Higher education expansion, economic reform and labor productivity

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First Version: May, 2014
This version: October, 2016

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 and state-owned enterprises, 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. This also directed physical capital allocation toward the state sector and further dampened average labor productivity. It was the economic reform that greatly improved the allocation efficiency and complemented educational policy in enhancing labor productivity (by nearly 50 percent).

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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 college enrollment and, subsequently, skilled labor share, have increased by more than five times since its higher education expansion policy took effect in the late 1990's (see Figure 1). A one-sector growth model would predict a significant increase of average labor productivity following the policy since skilled labor complements more productive technology. This prediction, however, may not hold for a two-sector economy, where the increased human capital is not necessarily employed by the more productive sector due to allocation distortions. In China, such distortions have been momentous, especially when it comes to the state sector versus the private sector. The subsidized state sector, though lower in productivity, may yet attract some skilled workers by providing better job security. This would drain human capital of the private sector and may thus dampen the economy-wide average labor productivity. The situation would be worsened should physical capital then be directed to the state sector due to the complementarity of the two types of capital.

A reduction of allocation distortions would thus be crucial for the educational policy to take a positive part, and China's economic reform of the state sector may have played such a role. By cutting off subsidies to most state-owned enterprises (SOEs), privatizing the least productive ones, and laying off millions of excessive workers, the state sector reform in the late 1990's redirected substantial resources from the state sector to the private. The concurrence of the two policies, nonetheless, adds difficulties to an empirical assessment of the educational policy, since human capital stock and allocation under the no-economic-reform regime is unobservable in

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data. Thus, in this paper, I turn to a structual model to characterize key features of the economy and to quantify the role of each policy.

Motivated by the thoughts above, I construct a two-sector general equilibrium model in which human capital stock and allocation is an endogenous outcome of households' choice, conditional on exogenous policies and institutions. The key ingredients of the model are as follows. (i) Firms of two sectors – a state sector and a private sector (SOEs and PEs, correspondingly), produce with unskilled labor, skilled labor, and physical capital. SOEs have lower TFP than PEs, but are subsidized in renting capital and hiring skilled workers. (ii) Households (or, individuals, interchangeably), heterogeneous in ability, live for three periods. They make an educational choice of whether to acquire college education in the first period, and then an occupational choice of whether to work for a PE or an 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, as higher ability not only lowers the disutility of education, but also lowers the chance of being fired for a skilled worker in PE, while a skilled worker in SOE would never be fired. (iv) Finally, the higher education policy enters the model via an exogenous component of the disutility cost of college education, i.e., higher education expansion lowers the disutility.

The model characterizes two main tradeoffs regarding the educational and the occupational choices. For the former, college education increases one's labor income later in life, but incurs a disutility cost. For the latter, PEs pay higher wages to skilled workers than SOEs, but impose the risk of losing a job. In equilibrium, households are sorted into three categories by ability: those with high ability acquire college education and then become skilled workers of PEs, those with low ability do not go to college and become unskilled workers, and those in the middle enter college and then become skilled workers of SOEs.

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 skill 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 SOEs to PEs, since they would have a higher chance to be fired if choosing the lat-

ter. This would reallocate relatively more skilled workers to SOEs and hence *lower* average labor productivity. Furthermore, the misallocation of human capital would magnify misallocation of physical capital since the two types of capital are complements in skilled production. 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 from the year 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, 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 decreased by nearly 50 percent. Second, a decomposition of the educational policy effect shows that a reduction of physical capital available for production and a 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 SOEs turns out to be the major factor that crowds out physical capital for production.

Background and Stylized Facts

China's nationwide college enrollment expansion, taking effect in 1999, was a means of its 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, an increase of 48 percent 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[1]. 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

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[1]1977 is the first year China resumed its college admission since the cultural revolution

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before 1999, but nearly 60 percent after 1999[2].

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 or privatized the least productive ones, and laid off millions of excessive workers ("Xiagang") [3].

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[4], 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 (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, we do not know 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.

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 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-

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[2]See Wan (2006) and Chen (2004) for more information of the policy background.

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

[4]2002 is the year when the first generation of college students since college enrollment expansion entered the labor market.

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 has also been 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, most studies focus on the effect of human capital stock, while ignore human capital allocation. The latter could account for a significant proportion of TFP differences, since allocation distortions widely exist in 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. In particular, there is literature focusing on misallocation in China. For example, Dollar and Wei (2007), Dobson and Kashyap (2006), Allen, Qian and Qian (2005), and Boyrean-Debray and Wei (2005) document that China's state-dominated financial system still favors financing less-productive

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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[5]. However, this literature primarily focuses on allocations of physical capital and unskilled labor, while my paper emphasizes the allocation of human capital, or skilled labor. In particular, I study how an educational policy may affect labor productivity by affecting 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 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 aggregate labor productivity and economic development.

In summary, the main contribution of this paper is that it links human capital literature and misallocation literature related to economic growth and development. It adds to the former by proposing an allocation effect of an educational policy and to the latter by emphasizing the role of human capital misallocation in aggregate productivity. A calibrated general-equilibrium model is applied to investigate the effect of the concurrent two policies regarding higher education expansion and economic reform, and underlying channels of policy effects are explored. My results indicate the importance of human capital misallocation as a consequence of an educational policy, since it not only induces relatively more human capital to match with less-productive technology, but also directs physical capital toward the less-productive sector. These also increase the demand for subsidies and crowd out capital for production use.

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

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[5]In an earlier article, Brandt, Hsieh and Zhu (2008) show that reductions in barriers to labor reallocation, including from agricultural to nonagricultural sector, and from state to non-state sector, were important for China's structural transformation and growth.

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 physical 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 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 not only reduces the disutility cost of college education, but also reduces the probability of being laid off in the private sector.

2.1   Production and distortions

There are two types of firms – 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:

$$PE: \quad Y^P(K^P, H^P, L^P) = vL^P + A^P(K^P)^{\alpha^P}(\Psi(\overline{a}^P)H^P)^{1-\alpha^P} \tag{1}$$

$$SOE: \quad Y^S(K^S, H^S, L^S) = vL^S + A^S(K^S)^{\alpha^S}(\Psi(\overline{a}^S)H^S)^{1-\alpha^S} \tag{2}$$

where L^i (H^i) is the amount of unskilled (skilled) labor employed by type i firms, and K^i is physical 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 $\Psi(\overline{a}^i)$ is a function of average ability of skilled workers in type i firms and $\Psi'(\overline{a}^i) > 0$. 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

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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[6]. 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 α^P and α^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_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 τ_K and τ_w measure the degree of policy distortions on physical and human capital allocations respectively ($\tau_K \geqslant 0$, $\tau_w \geqslant 0$). 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 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. 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,

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[6]These production functions allow me to focus on human capital (or skilled labor) by greatly simplifying the unskilled producton to be identical across types of firms.

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:

$$u_t(a) = c_t^{t+2}(a) - \Omega \frac{\eta}{a}, \tag{3}$$

where c_t^{t+2} is her consumption at the third period of life, which is a function of her ability[7]. Ω 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. η 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 η 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 θ 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 doe not, 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 workers and make an occupational choice between working for PE or SOE, and would receive skilled wages w_H^P or w_H^S accordingly. They also need to repay their loan of education fee at a market interest rate, i.e., $(1+R)\theta$. Those who did not go to college continue working as unskilled workers. I assume that all middle-aged households are imposed a lump-sum tax τ 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

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[7] The linear form of utility function greatly simplifies my analysis of household choices.

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 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 higher-educated employment pool instead of making profits. In contrary, private firms rely more on workers' ability and are more likely to fire the excessive ones even if they have high educational achievement. Moreover, private firms themselves are less-secured as they receive less protection from the government and are hence more likely to be shut down. In this situation, their former employees would find themselves hard to find a new job if their ability is not high enough.

An unskilled worker will be laid off with a probability ϕ_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 δ is depreciation rate of capital). Her consumption when old under different choices is the following

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

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

$$c_{t,H,P}^{t+2}(a) = [w_{H,t+1}^P - (1 + R_{t+1})\theta - \tau_{t+1}](1 + r_{t+2}) + [1 - \Phi(a)]w_{H,t+2}^P \qquad (4)$$

3 Optimization and Equilibrium

3.1 The Household

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

Occupational choice

At the second period of life (date $t + 1$), a skilled individual (born at t) faces the occupational choice $o \in \{P, S\}$. She chooses to work for PE if and only if $c_{t,H,P}^{t+2} \geqslant c_{t,H,S}^{t+2}$ 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 $(w_{H,t+1}^P - w_{H,t+1}^S)(1 + r_{t+2}) + w_{H,t+2}^P - w_{H,t+2}^S \geqslant \Phi(a)w_{H,t+2}^P$, 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., τ_K, τ_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:

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

In the steady state where prices are constant, the above equation can be simplified as

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

Intuitively, there is a trade-off between wage and layoff for the occupational choice. Since PE has higher productivity, it can 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 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 $max\{E[c_{t,H,P}^{t+2}(a)], E[c_{t,H,S}^{t+2}]\} - \frac{\eta}{a} \geqslant E[c_{t,L}^{t+2}]$. From the utility function, we can see that at this stage a household 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 η 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

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

In the steady state the above equation can be rearranged to

$$\tilde{a} = \eta / \left\{w_H^{S}(2+r) - (1+R)\theta^2 - w_L\left[(2+r)(1+r)+1-\phi_L\right]\right\} \quad (8)$$

Intuitively, equation (8) says that the higher the exogenous disutility cost of college education (i.e., higher η), 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 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 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:
$$PE: \quad R = \alpha^P A^P \Psi (\overline{a}^P)^{1-\alpha^P}(k^P)^{\alpha^P-1} \quad (9)$$

$$SOE: \quad (1 - \tau_K)R = \alpha^S A^S \Psi(\overline{a}^S)^{1-\alpha^S}(k^S)^{\alpha^S - 1} \tag{10}$$

Skilled labor:

$$PE: \quad w_H^P = (1 - \alpha^P)A^P \Psi(\overline{a}^P)^{1-\alpha^P}(k^P)^{\alpha^P} \tag{11}$$

$$SOE: \quad (1 - \tau_w)w_H^S = (1 - \alpha^S)A^S \Psi(\overline{a}^S)^{1-\alpha^S}(k^S)^{\alpha^S} \tag{12}$$

where $k^i \equiv \frac{K^i}{H^i}, i \in \{P, S\}$ is the capital per skilled capita of each firm. unskilled wages are the same for PE and SOE:

$$w_L = \nu \tag{13}$$

3.3 Market clearing conditions

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

The unskilled labor market clearing condition at time t is

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

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

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

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

The loanable funds market clearing condition at t is

$$K_t^P + K_t^S + \theta_t(h_t^P + h_t^S) = (l_t^P + l_t^S)w_{L,t} + (l_{t-1}^P + l_{t-1}^S)\left[(1 + r_t)w_{L,t-1} + w_{L,t}\right]$$
$$+ h_{t-1}^P w_{H,t}^P + h_{t-1}^S w_{H,t}^S - (h_{t-1}^P + h_{t-1}^S)(1 + R_t)\theta_{t-1} - \tau_t \tag{17}$$

where l_t^i and h_t^i are the amount of unskilled and skilled workers of the generation

born at time t working for sector i ($i \in \{P, S\}$). From equation (17), we can see that the loanable funds demand side consists of two parts: capital demand from firms and educational loan demand from young college students. The loanable funds supply side consists of: a) wages earned by young unskilled workers, b) wages plus interest earned by 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

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

$$\overline{a}_t^S = \left[\int_{\tilde{a}_{t-1}}^{\hat{a}_{t-1}} a dF(a) + \int_{\tilde{a}_{t-2}}^{\hat{a}_{t-2}} a dF(a) \right] / H_t^S \tag{19}$$

τ_t satisfies the government budget constraint:

$$\tau_t = \tau_{K,t} R_t K_t^S + \tau_{w,t} w_{H,t}^S H_t^S \tag{20}$$

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 $\{R, w_H^P, w_H^S, w_L\}_t$, 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 clear at each time t, that is, equation $(15) - (17)$ are satisfied at each t.

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

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

The growth effect. As η 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 labor when graduating, 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-abled 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 intensifies misallocation. 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 average labor productivity since it enlarges misallocation of both human and physical capital.

4　Quantitative analysis

I calibrate two sets of parameters regarding pre- and post-regime using China's data for 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 before- and after-policy-change regimes, using the average value of 1990-1998 data for the first set, and the average of 2002-2008 for the second. I assume that these two sets of values correspond to the old and new steady states (steady state 1 and 2) of the economy respectively[8]. 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 much more missing and after 2008 could be affected by the global financial crisis[9].

I use employment and wage data of five industries from China labor statistical yearbook: manufacturing, real estate, finance, information technology, and science and technological service. 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 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. In the calibration, I normalize the pre-regime unskilled wage to be one, and then transform other wages to wage ratios.

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 be 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.

Households' ability follows Pareto distribution $F(a) = 1 - (a/a_m)^{-t_a}$, where the location parameter a_m (lower bound of ability) and shape parameter t_a are to be calibrated. I assume that the PE skilled laid-off probability in the third period of

[8]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.

[9]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.

life is $\Phi(a) = \varepsilon a^{-\gamma}$, where $\varepsilon > 0$ and $\gamma > 0$ are to be calibrated, and the ability function in production is $\Psi(\overline{a}^i) = \frac{\overline{a}^i}{a_m}$.

Sixteen parameters or variables need to be determined for each steady state: r, δ, t_a, a_m, θ, ν, A^P, A^S, ϕ_L, α^P, α^S, ε, γ, τ_K, τ_w, η_0. [10] Seven of them are assumed to be identical across the two steady states: r, δ, t_a, a_m, α^P, α^S, γ, 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. Education fee θ 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 over ss1 unskilled wage. τ_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, α^P, α^S, γ, ε, ϕ_L, A^P, A^S, τ_K, η_0, of which the first four have 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-owned firms), total unemployment rate ($unemp$) and unemployment rate of the skilled ($umpH$) (computed 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)[12], and the sectoral physical capital ratio (K^P/K^S). The target values are shown in Table 1 and calibration results in Table 2.

Table 2 shows several notable changes in parameter values from ss1 to ss2. First, the measure of college enrollment restrictiveness (exogenous disutility cost of education) η_0 is reduced from 1.220 to 0.316, by about three quarters, suggesting a large

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

[11]Bai et al. (2000) pointed 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 assumption about skill wage subsidy is 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.

[12]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.

expansion of college enrollment. Second, distortions are largely reduced: in addition to τ_w, τ_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 SOE productivity improvement following the reform. In addition, the multiplier of the skilled laid-off probability function ε also changes from 1.8 to 0.01, suggesting a structural change in the labor market. The decrease in ε 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 in the following way. For one thing, it turns out that laid-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 where 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.

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. I compute the dynamics of skilled labor in the following way. First, I extend my sample size forward to the year when the economy reaches a *true* steady state predicted by the model, that is, the year 2042[13]. 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

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[13]Remember that when I do calibration, the new steady state is not really reached due to lack of data.

decisions rules of the beginning and the ending point for each subperiod, and obtain a dynamic path of H during the whole period [14]. 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 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 in magnitude and the 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 rate through the years, while A^S had a significant jump around 1998, the economic reform year. The A ratio thus droped 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 compute comparative statics for each of the two steady states 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 is defined as $(\overline{a}^i/a_m)H^i, i \in \{P, S\}$, and $HC \equiv HC^P + HC^S$), average labor productivity(APL, which combines unskilled and skilled production), skilled production output share of PE (Yhp_share). The parameters under analysis are: η_0, τ_K, τ_w, A^S, A^P, ϕ_L, θ, and ν (or, w_L). Figure A1 and A2 in the Appendix shows the effect of percentage changes in η_0 and τ_K on variables listed above[15].

Figure A1 shows that a decrease in η_0 (a measure of college enrollment expansion)

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[14]I compute dynamics of H by making linear combinations of decision rules at the two ending points of a period instead of by computing decision rules for each cohort and each year. This is mainly due to the lack of data, i.e., in order to compute decision rules for each cohort, I have to use data over 40 years before 1990, which is unavailable for China. However, the current computation method should be sufficient to catch the main trend of dynamics.

Like 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.

[15] To save space, results of other parameter effects are not shown, and only results regarding the first steady state are shown, but that of the second steady state is qualitatively similar.

does increase society's skilled labor and human capital by a large amount. However, The PE share of skilled labor and human capital have a hump-shaped relationship with decreases in η_0. They increase when η_0 is large, but decrease when η_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 A2 shows that a reduction in distortion of physical capital allocation (τ_K) largely reduces skilled employment and human capital of SOE and meanwhile increases those of PE, but its effect on total skilled labor or human capital can either be negative (ss1) or hump-shaped (ss2, not shown here). APL increase as τ_K decreases, as more skilled workers and physical capital go to the more productive private sector. The PE output share increases as well. The effect of a reduction of τ_w is similar to that of τ_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 A^P has an opposite effect.

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_H^P/Y_H and Y_H^S/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 η_0), no state sector reform (changes in τ_K, τ_w) or no improvement of TFP (changes in A^S or A^P).

Table 4 shows the results. It can be seen that higher education expansion (a decrease in η_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 policy. As a result, the average labor productivity

would have 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 in skilled employment, as it significantly reduced allocation distortions (τ_K and τ_w). Had there been no SOE reform, the average labor productivity 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 factor contributes 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, $\bar{a}^P$, $\bar{a}^S$, 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 η_0, as in the first counterfactual experiment), and check how APL would change in each scenario. Table 5 shows the results. It can be seen that except for the increase of H which has a positive effect on APL in $ss2$, all other factors have a negative effect on APL, that is, APL in $ss2$ would have increased if these variable values were equal to no-η_0-change state values. 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 up 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 no-η_0-change case. Table 6 shows that while a drop of lonable funds supply from unskilled workers and an increase in tuition fees and loan repayment both contribute to the reduction of physical capital employed by firms, increases of subsidies to SOE is the major factor that squeezes out physical capital for production. This result suggests that as human capital misallocation becomes more severe following the higher education expansion, it leads to further misallocation of physical capital due to the complementarity of the two types of capital. Consequently, average labor productivity is further dampened as physical capital is reallocated not only from the private to the state sector, but

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also from production use to subsidies for SOEs.

4.5   Impacts of educational policy with different distortions

This section shows that the existence of allocation distortions does matter for the impact of higher education expansion on the economy. In particular, I examine the impact of the college enrollment expansion (changing η_0 from the pre-regime value to the post-regime value) on human capital stock and allocation, sectoral output share, and average labor productivity, under the assumption of full distortion (pre-regime distortion level) and zero distortion. This experiment is conducted based on the pre-regime economy. Table 7 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 educational policy would have disappeared. It would have increased human capital stock by 9 percent and average labor productivity by 3 percent.

One may think that the impact of college expansion on human capital stock and 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 technological progress. In the real world, the effect of an educational policy could be larger if it leads to directed technological change and labor market adjustment.

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 (η_0) and subsidy to SOE for skilled employment (τ_W) to maximize utility of the society. However, her choice is subject to labor market frictions (i.e., layoff probabilities) and capital market distortions (i.e., τ_K). In addition, a minimum SOE skilled output share is required for her decision for the concern that keeping a certain level of state sector production may be necessary, especially at certain development stages[16]. Thus her

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[16]Layoff probabilities $\Phi(a)$ and ϕ_L, and capital market distortions τ_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

problem is

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

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

Table 8 shows the results from 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 skilled workers should be further reduced at the same time. Under this optimal setting, the human capital share and skilled output share of the private sector would be close to those in ss2, but total human capital stock would improve by 9 percent, and APL would increase as well [17].

5   Conclusion

In this paper, I have investigated 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. Thus, its impact could be limited if misallocation becomes more severe following the policy. I have constructed a two-sector general equilibrium model in which policy distortions favor the less-productive state sector against the private sector. Households make educational choice and occupational choice depending on both their ability and economic policy. The higher education expansion not only affects the proportion of population acquiring college education, but also shifts the proportion of college graduates working for the state sector versus the private sector.

My quantitative results show that the higher education expansion in China overall had a slightly negative effect on its average labor productivity. Although it did increase China's skilled labor supply significantly, the policy had the effect of reallocating relatively more human capital toward the less-productive state sector. This also directed physical capital to be reallocated to the state sector. The intensified factor misallocation increased demand of subsidy from the state sector, crowding out

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output share in the second steady state.

[17]The results are the same when the social planner's objective is to maximize APL under the same constraints.

capital from proudction use and further dampening average labor productivity. Indeed, it was the economic reform of the state sector that greatly improved allocation efficiency and complemented educational policy in enhancing labor productivity.

This paper has some limitations. First, there is no directed technological progress in the model. Though increased skilled labor supply does directs more firms to employ better technology, the level of each type of technology is assumed to be independent from the society's educational 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 of them may end up with unskilled jobs as skilled labor market becomes tougher for them. This type of misallocation (or, mismatching) is not taken into account, which may cause an overestimate of the effect of college expansion. Finally, data is limited for computing a true new steady state following policy change, which may dampen the overall quality of my quantitative results to some extent. However, even if data of more than 40 years after the policy change is available which suffices the new steady state analysis, many other institutional changes may occur during those years, making it difficult to isolate effects of the policy of interest in this paper. Furthermore, even if other institutions are constant and higher education expansion follows the current pace, the impact of policy effects is more likely to be magnified rather than downplayed.

Tables and Figures

Table 1. Target values of calibration

target	ss1	ss2
H	0.10	0.32
L	2.07	1.80
TS	1.88	0.30
TP	0.64	1.47
$unemp$	0.027	0.041
$umpH$	0.024	0.036
$hpfr$	0.15	0.50
w^P	1.28	2.98
w^S	6.76	6.93
w_L	1.00	2.29
adj	1.30	1.00
K^P/K^S	0.24	1.46

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. w^P (w^S) is the average wage PE (SOE), and w_L is unskilled wage (normalized to be one in ss1). adj is the non-wage benefit adjusted for SOE wage.

Table 2. Calibration results

parameter	ss1	ss2	description
r	1.03^{20}-1	1.03^{20}-1	real interest rate
δ	1.04^{20}	1.04^{20}	depreciation rate
ta	2.500	2.500	tail of Pareto distr.
a_m	0.201	0.201	location of Pareto distr.
θ	0.166	0.332	college expense
ν	1.000	2.286	low-skilled productivity
A^P	3.514	4.447	high-skilled TFP of PE
A^S	2.190	4.008	high-skilled TFP of SOE
ϕ_L	0.062	0.095	low-skilled laid-off prob at 3rd pd. of life
α^P	0.819	0.819	capital share of PE H-production
α^S	0.842	0.842	capital share of SOE H-production
ε	1.792	0.008	multiplier in the Hp laid-off prob. at 3rd pd.
γ	7.271	7.271	power in the Hp laid-off prob. at 3rd pd.
τ_K	0.426	0.084	distortion on capital
τ_W	0.680	0.360	distortion on wage
η_0	1.220	0.316	relative exogenous disutility of edu ($\overset{\text{def}}{=} \eta/\bar{w}_H$)

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

	period	model dynamics	data /calibration
growth rate of H (%)	1990-2008	9.12	9.63
w_H ratio (w_H^P/w_H^S)	1990-1998	1.04	1.06
	2002-2008	1.45	1.29
A ratio (A^P/A^S)	1990-1998	1.62	1.60
	2002-2008	1.12	1.11
A^P	1990-1998	3.58	3.51
	2002-2008	4.43	4.45
A^S	1990-1998	2.22	2.19
	2002-2008	3.96	4.01

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: policy

variables	ss1	ss2	total % change	no η_0 change	no τ_K, τ_W change	no A^P change	no A^S change
H^P/H	0.129	0.481	273.0%	53.1%	-99.9%	-96.2%	107.8%
HC	0.569	1.094	92.4%	-47.7%	-7.6%	34.4%	-29.7%
HC^P/HC	0.317	0.647	103.9%	28.7%	-98.5%	-86.0%	54.5%
Y_H^P/Y_H	0.244	0.624	155.8%	27.9%	-99.8%	-96.0%	60.3%
Y_H^S/Y_H	0.756	0.376	-50.2%	-46.2%	165.4%	159.1%	-100.0%
APL_H	15.690	38.688	146.6%	213.1%	-57.4%	-30.2%	123.7%
APL	1.714	7.763	352.9%	5.1%	-47.1%	-19.3%	20.3%

Notes: This table reports the results of counterfactual analysis of policy effect. 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 from ss2 if there was no η_0 change, no τ_K and τ_W change, no A^p change or no A^S change.

Table 5. Counterfactual: decomposition of educational policy effect

variables	ss2 (E2)	no η_0 change (E1)	APL (E2) % change if using E1 value
H	0.32	0.11	-44.4%
H^P/H	0.48	0.74	10.8%
$\bar{a}^P, \bar{a}^S$	0.93, 0.47	1.23, 0.69	4.2%
K	3.52	4.19	11.6%
K^P/K	0.60	0.78	0.2%

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 the state where there is no η_0 change (E1). The last column shows the value of APL in E2 if a certain variable value (H, H^P/H, $\bar{a}^P$, $\bar{a}^S$, K, K^P/K, respectively) was set to equal its E1 value.

Table 6. Counterfactual: effect on the loanable funds market of educational policy

loanable funds market		ss2 (E2)	no η_0 change (E1)	E2-E1
supply	low-skilled wage and saving	3.24	3.45	-0.21
	skilled wage (middle-aged)	1.33	1.26	0.07
demand	K: capital for production	3.52	4.19	-0.67
	tuition and loan repayment	0.28	0.08	0.19
	subsidy to SOE	0.77	0.43	0.34

Notes: This table compares the loanable funds market supply- and demand- side components of the second steady state (E2) and the no-η_0-change state (E1).

Table 7. Impacts of college enrollment expansion under different distortions

value	full distortion			no distortion		
	η_0-pre	η_0-post	% change	η_0-pre	η_0-post	% change
H^P/H	0.129	0.091	-29.5	1.000	1.000	0.0
HC	0.569	0.896	57.6	0.231	0.252	9.2
HC^P/HC	0.317	0.238	-25.1	1.000	1.000	0.0
Y_H^P/Y_H	0.244	0.239	-2.1	1.000	1.000	0.0
Y_H^S/Y_H	0.756	0.761	3.1	0.000	0.000	0.0
APL_H	15.690	7.165	-54.3	190.661	171.546	-10.0
APL	1.714	1.644	-4.1	3.043	3.145	3.4

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 η_0 and post-regime η_0 (and the percentage change of the two values) with full distortion (i.e., τ_K and τ_W equal to ss1 values) and no distortion (τ_K and τ_W equal to 0).

Table 8. Social optimal

	optimal	ss2
U	8.50	7.78
η_0	0.00	0.32
τ_W	0.20	0.36
H^P/H	0.47	0.48
HC	1.19	1.09
HC^P/HC	0.64	0.65
Y_H^P/Y_H	0.62	0.62
Y_H^S/Y_H	0.38	0.38
APL_H	33.84	38.69
APL	7.85	7.76

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), η_0, τ_W and others the same as in Table 4.
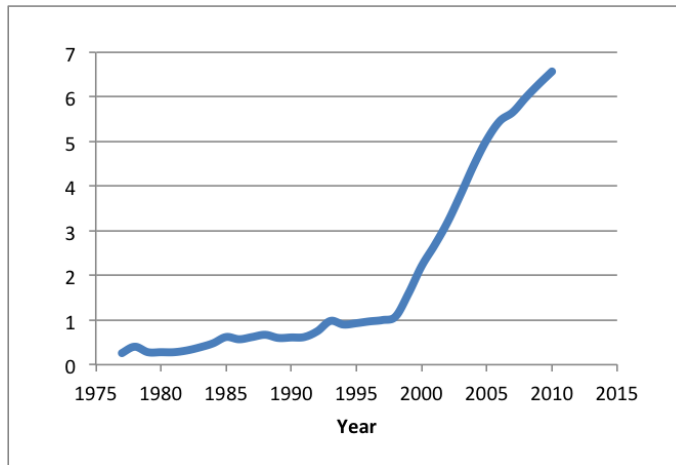
(a) College entry number (in million)
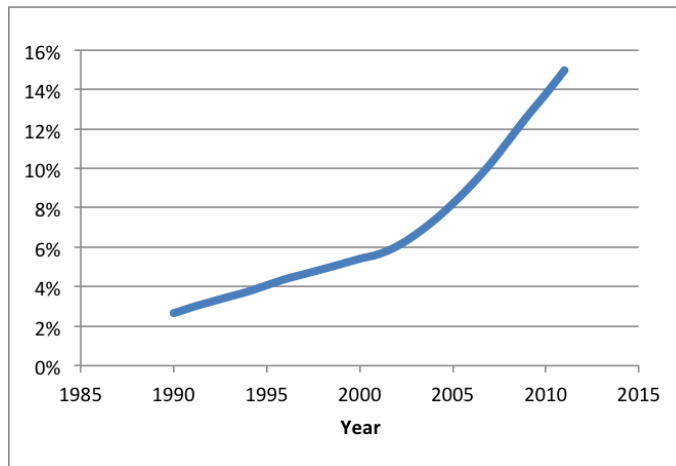
(b) Relative urban employment with college degree

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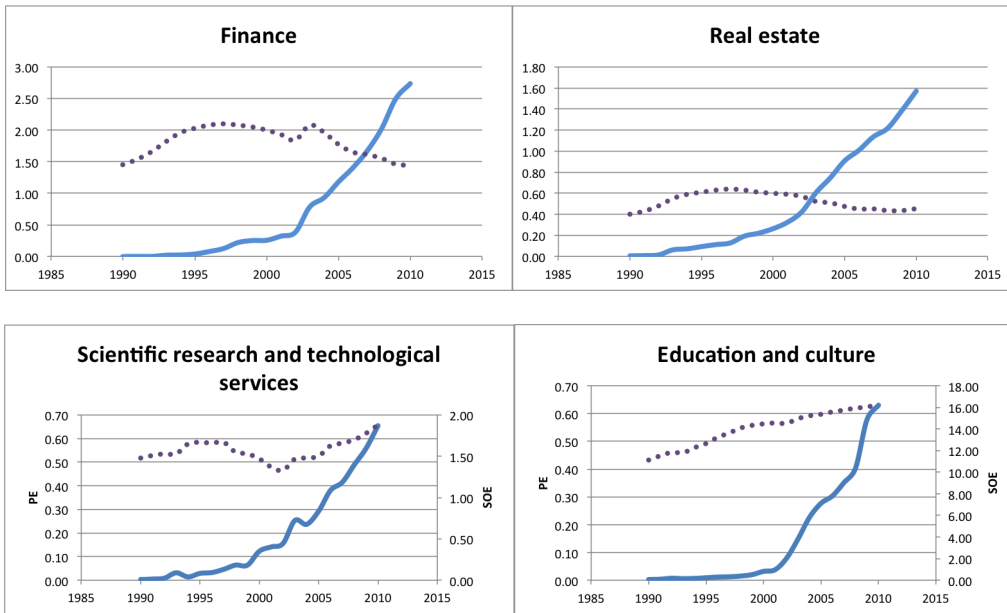
(a). Employment of skill-intensive industries (in million)
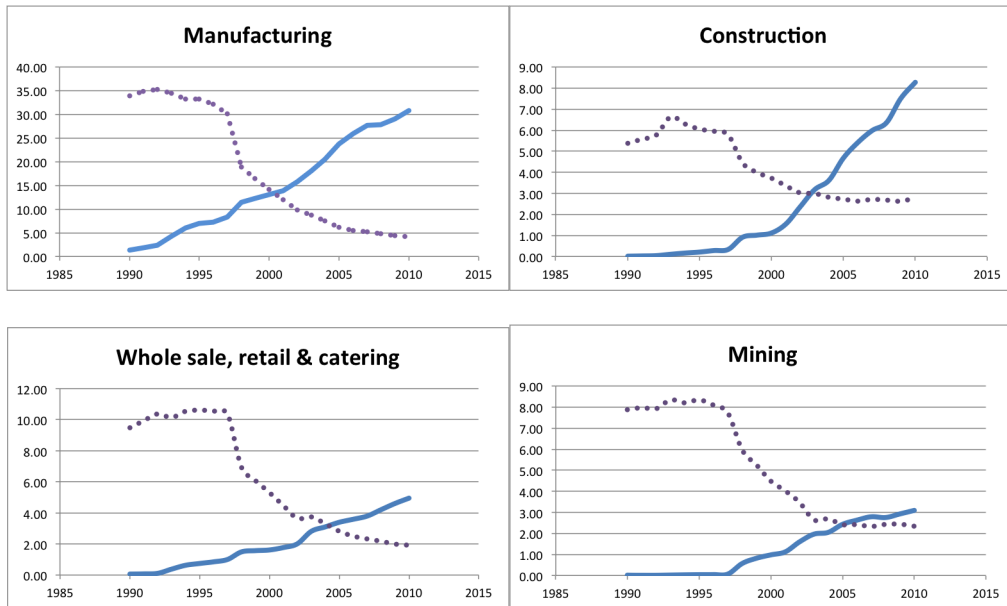
(b). Employment of labor-intensive industries (in million)

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.
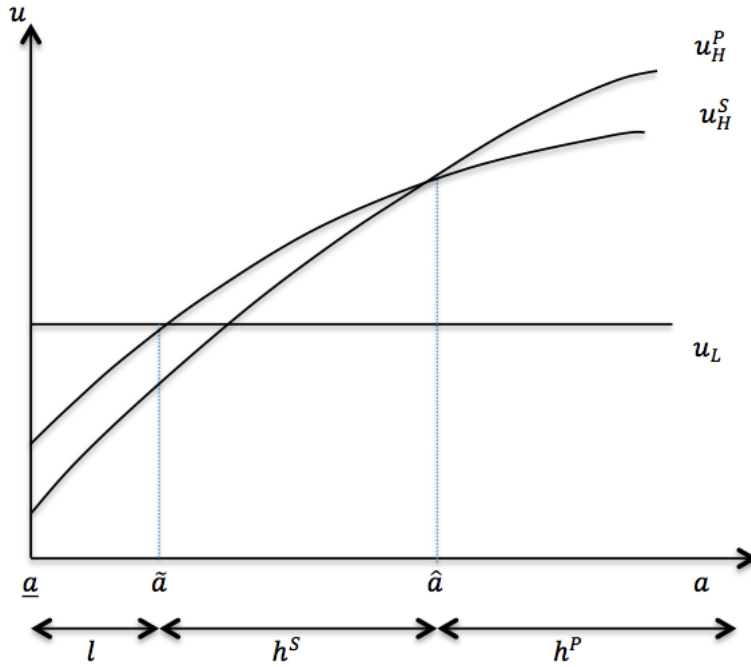
Figure 3. Lifetime choices by ability

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_H^P) and an SOE skilled worker (u_H^S). 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.

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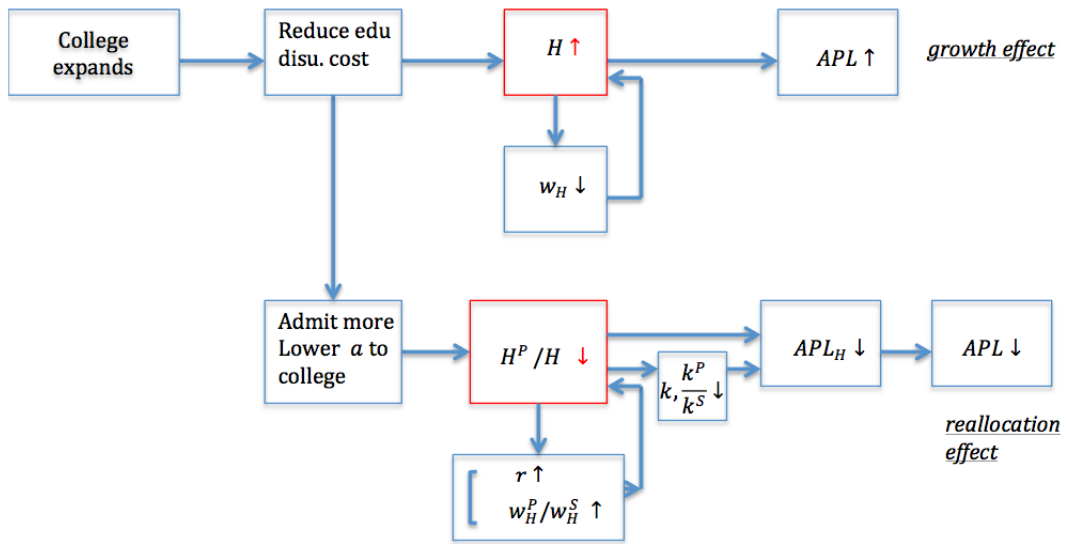
Figure 4. The effect of higher education expansion

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.

(a)

(b)

(c)

(d)
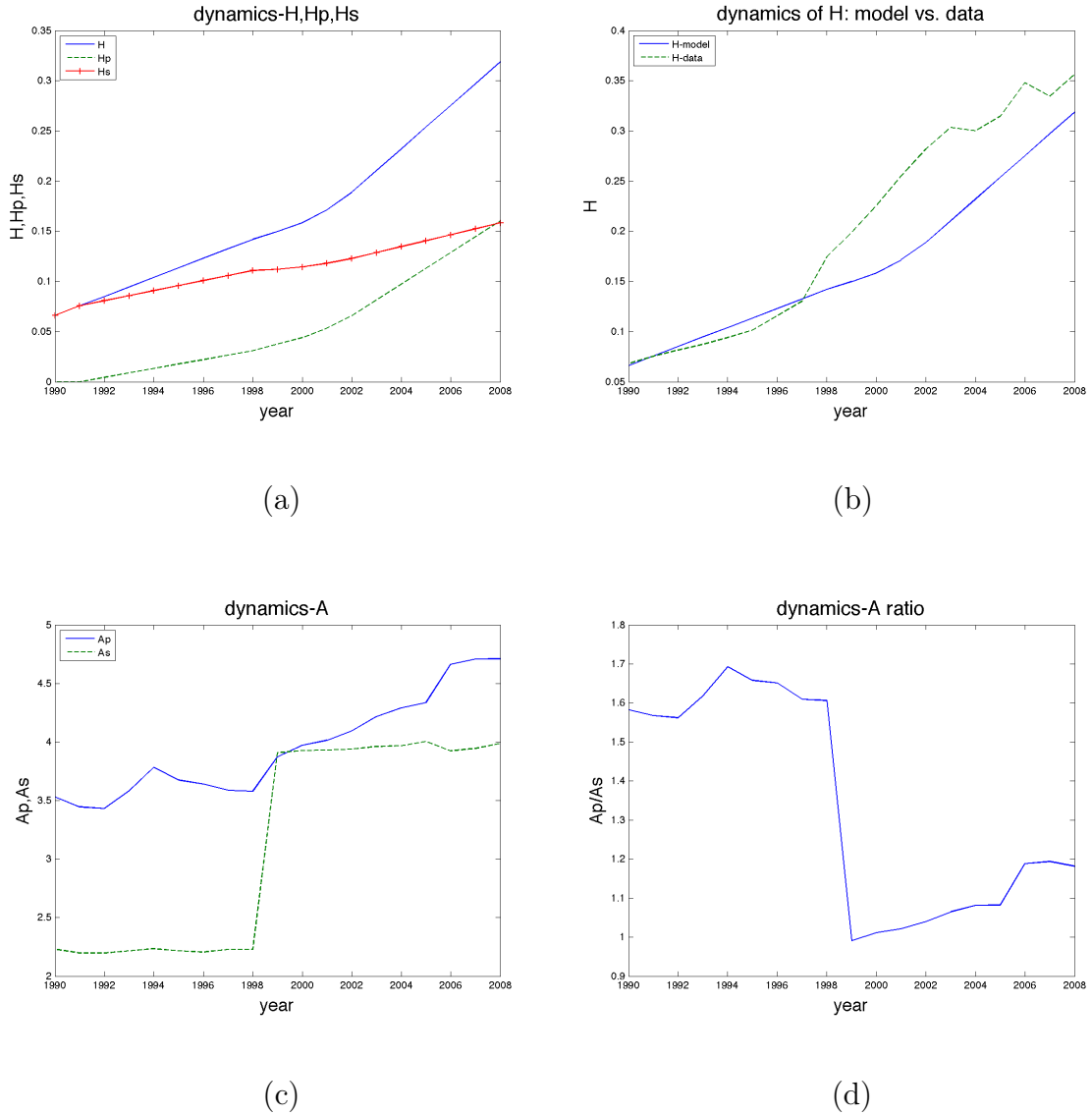
Figure 5. Model dynamics

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.

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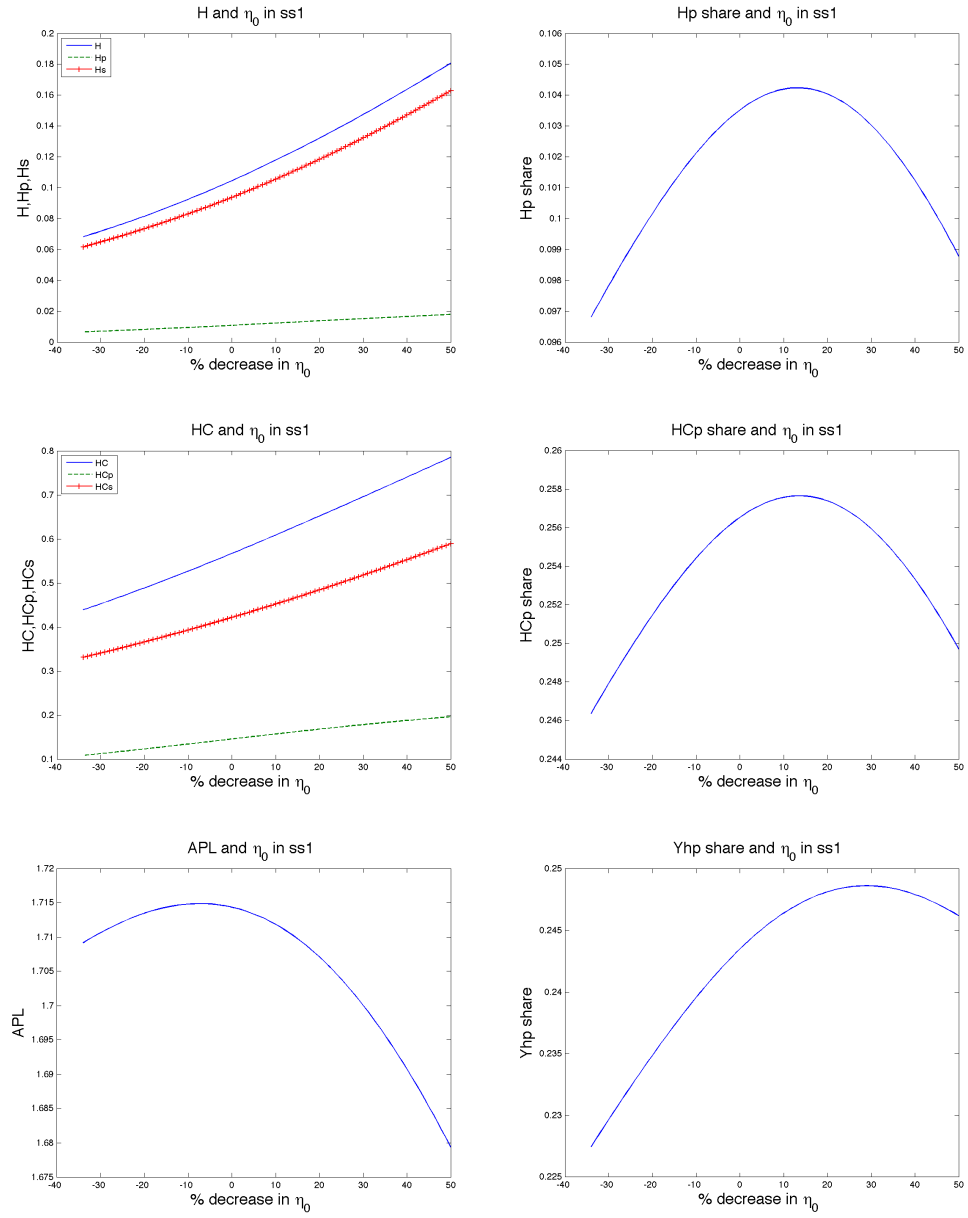
Appendix – Comparative statics

Figure A1. Comparative statics of η_0

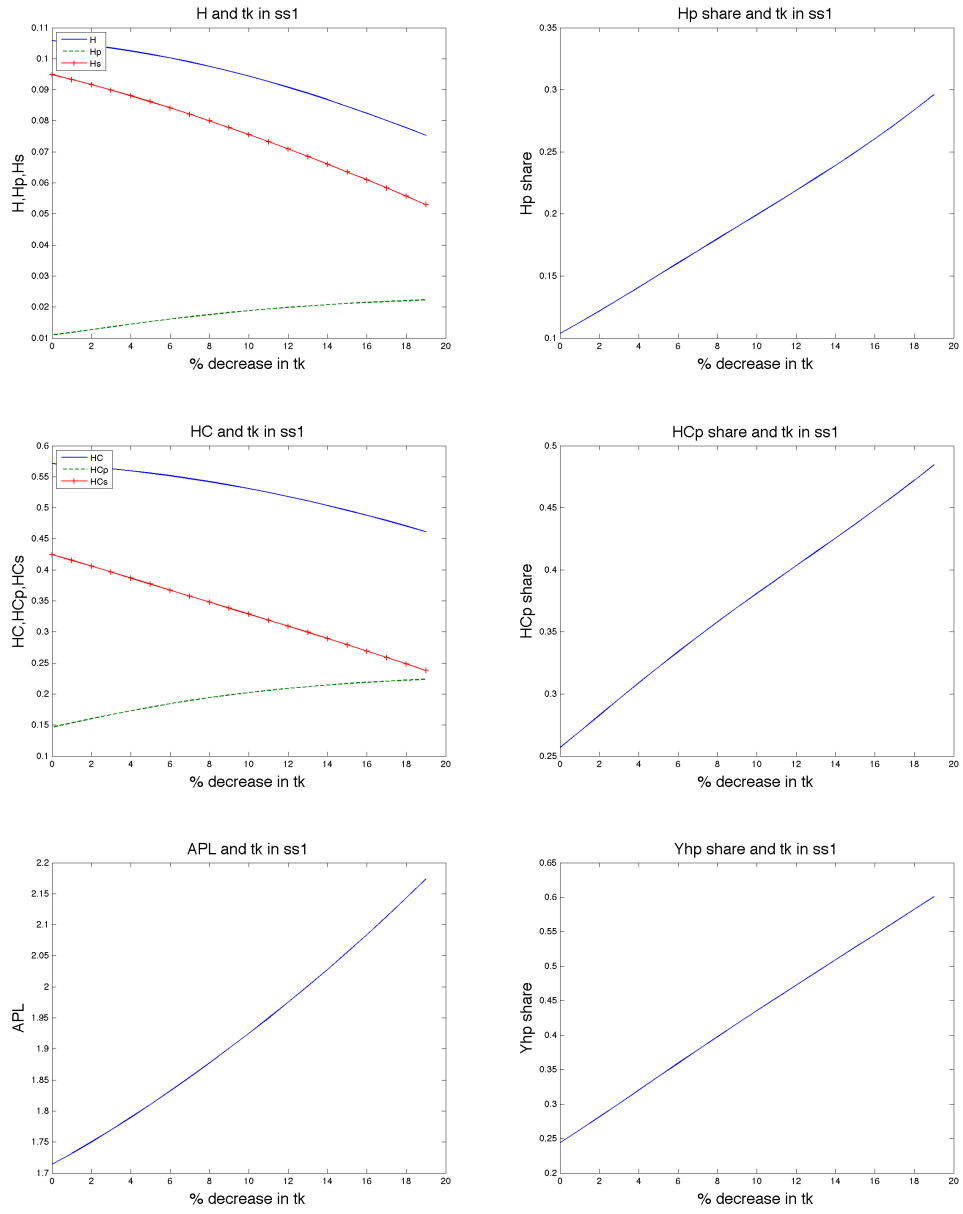*Notes:* This set of figures shows the results of comparative statics of percentage decreases in η_0.

Figure A2. Comparative statics of τ_K

Notes: This set of figures shows the results of comparative statics of percentage decreases in τ_K.