graduates are facing an increasingly tough labor market. For another, the structural change of labor market can be attributed to the fact that more job opportunities are created for the skilled workers in the private sector in the post-regime due to market-oriented policies.

$^{17}$The data of unemployment rates from CLSY can be very problematic, but it seems to be the best source I can get the information so far. 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 the 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 as $u_H$ and $u_L$ for ss2 as these estimates before 2005 are very volatile. As the unemployment data before 1997 is largely missing, I compute $u_H$ ($u_L$) of ss1 using its value of ss2 times the ratio of total unemployment rate of 1990-1998 to 2005-2008.

$^{18}$In particular, $w^S$ is the average SOE wage, taken from China statistical yearbook, times $\kappa$, adjustment for non-wage benefit. Liu (1995) estimates that the share of SOE wage bills to excessive workers was more than 30 percent before the state sector reform. Hence, I assume $\kappa$ to be 1.3 in ss1, and 0 in ss1.
4.2 Dynamics

This section shows the model dynamics of skilled labor stock and allocation, wage ratio, and TFP.

Figure 5 (a) shows the model dynamics of skilled labor and allocation ($H$, $H^P$, $H^S$) during my sample period. Due to data limitations, I compute dynamics of skilled labor by making linear combinations of decision rules of the beginning and the ending points of each regime, instead of computing decision rules for each cohort and each year\textsuperscript{19}. In particular, the dynamics of skilled labor is computed in the following way. First, I extend my sample period forward to the year when the economy reaches a true steady state predicted by the model, that is, the year 2042\textsuperscript{20}. I also extend backward until the amount of skilled labor becomes nonpositive (the first year for the $H$ to be positive is 1982). I make the extensions to match two things in data. One is the average value of $H$ for 1990-1998 and 2002-2008 respectively, and the other is the slope of $H$ of the two subperiods. Then I compute the decision rules of the beginning and the ending point of each subperiod, that is, 1981 and 2025 for pre-regime (2025 is the year that the pre-regime steady state would have been reached had there been no regime change), and 1998 and 2042 for post-regime. In particular, I compute the fraction of population that would choose to be unskilled workers, skilled workers of $PE$ and $SOE$. Finally, I make linear combinations of the decisions rules of the beginning and the ending point for each subperiod, and obtain a dynamic path of $H$ during the whole period. I compute dynamics of $H^P$ by employing similar strategies and make $H^S$ equal the difference between $H$ and $H^P$. Based on the dynamics of skilled labor, that of $TFP$ and wage are computed from the model by assuming each year as a steady state.

Figure 5(a) displays a structural change of $H$ and $H^P$ around 2000, while $H^S$ is relatively stable throughout the years. In addition, $H^P$ exceeds $H^S$ before 2008, which fits the data well. Figure 5(b) shows a comparison of $H$ of model dynamics and data (normalized). As can be seen, the model $H$ fits data well both in magnitude and trend.

Figure 5(c) and (d) show dynamics of $A^P$ and $A^S$ and their ratio. $A^P$ grows at

\textsuperscript{19}If we want to compute decision rules for each cohort and each year, we have to use data over 40 years before 1990, which is unavailable for China. Yet, the current computation should be sufficient to catch the main trend of dynamics.

As in the calibration, when computing the $H$ dynamics for the young generation, I assume that decision-making occurs in the last five years of this period, that is, at the age 16 to 20, rather than the whole period.

\textsuperscript{20}Remember that when I do calibration, the new steady state is not really reached due to lack of data.
a stable rate through the years, while $A^S$ had a significant jump around 1998, the economic reform year. The $A$ ratio thus dropped dramatically around 1998.

Table 4 compares the mean values of variables computed from model dynamics with those from data or the calibrated two-regime model, which turn out to be close, showing good fit.

### 4.3 Comparative statics

I compute comparative statics for each of the two steady states (i.e., two regimes) to examine the effects of changes in certain parameter values on variables including: skilled labor employment and sector share ($H$, $H^P$, $H^S$, $H^P/H$), skilled human capital and sector share ($HC$, $HC^P$, $HC^S$, $HC^P/HC$, where $HC^i = (\bar{w}^i/\bar{a}_m)H^i$, $i \in \{P, S\}$, and $HC \equiv HC^P + HC^S$), average labor productivity ($APL$, which combines unskilled and skilled production), skilled production output share of $PE$ ($Y^P_H/Y_H$).

The parameters under analysis are: $\eta_0$, $\tau_K$, $\tau_w$, $A^S$, $AP^P$, $\phi_L$, $\theta$, and $\nu$ (or, $w_L$). Figure 6 shows the comparative statics of $\eta_0$ and $\tau_K$.

Figure 6(a) shows that a decrease in $\eta_0$ (a measure of college enrollment expansion) does increase 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 increase when $\eta_0$ is large, but decrease when $\eta_0$ gets smaller. The similar relationship also applies to $APL$ and $PE$ output share. 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 6(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, offsetting the effect from an increase of SOE skilled wage. $APL$ increases as $\tau_K$ decreases as a result of improved allocation.

---

21 To save space, comparative statics of other parameters are not shown in this version, and only results regarding the first steady state are shown, but that of the second steady state is qualitatively similar.
efficiency. The effect of a reduction of $\tau_w$ is similar to $\tau_K$.

Other results not shown here include: an increase in $A^S$ increases skilled labor in SOE, reduces that in 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.

4.4 Impacts of policy: counterfactual analysis

In this section, I conduct counterfactual analysis to examine policy effects.

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 productivity of labor ($APL$ and $APL_H$, where the latter is the APL of skilled production), had there been no higher education expansion (changes in $\eta_0$), no state sector reform (changes in $\tau_K$, $\tau_w$) or no improvement of TFP (changes in $A^S$ or $A^P$).

Table 5 shows the results. It can be seen that higher education expansion (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 5 percent, as the average productivity of skilled labor 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 ($\tau_K$ and $\tau_w$). 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.

Second, I ask which factors contribute most to the overall impact of educational policy on average labor productivity. Model analysis suggests several factors: total human capital stock and allocation across sectors, average ability of skilled workers in each sector, and physical capital stock and 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 ss2, 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 6 shows the results. Except for the increase of $H$ which has a
large positive effect on $APL$, all other factors have a negative effect on $APL$, that is, $APL$ in $ss2$ would have increased if these variable values were equal to those in the no-$\eta_0$-change scenario. The most important two 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.

Finally, I pick the most important factor from the experiment above, the physical capital reduction, and investigate its main cause. In particular, I examine both supply and demand sides of loanable funds market in $ss2$ and in the no-$\eta_0$-change case. Table 7 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, increases of 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, 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.

### 4.5 Impacts of educational policy with different distortions

How does allocation distortion matter for the impact of the educational policy? In this section, I assess the impact of the college enrollment expansion (changing $\eta_0$ from its pre-regime, or $ss1$ value to its post-regime, or $ss2$ value) on human capital stock and allocation, sectoral output share, and average labor productivity, under the assumption of full distortion (i.e., pre-regime, or $ss1$, 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 8.

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 since misallocation is intensified. However, had the economy had no allocation 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 3 percent.
4.6 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 utility of the society. Meanwhile, her choice is subject to labor market frictions (i.e., lay-off 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 developing countries. The analysis is based on the post-regime economy (i.e., ss2), with the layoff probabilities $\Phi(a)$ and $\phi_L$, and capital market distortions $\tau_K$ unchanged, and the minimum SOE skilled output share is set to be the SOE skilled output share in ss2 as well. Then her problem is

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

s.t. $Y_H^P/Y_H \geq 0.376$, $\tau_K$, $\Phi(a)$, $\phi_L$ the same as in ss2.

Table 9 shows the results of the social welfare optimization and compare 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 \(^{22}\).

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.

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

\(^{22}\)The results are the same when the social planner’s objective is to maximize APL under the same constraints.
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 shifts the share of college graduates 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 of subsidy from 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.

This paper has some limitations. 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 reflect the impact of higher education expansion on the longer run. This impact could be more positive as economic reform was deepened and other market-oriented policy was launched.
### Tables and Figures

#### Table 1. Target values of calibration

<table>
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<th>target</th>
<th>ss1</th>
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<tr>
<td>$H$</td>
<td>0.10</td>
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<td>$L$</td>
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<td>$\kappa$</td>
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<td>$K^P/K^S$</td>
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</table>

**Notes:** This table reports the targeted values for calibration. Data is taken from China labor statistical yearbook, average of 1990-2008. $H$ ($L$) is normalized total number of skilled (unskilled) workers. $N^S$ ($N^P$) is the total SOE (PE) employment. $u$ is the unemployment rate, and $u_H$ is the unemployment rate of the skilled workers computed using the unemployment rate, skilled share of unemployment, and skilled share of employment. $h_{fr}$ is the fraction of new college graduates that are employed by PE. $w^P$ ($w^S$) is the average wage of PE (SOE), and $w_L$ is unskilled wage (normalized to be one in ss1). $\kappa$ is the non-wage benefit adjusted for SOE wage.

#### Table 2. Wage and Employment

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<th>variables</th>
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<th>ss2</th>
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<td>$w_L$</td>
<td>1.00</td>
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<td>$w_H^P$</td>
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<td>8.96</td>
<td>$PE$ skilled wage</td>
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<td>$w_H^S$</td>
<td>6.76</td>
<td>6.93</td>
<td>$SOE$ skilled wage</td>
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<td>$\overline{w_H}/w_L$</td>
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<td>3.47</td>
<td>skill premium</td>
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<tr>
<td>$w_H^P/w_H^S$</td>
<td>1.06</td>
<td>1.29</td>
<td>$PE$ premium (skilled)</td>
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<td>$l$</td>
<td>94.7</td>
<td>83.4</td>
<td>percentage of unskilled workers</td>
</tr>
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<td>$%h^P$</td>
<td>0.8</td>
<td>8.3</td>
<td>percentage of $PE$ skilled workers</td>
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<tr>
<td>$%h^S$</td>
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<td>8.3</td>
<td>percentage of $SOE$ skilled workers</td>
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</tbody>
</table>

**Notes:** This table reports wages of unskilled and skilled workers (of two sectors), skill premium (i.e., wage ratio of skilled to unskilled), $PE$ premium of skilled workers (i.e., wage ratio of $PE$ to $SOE$ skilled workers), and the percentage of unskilled and skilled workers (of two sectors) in one generation.
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>

Notes: This table reports the calibration results. It shows the calibrated values of parameters for the pre-regime (ss1) and post-regime (ss2) economies.
Table 4. Model dynamics vs. data/calibration

<table>
<thead>
<tr>
<th></th>
<th>period</th>
<th>model dynamics</th>
<th>data/calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>$gr_H$</td>
<td>1990-2008</td>
<td>9.12</td>
<td>9.63</td>
</tr>
<tr>
<td>$w_H^P/w_H^S$</td>
<td>1990-2008</td>
<td>1.04</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>2002-2008</td>
<td>1.45</td>
<td>1.29</td>
</tr>
<tr>
<td>$A_P/A_S$</td>
<td>1990-2008</td>
<td>1.62</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>2002-2008</td>
<td>1.12</td>
<td>1.11</td>
</tr>
<tr>
<td>$A_P$</td>
<td>1990-2008</td>
<td>3.58</td>
<td>3.51</td>
</tr>
<tr>
<td></td>
<td>2002-2008</td>
<td>4.43</td>
<td>4.45</td>
</tr>
<tr>
<td>$A_S$</td>
<td>1990-2008</td>
<td>2.22</td>
<td>2.19</td>
</tr>
<tr>
<td></td>
<td>2002-2008</td>
<td>3.96</td>
<td>4.01</td>
</tr>
</tbody>
</table>

Notes: This table reports the variable values for model dynamics. Average values of pre-regime (1990-1998) and post-regime (2002-2008) economies are reported for skilled wage ratio ($w_H$ ratio), TFP ratio ($A$ ratio) and TFPs of the private and the state sector ($A_P$, $A_S$). The average annual growth rate of human capital during 1990-2008 is shown in the first row. Values from model dynamics and from data or the two-regime calibrated model are reported.

Table 5. 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>$Y_H^P/Y_H$</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>$Y_H^S/Y_H$</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>

Notes: This table reports the results of counterfactual analysis of policy effects. It shows values of skilled workers’ share of the private sector ($H^P/H$), total human capital stock ($HC$), human capital share of the private sector ($HC^P/HC$), skilled output share of the private sector ($Y_H^P/Y_H$) and the state sector ($Y_H^S/Y_H$), average labor productivity of skilled output ($APL_H$) and of all output ($APL$). The first two columns show variable values of the two steady states, and column three shows percentage change of variable values from ss1 to ss2. Column four to seven show percentage changes of variable values of ss2 if there was no $\eta_0$ change, no $\tau_K$ and $\tau_W$ change, no $A_P$ change or no $A_S$ change.
Table 6. Counterfactual: decomposition of educational policy effect

<table>
<thead>
<tr>
<th>variables</th>
<th>E2 (ss2)</th>
<th>E1 (η₀ as ss1)</th>
<th>APL&lt;sub&gt;E₂&lt;/sub&gt;&lt;sub&gt;%&lt;/sub&gt; 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&lt;sub&gt;P&lt;/sub&gt;/H</td>
<td>0.48</td>
<td>0.74</td>
<td>10.8</td>
</tr>
<tr>
<td>ȧ&lt;sub&gt;P&lt;/sub&gt;, ȧ&lt;sub&gt;S&lt;/sub&gt;</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&lt;sub&gt;P&lt;/sub&gt;/K</td>
<td>0.60</td>
<td>0.78</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Notes: This table reports the results of counterfactual analysis on decomposition of the effect of higher educational expansion. The first two columns show the variables value of the second steady state (E2) and of the case where there is no η₀ change (E1) as reported in Table 4. The last column shows the percentage change of APL in E2 if a certain variable value (H, H<sub>P</sub>/H, ȧ<sub>P</sub> and ȧ<sub>S</sub>, respectively) was set to its E1 value.

Table 7. Counterfactual: effects on the loanable funds market of college expansion

<table>
<thead>
<tr>
<th>loanable funds market</th>
<th>E2 (ss2)</th>
<th>E1 (η₀ 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>

Notes: This table compares the loanable funds market supply- and demand- side components of the second steady state (E2) and the no-η₀-change case (E1).
Table 8. Impacts of college enrollment expansion under different distortions

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

Notes: This table reports the results of the impact of college enrollment expansion with different policy distortions. The variables reported are the same as in Table 4. Values reported are computed from the model with pre-regime (ss1) $\eta_0$, post-regime (ss2) $\eta_0$, and the percentage change of these two values, with full distortion (i.e., $\tau_K$ and $\tau_W$ equal to ss1 values) and no distortion ($\tau_K$ and $\tau_W$ equal to 0). This experiment is conducted based on the pre-regime (ss1) economy.

Table 9. Social optimal

<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>$Y^P_H/Y_H$</td>
<td>0.62</td>
<td>0.62</td>
</tr>
<tr>
<td>$Y^S_H/Y_H$</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>

Notes: This table reports the results of the social optimal exercise and compare them to steady-state 2 values. It shows variables values of total society’s utility ($U$), $\eta_0$, $\tau_W$ and others as in Table 4.
Figure 1. College enrollment expansion

Notes: This figure shows the college enrollment number (in million) of China during 1990-2010 (Panel(a)) and the share of urban employment with college degree (Panel(b)). The latter is estimated using the ratio of the number of college graduates in the year (assumed to be equal to the college entry number three years before that year) to total urban employment in the same year. Data source: http://edu.people.com.cn/n/2013/0503/c116076-21359059.html, and China labor statistical yearbook.
(a). Employment of skill-intensive industries (in million)

(b). Employment of labor-intensive industries (in million)

Figure 2. Industry labor allocation

Notes: This set of figures shows employment (in million) of the state sector and the private sector for four skill-intensive industries (Panel (a)) and four labor-intensive industries (Panel (b)) during 1990-2010. The Solid line represents the private sector, and the dotted line represents the state sector. Data is taken from China labor statistical yearbook.
Figure 3. Lifetime choices by ability

Notes: This figure shows an individual’s utility (vertical axis) as a function of ability (horizontal axis) when she chooses to be an unskilled worker ($u_L$), a PE skilled worker ($u^P_H$) or an SOE skilled worker ($u^S_H$). Under the model mechanism and reasonable parameterizations, individuals whose ability is higher than a threshold $\hat{a}$ choose to be PE skilled workers, those whose ability is lower than another threshold $\tilde{a}$ choose to be unskilled workers, and those whose ability is between $\tilde{a}$ and $\hat{a}$ will become SOE skilled workers.
Figure 4. The effect of higher education expansion

Notes: This figure shows the channels that the higher education expansion policy affects labor productivity \((APL)\). One channel is through the “growth effect”, that is, higher education expansion reduces disutility cost of college education and encourages more people to acquire college education. The other channel is through the “reallocating effect”, that is, by admitting more less-able individuals to college, a larger proportion of college graduates may choose to work for the state sector, intensifying resource misallocation.
Figure 5. Model dynamics

Notes: This set of figures shows the results of model dynamics. Figure (a) shows the normalized number of skilled workers ($H$) and that for two sectors ($H^P$, $H^S$) from model dynamics. Figure (b) compares the number of skilled workers of model and data. Figure (c) shows model dynamics of TFPs of the two sectors’ skilled production, and Figure (d) the TFP ratio from model dynamics.
Figure 6(a). Comparative statics of $\eta_0$

Notes: This set of figures shows the comparative statics of $\eta_0$. 

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Figure 6(b). Comparative statics of $\tau_K$

Notes: This set of figures shows the comparative statics of $\tau_K$. 
References


[28] Li, Shi and Chuming Xing, 2010. China’s higher education expansion and its labor market consequences.


