Labor Market Experience and Returns to Education in Fast Growing Economies

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Abstract

China's college admission rose from one million in 1998 to seven million in 2009, and associated with the expansion is the declining college premium for young workers. However, the college premium for senior workers increased in the same period. We show that the rising demand for skilled workers is the driving force. To explain this, we build a general equilibrium theory that considers two dimensions of human capital, i.e., education and labor market experience, and allow the supply of skilled labor to be endogenously determined. While the supply of education is elastic, the accumulation of labor market experience takes time. A demand shock will lead to a fast college expansion and thus depress the college premium for young workers, but experienced college graduates are in shortage and enjoy a rising premium for a while. Despite of a low immediate college premium, young individuals still flood into colleges because they foresee a high lifetime return to education.

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1 Introduction

China's college admission rose from one million in 1998 to seven million in 2009, with an annual growth rate as high as 17.5% (Figure 1). Associated with this rise are the increase of college graduates in the labor market (Figure 2) and a declining college premium for young workers (Figure 3, the lower line). Previous studies have argued that the supply shock resulted from college expansion policies can explain the falling college premium (Wan, 2006; Yao, Xin and Zhang, 2013; Appleton, Song and Xia, 2014; Gao and Smyth, 2015). Indeed, the college enrollment quota, which is set by the Chinese government, has risen dramatically since 1999.

However, supply fails to explain the fact that the college premium for older workers has actually increased over the same period (Figure 3, the upper line). The diverging trend of college premiums for young and experienced workers suggests that they are not perfect substitutes, as pointed out by the seminal work of Card and Lemieux (2001), but it is still unclear why the college premium for experienced workers should increase. Moreover, evidence from other fast growing economies, such as Korea, Taiwan, and Thailand, which do not have a rigid quota system for college enrollment, shows a similar labor market pattern. During their periods of rapid growth, 1980-2000, college enrollments also rose rapidly, and similarly, the college premium for young workers declined, while that for experienced workers rose (Baraka, 1999; Choi and Jeong, 2003; Mehta et al., 2007). Evidence from these economies suggests that there must be some forces other than supply at work, and the most likely candidate is a demand shock for skilled workers.

In this study, we build a general equilibrium theory to show that a demand shock for skilled workers could be the driving force for the observed labor market phenomena in fast growing economies. Following prior studies, we assume that the labor market is competitive, but we model both labor demand and supply differently from prior studies. For labor supply, we consider two dimensions of human capital, i.e., education and labor market experience,[1] and allow the supply

[1]Human capital is acquired not only in schools but also from workplace training and labor market experience. Since the seminal work of Becker (1962) and Mincer (1962), economists have recognized that labor market experience can be an important determinant of wages. The literature on technological change and diffusion highlights the important role of learning-by-doing (or using) and operating experience, as contrasted with schooling, for the advance, adoption, and assimilation of technologies (Arrow, 1962; Dosi and Nelson, 2010). Empirical evidence also indicates that firms value experienced workers more than inexperienced workers (Kotlikoff and Gokhale, 1992; Boisjoly, Duncan and Smeeding, 1998).

of skilled workers to be endogenously determined. Specifically, there are three types of workers: low-skilled (non-college education), medium-skilled (college education and inexperienced) and high-skilled (college education and experienced). A key difference between education and experience is that it takes much longer for workers to accumulate labor market experience than to acquire an education.[2] In other words, although the supply of medium-skilled workers is elastic, that of high-skilled workers is less so.

We model labor demand differently from Card and Lemieux (2001). In particular, we note that firms produce differentiated goods in a monopolistically competitive environment, and that the productivity of each firm is different when using the same type of workers. This implies that the productivity gap between different types of workers for each firm is not necessarily equal to the market wage gap. Consequently, even if we allow workers to be perfect substitutes in the production function for each firm, they may not be substitutable in equilibrium. Our theory suggests that college premiums for young and for experienced workers could have diverging trends following a demand shock.

The simulated dynamics from our theory fit well the observed facts from China and other fast growing economies. At a certain stage of development for all these economies, probably related to policy shocks associated with foreign direct investment (FDI) and trade, there was a sudden surge in the demand for human capital, and in particular for high-skilled workers with both college education and labor market experience (Nelson and Pack, 1997; Noorbakhsh, Paloni, and Youssef, 2001). The supply of education is elastic, and in response to the demand shock many young college graduates can be produced in a short time. It is likely that the supply of education will increase so substantially as to reduce the college premium for young graduates. In contrast, the accumulation of labor market experience takes time or its supply is inelastic, resulting in a shortage of high-skilled workers and a rising experience premium for college graduates in the short and medium run. Note that it is rational for young individuals to go to college even if the immediate return is low and falling, because they foresee a high college premium when they get older. In other words, because of the high lifetime return

[2] It takes time to absorb or assimilate advanced technologies through learning by doing (or operating experience), and it takes even longer to develop management and organizational skills and form business judgment (Nelson and Pack, 1999; Bresnahan, Brynjolfsson and Hitt, 2002; Dosi and Nelson, 2010).

to education, young people will choose to go to college even when the immediate return is low.

Our theory suggests that in fast growing economies where the return to education varies with both cohort and experience (age), the lifetime return to education for an individual could be very different from the cross-sectional return estimated by the classic Mincer equation.[3] For example, in 1990, the college premium for the 21-25 age group was zero, but the 10-year lifespan premium for this group was as high as 30%. The normally used cross-sectional Mincer estimate, which is essentially the wage premium averaged across all age groups, is only 10%, much lower than the 10-year lifespan premium. Thus, it could be misleading to use cross-sectional premiums to evaluate individual decisions about education investment or government policies.

We also show that without a demand shock, a pure supply shock of college enrollment cannot generate the labor market dynamics as observed in China. Although supply shocks can lead to a sharp increase in the number of educated workers, it will also cause the wages of both medium- and high-skilled workers to decline. In other words, without a demand shock, a supply shock will depress both the college premium and experience premium, as well as the lifetime return to education.

Our study is related to a large body of research examining the evolution of college wage premiums and wage inequality over time in the US.[4] The main explanations for the US wage dynamics are the increasing demand for skills, particularly those induced by skill-biased technology change (SBTC, see for example, Bound and Johnson 1992; Katz and Murphy, 1992; Krueger, 1993; Katz and Autor, 1999; Acemoglu, 2002; Bresnahan, Brynjolfsson, and Hitt, 2002; Author, Levy, and Murnane, 2003; Autor, Katz, and Kearney, 2008; Goldin and Katz, 2008; Acemoglu and Autor, 2011), the change in the supply of college graduates in the labor market over time (Card and Lemieux, 2001; Borjas, 2003), the erosion of labor market institutions (Card and DiNardo, 2002; DiNardo, Fortin and

[3] See the literature that uses the Mincer equation to estimate the average return to education in developing countries (Baraka, 1999; Choi and Jeong, 2003; Mehta et al., 2007; Glewwe, 2002; Zhang et al., 2005). Two review papers by Lemieux (2006b) and Heckman, Lochner and Todd (2006) summarize the potential problems in the underlying assumptions of the Mincer equation.

[4] See, for example, Katz and Murphy (1992), Juhn, Murphy and Pierce (1993), Buchinsky (1994), Beaudry and Green (2000), Gosling, Machin and Meghir (2000), Card and Lemieux (2001), and Autor, Katz and Kearney (2008).

Lemieux, 1996; Lemieux, 2006a), and the changing quality of college graduates (Carneiro and Lee, 2011).

We differ from previous research in the following dimensions. First, previous studies generally focus on one dimension of skills, i.e., education, while we examine the evolution of both education and experience. Because the supply of education is elastic but the supply of experience is relatively inelastic, interesting dynamics are derived. Second, previous studies normally assume a given supply of college graduates or an exogenously changing supply, whereas we allow the supply to endogenously respond to demand shocks.[5] Third, we show that the classic Mincer equation does not hold in fast growing countries, but for a different reason from that given by Card and Lemieux (2001). While Card and Lemieux (2001) empirically demonstrate that workers of different types are not perfect substitutes in the production function, we show that imperfect substitution could be a result of heterogeneous firms.[6]

Our analysis has the following policy implications. Currently, in view of the low and declining wage premiums of recent college graduates, there are heated debates in China about whether China already has too many college graduates, and whether the government should limit growth in college education (Bai, 2006; Li, Whalley and Xing, 2014; Freeman, 2010). In fact, similar issues on unemployed college graduates and over-education have been raised in other East Asian economies such as Korea and Taiwan during their rapid expansion of higher education (Wang, 2003; Schofer and Meyer, 2005; Shin and Harman, 2009). Our theory shows that the expansion was a response to the rising demand for human capital, and individual's choices can be fully rationalized by the high lifetime return to education.

Our analysis also suggests that policies for human capital development should target the long run. As we have shown, although education can expand very fast during the early stage of economic development, the accumulation of labor market experience takes time. In a sense, a developing country cannot reach the ideal level

[5]Heckman, Lochner and Taber (1998) endogenize both schooling and experience or on-the-job investment. The essence of our model aligns with theirs but we assume away the endogenous choice of experience and focus on how the inelasticity of the supply of experience can explain the labor market dynamics following demand shocks.

[6]In the classical Mincer equation, the return to education is assumed to be the same for all age groups. There are two necessary conditions for this to be true: educated workers of different experience levels are perfect substitutes in production and the product market is competitive.

of human capital as that of a developed economy, even if it can expand college enrollment in a short period.[7] The large benefit of expanding education will only be realized in the long run. In fact, Korea and Taiwan have set good examples for mainland China. The fast expansion of college enrollment in Korea and Taiwan since the 1980s has raised education levels, and these educated workers are now experienced high-skilled workers. Today, these two economies are role models for innovation (Stiglitz, 1996; Nelson and Pack, 1997).

The rest of the paper is organized as follows. In Section 2, we provide empirical observations on human capital and wages, and on potential demand shocks in fast growing economies. We set up the theoretical model in Section 3 and carry out numerical simulations to mimic the observed facts in Section 4. In Section 5, we offer our conclusions.

2 Human Capital and Wages in Rapidly Growing Economies

In this section, we first provide empirical facts about the evolution of human capital and wages in China. We then discuss one of the potential demand shocks associated with the changes in the labor market, i.e., the rise of FDI that has set off the increasing demand for high skills. Finally, we will show similar evidence from other fast growing economies including Korea, Taiwan, and Thailand.

2.1 Human Capital and Wages in China

We first describe the Chinese labor market, and in particular the accumulation of human capital and its return over time. We use data from the annual Urban Household Survey (UHS) conducted by the National Bureau of Statistics in China for the 1990-2009 period.[8] The UHS collects demographic and basic job information for every member of the sampled households. It is a rotating panel, in which one-third of the sample is replaced each year, and the full sample is changed every

[7]Nelson and Pack (1999) argue that the growth of some Asian economies will slow down because of the unavoidable long process of accumulating enough experience for the absorption or assimilation of modern technology. Rising education levels and physical capital are necessary but far from sufficient conditions for the assimilation process.

[8]Unfortunately, the rural household survey is not available. For most of our analysis, we start from 1992 rather than 1990 because the UHS survey instrument was revised in 1992.

three years. We have access to all provinces except Tibet. This study focuses on the wage dynamics of the employees aged 16-60, and thus we drop the self-employed. We are left with 943,753 individuals in the sample, with an average annual sample size of 57,683. The mean values of the most important variables in each year are reported in Table A1. In addition to this household dataset, we also use several statistical yearbooks to provide macro-level data, including the Educational Statistics Yearbooks of China 1980-2013, China Commerce Yearbooks 1980-2013, and China Statistical Yearbooks 1980-2013.

Education of Workers

The expansion of college enrollment in China in the past 15 years is unprecedented. As seen in Figure 1, college admission increased slowly between 1985 and 1998, from 0.6 to 1.1 million with a growth rate of 4% per year. Then in 1999, the Chinese government launched the college expansion program by increasing the college admission quota of that year by 43%, the highest annual growth rate of college admissions since 1978. Between 1999 and 2009, the enrollment of freshmen increased to 6.4 million, with an annual growth rate of 17.5%. The gross enrollment rate (ages 18 to 22) rose from 3.4% in 1990 to 9.8% in 1998, and then to 30.0% in 2012. In 2012, China's colleges enrolled 23.9 million students.

The rising enrollment quota reflected a rapid increase in the demand for high-skilled workers in China. Although the enrollment quota is controlled by the Ministry of Education (MOE), the quota for each province is assigned according to local demand factors such as the number of college applicants in that year, the admission rate in the previous year, and expected future demands for high skilled workers in a province. Colleges can seek to raise their enrollment quota by negotiating with the MOE.[9] The objective of meeting the local demand was highlighted by Li Lanqing, then Vise Premier of China, in 2003, "One main objective of the college expansion policy is to meet and prepare for increased demand for skilled workers."[10]

With the fast expansion in college enrollment, the education level of workers, and especially young workers, increased rapidly. In Figure 2, we show the

[9] See the detailed quota allocation mechanism at this website (http://edu.people.com.cn/GB/5681281.html).

[10] "The Memoir of Lanqing Li: The Inside Story of the College Expansion." (http://edu.sina.com.cn/l/2003-12-11/57825.html)

proportion of college graduates in the workforce for four age groups: the inexperienced group (ages 21-25) and the experienced groups (ages 26-30, 31-35, and 36-40). The growth rate for ages 21-25 was the fastest, closely resembling the trend in college enrollment. As expected, the growth for older groups lagged a few years.

The College Premium

We estimate college premiums cross-sectionally by the Mincer equation for two age groups, inexperienced workers (ages 21-25) and experienced workers (ages 26-40), controlling for gender and province fixed effects. As shown by Figure 3,[11] the college wage premium for inexperienced workers increased slowly from only 5.4% in 1992 to the peak of 23.4% in 2004, and then started to decline. By 2009, it had declined to the level of 15.2%, which is about 35% lower than the 2004 peak. In stark contrast, the college wage premium for experienced workers rose at a much higher speed starting from the mid 1990s, and it continued to increase even after 2004, when the college premium for inexperienced workers started to decline.[12] By 2009, it reached the level of 39.6%.

These results suggest that the estimate of the college premium for all workers as a whole may be misleading in the case of China. First, the college premiums differ substantially by age, and to empirically capture this difference, we need to revise the Mincer equation by adding an interaction term between education and age. Second, the difference between the college premiums of experienced and inexperienced workers changes substantially over time. This means that the interaction term evolves over time, and thus a cross-sectional estimate of the college premium could be different from the lifetime college premium. The latter is more important for an individual who is making decisions about education investment.

The Experience Premium

We next examine the evolution of experience premiums over time. Empirically, the experience premium between two age groups, ages 26-40 versus ages

[11] We use the sample of individuals with at least a high school degree to estimate college premium. The curves are smoothed using the Lowess method (running-mean smoothing, with a bandwidth of 0.8). The estimated numbers for each year are reported in Table A2.

[12] The overall trends for other age groups, 26-50, 31-40, 41-50, and 51-60, are similar. The results also hold when we define experience by the years of work experience rather than age or when we estimate college premiums using the sample of all individuals rather than the sample of individuals with at least a high school degree. See Table A2.

21-25, is defined as the wage gap (in log value) between the two age groups. We estimate experience premiums for college and high school graduates respectively for each year by cross-sectional regressions, with log wage as the dependent variable and being experienced (equal to one if an individual is in the age group 26-40 and zero if in the age group 21-25), gender, and province fixed effects as independent variables.

As shown by Figure 4, the patterns of the experience premiums also diverge between the two education groups. The experience premium for high school graduates declined in the 1990s and has become stabilized since 2002. However, the pattern for educated workers is completely different. It had been increasing steadily throughout the whole time, and reached 53.8% in 2009, which is much larger than the college premium for the 26-40 age group (39.6%).[13]

One concern is that the rising premium associated with age for college graduates could be a result of declining cohort quality for younger college graduates due to the college expansion. While this is probably true, cohort effects do not seem to be the whole story. In fact, the experience premium for college graduates started to increase before the college expansion. Furthermore, by plotting the age profile of college premium for different cohorts (Figure A1), we find that the growth rate of college premium with age is greater for the youngest cohort.

The 10-Year Return to Education

The above results suggest that cross-sectional estimates of education premiums are misleading. To illustrate this, we estimate the college premium for a 10-year lifespan of an individual, which is a better proxy for the true lifetime return. For each cohort, we use the sample for the age range of 22 to 31, where 22 is the year a college graduate enters the labor market. We use their wage information for 10 years. Take the birth cohort of 1970 as an example. This cohort, if going to college, enters the labor market in 1992. We then take those born in 1970 (both college graduates and high school graduates) from the samples covering the 1992-2001 period. Using this pooled sample, we run a Mincer regression, which generates the average college premium for the first 10 years after graduating from college for the cohort born in 1970.[14]

[13]See Table A3 for the estimated numbers. The pattern using other age groups, such as 26-50, 31-40, and 41-50 (all versus the 21-25 age group), are very similar.

[14]Alternatively, we could calculate the average premium for a longer lifespan for each cohort,

The estimated 10-year college premium is much larger than the cross-sectional premiums, as shown in Figure 5. In 1990, the first year of our calculation, the cross-sectional college premium, which essentially is the average premium for all ages in that year, is only 8.9%, whereas the 10-year return is as high as 29.2%. The gap between the 10-year premium and the cross-sectional premium for ages 21-25 is even larger: 29.2% versus almost no return. Over time, the 10-year return increased dramatically from 29.2% in 1990 to 47.3% in 1997; then declined slightly but stayed above 42%.

2.2 Demand for Skilled Labor

While college enrollment was expanding, the Chinese economy also experienced dramatic changes. During 1990-2009, GDP per capita rose from 799 dollars (international dollars based on purchasing-power-parity) to 2,884 dollars. Fast economic growth is both a result and a cause of movements in the labor market. In this study, we theoretically examine the labor market dynamics after some demand shocks.

One major shock affecting the demand for human capital in China is FDI, which started to rise preceding the changes to the labor market. China was completely closed to the outside world, before it opened its door and adopted a series of policies to attract FDI and trade (Zebregs and Tseng, 2002) in 1978. Five Special Economic Zones (SEZs) were established, 14 coastal cities were opened to foreign investment, and two Free Trade Areas with favorable policies for FDI were set up since the early 1980s. Moreover, throughout the whole country, foreign firms enjoyed preferential tax treatments and discounted land prices.[15]

These preferential policies for FDI started to pay off in the 1990s. Following Deng Xiaoping's tour of the southern coastal provinces in 1992, FDI surged, rising from only 3 billion US dollars in 1990 (1% of GDP) to 38 billion (5% of GDP) by 1995. After a temporary setback during the Asian financial crisis, the growth of FDI picked up steam again in 2001, when China entered the WTO. In 2003,

but we could only do so for a smaller number of cohorts.

[15]For example, foreign-funded enterprises (FFEs) generally were exempt from income tax for two years and eligible for a 50% reduction in the following three years. After five years, the income tax rate was 18% in the SEZs and 27% in the open coastal cities and regions, whereas the tax rate was 33% for domestic firms. These favorable tax terms were abolished in 2008.

China overtook the US and became the top destination for FDI. The share of FDI in the industrial sector is even higher; it increased from 2.3% in 1990 to 35.9% in 2003, although it has declined slightly in recent years (26% in 2011). As of today, FDI is still mainly in the form of joint ventures or wholly foreign-owned firms.[16]

Foreign firms brought profound changes to the local labor market. The number of workers employed by foreign firms increased from 0.7 million (less than 0.5% of the labor force) in 1990 to about 22 million (6.0% of the labor force) in 2012 (Figure 6). Foreign firms use advanced production technologies and management practices (Javorcik, 2004; Feenstra and Hanson, 2005; Liu, 2008), and thus have much higher labor productivity than local firms (Blomström and Sjöholm, 1999; Brandt, et al. 2012). They also hire workers with better human capital (Zhao, 2001; Noorbakhsh, Paloni, and Youssef, 2001). According to China Family Panel Studies (CFPS), a national representative household survey in China, 31% of workers in foreign firms were college graduates in 2010 whereas this ratio was 22% for domestic private firms.[17] Foreign firms also hired more workers with experience; 81% of the employees in foreign firms were 25 or above, but only 70% of the employees in domestic private firms were in this age group.

There is little doubt that foreign firms, by exerting a strong demand for high-skilled workers, help to raise the return to human capital. Consequently, the high return should also greatly influence the development of human capital in China. We will show this theoretically in the next section after providing facts from other economies.

2.3 Other Fast Growing Economies

Other fast growing economies, such as Korea, Taiwan, and Thailand, show a similar pattern (Baraka, 1999 on Taiwan, Choi and Jeong, 2003 on Korea, and Mehta et al., 2007 on Thailand). These economies all have achieved very high growth rates (over 7%) over a long time period (1980-2010). Their GDP (PPP) per capita reached \$3,000 USD in 1980 (Taiwan), 1982 (Korea), and 1991 (Thailand),

[16]FDI took four forms: equity joint ventures, contractual joint ventures, wholly owned foreign firms, and joint explorations (mainly for offshore oil). Joint ventures and wholly owned foreign firms account for the majority of FDI. Early in the reform period, China only allowed joint ventures. However, wholly owned foreign firms have been growing the fastest since 1990, accounting for more than half of the FDI in 1999 (Zebregs and Tseng, 2002).

[17]The numbers in another household survey, CHIP (2002), are 37% versus 22%.

respectively. In Korea and Taiwan, after an initial stage of moving workers from agriculture to the labor-intensive industrial sector in the 1960s, both economies started to expand export-oriented knowledge-intensive and capital-intensive industries. Their governments actively promoted high value-added industries through policies such as building high-tech parks and subsidizing private R&D. With the successful development of these high value-added industries, both economies continued to grow rapidly throughout the 1980s (Rodrik, 1996; Stiglitz, 1996; Nelson and Pack, 1997). The case of Thailand is similar, with a starting point 15 years later than Korea, and about 5 years before China.

As in China, the surge in FDI and exports in Korea, Taiwan, and Thailand was followed by a large increase in the demand for human capital. As shown in Figure 7, the college enrollment rates of these three economies started to rise rapidly 5 to 10 years after this initial demand shock. Specifically, the college enrollment rate rose substantially in the 1980s in Korea (from 13% in 1980 to 37% in 1990) and Taiwan (from 12% in 1983 to 25% in 1993), and about ten years later in Thailand (from 16% in 1990 to 37% in 2000).

In all three economies, the college wage premiums for the young and old evolve in the way similar to that seen in China. In all three economies, college enrollments increased so quickly that the college premium for young workers actually declined (Figure 8), but the college premium for experienced workers either rose or stayed unchanged. Compared to China, the magnitudes of the divergence in college premiums were smaller in these economies, perhaps because the rise in the demand for skilled workers and the resulting expansion in college enrollment were slower than in China.

2.4 A Summary of Empirical Findings

In this section, we have examined the evolution of human capital and wages in China and a few other fast growing economies, and we have the following observations.

1. College enrollment and the number of college graduates in the work force increased very rapidly after some major demand shock such as a rise in FDI.

2. The college premium for young workers declined whereas the premium for older workers increased with a rapid increase in college enrollment.

3. The experience premium for college graduates increased rapidly at the same time.
4. The cross-sectional Mincer estimate of the college premium did not accurately predict the long-term return to education.

Next, we will build a theoretical model and conduct simulations to match these observed facts.

3 The Theory

In this section, we build a theoretical model that can generate predictions that match the observations described in the last section. In our general equilibrium model, a representative consumer will choose among differentiated goods produced by firms. The only input of production is labor and its productivity depends on both education and experience. We first set up the model and derive the equilibrium conditions, and then solve it numerically and simulate the dynamics following a demand shock to the system.

We start with a model that assumes anyone who wants to go to college can do so, that is, the college enrollment quota is larger than the demand for college education. With this assumption, we do not need to worry about a constraint on the supply of college graduates and can focus on how individuals' college enrollment decisions change in response to a demand shock. In later analysis, we examine how the quota on enrollment affects the labor market dynamics, by itself or together with a demand shock.

3.1 The Model Setup

We have two markets in this economy, the goods and labor markets. The goods market is monopolistically competitive and the labor market is competitive. We apply the Dixit-Stiglitz framework to analyze monopolistic competition. A representative consumer chooses among a set of differentiated goods $\{j\}_{j\in\Omega}$, and a numeraire good Q. The utility function follows the quasilinear form,

$$U = \int_{j\in\Omega} (q_j)^{1-1/\sigma} dj + Q, \tag{1}$$

where q_j is the quantity of good j and Q is the quantity of the numeraire, and σ, with $\sigma > 1$, is the elasticity of substitution.[18]

The production function for differentiated good j is a linear function of three types of workers hired, i.e., z_l^j, z_m^j, and z_h^j, given by

$$q^j = z_l^j + (\delta^j)^\alpha z_m^j + (\delta^j)^{1+\alpha} z_h^j, \tag{2}$$

where the subscripts l, m, and h denote low-, medium- and high-skilled workers. The linear production function can not only simplify the calculation, but also help us to illustrate that workers of different types are not substitutable in equilibrium even if they are perfect substitutes in the production function. Our main results will not change when we use other forms of production functions such as the CES.

Workers differ in their productivities, which depend on both education and experience. Low-skilled workers, l, have a high school degree (or lower), medium-skilled workers, m, are college-educated but inexperienced, and high-skilled workers, h, are college-educated and experienced. To simplify the model without loss of generality, we assume the return to experience for non-college graduates to be zero.[19]

The randomly distributed parameter δ^j is the firm-specific productivity gap between medium- and high-skilled workers, and the productivity gap between m-type and l-type workers is $(\delta^j)^\alpha$, where α is assumed to be a constant.[20] For ease of exposition, the index j is dropped hereafter.

There are two types of firms: local firms and high-productivity firms with superior productivity. A mass of n_d local firms have productivity δ that follows a distribution with c.d.f. $F(\delta)$ in the range $[1, \Delta]$ (where $0 < f(.) < \infty$), and n_f high-productivity firms have productivity at the upper bound of the productivity

[18] This utility function follows the general Dixit-Stiglitz form $U = U(V, Q)$ and $U = (V)^{1-1/\sigma} + Q$, where V=$(\int_{j \in \Omega} (q_j)^{1-1/\sigma} dj)^{\frac{1}{1-1/\sigma}}$. σ is equal to the (own) price elasticity of demand when there is a sufficiently large number of varieties.

[19] This simplification assumption is justified as we find empirically in the last section that the return to experience for low-skilled workers has stabilized after 2002, which suggests that experienced low-skilled workers are perfect substitutes for inexperienced low-skilled workers. Moreover, relaxing the assumption does not affect our results analytically. For example, we could think an experienced low-skilled worker as an equivalence to $1 + a$ (where $a > 0$ is a exogenously given constant) inexperienced workers. The wage of experienced low-skilled workers is also proportional to the wage of inexperienced low-skilled workers, i.e., $(1 + a)w_l$. All our theoretical results should be the same analytically.

[20] The functional form is a simplifying assumption, which does not affect the results analytically.

distribution. We also assume that the sector producing the numeraire has the lowest productivity and hires only l-type workers. In other words, the production function of the numeraire is given by a constant scale function $Q = z_l'$. This sector can be interpreted as the low-skilled sector. The wage for l, w_l, is normalized to 1.

Workers can move up skill levels. l-type (low-skilled) workers can get a college education (taking 4 years) and become m-type workers, and m-type (medium-skilled) workers may become h-type (high-skilled) workers after working for some time. In each period, a portion η of m-type workers turn into h-type workers and this portion is exogenously given. This means that it generally takes $1/\eta$ years for an m-type worker to become an h-type worker. Also, in each period, $1 - \mu$ workers exit the labor force, and we simplify the problem by assuming that the probability of leaving is the same across different types of workers. At the same time, $1 - \mu$ individuals (young people) enter the labor force, keeping the total labor force constant. We normalize the labor force to 1.[21]

We simplify the model by assuming away individuals' labor supply decisions, and focus on their education decisions. As the labor market is competitive, all individuals face the same market wages and thus the same returns to education. To obtain a college education, individuals need to pay both a tuition cost C and some individual-specific effort costs (depending on innate abilities). We then define the net lifetime return to education, v, as the expected lifetime wage premium net the tuition cost of education. An individual will choose to obtain a college education if the net return is greater than the effort cost.

At the aggregate level, we can derive the supply function of college graduates, $G(v)$, which is the number of individuals who obtain college education as a function of the net return to education v. Specifically, $G(v)$ is equal to the fraction of people whose effort cost of education is less than the net lifetime reward v (assume $G'(.) > 0$). In other words, $G(v)$ can be interpreted as the distribution function of the effort cost of a college education.

For simplicity, we assume risk neutrality and no time discounting for consumers. We also assume that firms all have zero fixed costs, all profits are spent on the numeraires, and there is no unemployment. We will derive the equilib-

[21] The change in the size of labor force will not alter our results qualitatively.

rium conditions in the next subsection and carry out the comparative statics and transition dynamics after a demand shock.

3.2 Equilibrium

To derive the steady state equilibrium, we need to get the demand and supply of each type of workers and use the market clearing conditions. We start with the supplies.

Given the rate of labor turnover, the number (stock) of high-skilled workers in period t would be $L_h^t = \mu L_h^{t-1} + \mu\eta L_m^{t-1}$. Equilibrium requires $L_h^t = L_h^{t-1} = L_h$, and solving the above equations yields

$$k \equiv L_h/L_m = \frac{\mu\eta}{1-\mu}. \tag{3}$$

This means that in equilibrium, the ratio of L_h to L_m will be a constant.

Furthermore, the sum of the supplies of m and h is given by $G(v)$,

$$L_h + L_m = G(v). \tag{4}$$

Solving these two equations, we have $L_h = \frac{k}{k+1}G(v)$ and $L_m = \frac{1}{k+1}G(v)$. In other words, the supplies (stocks) of m and h are both constant proportions of $G(v)$. The expected net reward of obtaining a college education (amortized per period), v, is then given by,

$$v = \frac{1}{1+k}w_m + \frac{k}{1+k}w_h - 1 - C. \tag{5}$$

This is a weighted average of w_m and w_h minus the unskilled wage 1 and the tuition cost of education C.

Next, we turn to the demand function of each type of worker. Hereafter, we define $w \equiv \frac{w_h}{w_m}$, which can be interpreted as the return to experience for college graduates (note that the return to experience for low-skilled workers is normalized to be 0). The equilibrium is characterized by wage schedules w_m and w_h (or equivalently w_m and w).

From the utility function, the demand for goods q^j can be derived given price p^j. For ease of exposition, the index j is dropped. The demand function is $p(q) = Aq^{-\frac{1}{\sigma}}$, where A is a constant $(1-\frac{1}{\sigma})$. This demand function has a constant elasticity σ.

Firms and workers will sort each other. The labor market is competitive and thus all firms face the same wage level for each type of worker. However, firms are heterogeneous in the productivities of the medium- and high-skilled workers, and thus for each firm, the probability of $\delta^\alpha = w_m$ or $\delta = w$ is 0. This means that each firm only hires one type of workers in equilibrium, the one with the lowest relative cost. If a firm decides to hire workers of type-l, with wage 1, the demand function is $z_l = B$, where the constant $B \equiv (1 - \frac{1}{\sigma})^\sigma A^\sigma$. If a firm decides to hire workers of type-m, the demand function is $z_m = B w_m^{-\sigma} \delta^{\sigma-1}$. If a firm decides to hire workers of type-h, the demand function is $z_h = B w_h^{-\sigma} (\delta^{1+\alpha})^{\sigma-1}$.

We focus on the most interesting equilibrium in which all three types of workers are employed and the matching between workers and firms is assortative, i.e., higher-productivity firms hire more productive workers. This will require that $1 < w_m^{1/\alpha} < w < \Delta$.[22] In this case, the hiring decisions are such that firms with $\delta \in (1, w_m^{1/\alpha})$ will hire l-type workers; firms with $\delta \in (w_m^{1/\alpha}, w)$ will hire m-type workers; and firms with $\delta \in (w, \Delta)$ will hire h-type workers. High-productivity firms, which have the highest productivity Δ, will hire h-type workers; we assume that there are enough h-type workers in the economy to be hired.

The labor market clearing conditions for m- and h-type workers are given by the following equations,

$$nBw_m^{-\sigma} \int_{w_m^{1/\alpha}}^{w} (\delta^\alpha)^{\sigma-1} dF(\delta) = \frac{1}{k+1} G(v), \tag{6}$$

$$Bw_h^{-\sigma}[n \int_{w}^{\Delta} (\delta^{1+\alpha})^{\sigma-1} dF(\delta) + n_f (\Delta^{1+\alpha})^{\sigma-1}] = \frac{k}{k+1} G(v). \tag{7}$$

The left-hand sides are the labor demands for the two types of workers: the demand for m-type workers is generated by domestic firms with productivity δ satisfying $w_m^{1/\alpha} \leq \delta < w$, and the demand for h-type workers is generated by domestic firms with $w \leq \delta < \Delta$ and n_f high-productivity firms. The right-hand sides are supplies. We could solve these two equations for the two unknowns w_m and w_h as a function of v. Substituting them into equation 5, we can derive v and thus w.

The labor employed by the unskilled sector (producing the numeraire Q) is calculated as the remaining workers in the economy using the following clearing

[22] If $w_m^{1/\alpha} < 1$, no l-type workers will be hired. If $w < w_m^{1/\alpha}$, no m-type workers will be hired. If $w > \Delta$, no h-type workers will be hired.

condition,

$$Q = 1 - G(v) - nBF(w_m^{1/\alpha}). \tag{8}$$

Q is calculated as the total labor force minus all medium- and high-skilled workers and some low-skilled workers.

Hereafter, we will focus on the case of $1 < w_m^{1/\alpha} < w < \Delta$, which leads to an equilibrium of assortative matching between workers and firms and of all three types of workers being employed by the differentiated goods sector. We summarize this equilibrium in the following proposition, giving the proof in Appendix A.

Propostion 1 *In the steady state where $1 < w_m^{1/\alpha} < w < \Delta$, there is a unique solution for w_m, w_h, v, and w respectively.*

3.3 Dynamics after a Demand Shock

In this section, we examine how the labor market evolves when there is an exogenous increase of high-productivity firms. We consider a case in which initially, at time $t = 0$, there are no high-productivity firms, i.e., $n_f = 0$, and L_h^0, L_m^0, w^0, and w_m^0 are at the steady state levels given the information at $t = 0$. Suppose, at $t = 1$ some high-productivity firms enter, or $n_f^t > 0$ for $t > 0$. Assume n_f^t is exogenously given and it stabilizes over time, i.e., it becomes a constant after some time. Formally, this means that there exists some $\tau > 0$ such that $n_f^t = n_f^{t+1}$ for all $t > \tau$.

Assume that in every period, only young potential workers can choose to obtain a college education, and it takes four years to graduate. The dynamic equilibrium (or the wage path, w_m^t and w_h^t) is defined so that every individual will make an optimal decision about attending college when he/she is young, according to the rational expectations about the lifetime return to education.[23]

The only decision made by an individual is on college enrollment. By assumption, in each period, $(1 - \mu)$ young individuals join the labor force, and they can either work or go to college. The number of people who go to college in each period is $(1 - \mu)G(v^t)$, where v^t is the expected net return of going to college at

[23] Heckman, Lochner, and Taber (1998) find that with myopic expectations their model may not converge to a new steady state but may instead exhibit some explosive cobweb behavior.

time t amortized per period. v^t can be written as

$$v^t = [w_m^{t+4} + \sum_{j=1}^{\infty} \mu^j (1-\eta)^j w_m^{t+j+4} + \sum_{j=1}^{\infty} \mu^j (1-(1-\eta)^j) w_h^{t+j+4}](1-\mu) - 1 - C. \quad (9)$$

The dynamics of $\{v^t, w_m^t, w_h^t\}$ can be fully characterized by the following four equations

$$L_h^t = \mu L_h^{t-1} + \mu\eta L_m^{t-1}, \quad (10)$$

$$L_m^t = \mu L_m^{t-1} + (1-\mu) * G(v^{t-4}) - \mu\eta L_m^{t-1}, \quad (11)$$

$$nB(w_m^t)^{-\sigma}[\int_{(w_m^t)^{1/\alpha}}^{w^t} (\delta^\alpha)^{\sigma-1} dF(\delta)] = L_m^t, \quad (12)$$

$$B(w_h^t)^{-\sigma}[n\int_{w^t}^{\Delta} (\delta^{1+\alpha})^{\sigma-1} dF(\delta) + n_f^t (\Delta^{1+\alpha})^{\sigma-1}] = L_h^t. \quad (13)$$

The first two equations model the evolution of the stocks of h- and m-type workers, and the last two equations are the labor market clearing conditions in each period.

The New Equilibrium

The five equations above fully characterize the equilibrium $\{w_m^t, w_h^t, L_h^t, L_m^t, v^t\}$. Notationally, the new steady state equilibrium is denoted as $\{w_m^s, w_h^s, L_h^s, L_m^s, v^s\}$. This leads to the following proposition, with the proof in Appendix A.

Propostion 2 *With this setup, a steady state equilibrium exists.*

The relative wages w_h and w will increase with the demand shock. Intuitively, with more high-productivity firms, the demand for experienced college graduates (h-type) increases. As a result, the wage for h-type workers (w_h), the return to experience (w), and the lifetime return to education (v) increase. This intuition can be summarized as the following proposition, with the proof given in Appendix A.

Propostion 3 *When n_f increases, w,v,and w_h will increase in equilibrium.*

However, the effect on w_m is ambiguous, because both the demand and supply of m-type workers will rise. On the one hand, when the return to experience (w) increases, some firms will not be able to afford h-type workers anymore and will switch to m-type workers, thus increasing the demand for m-type workers. On the other hand, when the return to education (v) increases, the supply of m-type workers also increases.

Therefore, the change in w_m depends on the supply elasticity of college education. If the education system is very responsive to a higher return, an increase in the number of high-productivity firms can even lead to a lower w_m. In the extreme case, the supply of m-type workers is perfectly elastic at some point v_0, then when w increases, w_m will decrease so as to keep $v = v_0$. In contrast, if $G(v)$ is perfectly inelastic, i.e., the supplies of m- and h-type workers are fixed, then as w increases, the demand for m-type workers increases while the supply is unchanged, which bids up w_m. This intuition is summarized in the following proposition, with the proof given in Appendix A.

Propostion 4 *When n_f increases, w_m increases in equilibrium if $G'()$ is sufficiently small, and w_m decreases in equilibrium if $G'()$ is sufficiently large.*

Note that the supply effect is also present for h-type workers, but at a smaller magnitude and/or at a later stage, as only a portion η of the m-type workers turn into h-type workers in each period. In other words, it takes time for an m-type worker to become an h-type worker.

Fast College Expansion

One main result of the transition dynamics is the fast increase in the stock of m-type workers, i.e., the supply of m-type workers will rise above the long-term steady state level. The intuition is the following. h-type workers will be in short supply for a while because it takes time for medium-skilled workers to gain experience, therefore, w_h and the expected lifetime return to education are higher in the short run than in the long run. To take advantage of this, more people (with rational expectations) will go to college and more m-type workers will pour into the labor market, creating an oversupply of m-type workers in the medium run. We summarize this in the following proposition, with the proof given in Appendix A.

Propostion 5 *On the equilibrium path, if $G'(.) > 0$, there exists some period τ, such that $L_m^\tau > L_m^s$.*

4 Simulating China's Labor Market Dynamics

In this section, we draw on our theory to examine how a demand shock for high skilled workers affect the evolution of wages, the return to education, the return to experience, and the skill mix in the Chinese economy. We do so by carrying out some numerical simulations.

4.1 The Simulation Procedure and Parameters

We carry out numerical simulations to characterize the dynamics of China's labor market following an exogenous rise of firms that demand high skills (a rise of n_f), i.e., firms with superior technology or productivity. We first numerically solve equations 9 to 13 and then repeatedly apply the mapping as in the proof of Proposition 2.[24] The parameter values are selected to reflect the data in the 1980s and early 1990s (see Table A5).

Elasticity of Substitution σ

We follow Kee, Nicita and Olarreaga (2008) to set the elasticity of substitution in China (σ) to be 2.54. This value is close to the baseline value of 2.9 used in Broda and Weistein (2006) for the US. To check the sensitivity of the results to parameters, we try two alternative values, 1.1 (the lower bound used in Broda and Weistein, 2006) and 7.1 (Hering and Poncet, 2001), and the main pattern of the labor market dynamics persists.

Firm Compositions n_d and n_f

We first set values for parameters of firm compositions n_d and n_f, which characterize the demand shock. We normalize the number of local firms n_d to be a constant 10. The number of high-productivity firms n_f starts from zero and increases to 5 or 1/3 of the total number of firms in the new steady state. Indeed,

[24] The iteration starts with the sequence of $\{v^t\}$ at the initial steady state. Given the parameters and the initial sequence of $\{v^t\}$, we calculate the college enrollment rate $\{G(v^t)\}$ and the evolution of L_m^t and L_h^t over time, using equations 10 and 11. Then we apply the dichotomy method to find solutions for wages w_m^t and w_h^t in each period, using equations 12 and 13. Next, we compute a new sequence of $\{v^t\}$ based on equation 9 and use the new sequence of $\{v^t\}$ for the next round of iteration. We continue the iteration until the changes in w_m^t, w_h^t, and v^t are within the tolerance level of 0.00001. The theory guarantees the convergence of the iteration and the uniqueness of the solution.

the proportion of the industrial output by foreign firms increased from zero to 36% in 2003. Besides the starting and steady state levels, we also need to set the arrival rate for high-productivity firms in the process. We assume that the arrival of high-productivity firms follows a normal distribution as in the theory, and obtain parameters for the distribution (a mean of 7.1 and standard deviation of 4.1) by fitting nonlinear least squares on the time series of the output of foreign firms. With this distribution, high-productivity firms initially grew very fast but stabilizes in 20 years.

Productivity Parameters δ and α

We set productivity parameters δ and α to reflect the college and experience premiums in the data. A larger δ implies larger college and experience premiums, while a larger α means a higher college premium for young college graduates and a lower experience premium. Specifically, δ is assumed to follow a uniform distribution in the range of [1, 1.6], and the value of α is set to be 0.3. These parameters imply a college premium of 13% for young college graduates ($log(w_m)$) and an experience premium of 46% ($log(w_h/w_m)$), close to the corresponding numbers in the data in initial years (the college premium is 13% for the age group 21-25 and the experience premium is 47% for college graduates in 1992-1994).

Labor Market Parameters μ and η

The probability of staying in the workforce μ is set to be 96%, which corresponds to the annual labor turnover rate of about 4% in urban China from 1990 to 2013. The probability of junior college graduates becoming high-skilled workers, η, is 0.15, which means that a worker is expected to become experienced in 6.7 years. The values of μ and η imply that the proportion of inexperienced skilled-workers among all skilled workers in the initial steady state ($1/(1+k)$) is 22%, close to the ratio in the data in the 1980s.

Education Parameters C and v

College tuition C and the net return to education v affect the demand for education or college enrollment rates. C is benchmarked to the wage of low-skilled workers, which is normalized to 1 in the paper. In reality, the amortized 4-year college tuition is about 1% of the lifetime earnings of low-skilled urban workers in 1990, and thus we set C to be 1% of the low-skill wage. In order to derive the demand for college education, we also need to parameterize v, which is normally distributed. We would hope to parameterize v to reflect the demand in the initial steady state, but unfortunately the true demand for college education is unobserved due to the admission quota. Thus, we use the enrollment rate in early years of the massive college expansion as a proxy for the demand for college education in the initial steady state. Specially, we set the mean and variance of v to be 0.4 and 0.1. These parameters imply a college enrollment rate of 72% for high school graduates when the college wage premium (in percentage) is 0.46, and 80% when the college wage premium is 0.48, which are consistent with data.[25]

4.2 Simulated Results

Education and Experience

The simulation results in Figure 9 show that the supply of educated young workers, the medium-skilled (m-type) workers in our theory, indeed rises sharply in response to a positive demand shock for skills. It soon reaches the peak and then slowly decreases to the long run equilibrium. In contrast, the growth path for the supply of high-skilled (h-type) workers is flatter than that of medium-skilled workers in the earlier years as it takes longer for workers to gain experience. The number of high-skilled workers will monotonically increase until reaching the equilibrium. Note also that the numbers of medium- and high-skilled workers in equilibrium are both higher than those before the demand shock.

The College Premium

Figure 10 shows the evolution of wage schedules. The wage for young college graduates w_m goes up in the short run as the demand for them increases, but the trend is quickly reverted. Because of the sharp increase of college enrollment in the medium run, the wage of young college graduates relative to low-skilled workers could even be lower than the new steady state level during the transition. The wage for young college graduates gradually reaches the new steady state level in the long run, which is slightly higher than the value before the shock.

[25]When the 10-year college premium was 0.46 (0.48) in 1999 (2001), the enrollment rate was 64% (79%).

The Experience Premium

The experience premium w goes up steeply initially, and continues to go up for a number of periods before it peaks (Figure 10). It then comes down and gradually converges to the new steady-state value, which is higher than the level before the influx of high-productivity firms w^0. It takes a relatively longer time for w to peak as the supply of experience is not as elastic as that of education. In response to a higher return to education, many medium-skilled workers pour into the work force in the first few years, but it takes time for them to become high-skilled workers. Therefore, the ratio of L_m to L_h, and hence w, keeps increasing after w_m starts to decline. Similarly, w_h increases for a longer period than w_m. The wages of experienced college graduates and the experience premium will also decline as young college graduates gradually turn into experienced workers.

Lifetime Returns to College Education

Figure 11 shows the evolution of the lifetime return to college education for each cohort, defined as the year of entering college. The lifetime college premium (v_t) shoots up initially, but the speed of growth declines quickly. It keeps growing for some time and then converges to a new steady state value, which is higher than the initial equilibrium level v^0. The fast rise and high lifetime return of the earlier cohorts is a result of the lack of high-skilled workers in the short and medium run. The lifetime return starts to decline as more young college graduates turn into high-skilled workers and the experience premium decreases. Note that the return to education for young workers w_m stays far below the lifetime return the whole time.

A Summary of Simulation Results

In summary, the labor market dynamics following the demand shock are consistent with the theoretical predictions: College enrollment and the number of college graduates increase quickly after the demand shock; although the college premium for medium-skilled workers rises right after the shock, it starts to decline in the medium run; the experience premium continues to increase over a long period; the lifetime college premium is much larger than the cross-sectional return for for young college graduates.

4.3 The Supply Constraint and Supply Shocks

In the above analysis, we have assumed away the constraint on the supply of college education. In other words, we assume that anyone can go to college if he or she chooses to do so. However, in reality, there is a college enrollment quota in China, and this quota could be binding. We believe that an important reason for the fast expansion of the quota since 1998 is an endogenous response of the government to the increasing demand for college graduates in the labor market. Nevertheless, we examine how having a quota, specifically an exogenously changing quota, affects the labor market dynamics.

A Quota on College Enrollment

Suppose there is a binding quota on college enrollment. This means that we set the college enrollment equal to the quota Q whenever $G(v) > Q$. In our case, we set Q to be 70% of the long-term steady state level.

The enrollment quota changes the evolution of the labor market. As expected, the supplies of both medium- and high-skilled workers are lower than they are in the case without an enrollment quota (Panel (a) of Figure 12). Most importantly, with a quota, the supply of medium-skilled workers (inexperienced college graduates) increases monotonically. Also as expected, with a quota on the supply of education, the wages of both medium- and high-skilled workers are higher than in the case without a quota (Panel (b)), as is the lifetime return to education (Panel (c)).

Supply Shocks Only

In the above analysis, we show that a demand shock for human capital can drive the observed phenomena in the Chinese labor market. An interesting question is whether these observed facts in the labor market can also be explained by supply shocks alone. To answer this question, we study a case in which there are consecutive supply shocks but no demand shock.

The supply shocks mimic the massive college expansion in China since 1999. We assume that the stock of college graduates and quota on college enrollment are 25% of the corresponding levels in the steady state without quota. This assumption implies that the stock of college graduates ($L_m + L_h$) is 5.2% of the labor force and that of young college graduates (L_m) is 1.1% of the labor force, which are close to the the corresponding numbers in the data (5.0% and 1.3% in 1990). We then allow the quota to grow by 18% a year, the same as the annual growth rate in the ten years of massive college expansion (1999-2009).

The labor market dynamics with only supply shocks look different from those following demand shocks. We first exert a series of supply shocks that can lead to similar evolutions of the two supply curves for medium- and high-skilled workers, as shown in Panel (a) of Figure 13. Although the evolutions of education and experience look similar to those following demand shocks, the wages of both medium- and high-skilled workers decline over time when there are only supply shocks. In other words, without a demand shock, a supply shock makes both the college premium and experience premium decline over time. The lifetime return to education also declines. The results are not surprising because without demand shocks for high skills, more supply of skills only depresses their price in equilibrium.

To summarize, the labor market dynamics following only supply shocks differ from both those following demand shocks and the observed facts from China. This means that demand factors are important in explaining the accumulation of human capital and the evolution of skill premiums in fast growing economies.

4.4 Matching Data and Predictions

To fit data better, we relax a few assumptions of the model. First, we relax the normality assumption for the arrival rate of high-productivity firms and use the arrivals in the real data. Moreover, we adopt an additional measure for the demand shock for high skilled workers, i.e., the proportion of high-tech products in trade. Different from the previous measure of the production by foreign firms, this measure will capture high-tech productions in both domestic and foreign firms. A drawback would be that it does not cover the non-trade sector. As shown by Figure 14, the high-tech proportion in trade grows slightly slower than the output of foreign firms. We use a simple average of the two as a measure for the demand shocks.

Second, we allow the number of local firms to increase rather than to stay as a constant. The rate of increase is set as the growth rate of the real GDP index (1990=100). Third, we let the college enrollment quota increase at the same speed as in the data rather than keeping it a constant. Fourth, we let tuition grow at the rate we observe in the data. Finally, the turnover rate of labor force is defined as the proportion of the entry cohort (aged 18) in the labor force, which varies from year to year. We assume that all these parameters stabilize in 2013, which is more or less true in the data.

As shown by Figure 15, the simulation results with relaxed assumptions indeed match the data well. The simulated stocks of medium- (Panel (a)) and high-skilled workers (Panel (b)) as well as the skill premiums (Panel (c)) trend closely with the real data. The largest discrepancy between simulated results and data is on the 10-year lifespan college premium (Panel (d)), but the average difference is only 10%.

The model also allows us to predict the future labor market dynamics. To do so, we make a simplification assumption that all the parameters stabilize after 2013. As shown by Figure 16, the number of medium skilled workers will reach its new steady state (9.1% of the labor force) in about 50 years, but it will take a century for the number of high skilled workers to reach its new steady state (66.7% of the labor force). The long-run equilibrium levels for the college and experience premiums are 15.8% and 53.5%, both of which are much larger than the initial levels (though lower than the peak during transition). The 10-year lifetime college premium will also reach its long-run equilibrium of 44.3%, higher than the initial level.

5 Conclusions

In this study, we show some common characteristics of the labor markets in fast growing economies such as mainland China, Korea, Taiwan, and Thailand. In particular, all of these rapidly growing economies saw a rapid college expansion, and an associated decline in college premium for young workers. In contrast, the college premium for experienced workers increased at the same time, or alternatively, the experience premium for college graduates rose. This means that the lifetime return to education for the affected cohorts will be very different from that estimated by a cross-sectional Mincer equation.

We build a general equilibrium theory and use it to show that a demand shock for high skilled workers, such as a sudden inflow of FDI, could be the driving force for these observed facts in fast growing economies. The new features of our model are that we consider two dimensions of human capital, i.e., education and labor market experience, and we endogenize the supply of human capital. We show that when firms are heterogeneous, workers of different levels of human capital are not substitutable in equilibrium.

The simulated results from our theory fit the empirical findings well. We also show that without a demand shock, a pure supply shock of college graduates cannot generate the labor market dynamics observed in China and other fast growing economies.

Our findings suggest that human capital has a high return in fast growing economies, but the classic Mincer equation cannot fully capture it. We show that it is perfectly rational for young individuals to go to college even if the immediate return from going to college is low and falling, because they foresee a high return later in life. To capture the true rationale for an individual's decision on education, we need to estimate the lifetime return to education.

The dramatic college expansion in China has been criticized by some policy makers and academics, because of the resultant oversupply of young college graduates and the declining college premium. However, our theory and empirical results suggest that college expansion is in fact an endogenous response to the rising demand for human capital, and individuals' choices can be fully rationalized. We also show that although the pool of educated workers can expand very fast at the early stage of development, the accumulation of labor market experience takes time. In a sense, a developing country cannot in the short-term reach the same level of human capital as that of a developed economy, even if it can expand college enrollment quickly. Thus, development policies should be patient and target the long run.

Appendix A. Proofs of Propositions

Proof of Proposition 1

By the definition of v (equation 5), we get $w_m = \frac{(1+k)(v+1+C)}{1+kw}$. Substituting it into the market clearing equation for m (equation 6), we get the following equation,

$$nB[\frac{(1+k)(v+1+C)}{1+kw}]^{-\sigma}\int_{(\frac{(1+k)(v+1+C)}{1+kw})^{1/\alpha}}^{w}(\delta^{\alpha})^{\sigma-1}dF(\delta) = \frac{1}{k+1}G(v). \tag{14}$$

We first show that v and w have a one-to-one functional relationship. Equation 14 provides a functional relationship between v and w. The left hand side is decreasing in v, but the right-hand side is increasing in v. When $v = 0$, the left hand side is positive, and the right-hand side is 0. When v is very large, such that $w_m^{1/\alpha} = (\frac{(1+k)(v+1+C)}{1+kw})^{1/\alpha} >= w$, the left hand side is less than or equal to 0, and the right hand side is greater than 0. Therefore given w, the above equation has a unique solution; in other words, v and w have a one-to-one functional relationship.

We then show that w increases with v. Increasing w shifts the left hand side of equation 14 (demand) up. Therefore, the right hand side (supply) has to increase, and thus v needs to increase. Therefore $w = w^*(v)$ is an increasing function. We then substitute w by $w^*(v)$ into $w_h = \frac{(1+k)(v+1+C)}{1/w+k}$ to get $w_h = \frac{(1+k)(v+1+C)}{1/w^*(v)+k}$. This is an increasing function of v, denoted as $w_h^*(v)$. Substituting $w_h = w_h^*(v)$ and $w = w^*(v)$ into the clearing condition for h (equation 7), we get the following equation,

$$B(w_h^*(v))^{-\sigma}[n\int_{w^*(v)}^{\Delta}(\delta^{1+\alpha})^{\sigma-1}dF(\delta) + n_f(\Delta^{1+\alpha})^{\sigma-1}] = \frac{k}{k+1}G(v). \tag{15}$$

We next show that there is a unique solution for v. Given that $w_h^*(v)$ and $w^*(v)$ are increasing, the left hand side is decreasing in v; and it goes from a positive number at $v = 0$ to zero or a negative number when v is big (when $w^*(v) >= \Delta$). In contrast, the right hand side is increasing from 0 to a positive number. Thus, a unique solution v exists.

We can then conclude that $w = w^*(v)$, $w_h = \frac{(1+k)(v+1+C)}{1/w+k}$, and $w_m = \frac{(1+k)(v+1+C)}{1+kw}$ each have a unique solution. Q.E.D.

Proof of Proposition 2

Given a sequence of college enrollment rates $\{g^t \equiv G(v^t)\}$, we will use Schauder's fixed point theorem by establishing a mapping between g^t to $g^{t'}$ to prove the Proposition. Specifically, from the enrollment path g^t, we can compute the evolution of L_m^t and L_h^t. Then, using the period-by-period demand and supply equations (equations 12 and 13), we can compute the wages w_m^t and w_h^t, from which we can compute v^t. Finally, we can get a new set of enrollment rates $g^{t'} = G(v^t)$, and establish the mapping from $\{g^t\}$ to $\{g^t\}'$.

We define a Banach space for all of the sequences bounded by $[0, 1]$ with a sup norm. Clearly this space is compact and convex. The above-defined mapping can be easily shown to be a continuous self-mapping. Therefore we can use the Schauder Fixed Point Theorem to establish the existence of a fixed point such that $\{g^t\} = \{g^t\}'$.

Proposition 1 implies that any convergent equilibrium will converge to the unique steady state equilibrium derived in the previous section. Notationally, as t goes to ∞, $\{w_m^t, w_h^t, L_h^t, L_m^t, v^t\}$ converges to $\{w_m^s, w_h^s, L_h^s, L_m^s, v^s\}$, which satisfies equations 6 and 7. Q.E.D.

Proof of Proposition 3

We will first show that w increases with n_f by contradiction. Suppose not, if w decreases, then the left hand side of the market clearing equation for the medium-type workers (equation 14) will shift down, and thus the right hand side or v has to decrease to balance. Then, $w_h = \frac{(1+k)(v+1+C)}{1/w+k}$ also decreases, but this would violate the market clearing condition for h-type workers (equation 15). To see this, the left hand side of equation 15 increases from the previous equilibrium since w_h decreases, w decreases, and n_f increases, but the right hand side decreases from the previous equilibrium as v decreases. This is a contradiction, and therefore w must increase.

We next show that w_h increases with n_f. As w increases, the left hand side of equation 14 shifts up, so v also increases to balance the equation. Then $w_h = \frac{(1+k)(v+1+C)}{k+1/w}$ must increase too. So we have shown that w, v, and w_h all increase. Q.E.D.

Proof of Proposition 4

To analyze the change in w_m when n_f increases, we first need to sign dw_m/dw. We implicitly differentiate the demand equation for m (equation 6), which establishes a functional relationship between w and w_m. We already know that w increases with the arrival of high-productivity firms, therefore to sign dw_m, all we need to do is to sign dw/dw_m. Implicitly differentiating it, we can obtain an expression for dw_m/dw as follows,

$$nBw_m^{-\sigma-1}(-\sigma)\int_{w_m^{1/\alpha}}^{w}\delta^{\sigma-1}dF(\delta)+nBw_m^{-\sigma}(-w_m^{\sigma-1}f(w_m))+nBw_m^{-\sigma}w^{\sigma-1}f(w)\frac{dw}{dw_m}=\frac{1}{k+1}G'(v)[\frac{1+kw}{1+k}+\frac{w_m k}{1+k}\frac{dw}{dw_m}].$$

After re-arranging and simplification, we get

$$\frac{dw}{dw_m}=\frac{-\sigma nBw_m^{-\sigma-1}\int_{w_m^{1/\alpha}}^{w}\delta^{\sigma-1}dF(\delta)-nBw_m^{-1}f(w_m)-\frac{1}{k+1}G'(v)\frac{kw_m}{1+k}}{\frac{1}{k+1}\frac{1+kw}{1+k}G'(v)-nBw_m^{-\sigma}w^{-\sigma-1}f(w)}.$$

By examining this expression, we know that when $G'()$ is sufficiently small, i.e., the supply is very elastic, $dw/dw_m > 0$. On the other hand, if $G'()$ is sufficiently large, i.e., the supply is very elastic, then $dw/dw_m < 0$.

Lemma 1 *In period by period demand/supply equations for h- and m-type workers, if both L_h and L_m decrease and one of them decreases strictly, then w_m and w_h increase strictly. (Conversely if both L_h and L_m increase, and one of them increases strictly, then w_m and w_h decrease strictly.)*

Proof: We prove by contradiction, using market clearing equations 12 and 13. If w_m decreases, then the left hand side of equation 12 increases, but the right hand side L_m decreases. Thus, w must decrease to keep the equation balance. Then, $w_h = w * w_m$ must also decrease. However, if w decreases, then equation 13 indicates that w_h must increase to be equal to L_h, which has decreased. This is a contradiction. Therefore, w_m must increase.

Similarly, to show that w_h increases, we also prove by contradiction. Suppose w_h decreases, then the left hand side of equation 13 increases, but the right hand side (L_h) decreases, which is a contradiction. Therefore, w_h must increase. Q.E.D.

Lemma 2 *Define W_m as the solution to the period by period demand and supply equations (12 and 13), given L_m and L_h. Then, the partial $-\frac{\partial W_m}{\partial L_h}$ is bounded from* *below.*

Proof: We first differentiate the market clearing equations for m-type (equation 12) and h-type workers (equation 13). More specifically, we denote function $M(.)$ as $M(w_m, w_h) = nBw_m^{-\sigma} \int_{w_m^{1/\alpha}}^{w_h/w_m} (\delta^\alpha)^{\sigma-1} dF(\delta)$, and $H(.)$ as $H(w_m, w_h) = Bw_h^{-\sigma}[n \int_{w_h/w_m}^{\Delta} (\delta^{1+\alpha})^{\sigma-1} dF(\delta) + n_f(\Delta^{1+\alpha})^{\sigma-1}]$. Implicitly differentiating both equations on both sides by L_h, holding L_m constant, we have

$M_1 \frac{\partial w_m}{\partial L_h} + M_2 \frac{\partial w_h}{\partial L_h} = 0$, and $H_1 \frac{\partial w_m}{\partial L_h} + H_2 \frac{\partial w_h}{\partial L_h} = 1$.

Solving the above equations, we get $\frac{\partial W_m}{\partial L_h} = (H_1 - H_2 M_1/M_2)^{-1}$. As $M_1 < 0$, $M_2 > 0$, $H_1 < 0$ and $H_2 > 0$, then by Lemma 1, $\frac{\partial W_m}{\partial L_h} < 0$.

We know that the absolute values of M_1, M_2, H_1 and H_2 are bounded from below and above (by assumption, all wages are in the range of $[1, \Delta^{1+\alpha}]$, and $f() < \infty$). Therefore, the absolute value $H_1 - H_2 M_1/M_2$ is bounded from above, and hence the absolute value of $\frac{\partial W_m}{\partial L_h}$ is bounded from below.

Lemma 3 *If $v^t > v^s$ and both L_m^t and L_h^t converge from below, then*

$$\lim_{t \to \infty} \frac{L_h^s - L_h^t}{L_m^s - L_m^t} = \infty. \tag{16}$$

Proof: Expanding the recursive formula for L_h, we have $L_h^t = \sum_{j=1}^{t} \eta \mu^j L_m^{t-j}$, and hence $L_h^s - L_h^t = \sum_{j=1}^{t} \eta \mu^j (L_m^s - L_m^{t-j})$. We know that $L_m^s - L_m^t < \mu(1-\eta)(L_m^s - L_m^{t-1})$ for all t. This is because $L_m^s - L_m^t = \mu(1-\eta)(L_m^s - L_m^{t-1}) + (1-\mu)(G(v^s) - G(v^t))$, and $G(v^t) > G(v^s)$.

Recursively applying the above inequality, we have

$$L_m^s - L_m^{t-j} > \mu^{-j}(1-\eta)^{-j}(L_m^s - L_m^t) \tag{17}$$

Substitute this inequality into the expression for $L_h^s - L_h^t$, we get $L_h^s - L_h^t > (L_m^s - L_m^t) \sum_{j=1}^{t} (1-\eta)^{-j}$. Therefore $\frac{L_h^s - L_h^t}{L_m^s - L_m^t}$ will go to infinity as t goes to infinity. Q.E.D.

Proof of Proposition 5

We prove this by contradiction. If L_m never overshoots, i.e., $L_m^t \leq L_m^s$ for all t, then L_h also never overshoots ($L_h^t \leq L_h^s$ for all t). The inequality is strict, as long as $L_h^0 < L_h^s$ (this can be shown easily by an induction on equation 10). Since the demand for labor n_f^t will be a constant for a t large enough ($t > \tau$) by assumption, and the supply never overshoots ($L_m^t \leq L_m^s$ and $L_h^t < L_h^s$, for $t > \tau$), then by Lemma 1, the wages will be higher than the long term values for $t > \tau$, i.e., $w_m^t > w_m^s$, $w_h^t > w_h^s$, and $v^t > v^s$.

Next, we will show that this is not possible when $G'() > 0$. First, we will establish that given $L_m^{t+1} < L_m^s$ for all t, we have

$$\frac{G(v^{t-4}) - G(v^s)}{L_m^s - L_m^t} < \frac{\mu(1-\eta)}{1-\mu}. \tag{18}$$

This follows from simple algebra as, $L_m^{t+1} = (1-\mu)G(v^{t-4}) + \mu(1-\eta)L_m^t < L_m^s$. Re-arranging this, we get $(1-\mu)G(v^{t-4}) < L_m^s - \mu(1-\eta)L_m^t = \mu(1-\eta)(L_m^s - L_m^t) + (1-\mu+\mu\eta)L_m^s$. Given $(1-\mu+\mu\eta)L_m^s = (1-\mu)G(v^s)$, we have $G(v^{t-4}) - G(v^s) < \frac{\mu(1-\eta)}{1-\mu}(L_m^s - L_m^t)$.

Second, we know that $v^{t-4} - v^s > (1-\mu)\mu^4(1-\eta)^4(w_m^t - w_m^s)$. By the formula for v_t, for all $t > \tau$, $w_m^t > w_m^s$ and $w_h^t > w_h^s$.

Third, applying the mean value theorem, we have $w_m^t - w_m^s = (-\frac{\partial W_m}{\partial L_m})(L_m^s - L_m^t) + (-\frac{\partial W_m}{\partial L_h})(L_h^s - L_h^t)$, where W_m is the function that solves for w_m taking as given L_m and L_h in the period by period supply and demand equations. The partials are evaluated at some values in the range (L_m^t, L_m^s) and (L_h^t, L_h^s).

Combining the second and third steps, we have $v^{t-4} - v^s > (1-\mu)\mu^4(1-\eta)^4[(-\frac{\partial W_m}{\partial L_m})(L_m^s - L_m^t) + (-\frac{\partial W_m}{\partial L_h})(L_h^s - L_h^t)]$. Again, applying the mean value theorem on $G()$, we get $G(v^{t-4}) - G(v^s) > G'()(1-\mu)\mu^4(1-\eta)^4[(-\frac{\partial W_m}{\partial L_m})(L_m^s - L_m^t) + (-\frac{\partial W_m}{\partial L_h})(L_h^s - L_h^t)]$. Dividing both sides by $L_m^s - L_m^t$, we have

$$\frac{G(v^{t-4}) - G(v^s)}{L_m^s - L_m^t} > G'()(1-\mu)\mu^4(1-\eta)^4[(-\frac{\partial W_m}{\partial L_m}) + (-\frac{\partial W_m}{\partial L_h})\frac{L_h^s - L_h^t}{L_m^s - L_m^t}]. \tag{19}$$

By Lemma 2, $-\frac{\partial W_m}{\partial L_h}$ is uniformly bounded from below, and by Lemma 3, $\frac{L_h^s - L_h^t}{L_m^s - L_m^t}$ goes to ∞. As long as $G'()(>0)$ is evaluated near v_s, $\frac{G(v^{t-4})-G(v^s)}{L_m^s - L_m^t}$ will go to ∞. This contradicts to the first step where we have shown that $\frac{G(v^{t-4})-G(v^s)}{L_m^s - L_m^t} < \frac{\mu(1-\eta)}{1-\mu}$ for a t big enough. Therefore, L_m^t will overshoot. Q.E.D

References

Acemoglu, Daron. "Technology and the Labor Market." Journal of Economic Literature 40 (2002): 7-72.

Acemoglu, Daron and David Autor. "Skills, Tasks and Technologies: Implications for Employment and Earnings." In Ashenfelter and Card (eds.), Handbook of Labor Economics 4 (2011): 1043-1171.

Appleton, Simon, Lina Song, and Qingjie Xia. "Understanding Urban Wage Inequality in China 19882008: Evidence from Quantile Analysis." World Development 62 (2014): 1-13.

Arrow, Kenneth J. "The Economic Implications of Learning by Doing." Review of Economic Studies 29.3 (1962): 155-173.

Autor, David H., Lawrence F. Katz, and Melissa S. Kearney. "Trends in U.S. Wage Inequality: Revising the Revisionists." The Review of Economics and Statistics 90.2 (2008): 300-323.

Autor, David H., Frank Levy, and Richard J. Murnane. "The Skill Content of Recent Technological Change: An Empirical Exploration." The Quarterly Journal of Economics 118.4 (2003): 1279-1333.

Bai, Limin. "Graduate Unemployment: Dilemmas and Challenges in China's Move to Mass Higher Education." The China Quarterly 185 (2006): 128-144.

Baraka, Jessica. "Returns to Education in Taiwan." Working Paper, 1999.

Beaudry, Paul, and David A. Green. "Cohort Patterns in Canadian Earnings: Assessing the Role of Skill Premia in Inequality Trends." Canadian Journal of Economics 33.4 (2000): 907-936.

Becker, Gary S. "Investment in Human Capital: A Theoretical Analysis." Journal of Political Economy 70, suppl. (October 1962): 9-49.

Blomström, Magnus, and Fredrik Sjöholm. "Technology Transfer and Spillovers: Does Local Participation with Multinationals Matter?" European Economic Review 43.4 (1999): 915-923.

Boisjoly, Johanne, Greg J. Duncan, and Timothy Smeeding. "The Shifting Incidence of Involuntary Job Losses from 1968 to 1992." Industrial Relations 37 (1998): 207-231.

Borjas, George J. "The Labor Demand Curve is Downward Sloping: Reexamining the Impact of Immigration on the Labor Market." The Quarterly Journal of Economics 118.4 (2003): 1335-1374.

Broda, Christian and David Weinstein. "Globalization and the gains from variety. The Quarterly Journal of Economics 121.2 (2006): 541-585.

Bound, John and George Johnson. "Changes in the Structure of Wages in the 1980s: An Evaluation of Alternative Explanations." American Economic Review 82 (1992): 371-92.

Brandt, Loren, Johannes Van Biesebroeck, Luhang Wang, and Yifan Zhang. "WTO Accession and Performance of Chinese Manufacturing Firms." Centre for Economic Policy Research (CEPR) Discussion Papers, 2012.

Bresnahan, Timothy F., Erik Brynjolfsson, and Lorin M. Hitt. "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence." The Quarterly Journal of Economics 117.1 (2002): 339-376.

Buchinsky, Moshe. "Changes in the US Wage Structure 1963 to 1987: An Application of Quantile Regressions." Econometrica, 62 (1994), 405-458.

Card, David E., and John Enrico DiNardo. "Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles." Journal of Labor Economics 20.4 (2002): 733-783.

Card, David, and Thomas Lemieux. "Can Falling Supply Explain the Rising Return to College for Younger Men? A Cohort-Based Analysis." The Quarterly Journal of Economics 116.2 (2001): 705-746.

Carneiro, Pedro, and Sokbae Lee. "Trends in quality-adjusted skill premia in the United States, 19602000." The American Economic Review 101.6 (2011): 2309-2349.

Choi, Kang-Shik and Jin-Ho Jeong. "The Rising Returns to Education and Skill-Biased Technological Change in Korea." Working Paper, 2003.

DiNardo, John, Nicole M. Fortin, and Thomas Lemieux. "Labor Market Institutions and the Distribution of Wages, 1973-1992: A Semiparametric Approach." Econometrica 64.5 (1996): 1001-1044.

Dosi, Giovanni, and Richard R. Nelson. "Technical Change and Industrial Dynamics as Evolutionary Processes." Handbook of the Economics of Innovation 1 (2010): 51-127.

Feenstra, Robert C, and Gordon H. Hanson. "Ownership and Control in Outsourcing to China: Estimating the Property-rights Theory of the Firm." Quarterly Journal of Economics, 120.2 (2005): 729761.

Freeman, Richard B. "What Does Global Expansion of Higher Education Mean for the United States?." American Universities in a global market. University of Chicago Press, 2010. 373-404.

Gao, Wenshu, and Russell Smyth. "Education expansion and returns to schooling in urban China, 20012010: evidence from three waves of the China Urban Labor Survey." Journal of the Asia Pacific Economy 20.2 (2015): 178-201.

Glewwe, Paul. "Schools and Skills in Developing Countries: Education Policies and Socioeconomic Outcomes." Journal of Economic Literature 40.2 (2002): 436-482.

Goldin, Claudia, and Lawrence Katz. "The Race between Education and Technology." Cambridge, MA: Harvard University Press. 2008.

Gosling, Amanda, Stephen Machin, and Costas Meghir. "The Changing Distribution of Male Wages in the UK." The Review of Economic Studies 67.4 (2000): 635-666.

Heckman, James J., Lance Lochner, and Christopher Taber. “Explaining Rising Wage Inequality: Explorations with a Dynamic General Equilibrium Model of Labor Earnings with Heterogeneous Agents.” Review of Economic Dynamics 1.1 (1998): 1-58.

Heckman, James J., Lance J. Lochner, and Petra E. Todd. “Fifty Years of Mincer Earnings Regressions.” Hanushek, E. and F. Welch (eds.) Handbook of Education Economics, Vol. 1. The Netherlands: Elsevier, 2006.

Hering, Laura, and Sandra Poncet. “Market Access and Individual Wages: Evidence from China,” The Review of Economics and Statistics, MIT Press, 92.1(2010): 145-159, February.

Javorcik, Beata Smarzynska. “Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages.” American Economic Review 94.3 (2004): 605-627.

Juhn, Chinhui, Kevin M. Murphy, and Brooks Pierce. “Wage Inequality and the Rise in Returns to Skill.” Journal of Political Economy 101.3 (1993): 410-442.

Katz, Lawrence F. and David H. Autor. “Changes in the Wage Structure and Earnings Inequality.” In O. Ashenfelter and D. Card, (eds). Handbook of Labor Economics, volume 3 (1999): 1463-1555, North Holland.

Katz, Lawrence F. and Kevin M. Murphy. “Changes in Relative Wages, 1963-87: Supply and Demand Factors.” Quarterly Journal of Economics 107.1 (1992): 35-78.

Kee, Looi H., Alessandro Nicita, and Marcelo Olarreaga. “Import Demand Elasticities and Trade Distortions.” The Review of Economics and Statistics 90.4 (2008): 666-682.

Kotlikoff, Lawrence, and Gokhale, Jagadeesh. “Estimating a Firms Age-Productivity Profile Using the Present Value of Workers’ Earnings.” Quarterly Journal of Eco-nomics 107.4 (1992): 1215-1242.

Krueger, Alan B. “How Computers Have Changed the Wage Structure: Evidence from Microdata.” Quarterly Journal of Economics 108.1 (1993): 33-60.

Lemieux, Thomas. “Increasing Residual Wage Inequality: Composition Effects, Noisy Data, or Rising Demand for Skill?.” American Economic Review 96.3 (2006a): 461-498.

Lemieux, Thomas. “The “Mincer Equation” Thirty Years after Schooling, Experience, and Earnings.” Springer, U.S., 2006b.

Li, Shi, John Whalley, and Chunbing Xing. “China’s Higher Education Expansion and Unemployment of College Graduates.” China Economic Review 30(2014): 567-582.

Liu, Zhiqiang. “Foreign Direct Investment and Technology Spillovers: Theory and Evidence.” Journal of Development Economics 85.1 (2008): 176-193.

Mehta, Aashish, Jesus Felipe, Pilipinas Quising, and Shiela Camingue. “Changing Patterns in Mincerian Returns to Education and Employment Structure in Three Asian Countries,” Center for Global Studies, Institute for Social, Behavioral, and Economic Research, UC Santa Barbara, 2007.

Mincer, Jacob. “On-the-Job Training: Costs, Returns, and Some Implications.” Journal of Political Economy 70, suppl. (October 1962): 50-79.

Nelson, Richard R., and Howard Pack. “The Asian Miracle and Modern Growth Theory.” The Economic Journal 109.457 (1999): 416-436.

Noorbakhsh, Farhad, Alberto Paloni, and Ali Youssef. “Human Capital and FDI Inflows to Developing Countries: New Empirical Evidence.” World Development 29.9 (2001): 1593-1610.

Rodrik, Dani. “Understanding Economic Policy Reform.” Journal of Economic Literature 34.1 (1996): 9-41.

Schofer, Evan, and John W. Meyer. “The Worldwide Expansion of Higher Education in the Twentieth Century.” American sociological review 70.6 (2005): 898-920.

Shin, Jung Cheol, and Grant Harman. “New Challenges for Higher Education: Global and Asia-Pacific Perspectives.” Asia Pacific Education Review 10.1 (2009): 1-13.

Stiglitz, Joseph E. “Some Lessons from the East Asian Miracle.” The World Bank Research Observer 11.2 (1996): 151-177.

Wang, Ru-Jer. “From Elitism to Mass Higher Education in Taiwan: The Problems Faced.” Higher Education 46.3 (2003): 261-287.

Wan, Yinmei. “Expansion of Chinese higher education since 1998: Its causes and outcomes.” Asia Pacific Education Review 7.1 (2006): 19-32.

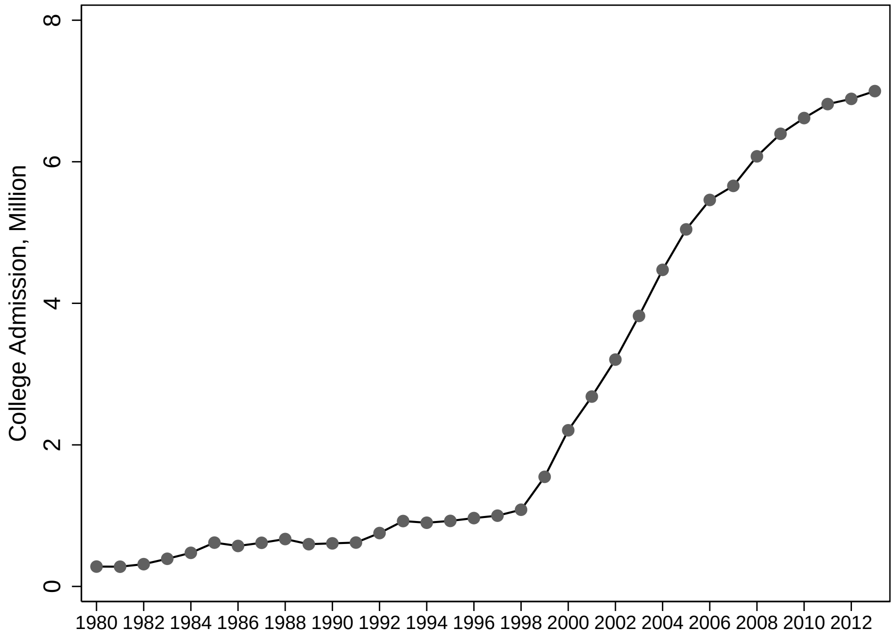
Yao, Xianguo, Fang Xin, and Zhang Haifeng. “Changes in Economic Return to Schooling and Employment Rate with the Expansion of Higher Education.” Economic Issues in China,2 (2013): 3-11.

Zebregs, Harm, and Wanda Tseng. “Foreign Direct Investment in China: Some Lessons for Other Countries.” No. 2-3. International Monetary Fund, 2002.

Zhang, Junsen, Yaohui Zhao, Albert Park, and Xiaoqing Song. “Economic Returns to Schooling in Urban China, 1988 to 2001.” Journal of Comparative Economics 33.4 (2005): 730-752.

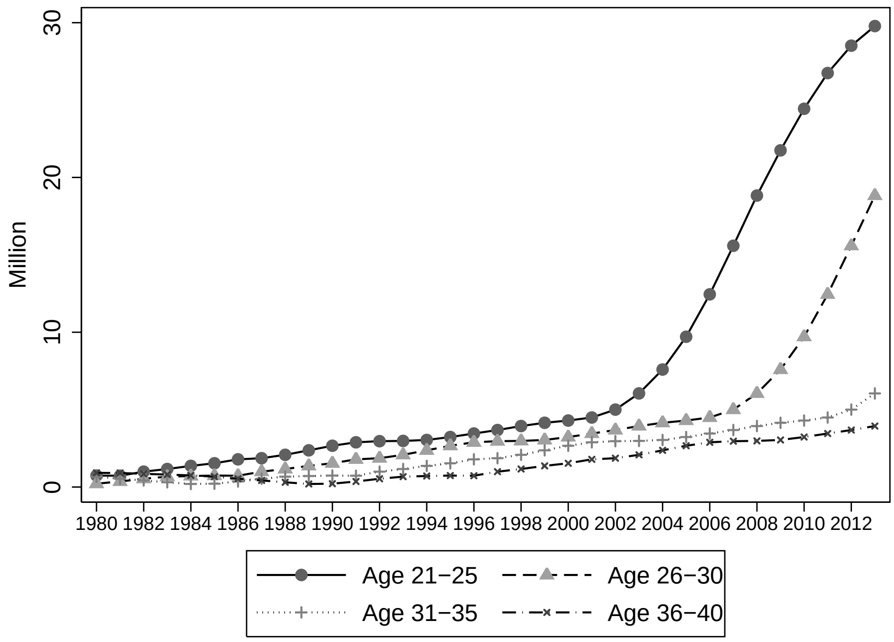
Zhao, Yaohui. “Foreign Direct Investment and Relative Wages: The Case of China.” China Economic Review 12.1 (2001): 40-57.

Figure 1: College Admissions in China (1980-2013)



Note: China Statistics Yearbooks.

Figure 2: College Graduates in the Labor Force for Different Age Groups in China (1980-2013)

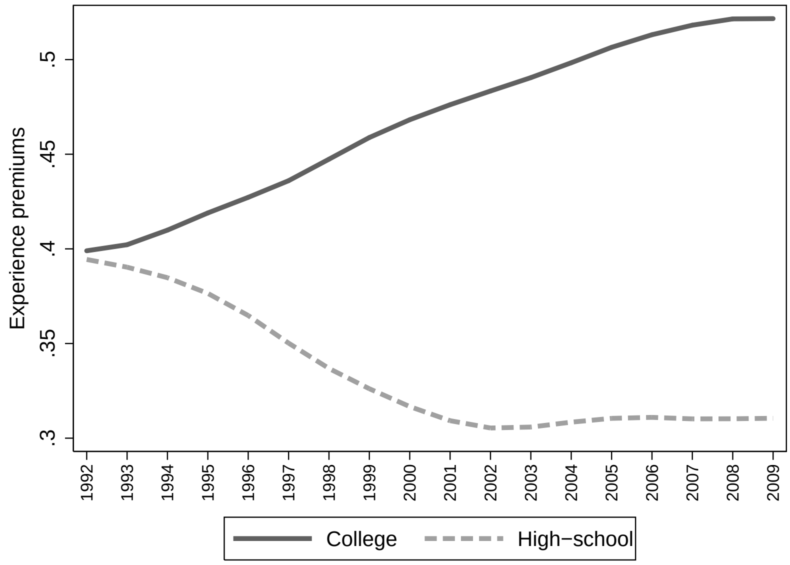


Note: Educational Statistics Yearbooks of China 1980-2013.

Figure 3: College Premiums of Inexperienced (age 21-25) vs. Experienced (age 26-40) Workers in Urban China

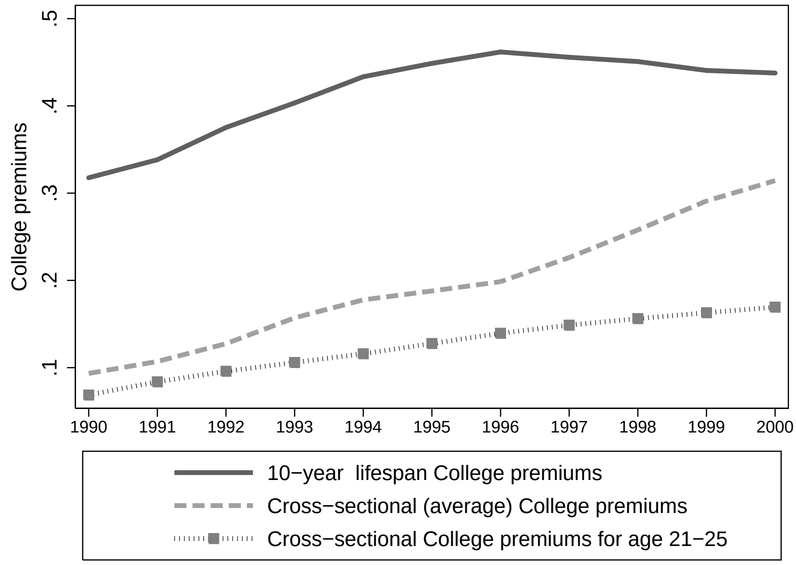
Note: Estimated by cross-sectional regressions for each age group for each year, with log wage as the dependent variable, and the college dummy, gender, and province fixed effects as independent variables.

Figure 4: Experience Premiums of College vs.
High-school Graduates in Urban China



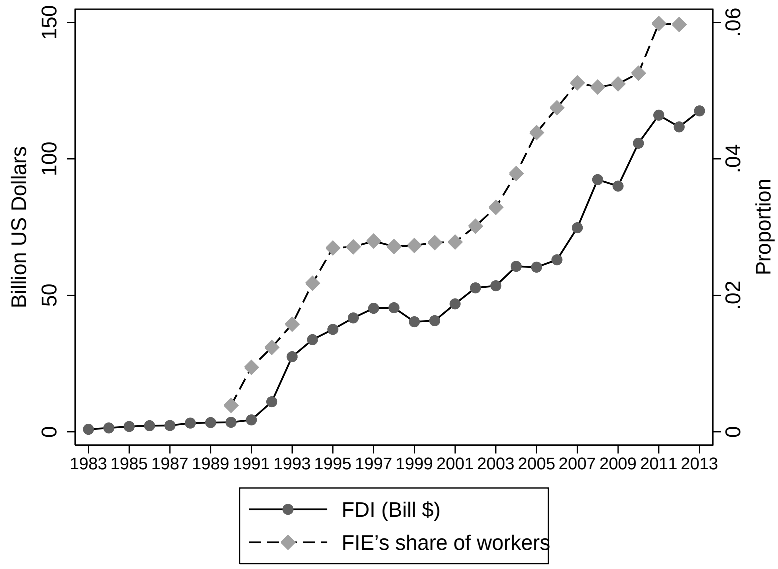
Note: Experience premiums are estimated by cross-sectional regressions for each education group for each year, with log wage as the dependent variable, and the experience dummy (1 if age is 26-40, 0 if age is 21-25), gender, and province fixed effects as independent variables. We report the coefficients on the experience dummy in the figure.

Figure 5: 10-year Lifespan College Premiums vs.
Cross-Sectional College Premiums in Urban China



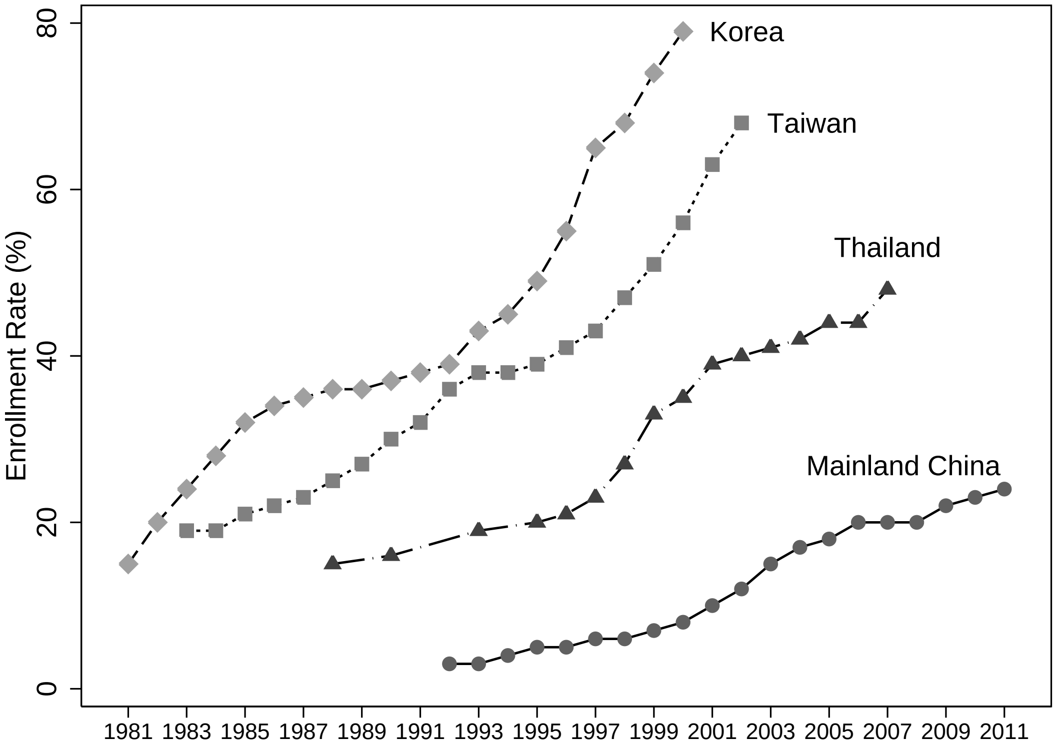
Note: The 10-year lifespan college premium is estimated for cohort t, where t represents the year a college graduate cohort enters the labor market (age 22). Take year 1990 as an example. The birth cohort of 1968, if going to college, enters the labor market in 1990. We take those born in 1968 (both college graduates and high school graduates) from the samples covering the period 1990-1999. Using this pooled sample, we run a Mincer regression, which generates the average college premium for the first 10 years after graduating from college, specific for the entry cohort of 1990 or the cohort born in 1968. The cross-sectional (average) college premium in a year is estimated by the Mincer equation. The college premium for age group 21-25 is estimated for the sample of workers aged 21 to 25.

Figure 6: Foreign Direct Investment (FDI) and Workers in
Foreign-Invested Enterprises (FIE) in China



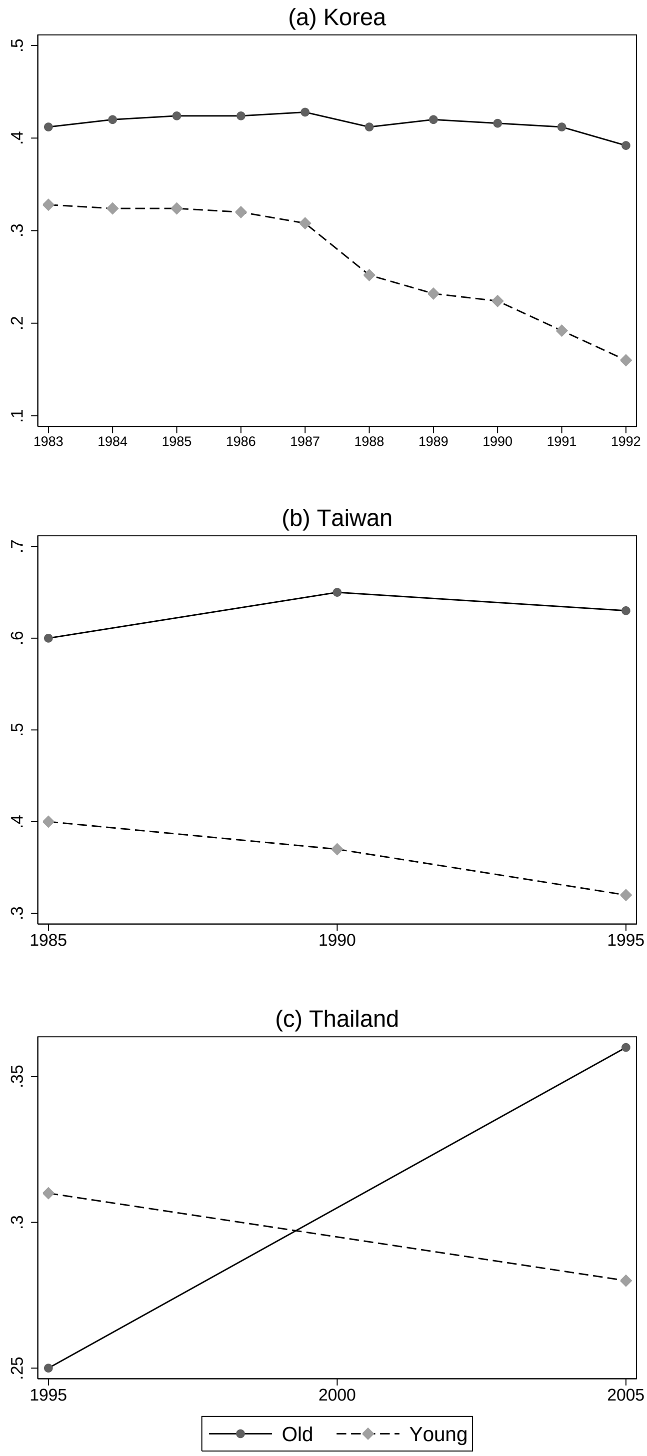
Note: China Commerce Yearbooks and Chinese Statistical Yearbooks 1980-2013.

Figure 7: College Enrollment Rates in Rapidly Growing Economies



Note: World Economic Outlook Database.

Figure 8: College Premiums of Young vs. Old Workers in Rapidly Growing Economies



Note: Choi and Jeong (2003) for Korea; Baraka (1999) for Taiwan; Mehta et al. (2007) for Thailand.

Figure 9: Dynamics Following Demand Shocks:
The Stock of Medium- and High-Skilled Workers

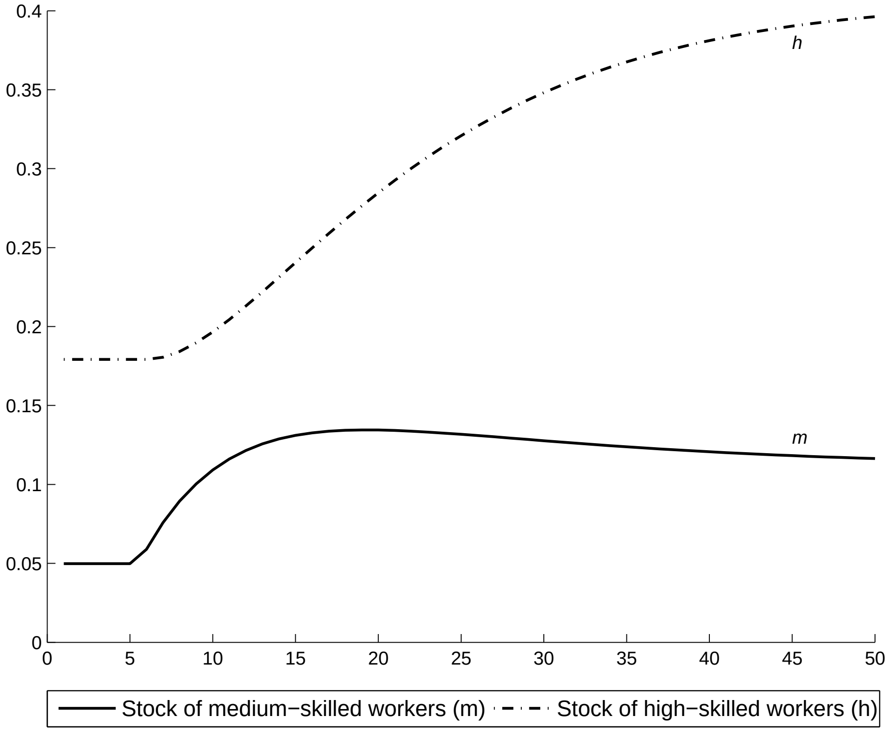
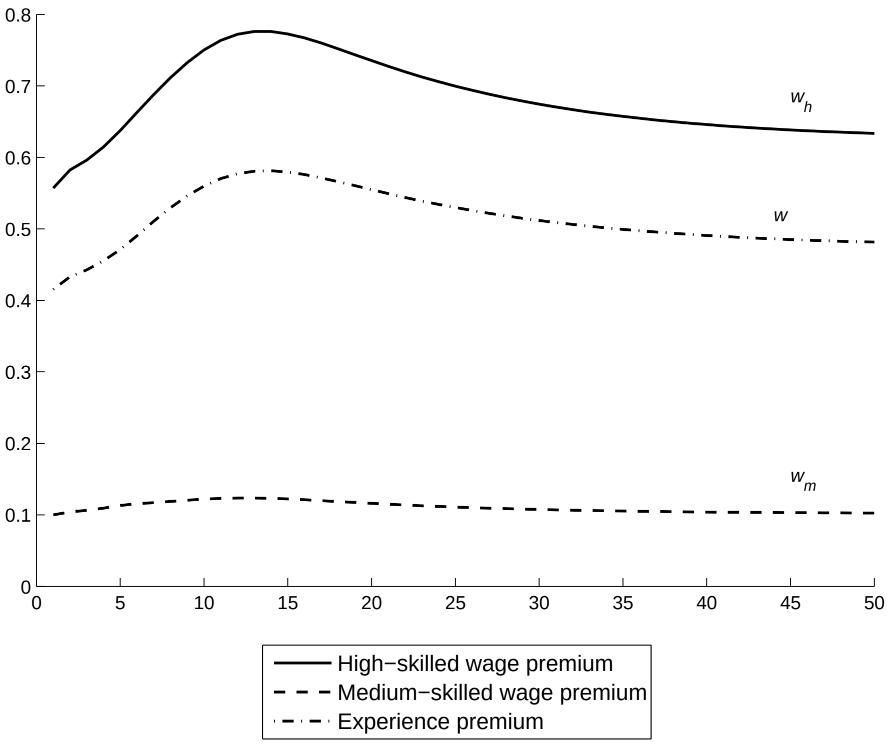
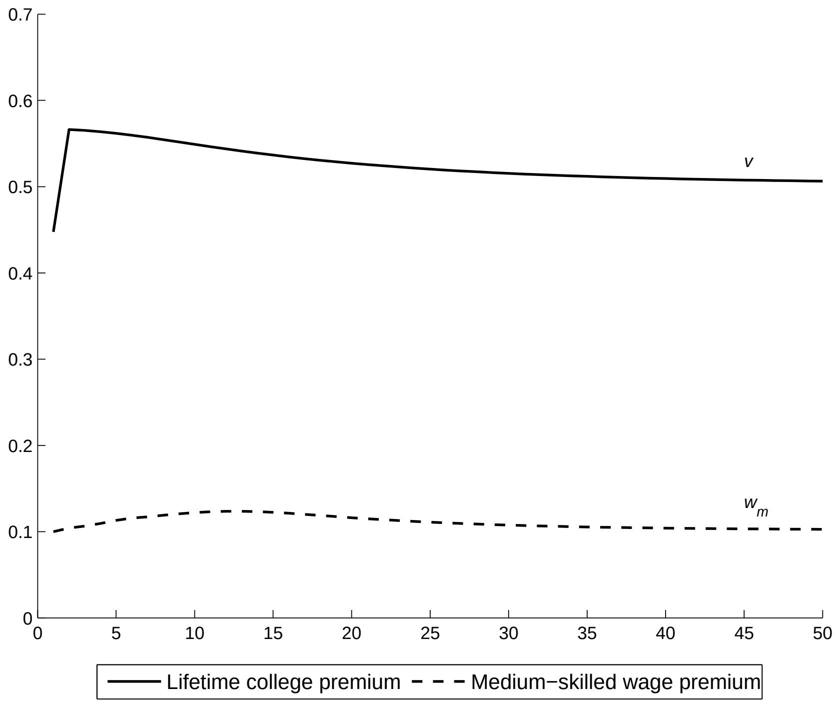


Figure 10: Dynamics Following Demand Shocks: Wages and Wage Premiums



Note: We calculate the wage premium for high-skilled workers by $(w_h - 1)/1$, where w_h is the high-skilled wage and 1 is the low-skilled wage. Similarly, the wage premium for medium-skilled workers is $(w_m - 1)/1$. The experience premium is $(w_h - w_m)/w_m = w_h/w_m - 1$.

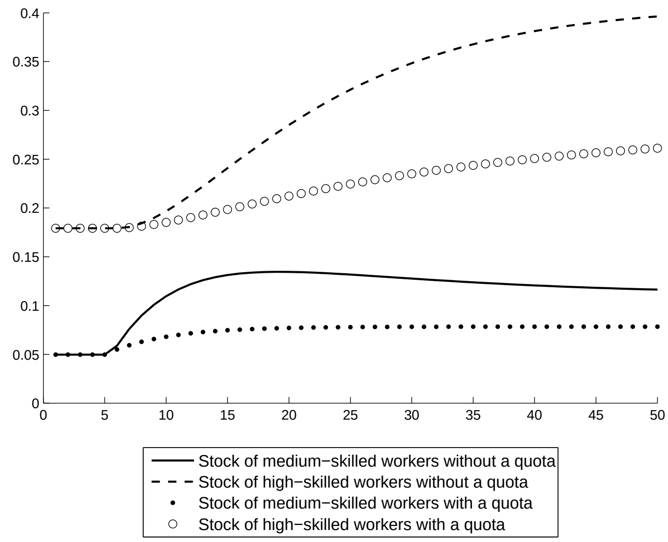
Figure 11: Dynamics Following Demand Shocks: Returns to College Education



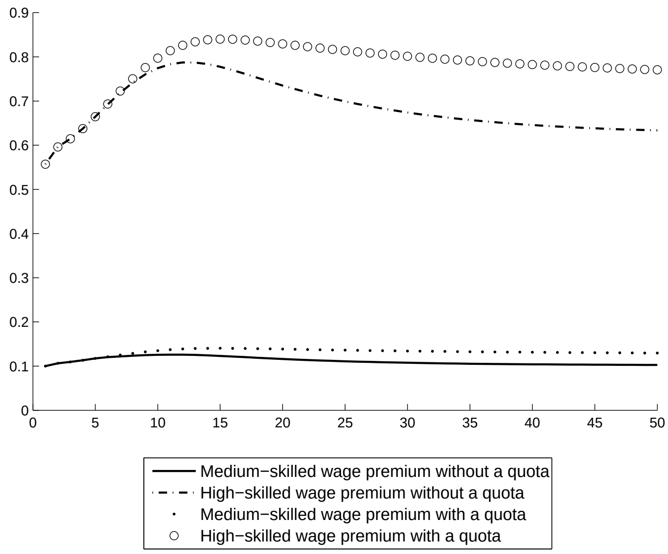
Note: The expected lifetime college premium v in period t is the expected lifetime return to college education for the cohort that is at the college-going age (age 18) in period t. We calculate it using equation 9, which is a linear combination of future wages of high- and medium-skilled workers weighted by the probability of being that type of worker, net the unskilled wage (1) and tuition cost of education (C).

Figure 12: Dynamics Following Demand Shocks:
With vs. Without a Quota on College Enrollment

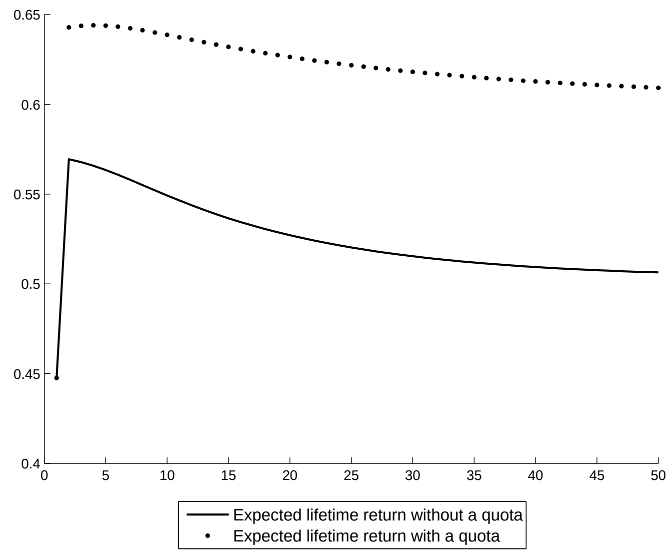
(a) Stock of Medium- and High-skilled Workers



(b) Wage Dynamics



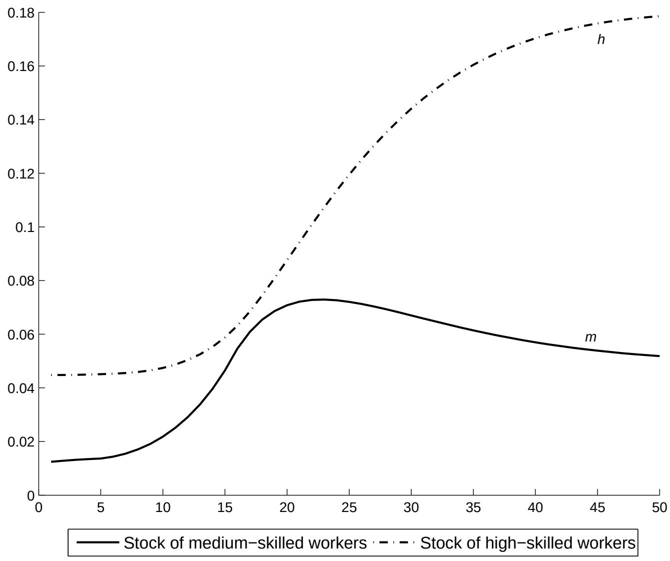
(c) Lifetime Returns to College Education



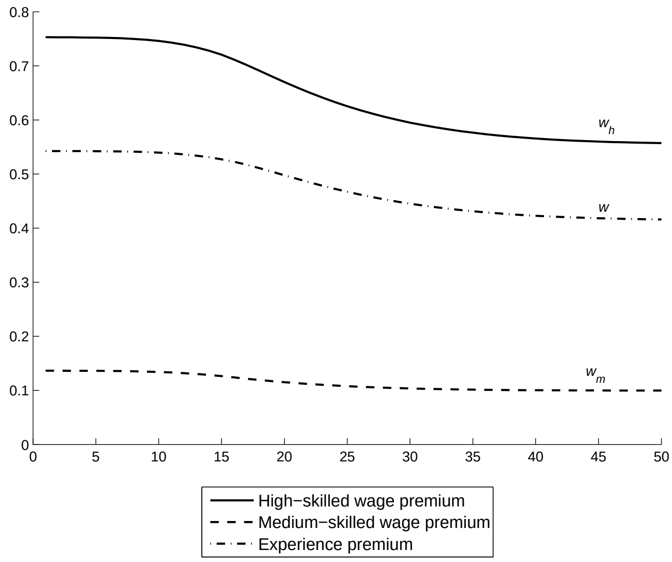
Note: We set a very tight (small) quota, which requires enrollment to be 70% lower than the long-term steady state level, and solve the equilibrium numerically. The expected lifetime college premium v in period t is the expected lifetime return to college education for the cohort who is at the college-going age (age 18) in period t. We calculate it using equation 9, which is a linear combination of future wages of high- and medium-skilled workers weighted by the probability of being that type of worker, net the unskilled wage (1) and tuition (C).

Figure 13: Dynamics Following only Supply Shocks (Increasing Quota)

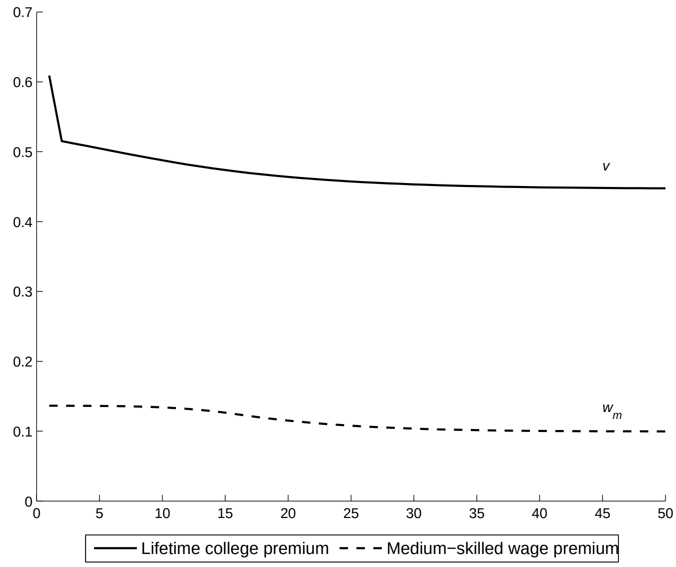
(a) Stock of Medium- and High-skilled Workers



(b) Wage Dynamics

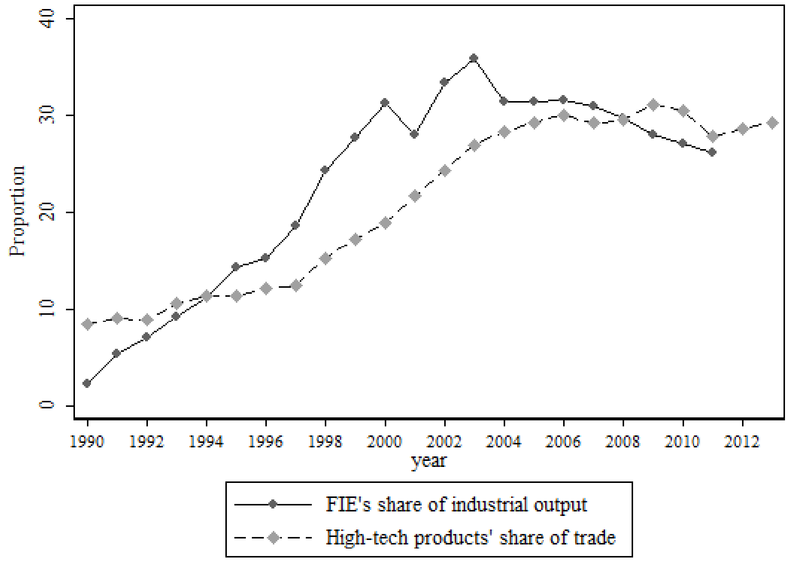


(c) Returns to College Education



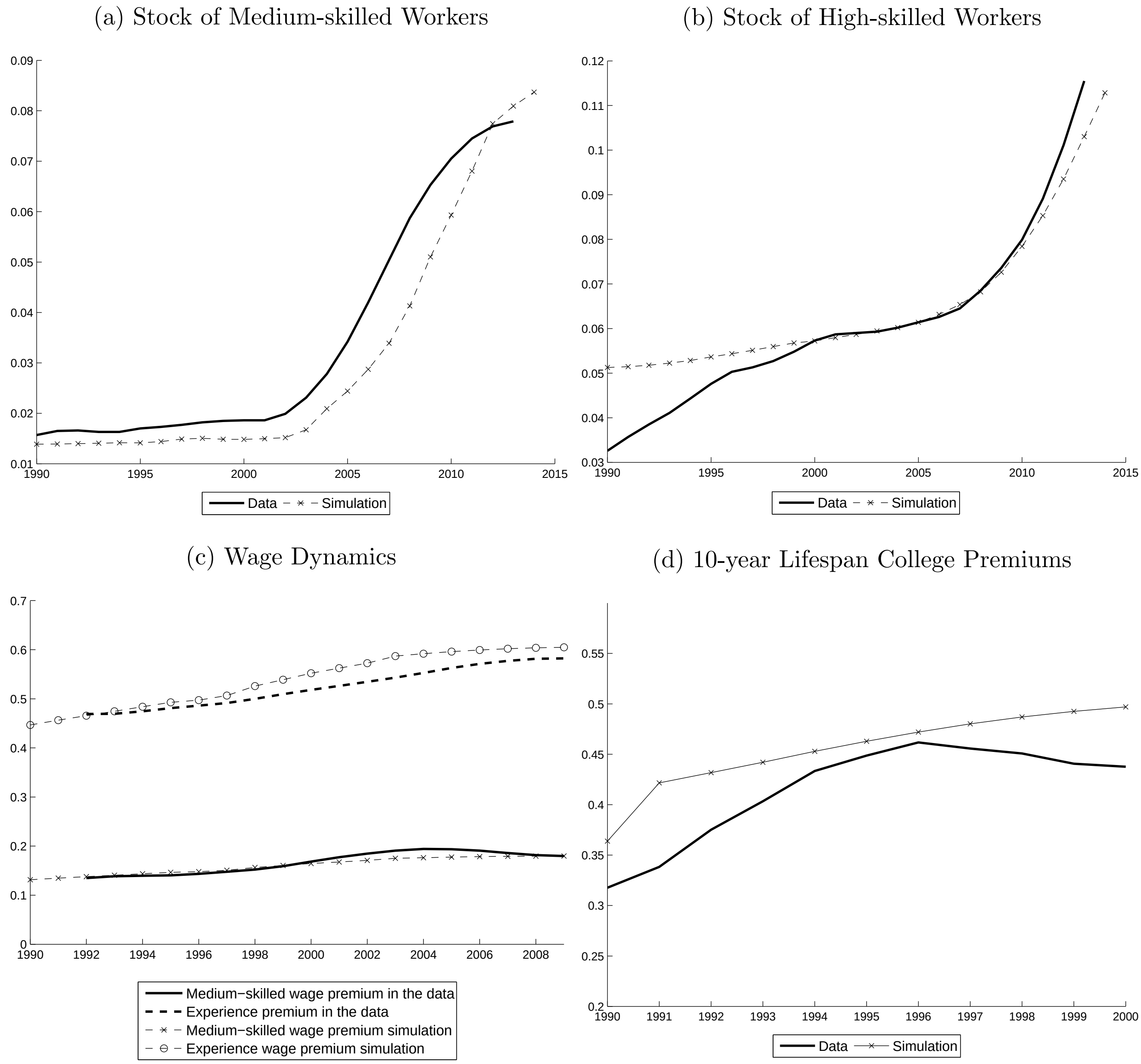
Note: We assume that the stock of college graduates is 25% of the steady state level of the stock in the absence of a constraint. The quota on college freshman enrollment is also 25% of the steady state freshman enrollment level. We allow the quota to grow by 18% a year. The expected lifetime return to college v in period t is the expected lifetime return to college education for the cohort that is at the college-going age (age 18) in period t. We calculate it by equation 9, which is a linear combination of the future wages of high- and medium-skilled workers weighted by the probability of being that type of worker, net the unskilled wage (1) and tuition (C).

Figure 14: The Output Share of Foreign Invested Enterprises
and the Share of High-tech Products in Trade



Note: China Commerce Yearbooks and Chinese Statistical Yearbooks 1990-2013.

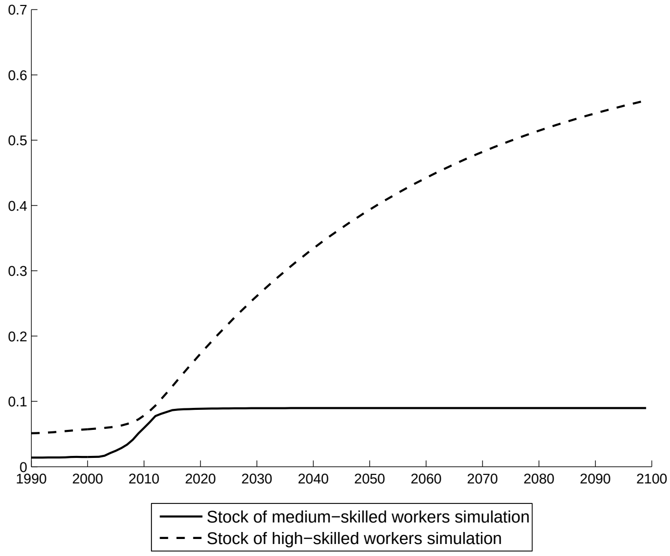
Figure 15: Simulated Results vs. Data



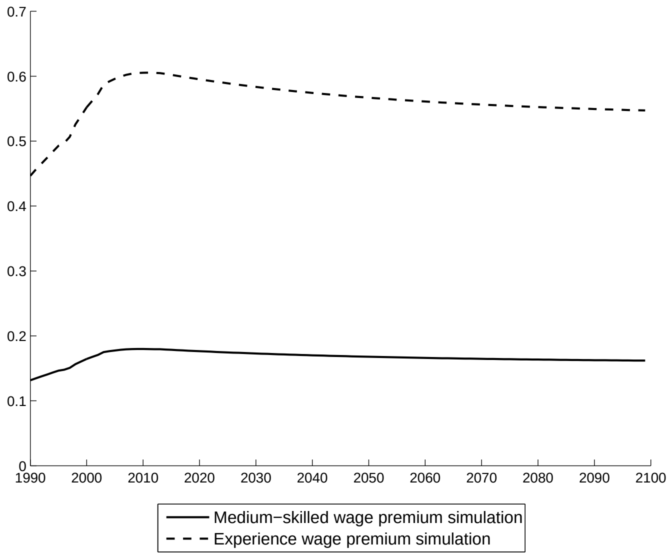
Note: We use the simple average of the output share of foreign invested enterprises and the share of high-tech products in trade to measure demand shocks. We let the college enrollment quota increase at the same speed as college enrollment in each year. The number of local firms to increase at the growth rate of industrial outputs. The labor force grows at the same rate as the urban labor force. Tuition grow at the rate we observe in the data. We assume that all these parameters stabilize in 2013. The time series of these parameters are shown in Table A6. The expected 10-year lifespan college premium v in period t is the expected lifetime return for the cohort that is at the college-going age (age 18) in period t. We calculate it by equation 9, which is a linear combination of the future wages of high- and medium-skilled workers weighted by the probability of being that type of worker, net the unskilled wage (1) and tuition (C).

Figure 16: Long-run Equilibrium

(a) Stock of Medium- and High-skilled workers



(b) Wage Dynamics



(c) 10-year Lifespan College Premiums

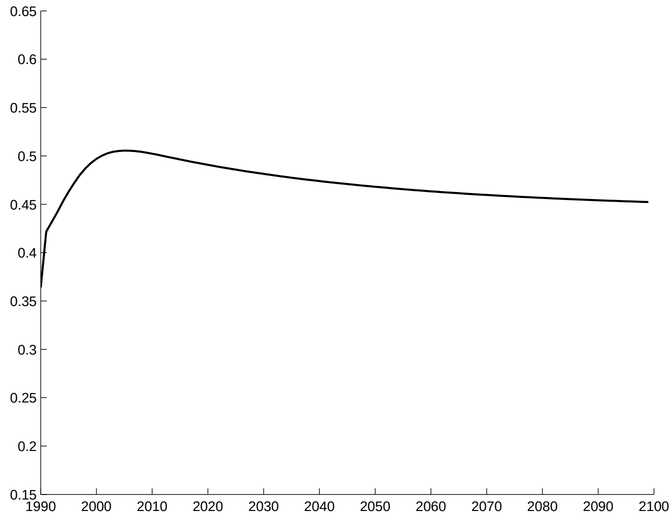
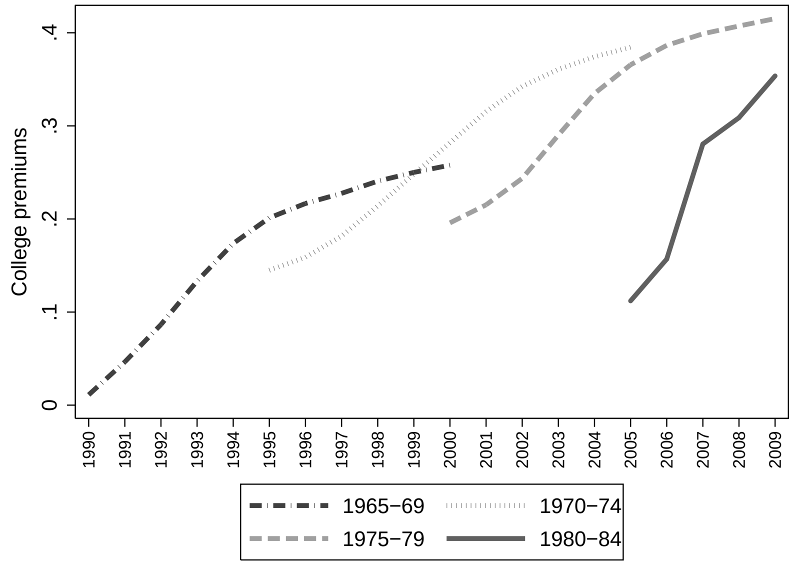


Figure A1: Age Profiles of College Premiums for Different Cohorts



Note: The four cohorts are individuals born in 1965-1969, 1970-1974, 1975-1979, and 1980-1984. College premiums are estimated by cross-sectional regressions for each cohort for each year, with log wage as the dependent variable, and the college dummy, gender, and province fixed effects as independent variables.

Table A1: Summary Statistics of Workers in Urban China
(the Urban Household Survey)

Year	Number of Obs. (1)	Years of experience (2)	Years of schooling (3)	Age (4)	Wage (5)	Female (6)	College graduate (7)	High school graduate (8)
1990	26405	17.9	10.9	37.3	4992	0.476	0.14	0.398
1991	26341	17.6	11.1	37	5199	0.475	0.155	0.417
1992	31598	18	11.3	37.5	5959	0.476	0.187	0.426
1993	30581	18.4	11.3	37.9	6370	0.476	0.194	0.43
1994	29854	18.5	11.5	37.8	7063	0.476	0.213	0.44
1995	29588	18.9	11.5	38.2	7452	0.476	0.212	0.446
1996	29503	19.3	11.6	38.6	7637	0.475	0.219	0.448
1997	28961	19.1	11.6	38.6	8527	0.472	0.222	0.446
1998	28442	19.5	11.8	38.9	8921	0.468	0.242	0.45
1999	27682	19.9	11.9	39.4	9721	0.468	0.261	0.452
2000	25718	19.6	12	39.2	10766	0.456	0.292	0.435
2001	25178	20.2	12.1	39.8	11880	0.45	0.294	0.439
2002	62646	19.4	12.2	40	13248	0.449	0.322	0.423
2003	68709	19.6	12.3	40.2	14784	0.448	0.33	0.423
2004	70251	19.9	12.4	40.6	16327	0.446	0.351	0.413
2005	73534	19.5	12.5	40.4	18423	0.44	0.383	0.388
2006	75717	19.9	12.6	40.8	20143	0.442	0.398	0.384
2007	80545	20.3	12.7	40.8	22102	0.442	0.417	0.376
2008	86054	19	12.7	39.9	24772	0.438	0.418	0.345
2009	86446	19.5	12.8	40.5	27267	0.441	0.434	0.343

Note: Wages (in 2009 RMB prices) include salary, bonus, commissions, tips, pecuniary subsidies, and overtime pay. Workers are aged 16-60.

Table A2: College Wage Premiums by Age or Years of Experience

	College premiums (college vs. high school)											College premiums (college vs. all others)		
	Age groups							Experience groups				Age groups		
	16-60	21-25	26-40	26-50	31-40	41-50	51-60	0-4	5-20	5-30	11-20	16-60	21-25	26-40
Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1990	0.089	-0.063	0.112	0.128	0.103	0.088	0.096	0.064	0.122	0.158	0.108	0.143	-0.008	0.111
1991	0.101	0.056	0.098	0.107	0.113	0.078	0.081	0.138	0.107	0.135	0.110	0.151	0.087	0.111
1992	0.135	0.054	0.127	0.136	0.132	0.118	0.104	0.173	0.140	0.165	0.135	0.186	0.080	0.151
1993	0.143	0.168	0.117	0.131	0.122	0.119	0.104	0.247	0.139	0.163	0.116	0.202	0.211	0.157
1994	0.200	0.177	0.176	0.180	0.176	0.168	0.172	0.306	0.197	0.210	0.173	0.275	0.245	0.229
1995	0.179	0.129	0.150	0.152	0.150	0.144	0.183	0.222	0.184	0.185	0.152	0.246	0.187	0.195
1996	0.189	0.173	0.174	0.161	0.171	0.135	0.165	0.243	0.200	0.186	0.174	0.255	0.210	0.221
1997	0.233	0.150	0.236	0.221	0.239	0.202	0.182	0.281	0.243	0.225	0.238	0.312	0.208	0.298
1998	0.254	0.102	0.259	0.242	0.272	0.240	0.182	0.218	0.279	0.251	0.287	0.340	0.168	0.316
1999	0.289	0.107	0.288	0.276	0.285	0.289	0.259	0.209	0.318	0.291	0.301	0.383	0.180	0.357
2000	0.331	0.212	0.311	0.306	0.317	0.341	0.304	0.289	0.341	0.318	0.333	0.429	0.267	0.396
2001	0.353	0.154	0.346	0.337	0.352	0.367	0.292	0.304	0.356	0.336	0.351	0.451	0.209	0.426
2002	0.370	0.224	0.357	0.352	0.357	0.394	0.312	0.373	0.371	0.348	0.367	0.457	0.263	0.439
2003	0.387	0.217	0.374	0.371	0.383	0.403	0.328	0.372	0.390	0.369	0.395	0.472	0.259	0.453
2004	0.411	0.234	0.401	0.401	0.411	0.431	0.341	0.392	0.412	0.393	0.415	0.492	0.279	0.472
2005	0.424	0.168	0.398	0.417	0.401	0.466	0.369	0.378	0.408	0.407	0.406	0.511	0.224	0.482
2006	0.404	0.139	0.379	0.392	0.386	0.430	0.373	0.341	0.390	0.387	0.387	0.485	0.194	0.457
2007	0.432	0.212	0.383	0.410	0.395	0.468	0.425	0.376	0.406	0.409	0.402	0.513	0.260	0.466
2008	0.444	0.207	0.397	0.425	0.419	0.491	0.461	0.382	0.414	0.422	0.410	0.529	0.257	0.479
2009	0.441	0.152	0.396	0.422	0.415	0.481	0.460	0.372	0.410	0.419	0.409	0.521	0.201	0.471

Notes: The college premiums are estimated by cross-sectional regressions for each age group or experience group for each year with the following independent variables: a college dummy, gender, and province fixed effects. Columns 1-11 use the sample of individuals with at least a high school degree. The years of experience variable is defined as the difference between the current year and the year in which the individual joined the labor market.

Table A3: Estimated Experience Premiums for Different Age Groups

	College					High-school				
	26-40	26-50	31-40	41-50	51-60	26-40	26-50	31-40	41-50	51-60
Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1990	0.578	0.681	0.635	0.785	0.884	0.393	0.480	0.453	0.649	0.707
1991	0.454	0.532	0.518	0.767	0.860	0.411	0.474	0.453	0.581	0.695
1992	0.467	0.542	0.513	0.626	0.705	0.404	0.466	0.438	0.517	0.624
1993	0.359	0.439	0.398	0.514	0.527	0.418	0.479	0.448	0.528	0.639
1994	0.370	0.434	0.409	0.497	0.592	0.376	0.438	0.410	0.472	0.600
1995	0.394	0.460	0.430	0.553	0.657	0.379	0.442	0.409	0.444	0.542
1996	0.391	0.443	0.427	0.475	0.656	0.382	0.448	0.416	0.530	0.643
1997	0.455	0.507	0.496	0.561	0.638	0.369	0.430	0.403	0.546	0.646
1998	0.512	0.559	0.575	0.565	0.624	0.336	0.405	0.378	0.444	0.590
1999	0.498	0.554	0.534	0.641	0.743	0.308	0.367	0.339	0.412	0.530
2000	0.429	0.475	0.480	0.581	0.675	0.301	0.355	0.339	0.432	0.579
2001	0.442	0.483	0.494	0.558	0.680	0.248	0.300	0.285	0.303	0.487
2002	0.489	0.542	0.537	0.639	0.700	0.345	0.392	0.389	0.480	0.658
2003	0.485	0.537	0.543	0.632	0.712	0.314	0.360	0.357	0.449	0.629
2004	0.472	0.525	0.528	0.617	0.698	0.288	0.333	0.330	0.376	0.572
2005	0.548	0.608	0.593	0.673	0.780	0.314	0.344	0.353	0.327	0.527
2006	0.568	0.627	0.622	0.687	0.802	0.319	0.361	0.357	0.364	0.513
2007	0.492	0.557	0.542	0.604	0.715	0.332	0.367	0.363	0.363	0.487
2008	0.495	0.550	0.553	0.631	0.767	0.302	0.327	0.333	0.334	0.454
2009	0.538	0.602	0.593	0.696	0.799	0.295	0.329	0.327	0.390	0.482

Notes: The experience premiums are estimated by cross-sectional regressions for college graduates (columns 1-5) and high school graduates (columns 6-10) for each year with the following independent variables: the experience dummy, gender, and province fixed effect. The experience dummy for the specific age group in each column is defined such that it equals 1 if an individual falls in that age group (e.g., 26-40 in column 1) and 0 if aged 21-25.

Table A4: 10-Year Lifespan vs. Cross-Sectional College Premiums

	College premiums for age 21-25		Cross-sectional average college premiums		10-year lifespan college premiums	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
	(1)	(2)	(3)	(4)	(5)	(6)
1990	-0.062	(0.038)	0.089***	(0.0057)	0.292***	(0.023)
1991	0.056	(0.040)	0.101***	(0.0084)	0.355***	(0.024)
1992	0.054	(0.038)	0.135***	(0.0087)	0.359***	(0.021)
1993	0.168***	(0.035)	0.143***	(0.0089)	0.420***	(0.023)
1994	0.177***	(0.036)	0.200***	(0.0099)	0.423***	(0.029)
1995	0.129**	(0.047)	0.179***	(0.0093)	0.462***	(0.029)
1996	0.173***	(0.035)	0.189***	(0.010)	0.454***	(0.024)
1997	0.150***	(0.043)	0.233***	(0.010)	0.473***	(0.027)
1998	0.102**	(0.043)	0.254***	(0.011)	0.432***	(0.032)
1999	0.107**	(0.046)	0.289***	(0.011)	0.458***	(0.029)
2000	0.212***	(0.036)	0.331***	(0.015)	0.424***	(0.023)

Notes: College premiums in columns 1-4 are estimated using Mincer regressions for each year. Columns 1 and 2 use the sample of workers aged 21-25. The 10-year lifespan college premium in columns 5 and 6 are estimated for each cohort. Specifically, the 10-year college premium for year t represents the 10-year premium for cohort t, where t is the year a college graduate cohort enters the labor market (age 22). Take year 1990 as an example. The birth cohort of 1968, if going to college, enters the labor market in 1990. We take those born in 1968 (both college graduates and high school graduates) from the samples covering the period 1990-1999. Using this pooled sample, we run a Mincer regression, which generates the average college premium for the first 10 years after graduating from college, specific for the entry cohort of 1990 or the cohort born in 1968.

Table A5: Simulation Parameter Values

Symbols	Description	Value used in simulation	Reference or justification	Alternative values
σ	Elasticity of demand	2.54	Kee, Nicita, Olarreag (2008)	1.1; 7.1
n_d	Number of local firms	10	A normalization	
n_f	Number of high-productivity firms	Increases from 0 to 5; the arrival follows a normal distribution $N(7.1, 4.1)$	The distribution fits best (nonlinear least squares model) on the increase in the proportion of industrial outputs produced by foreign firms.	$N(8.9, 6.8)$
δ	Productivity of firms; productivity gap between the high and medium skilled workers	Uniform distributed on [1,1.6]	The distribution of δ and the value of α imply that a college premium of 13% and an experience premium of 46% in the initial steady state, close to the real values (13% and 47%) in 1992-1994.	[1,1.5]; [1,2]
Δ	Productivity of high-productivity firms	1.6	Upper bound of the distribution of δ	1.5; 2
α	δ^{α} is the productivity gap between the medium and low skilled workers	0.3	See above	0.2; 0.4
μ	Probability of staying in the labor force	0.96	Same as the annual labor turnover rate from 1990 to 2013.	
η	Probability of the medium type (m) becoming the high-type (h)	0.15	A worker is expected to become experienced in 6.7 years; The proportion of inexperienced college graduates among all college graduates $(= (1-\mu)/(\mu\eta + 1 - \mu))$ is 22% in equilibrium, which is close to the level in the data in early 1980.	0.1; 0.2
C	College tuition cost	0.01	The ratio of amortized 4-year college tuition to the wage of low-skilled (without a college degree) urban workers in 1990.	Varies year by year, using numbers in the data.
$G(.)$	Supply function of college graduates; distribution of effort cost of education	Normal Distribution ($\mu = 0.4$, $\sigma = 0.1$)	The enrollment rate would be 72% when the college premium is 0.46 and 80% when the college premium is 0.48, which are consistent with the data.	$\mu = 0.3, \sigma = 0.2$

Table A6: Time Series Used for Simulation

Year	The proportion of industrial output by foreign firms (1)	The proportion of high-tech products in trade (2)	Real GDP index (1990=10) (3)	The growth rate of college enrollment quota (4)	Amortized college tuition as a % of wage (5)	The proportion of new entrants (age 18) in the labor force (18-60) (6)
1990	0.023	0.084	10.0	0.020	0.005	0.039
1991	0.053	0.091	10.6	0.018	0.005	0.036
1992	0.071	0.089	12.7	0.217	0.009	0.033
1993	0.091	0.105	15.4	0.225	0.020	0.030
1994	0.113	0.114	17.9	-0.026	0.021	0.028
1995	0.143	0.114	20.1	0.029	0.022	0.024
1996	0.151	0.121	19.6	0.043	0.026	0.025
1997	0.186	0.124	21.3	0.035	0.028	0.025
1998	0.243	0.153	21.8	0.084	0.031	0.024
1999	0.278	0.173	23.8	0.429	0.041	0.025
2000	0.313	0.189	27.1	0.425	0.027	0.030
2001	0.280	0.217	33.6	0.216	0.045	0.025
2002	0.334	0.243	34.8	0.195	0.048	0.025
2003	0.359	0.270	42.4	0.193	0.045	0.025
2004	0.314	0.283	57.8	0.170	0.043	0.028
2005	0.314	0.293	73.5	0.128	0.041	0.031
2006	0.315	0.300	88.2	0.082	0.036	0.029
2007	0.309	0.292	104.2	0.036	0.043	0.031
2008	0.297	0.295	116.4	0.074	0.042	0.032
2009	0.280	0.311	124.9	0.052	0.039	0.024
2010	0.271	0.304	150.8	0.035		0.023
2011	0.261	0.278	167.8	0.030		0.023
2012		0.287		0.011		0.021
2013		0.293		0.016		0.020

Notes: For post-2013 years (some measures start missing earlier), we use the the number in the most recent year that is available.