Higher Education Expansion, Economic Reform, and Labor Productivity

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Abstract

This paper studies the impact of higher education expansion, along with economic reform of the state sector, in the late 1990’s in China on its labor productivity. 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 across sectors. Thus, its impact could be very limited if misallocation becomes more severe following the policy. I construct a two-sector general equilibrium model with private enterprises (PE) and state-owned enterprises (SOE), with policy distortions favoring the latter. Households, heterogeneous in ability, make educational choices and occupational choices in a three-period overlapping-generations setting. Counterintuitively, quantitative analysis shows an overall negative effect of higher education expansion on average labor productivity (by 5 percent). Though it did increase China’s skilled human capital stock significantly (by nearly 50 percent), the policy had the effect of reallocating relatively more human capital toward the less-productive state sector. It is the economic reform that greatly improves the efficiency of human capital allocation and complements educational policy in enhancing labor productivity (by nearly 50 percent).
1 Introduction

As a fast-growing economy, China has experienced tremendous institutional changes in the past decades. One of these changes is higher education expansion. It is natural to think that this educational policy improved human capital of the economy and thus contributed to productivity growth. However, as documented by Hsieh and Klenow (2009), China has suffered substantial productivity losses due to factor misallocation across sectors. Since the working of this educational policy is expected to channel through a production factor – human capital, its effects may be limited if factor misallocation may dampen the effectiveness of the policy. In this paper, I examine how the higher education expansion policy may affect China’s labor productivity through its effect on human capital allocation as well as stock, and how an economic reform may influence the role of the educational policy by triggering more efficient allocation.

China’s nationwide college enrollment expansion policy took effect in 1999. In this year alone, the college enrollment number reached nearly 1.6 million, an increase of 48 percent from the previous year. The expansion continued throughout the following years, which significantly increased China’s skilled labor stock subsequently (see Figure 1). The college enrollment expansion was accompanied by a massive-scale economic reform of the state sector, which cut off subsidies to most state-owned enterprises (SOEs), shut down or privatized the least productive ones, and laid off millions of excessive workers.

1China’s college enrollment expansion is a means of the central government to “stimulate domestic demand, promote economic growth, and alleviate employment pressure”. The policy made college education more accessible by substantially expanding college admissions. As a consequence, the average annual growth rate of China’s college enrollment reached over 16 percent during 1998-2010, a significant increase from 6.8 percent during 1977 (i.e., the first year China when resumed its college admission)-1998 (see Figure 1(a)). The college enrollment rate, defined as the ratio of total population being admitted to colleges to the population taking the college entrance examination, was less than a quarter before 1999, but nearly 60 percent after 1999. See Wan (2006) and Chen (2004) for more details of the background of the policy.

2China’s economic reform of the state sector began in the mid-1990’s prior to the college enrollment expansion, but became substantial since 1998. The SOEs, while given priority for various resources, were generally considered to be highly inefficient with redundant employment. This situation was particularly severe before the 1990’s reform, becoming a barrier for China’s further
Following the two policies, labor allocation of the private and the state sectors shows a structural change. For skill-intensive industries, the private-sector employment has been growing rapidly since 2002, 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 significantly around 1998 due to the reform, and the private-sector employment had a roughly linear growth. These observations illustrate that China’s skill-intensive industries has grown faster relative to the labor-intensive ones, and that within skill-intensive industries, the private sector has expanded more quickly than the state sector since 2002. The latter suggests a reallocation of skilled labor toward the private sector. The question is: which policy accounts for the structural change of human capital allocation, and what are the implications for labor productivity?4.

Taking the observations delineated above into account, I construct a two-sector general equilibrium model that characterizes human capital growth and allocation across sectors, in an environment where allocation distortions exist. The key ingredients are following. (i) Firms of two sectors – the private sector (PE) and the state sector (SOE), produce with unskilled labor, skilled labor, and (physical) capital. SOE has lower TFP than PE, but is subsidized in both renting capital and hiring skilled labor. (ii) Households (or, individuals, interchangeably), heterogeneous in ability, live for three periods. They make the educational choice of whether or not to acquire college education in the first period, and the occupational choice of whether to work for PE or SOE in the second period upon graduating. Household utility depends on consumption and a disutility cost from college education. (iii) Individuals’ ability matters for both choices. It affects educational choice as higher ability lowers the disutility cost of education. It also affects occupational choice since higher ability lowers the probability of being unemployed as a skilled PE worker (while a skilled

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3For more references of the SOE reform, see Bai et al. (2000).

32002 is the year when the first generation of college students since college enrollment expansion entered the job market.

4This paper focuses on the growth and allocation of skilled labor (i.e., college graduates). The unskilled labor could be affected by other factors such as growing rural-to-urban migration during this episode, which is not of main interest in this paper.
SOE worker is never unemployed). (iv) Finally, the college enrollment policy enters
the model via an exogenous component of the disutility cost of college education.

The model characterizes two tradeoffs regarding the educational choice and the
occupational choice. For the former, going to college increases one’s labor income
later in life, but incurs a disutility cost. For the latter, a skilled worker earns higher
wages in PE than in SOE, but faces a higher layoff probability when working for PE.
In equilibrium, households are sorted into three categories by their ability: those
with high ability acquire college education and then become PE skilled workers,
those with low ability do not go to college and become unskilled workers, and those
in the middle go to college and then become SOE skilled workers.

The college enrollment policy affects average labor productivity via two channels.
One is the “growth effect”. Higher education expansion encourages more people to
go to college since it lowers the disutility cost of college education. This increases
the society’s human capital stock and hence improves average labor productivity.
The other channel is the “reallocation effect”. Under this policy more people with
lower ability become skilled workers, and many of them would prefer working for
SOE rather than for PE, since their probability of being unemployed is higher if
choosing the latter. This may reallocate relatively more skilled workers as well as
other resources to SOE and hence lowers average labor productivity.

I calibrate the model to match China’s data on wage and employment for years
1990 to 2008, and analyze the policy effects. The main results are as follows. First,
the college enrollment expansion policy in China did increase the society’s human
capital stock significantly (by nearly 50 percent). However, it reallocated more hu-
man capital toward the less-productive state sector. Overall, the average labor pro-
ductivity would have increased by 5 percent had the college enrollment not been expanded. Second, the economic reform of the state sector contributed significantly
to labor productivity. Had there been no reform, average labor productivity would
have decreased by nearly 50 percent, as the human capital share of the private sector
would have dropped by 98 percent. Hence, SOE reform is a crucial complement to
the educational policy in enhancing labor productivity.
Related Literature

This paper is first 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). While economic theory predicts a positive impact of human capital on economic growth, empirical studies show substantially mixed findings on the causal relationship (e.g., Barro, 1991; Romer, 1990a; Mankiw, Romer, and Weil, 1992; Benhabib and Spiegel, 1994; Barro and Sala-i-Martin, 1995; Bils and Klenow, 2000). Some recent studies pursue a more accurate measure of human capital or labor quality and suggest a strong and positive role of human capital in growth (e.g., Hanushek and Kimko, 2000; Hanushek and Woessmann, 2008; Manuelli and Seshadri, 2010; Erosa, Koreshakova, and Restuccia, 2010; Ravikumar and Ventura, 2012; Hanushek and Woessmann, 2012). Others argue that the most cross-country differences in output per worker are not driven by differences in human capital or physical capital, but are due to differences in a residual, total factor productivity (TFP) (Klenow and Rodriguez-Clare, 1997; Hall and Jones, 1999; Parente and Prescott, 2000; Bils and Klenow, 2000). The role of human capital in the economic transition is also theoretically investigated in the literature. For example, Galor and Moav (2004) consider the replacement of physical capital accumulation by human capital accumulation as a prime engine of growth along the process of development. Goodfriend and McDermott (1995) emphasize the role of human capital in pushing the economic transition from pre-industry development stage to modern balanced growth path. Nevertheless, all these studies focus on the effect of human capital stock, but ignore human capital allocation. The latter could account for a significant proportion of TFP differences, since allocation distortions widely exist in many developing economies and become a barrier to economic growth.

Country-level study is relatively few, despite its advantage in understanding important country-specific characteristics related to economic development. Tallman and Wang’s (1994) provide an excellent example with a case study of Taiwan. The authors assess Taiwan government policy since the early 1950’s that stressed the importance of improving human capital stock of its population. They argue that
the endogenous enhancement of human capital due to educational policy and improved institutions generates a “big push”. Their work relates to my paper in that human capital policy interacts with market-oriented policies and stimulates economic growth.

This paper is also related to the growing literature of the impact of misallocation on aggregate productivity (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009; Alfaro et al., 2008; Bartelsman et al., 2013; Banerjee and Duflo, 2005; Schmitz, 2001). This literature highlights the role of resource allocation rather than the aggregate level in cross-country income differences, and argues that misallocation of resources slows down output TFP growth for many developing countries and some developed countries. In particular, there is literature focusing on distortion and misallocation in China. For example, Dollar and Wei (2007), Dobson and Kashyap (2006), Allen, Qian and Qian (2005), and Boyreau-Debray and Wei (2005) document that China’s state-dominated financial system still favors financing less-productive SOEs, which prevents the efficient allocation of capital. In their influential article, Hsieh and Klenow (2009) investigate the impact of resource misallocation across manufacturing firms on aggregate TFP in China and India. They find that a more efficient allocation of resources would have contributed to manufacturing TFP gains of 30-50 percent in China. Following this approach, Brandt, Tombe and Zhu (2013) measure TFP losses in China’s non-agricultural economy associated with labor and capital misallocation across provinces and sectors, and find that misallocation lowers aggregate non-agricultural TFP by 20 percent. However, the literature on misallocation mostly focuses on allocations of physical capital and unskilled labor, while my paper emphasizes that of human capital, or skilled labor. In particular, I study how an educational policy that improves human capital stock affects human capital allocation in a distorted economy.

Finally, this paper is related to the relatively thin literature of China’s higher education expansion. This literature, however, focuses on the impact of the college

\footnote{In an earlier article, Brandt, Hsieh and Zhu (2008) show that reductions in barriers to labor reallocation, including from agricultural to non-agricultural sector, and from state to non-state sector, were important for China’s structural transformation and growth.}
expansion on education opportunities for subgroups of people and income inequality (e.g., Meng et al., 2013; Li and Xing, 2010; Yeung et al., 2008; Yeung, 2013). This current paper is so far, to my best knowledge, the first paper that evaluates the impact of China’s higher education expansion on its labor productivity and economic development.

In summary, this paper contributes to the literature by examining the impact of higher education expansion on labor productivity in an economy with allocation distortions. I argue that in such an economy, an educational policy affects labor productivity not only through its effect on human capital stock, but also through its effect on human capital allocation across sectors. The latter can be crucial since the policy may potentially trigger greater misallocation and negatively affect labor productivity. I construct a theoretical framework to analyze the effects of the educational policy and the economic reform policy. Under this framework, households not only face educational choice between college education or not, but also face occupational choice between the private sector and the state sector. Both choices are affected by the government policy. I conduct quantitative analysis to decompose the effect of each policy in China, and find that higher education expansion alone has slightly negative effect on China’s labor productivity, and that economic reform complements the educational policy in enhancing labor productivity.

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. Firms in both sectors produce with unskilled labor, skilled labor and capital. State-sector firms have lower TFP in skilled production than private-sector firms, but enjoy a subsidy for renting capital and hiring skilled workers. Households live for three periods. They have perfect foresights about lifetime income and are heterogeneous in ability. They make educational choices of whether acquiring college education or
not in the first period, and make occupational choices between the private sector and the state sector in the second period. College education incurs a disutility cost, but increases labor income later in life. Private-sector firms pay higher wages to skilled workers due to their higher productivity, but may lay them off in the third period. Households’ ability affects both choices. Higher ability reduces the disutility cost of college education, and also reduces the probability of being laid off in the private sector.

2.1 Production and distortions

There are two types of firms (one in each sector) – private enterprises (PE) and state-owned enterprises (SOE). Both types of firms produce homogeneous goods which are the numeraire, using unskilled labor, skilled labor and (physical) capital with a CRS technology. Hence the number of firms does not matter. Markets are competitive except for the price distortions described below. The production functions are:

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

where \(L^i (H^i)\) is the amount of unskilled (skilled) labor employed by type \(i\) firms, and \(K^i\) is capital used 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 \(i\) firm. Later I assume \(\Psi(\bar{\pi}^i) = \frac{\bar{\pi}^i}{a_m}\), where \(a_m\) is the lower bound of ability of all individuals. 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\(^6\). I assume \(A^P > A^S\) since it is widely documented that private firms have higher TFP than state firms due to their better profit incentives, and it is reasonable

\(^6\)This form of production functions allows me to focus on human capital (or skilled labor) by greatly simplifying the unskilled part to be identical for both types of firms.
that better incentive matters 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 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 renting capital and hiring skilled workers. Denote the market rental rate of capital by $R$ and denote 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 $\tau_K (> 0)$ and $\tau_w (> 0)$ measure the degree of policy distortions on physical and human capital allocations respectively. PE receives no subsidy hence pays $R$ for capital and $w^P_H$ to its skilled workers, which may differ from $w^S_H$. Both firms pay the same wage $w_L = \nu$ to their unskilled workers due to the linear unskilled production function.

2.2 The household

Time is discrete. The economy is populated with three-period overlapping generations, in which households make the educational choice – whether to acquire college education when young, and the occupational choice – whether to work for PE or SOE when becoming a skilled worker at 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 $F(a)$ and lower bound $a_m$. This ability affects one’s disutility cost of acquiring higher education (i.e. going to college), and also her job security if working for the 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:

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

where \( c_t^{t+2} \) is her consumption at the third period of life, which is a function of her ability\(^7\). \( \Omega \) 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 \( \frac{\eta}{a} \), 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 higher \( \eta \) means more restrictiveness to be admitted to a college. 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 (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. If she does not, she will become an unskilled worker and receive unskilled wage for her entire life but can start working immediately.

In the second period, those who went to college when young become skilled workers and make an occupational choice between working for a \( PE \) or \( SOE \), 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 also 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 job positions.

In the third period, workers cannot change their working sector. One may consider this as that when people have been working on a particular kind of job for a long time, it would be too costly for them to make a change, or they will be restricted

\(^{7}\) The linear form of utility function greatly simplifies my analysis of household choices.
to switch by institutional factors. 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. This mirrors the reality that the SOEs usually offer better-secured, “stable” jobs to the highly educated workers regardless of their ability, since they have less profit incentive but better motivation to maintain a high average educational level, whereas the private firms select workers more by their ability and are more willing to fire the “surplus” ones even if they have high educational achievement; moreover, private firms themselves are less-secured and are much more likely to be shut down than the SOEs since they have little protection from the government – in this situation, their former employees would find themselves harder to find a new job if their ability is not high enough.

An unskilled worker will be laid off with a probability $\phi_L$ in this period regardless of the type of firm she works for (this is again for simplicity and for my focus on analysis of the skilled part). 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, the 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

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

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

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

(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 occupational choice \( o \in \{P, S\} \). She chooses to work for \( PE \) if and only if \( c_{t,H,P}^{t+2} \geq c_{t,H,S}^{t+2} \) as 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 advantage 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 a household with ability above \( \hat{a} \) chooses to work for \( PE \) and the one with ability below \( \hat{a} \) works for \( SOE \). \( \hat{a} \) can be determined by:

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

(5)

In the steady state where prices are constant, 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 can offer 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 too low. Hence, only those with sufficient 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 \(\max\{E[c_{t,H,P}^t(a)], E[c_{t,L,S}^t]\} - \frac{n}{a} \geq E[c_{t,L}^t]\). From the utility function, one can see that a household at this stage weighs the higher wage she would receive when becoming 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

\[
[w_{H,t+1}^S - (1 + r_{t+1})\theta] (1+r_{t+2}) + w_{H,t+2}^S -\frac{\eta}{\tilde{a}} = [w_{L,t}(1 + r_{t+1}) + w_{L,t+1}] (1+r_{t+2})+(1 - \phi_L)w_{L,t+2} \tag{7}
\]

In the steady state the above equation can be rearranged to

\[
\tilde{a} = \eta/ \left\{ w_{H}^S (2 + r) - (1 + R)\theta^2 - w_{L} [(2 + r)(1 + r) + 1 - \phi_L] \right\} \tag{8}
\]

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 the SOE skilled worker and the unskilled worker, the higher would be \(\tilde{a}\).

Lifetime choices by ability

Now one can see that under certain conditions, households endogenously sort into different categories of education and occupation by their abilities. This can be illustrated in Figure 3, which shows the utility of a household with different abilities under different choices. The utility of being unskilled is constant with respect to her
ability, while of being skilled increases in ability, with a $PE$ worker’s utility curve being steeper than an $SOE$ worker’s but starting lower. As a result, households sort into different skill levels and different types of firms: those with abilities in high percentiles acquire college education and then are employed by $PE$, 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 each period, and do not save for the future, thus their problem is a static one. 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 $k^i = \frac{k_i}{H_i}, i \in \{P, S\}$ is the capital per (skilled) capita of each 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 market.

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

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

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

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

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

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

The loanable funds market clearing condition at $t$ is

$$K_t^P + K_t^S + \theta_t(h_t^P + h_t^S) = (l_t^P + l_t^S)w_{L,t} + (l_{t-1}^P + l_{t-1}^S)[(1 + r_t)w_{L,t-1} + w_{L,t}]$$

$$+ h_{t-1}^P w_{H,t}^P + h_{t-1}^S w_{H,t}^S - (h_{t-2}^P + h_{t-2}^S)(1 + R_t)\theta_{t-1} - \tau_t$$  \hspace{1cm} (17)

where $l_t^i$ and $h_t^i$ are the amount of unskilled and skilled workers of each generation born at time $t$ working for sector $i$ ($i \in \{P, S\}$). From equation (17), one can see that the loanable funds demand consists of two parts: capital demand from firms and educational loan demand from young college students; the loanable funds supply consists of: a) wages earned by young unskilled workers, b) wages plus interest earned by the middle-aged unskilled workers from the last period, and their current wage, c) wages earned by middle-aged skilled $PE$ and $SOE$ workers, d) minus the repayment of educational loan of the middle-aged skilled, and e) minus the lump-sum tax raised from all the middle-aged.

The average ability of each type of firm is then
\[
\bar{a}_t^P = \left[ \int_{\hat{a}_{t-1}}^{\infty} adF(a) + \int_{\hat{a}_{t-2}}^{\infty} a(1 - \Phi_t(a))dF(a) \right] / H_t^P
\]

(18)

\[
\bar{a}_t^S = \left[ \int_{\hat{a}_{t-1}}^{\hat{a}_{t-1}} adF(a) + \int_{\hat{a}_{t-2}}^{\hat{a}_{t-2}} adF(a) \right] / H_t^S
\]

(19)

\(\tau_t\) satisfies the government budget constraint:

\[
\tau_t = \tau_{K,t}R_tK_t^S + \tau_{w,t}w_{H,t}^S H_t^S
\]

(20)

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

3.4 Dynamic general equilibrium

**Definition:** A competitive equilibrium is a set of allocations \(\{L^P, L^S, H^P, H^S, K^P, K^S, c(a)\}_t\), and a set of prices \(\{R, w^P_{H^P}, w^S_{H^S}, w_L\}_t\), 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 \(\{K^i, H^i, L^i\}_t\) \((i \in \{P, S\})\) to maximize profit (by satisfying equation (9) – (13));

(iii) labor and loanable funds markets are clearing 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, a higher education expansion policy can be measured in the model by a decrease in the parameter value of \(\eta\). This section characterizes the two separate channels through which the educational policy affects labor productivity (see Figure 4).

The growth effect. As \(\eta\) decreases, the exogenous cost of acquiring college education decreases, as does the overall disutility cost of education given an individual's
ability. This encourages more individuals to go to college and to become skilled labor upon graduating, thereby increasing the society’s stock of human capital. As the supply of skilled labor increases, average skilled wage decreases in equilibrium, suppressing further increase in skilled labor. By facilitating human capital growth of the economy, this channel has a positive effect on average labor productivity.

The reallocation effect. Under the mechanism of the model, only individuals with higher ability choose to go to college. When it encourages more individuals to acquire college education, the college enrollment expansion policy brings more less-abled individuals to the skilled labor market. These people would prefer working for SOE rather than PE, since their probability of being unemployed if choosing the latter is higher. This may lead to relatively more human capital being allocated to the less-productive SOE. The reallocation of human capital toward SOE also tightens the loanable funds market as SOE requires more subsidies for its skilled-worker employment and capital renting. This reduces capital per worker and further reduces average labor productivity of high-skilled production. The relative increase in skilled labor supply to SOE then pushes up relative PE skilled wage and interest rate (mainly due to a higher demand of loanable funds since more subsidies are required), offsetting the increase in SOE skilled labor supply. This channel has a negative effect on average labor productivity since it enlarges misallocation of both human and physical capital.

4 Quantitative analysis

In the quantitative analysis, I first calibrate two sets of parameters of before and after policy change using China’s data of 1990-2008, and do model dynamics by making cohort combinations of decision rules under different regimes. Then several experiments are conducted to examine the impacts of particular policies quantitatively.

4.1 Calibration

I calibrate two sets of parameters – before and after policy change (college enroll-
ment expansion and state sector reform) – by taking the average value of 1990-1998 data for the first set, and the average of 2002-2008 for the second one. I assume these average values to be corresponding to the old and new steady states (steady state 1 & 2) of the economy. 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 quite lacking and after 2008 could be much affected by the global financial crisis.

I use employment and wage data of five industries from China labor statistical yearbook: manufacturing, real estate, finance, information technology, and science and technology service. Manufacturing is a low-skill intensive industry with the fraction of employment with college or above degree only 6.3 percent in 2002; and the rest four are considered high-skill intensive industries with share of employment with college or above degree over 30 percent in 2002. Unskilled wage is taken from the average wage of construction industry of which the higher-education composition is among the lowest of all industries (5 percent in 2002) and remains stable over the years. In the calibration, I normalize the pre-regime mean unskilled wage to be one, and other wages are then transformed to wage ratios.

To match the three-period OLG setting, I assume three cohorts coexist at each period which lasts for twenty years, and population of each cohort is normalized to be one. Since the decision of whether to go to college normally happens at around the 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 certain period is 3, the “active” population is 2.25.

Households’ ability follows Pareto distribution \( F(a) = 1 - (a/a_m)^{-t_a} \), with the location parameter \( a_m \) (minimum ability) and shape parameter \( t_a \) to be calibrated.

---

8Since the state sector reform became substantial in 1998, roughly the same period as the college enrollment expansion, I assume these two policies to be simultaneous and thus the old steady state corresponds to before both policy changes, and the new one corresponds to after both policy changes.

9A caveat of the calibration is that the length of data available may be too short, only 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 quantitative analysis may be the best that can be done so far.
The $PE$ skilled laid-off probability in the third period of life is assumed to be $\Phi(a) = \varepsilon a^{-\gamma}$, $\varepsilon, \gamma > 0$.

Sixteen parameters (or variables) need to be calibrated for each steady state: $r, \delta, t_a, a_m, \theta, \nu, A^P, A^S, \phi_L, \alpha^P, \alpha^S, \varepsilon, \gamma, \tau_K, \tau_w, \eta_0$. 10 Seven of these are assumed to be the same for 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 normal in the literature; tail parameter $t_a$ is assumed 2.5 in the benchmark case but changing it would not make a qualitative difference. Education fee $\theta$ is 10,000 RMB yuan for steady state one (“ss1” hereafter) and 20,000 RMB yuan for steady state two (“ss2” hereafter) from data, and are normalized to the ratio to ss1 unskilled wage. $\tau_w$ is assumed to be 0.68 for ss1 and 0.36 for ss2.11

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 are of the same value for two steady states. I calibrate these parameters to match the following target: (normalized) total number of skilled workers ($H$) and unskilled workers ($L$), total SOE employment ($TS$), total $PE$ employment ($TP$, including domestic private firms and foreign firms)12, unemployment rate ($unemp$) and computed unemployment rate of the skilled ($umpH$) (using the unemployment rate, skilled share of unemployment, and skilled share of employment), fraction of new college graduates that are employed by $PE$ ($hpfr$), average wage of $PE$ and SOE respectively ($w^P$ and $w^S$) with non-wage benefit adjusted for SOE wage ($adj$)13, and the sectoral physical capital ratio ($K^P/K^S$).

---

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

11 This assumption is reasonable since before the late 1990’s state sector 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/total profit became about 1/8 in 2004, whereas still over one-third SOEs are loss makers. As Bai et al. (2000) pointed out that a large number of SOEs maintain their employment of surplus workers just as an obligation to the government and meanwhile receive subsidy for the employment. This was largely mitigated by the SOE reform but still lasts after that.

12 Since $TP$ and $TS$ are not normalized as in Table 1, I only use their relative values in the calibration.

13 In particular, $w^S$ is the average SOE wage taken from China statistical yearbook, times $adj$, adjustment for non-wage benefit , which is considered significant for SOE, especially before the late 1990’s reform.
target values are shown in Table 1 and the calibrated values are shown in Table 2.

The calibration shows several notable changes in parameter values from ss1 to ss2. First, the measure of college enrollment restrictiveness (exogenous disutility cost of education) $\eta_0$ is reduced from 1.220 to 0.316, 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 what literature documents for SOE productivity improvement following the reform. In addition, the multiplier of the skilled laid-off probability function $\varepsilon$ also changes from 1.8 to 0.01, suggesting a structural change in the labor market. This decrease in $\varepsilon$ seems not make much sense by making it easier for the growing skilled workers to keep the job, but can be justified in the following way: for one thing, it turns out that laid-off probabilities of the PE skilled with lowest ability $\hat{a}$ for the two regimes are comparable, which are 0.16 for ss1 and 0.64 for ss2 – that the latter is much larger than the former indeed fits the reality; for another, one may also attribute the structural change to that more job opportunities in private sector are available for the skilled in the later period\textsuperscript{14}.

### 4.2 Dynamics

This section shows the model dynamics of skilled labor stock and allocation, and TFP of skilled production, and compare the relevant results of model dynamics to those from data or calibration.

Figure 5 (a) shows the model dynamics of skilled labor and allocation ($H, H^P, H^S$) during my sample period. I compute the dynamics of skilled labor in the following way. First, I extend my sample size forward to the year when the economy

\textsuperscript{14} Although not explicitly illustrated here, that changes in $A^S$, $A^P$, and $\varepsilon$ could also be considered as by-products of the economic reform. The reform could improve $A^S$ by closing the less-productive SOEs and by improving profit incentives of the remaining ones; as the economy becomes more market-oriented, restrictions imposed on private firms were loosened and economic opportunities for them became more, as a result, $A^P$ could be improved and the job opportunities in the private sector significantly increase which lowers $\varepsilon$. 

20
reaches a real steady state predicted by the model, that is, the year 2042\(^\ddagger\). 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 \( H \) for 1990-1997 and 1998-2008 respectively\(^\ddagger\). 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 according to the model setting, and obtain \( H \) for each year\(^\ddagger\). 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 can be computed from the model.

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

Figure 5(c) and (d) show dynamics of \( A^P \) and \( A^S \) and their ratio. As can be seen, \( A^P \) grows at a stable speed through the years, while \( A^S \) has a significant improvement

\(\ddagger\)Note that when I do the calibration, the post-regime period is assumed to be a steady state but not a real one.

\(\ddagger\)For the matching of slope, I choose 1997 as the cutoff year in data because a structural change of \( H \) appears to occur in 1998 in data. But the separation year for the model dynamics is still 1998.

\(\ddagger\)I compute \( H \) dynamics by making combinations of decision rules at extremes instead of computing decision rules for each cohort, which is mainly due to lack of data, i.e., in order to compute decision rule for each cohort, I have to use data over 40 years before 1990, which is unavailable for China.

One deviation from the model when computing the \( H \) dynamics is that for the young generation, I assume the decision-making period is the last five years of this period, say, at the age of 16-20, rather than the whole period; this is also consistent with my calibration when I assume 1/4 of the young generation is “active” in the economy.
around 1998, the economic reform year; this is also reflected in the A ratio, which drops dramatically around 1998.

Table 3 compares the mean values of variables computed from model dynamics with those from data or calibration, which turn out to be close, showing good fit.

4.3 Comparative statics

I do comparative statics for each of the two steady states to examine the effects of changes in certain parameter values on values of the endogenous variables, such as 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 \(HC^i\) is defined as \((\bar{\pi}^i/a_m)H^i, i \in \{P, S\}\), and \(HC \equiv HC^P + HC^S\), average labor productivity \((APL)\), which is of combing unskilled and skilled production), skilled production output share of \(PE\) \((Y_{hp\_share})\). The parameters under analysis are: \(\eta_0, \tau_K, \tau_w, A^S, A^P, \phi_L, \theta, \text{and } \nu (w_L)\). Figure A1 and A2 in the Appendix shows the effect of percentage changes in \(\eta_0\) and \(\tau_K\) on variables listed above (to save space, the results of other parameter effect are not shown, and only results of the first steady state are shown, but that of the second steady state is qualitatively similar).

Figure A1 shows that a decrease in \(\eta_0\) (measure of college enrollment expansion) does increase society’s skilled labor and human capital by a large amount, but most of them end up in \(SOE\) rather than \(PE\); the \(PE\) share of skilled labor and human capital increases when \(\eta_0\) is large, but decreases when \(\eta_0\) gets smaller. This inverse-U-shape feature also applies to \(APL\) and \(PE\) output share. The downward side of \(APL\) curve is mainly due to the two-side effect of a decrease in \(\eta_0\): on the one hand, it increases skilled labor supply and human capital stock, and thus improves average labor productivity; on the other hand, it reallocates relatively more skilled labor or human capital towards \(SOE\) and thus reduces aggregate productivity by reducing the average productivity of the skilled labor – the latter effect dominates the former.

Figure A2 shows that a reduction in distortion of capital \((\tau_K)\) largely reduces skilled employment as well as human capital of \(SOE\) and increases those of \(PE\), but its effect on total skilled labor can either be negative (ss1) or hump-shaped (ss2, not
shown here). $APL$ increase as $\tau_K$ decreases, as more skilled go to the more productive private sector; and the $PE$ output share increases. The effect of reduction of $\tau_w$ is similar to that of $\tau_K$.

Though not shown here, an increase in $A^S$ increases skilled labor in $SOE$ as well as the overall skilled labor and reduces that in $PE$; it also reduces $APL$ as relatively more skilled workers go to the less-productive $SOE$. An increase in $AP$ has the opposite effect.

4.4 Counterfactual analysis

I do counterfactual analysis to examine the policy effects. In particular, 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 college enrollment expansion (changes in $\eta_0$), no state sector reform (changes in $\tau_K$, $\tau_w$) or no improvement of TFP ($A^S$ and $AP$).

Table 4 shows the results. It can be seen that college enrollment expansion (a decrease in $\eta_0$) did increase the society’s total human capital stock significantly, which would have been reduced by about 48 percent had there been expansion. However, it greatly reallocated 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 college policy. As a result, the average labor productivity would have been increased by 5 percent, as the average productivity of skilled labor would have increased by 213 percent.

In fact, it is the state sector reform that contributed to the private sector expansion of skilled employment, as it greatly reduced allocation distortions ($\tau_K$ and $\tau_w$). Had there been no $SOE$ reform, the average labor productivity would have been lowered by 47 percent, as almost all skilled labor would have been employed by $SOE$.

Increases in $AP$ and $A^S$ contribute to the increase in 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 as well.

4.5 Impacts of educational policy with different distortions

This section shows that the existence of allocation distortions does matter for the impact of college enrollment expansion policy on the economy. In particular, I assess the impact of the college enrollment expansion (changing $\eta_0$ from the pre-regime value to the post-regime value) on human capital stock and allocation, sectoral share of output, and average labor productivity, under the assumption of full distortion (pre-regime distortion level) and no distortion. This experiment is done under the pre-regime economy. Table 5 shows the results.

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 college policy would have disappeared. It would have increased the human capital stock by 9 percent and improved average labor productivity by 3 percent.

One may think that the impact of college policy on human capital stock and thus average labor productivity under the no-distortion economy is moderate. I argue that it may be reasonable given that the educational policy in this experiment is isolated from other government policies and technology progress that follow exogenously or endogenously with the human capital change. In the real world, the effect of an educational policy could be larger if it endogenously interacts with technological change and/or labor market adjustment.

4.6 Social optimal

This section analyzes social welfare optimization under certain constraints. In particular, a social planner is allowed to determine college enrollment policy ($\eta_0$) and subsidy to SOE for skilled employment ($\tau_W$) to maximize utility of the society. His choice is subject to labor market frictions (i.e., layoff probabilities), capital market
distortions (i.e., $\tau_K$), and a minimum $SOE$ skilled output share$^{18}$. The problem is

$$\max_{\{\tau_0, \tau_w\}} \quad U = u_L F(\bar{a}) + \int_{\tilde{a}}^{\bar{a}} u_{H,S}(a)dF(a) + \int_{\tilde{a}}^{\infty} u_{H,P}(a)dF(a)$$

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

Table 6 shows the results of the social welfare optimization and compare them to ss2 values. 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 high-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 are close to those in ss2, but total human capital stock improves by 9 percent, and $APL$ increases as well$^{19}$.

5 Conclusion

In this paper, I have investigated the impact of higher education expansion on labor productivity in a transition economy where allocation distortions exist. In such an economy, an educational policy affects labor productivity not only through its effect on human capital stock, but also through its effect on human capital allocation across sectors. The policy is likely to intensify human capital misallocation, since it encourages more less-abled people to acquire college education, many of whom may prefer to work for the less-productive sector. The impact of the educational policy on aggregate productivity may be negative through the reallocation channel. Within the two-sector general equilibrium framework I construct, the educational policy can affect labor productivity by affecting both the threshold of household ability for choosing college education and the threshold ability for choosing the private sector. I calibrate the model to match China’s data on wage and employment, and conduct quantitative analysis to evaluate policy effects.

Quantitative results show that the higher education expansion in the late 1990’s

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$^{18}$Layoff probabilities $\Phi(a)$ and $\phi_L$, and $\tau_K$ are set to be the same as in the second steady state; the minimum $SOE$ skilled output share is set to be the $SOE$ skilled output share in the second steady state.

$^{19}$This is also the allocation where $APL$ reaches maximum under the same constraints.
in China, though it did improve China’s human capital stock significantly, allocated relatively more human capital towards the state sector rather than the private sector. Overall, the educational policy alone has a slightly negative impact on China’s average labor productivity. It is the economic reform of the state sector that greatly reduced allocation distortions and enhanced the positive role of higher education expansion in productivity growth. These results suggest that the role of an educational policy in shifting resource allocation should be underscored, and that a complementary economic policy that improves allocation efficiency can be crucial in productivity growth.
Tables and Figures

Table 1. Target values of calibration

<table>
<thead>
<tr>
<th>target</th>
<th>ss1</th>
<th>ss2</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>0.103</td>
<td>0.320</td>
</tr>
<tr>
<td>L</td>
<td>2.072</td>
<td>1.798</td>
</tr>
<tr>
<td>TS</td>
<td>36.621</td>
<td>11.256</td>
</tr>
<tr>
<td>TP</td>
<td>5.756</td>
<td>25.792</td>
</tr>
<tr>
<td>unemp</td>
<td>0.027</td>
<td>0.041</td>
</tr>
<tr>
<td>umpH</td>
<td>0.024</td>
<td>0.036</td>
</tr>
<tr>
<td>hpfr</td>
<td>0.150</td>
<td>0.500</td>
</tr>
<tr>
<td>wp</td>
<td>1.279</td>
<td>2.983</td>
</tr>
<tr>
<td>wL</td>
<td>6.764</td>
<td>6.928</td>
</tr>
<tr>
<td>adj</td>
<td>1.300</td>
<td>1.000</td>
</tr>
<tr>
<td>Kp/Ks</td>
<td>0.24</td>
<td>1.46</td>
</tr>
</tbody>
</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. TS (TP) is the total SOE (PE) employment. unemp is the unemployment rate, and umpH is the unemployment rate of the skilled workers computed using the unemployment rate, skilled share of unemployment, and skilled share of employment. hpfr is the fraction of new college graduates that are employed by PE. wp (wL) is the average wage PE (SOE), and wL is unskilled wage (normalized to be one in ss1). adj is the non-wage benefit adjusted for SOE wage.
Table 2. Calibration results

<table>
<thead>
<tr>
<th>parameter</th>
<th>ss1</th>
<th>ss2</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>1.03$^{20}$</td>
<td>1.03$^{20}$</td>
<td>real interest rate</td>
</tr>
<tr>
<td>$\delta$</td>
<td>1.04$^{20}$</td>
<td>1.04$^{20}$</td>
<td>depreciation rate</td>
</tr>
<tr>
<td>$\tau_a$</td>
<td>2.500</td>
<td>2.500</td>
<td>tail of Pareto distr.</td>
</tr>
<tr>
<td>$a_m$</td>
<td>0.201</td>
<td>0.201</td>
<td>location of Pareto distr.</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.166</td>
<td>0.332</td>
<td>college expense</td>
</tr>
<tr>
<td>$\nu$</td>
<td>1.000</td>
<td>2.286</td>
<td>low-skilled productivity</td>
</tr>
<tr>
<td>$\lambda^P$</td>
<td>3.514</td>
<td>4.447</td>
<td>high-skilled TFP of PE</td>
</tr>
<tr>
<td>$\lambda^S$</td>
<td>2.190</td>
<td>4.008</td>
<td>high-skilled TFP of SOE</td>
</tr>
<tr>
<td>$\phi_L$</td>
<td>0.062</td>
<td>0.095</td>
<td>low-skilled laid-off prob at 3rd pd. of life</td>
</tr>
<tr>
<td>$\alpha^P$</td>
<td>0.819</td>
<td>0.819</td>
<td>capital share of PE H-production</td>
</tr>
<tr>
<td>$\alpha^S$</td>
<td>0.842</td>
<td>0.842</td>
<td>capital share of SOE H-production</td>
</tr>
<tr>
<td>$\xi$</td>
<td>1.792</td>
<td>0.008</td>
<td>multiplier in the Hp laid-off prob. at 3rd pd.</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>7.271</td>
<td>7.271</td>
<td>power in the Hp laid-off prob. at 3rd pd.</td>
</tr>
<tr>
<td>$\tau_K$</td>
<td>0.426</td>
<td>0.084</td>
<td>distortion on capital</td>
</tr>
<tr>
<td>$\tau_W$</td>
<td>0.680</td>
<td>0.360</td>
<td>distortion on wage</td>
</tr>
<tr>
<td>$\eta_0$</td>
<td>1.220</td>
<td>0.316</td>
<td>relative exogenous disutility of edu ($\equiv \eta/\overline{w}_H$)</td>
</tr>
</tbody>
</table>

Notes: This table reports the calibration results. It shows the calibrated values of parameters and variables for the pre-regime (ss1) and post-regime (ss2) economies.
Table 3. Model dynamics vs. data/calibration

<table>
<thead>
<tr>
<th>growth rate of $H$ (%)</th>
<th>period</th>
<th>model dynamics</th>
<th>data/calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w_H$ ratio ((w_H^F/w_H^S))</td>
<td>1990-1998</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>$A$ ratio ((A^P/A^S))</td>
<td>1990-1998</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>1990-1998</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>1990-1998</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 calibration are reported.

Table 4. Counterfactual analysis

<table>
<thead>
<tr>
<th>value</th>
<th>ss1</th>
<th>ss2</th>
<th>total % change</th>
<th>no $\eta_0$ change</th>
<th>no $\tau_K$, $\tau_W$ change</th>
<th>no $A^P$ change</th>
<th>no $A^S$ change</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H^P/H$</td>
<td>0.129</td>
<td>0.481</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>0.569</td>
<td>1.094</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>0.317</td>
<td>0.647</td>
<td>103.9%</td>
<td>28.7%</td>
<td>-98.5%</td>
<td>-86.0%</td>
<td>54.5%</td>
</tr>
<tr>
<td>$Y^F_H/Y_H$</td>
<td>0.244</td>
<td>0.624</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>0.756</td>
<td>0.376</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>15.690</td>
<td>38.688</td>
<td>146.6%</td>
<td>231.1%</td>
<td>-57.4%</td>
<td>-30.2%</td>
<td>123.7%</td>
</tr>
<tr>
<td>$APL$</td>
<td>1.714</td>
<td>7.763</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. 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 ($Y^F_H/Y_H$) and the state sector ($Y^S_H/Y_H$), 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 from 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 5. Impacts of college enrollment expansion under different distortions

<table>
<thead>
<tr>
<th>value</th>
<th>full distortion</th>
<th>no distortion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n_0$-pre</td>
<td>$n_0$-post</td>
</tr>
<tr>
<td>$H^p/H$</td>
<td>0.129</td>
<td>0.091</td>
</tr>
<tr>
<td>$HC$</td>
<td>0.569</td>
<td>0.896</td>
</tr>
<tr>
<td>$HC^p/HC$</td>
<td>0.317</td>
<td>0.238</td>
</tr>
<tr>
<td>$Y^p_H/Y_H$</td>
<td>0.244</td>
<td>0.239</td>
</tr>
<tr>
<td>$Y^S_H/Y_H$</td>
<td>0.756</td>
<td>0.761</td>
</tr>
<tr>
<td>$APL/H$</td>
<td>15.690</td>
<td>7.165</td>
</tr>
<tr>
<td>$APL$</td>
<td>1.714</td>
<td>1.644</td>
</tr>
</tbody>
</table>

Notes: This table reports the results of the impact of college enrollment expansion with different distortions. The variables reported are the same as Table 4. Values reported are computed from the model with pre-regime $n_0$ and post-regime $n_0$ (and the percentage change of the 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).

Table 6. 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>$HC^p/HC$</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>$Y^p_H/Y_H$</td>
<td>0.64</td>
<td>0.65</td>
</tr>
<tr>
<td>$Y^S_H/Y_H$</td>
<td>0.62</td>
<td>0.62</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 the same as in Table 4.
(a) College entry number (in million)

(b) Relative urban employment with college degree

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)). Data source: http://edu.people.com.cn/n/2013/0503/c116076-21359059.html
(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 ($u_{PH}$) and an SOE skilled worker ($u_{SH}$). 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 $\hat{a}$ choose to be 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 “reallocation effect”, that is, by admitting more less-abled people 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) shows the TFP ratio from model dynamics.
References


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


Yeung, Wei-Jun, 2013. China’s higher education expansion and social stratification.
Appendix – Comparative statics

Figure A1. Comparative statics of $\eta_0$

Notes: This set of figures shows the results of comparative statics of percentage decreases in $\eta_0$. 
Figure A2. Comparative statics of $\tau_K$

Notes: This set of figures shows the results of comparative statics of percentage decreases in $\tau_K$. 

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