Changes in China's Wage Structure†

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Abstract

Using a national sample of Urban Household Surveys, we document several profound changes in China's wage structure during a period of rapid economic growth. Between 1992 and 2007, the average real wage increased by 202 percent, accompanied by a sharp rise in wage inequality. Decomposition analysis reveals 80 percent of this wage growth to be attributable to higher pay for basic labor, rising returns to human capital, and increases in the state-sector wage premium. By employing an aggregate production function framework, we account for the sources of wage growth and wage inequality amid fast economic growth and transition. We find capital accumulation, skill-biased technological change, and rural-urban migration to be the major forces behind the evolving wage structure in urban China.

Keywords: wage growth, wage premium, capital accumulation, technological change, rural-urban migration, China

JEL code: J31, E24, O40

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1 Introduction

Over the past two decades, China's gross domestic product (GDP) has grown by more than 10 percent per year, turning the country into the world's fastest growing economy.[1] Against this backdrop of rapid economic growth, this paper documents the profound changes in China's wage structure using the unique national sample of Urban Household Surveys (UHS). We track the rising wage of unskilled workers and examine changes in wage premiums by education, gender, ownership type, industry, and geographic region. Further investigations are conducted to identify the sources of wage growth and wage inequality. Episodes of extraordinary economic growth also occurred in other East Asian economies, such as Japan in the 1950s and 1960s and South Korea in the 1970s and 1980s.[2] However, little is known about the structural changes in wages that took place during these episodes. The current study is intended to fill this void in the literature by illuminating the wage trends and mechanisms of wage determination during China's rapid development.

Between 1992 and 2007, the average real wage in urban China increased by 202 percent.[3] The wage gains in this period consist not only of growth in the base wage for unskilled workers but also in wage premiums. Although wages for workers with a middle school education grew by an extraordinary 135 percent, those for college-educated workers saw an even more phenomenal rise, increasing more than 240 percent, thus resulting in a sharp rise in the skill premium (see Table 1). The wage premium for state employees also achieved remarkable gains. The 260-percent wage growth enjoyed by these employees far surpassed that of their counterparts in collective, private, and foreign firms. Another significant wage trend during the 1992-2007 period was a significant increase in the gender earnings gap. Although some of our analyses provide novel observations on the Chinese labor market, others corroborate the results of existing studies covering select regions with a consistent national sample of workers over an extended period.[4] An important goal of this paper is

[1]See Song, Storesletten and Zilibotti (2011) for a recent study on the sources and mechanisms of China's phenomenal economic growth over the past two decades.

[2]In the 1980s, real per capita income grew by 64 percent in Hong Kong, 122 percent in the Republic of Korea, 78 percent in Singapore, and 88 percent in Taiwan (Fields, 1994). Real wages in Korea nearly tripled in the 1971–1986 period (Kim and Topel, 1995), and they also grew rapidly in postwar Japan, climbing by 180 percent between 1952 and 1965.

[3]Unless otherwise noted, all wage and employment statistics cited in this paper are based on data from the national UHS sample collected by China's National Bureau of Statistics (NBS), a dataset not previously available to researchers. Wages are defined as annual labor earnings, and we employ the two terms interchangeably in this paper. All references to wages are in real terms and measured in 2007 yuan. Section 3 and the appendix provide detailed descriptions of the data.

[4]For instance, our finding of a continued wage hike for unskilled labor challenges the popular view that the Lewis turning point has only just arrived in China, a view that posits a recent, sudden increase in the basic wage for unskilled labor after a long period of wage stagnation. The rising wage premium for the state sector and the long-term persistent increase in the gender earnings gap also lack documentation in the

to bring these findings to the fore and explore the forces of wage determination in a unified framework.

Our subsequent decomposition analysis identifies three main sources of wage growth in China: (a) a higher wage for basic labor, (b) increasing returns to human capital, and (c) a rise in the state-sector wage premium. Together, these three factors account for 80 percent of the wage growth observed during the 16-year period under study. Other factors—such as the rise in labor quality, the gender composition of the labor force, and labor reallocations across regions and industries—make only minor contributions.

To account for the driving forces behind China's wage growth, we develop a static two-sector model employing an aggregate production function framework. The model specifies skilled and unskilled labor as imperfect substitutes employed in the state or private sector, and posits that skills complement capital. Incorporated into the model are key features of the Chinese economy, including capital accumulation, skill-biased technological change (SBTC) through research and development (R&D) expenditures and foreign direct investment (FDI), economic restructuring that has lessened the protection of state employment, and changes in the relative skill supply. Taking these potential driving forces of wage trends as given, we apply market equilibrium conditions to solve the model for the base wage, schooling premium, and state-sector wage premium. Supplementing the UHS data with our own collection of aggregate data across ownership sectors, we estimate the model parameters structurally. Subsequently, through counterfactual experiments, we find capital accumulation and SBTC to be the key contributors to the rise in the base wage and skill premium. The restructuring of the state sector has also played an essential role in raising the state-sector wage premium. This empirical framework also enables us to assess the labor market consequences of massive rural-to-urban migration in China. We find that the inflow of rural labor to cities has mitigated the upward pressure on the wage of low-skilled labor, thus contributing significantly to the recent increase in skill premium. Overall, our estimated model accounts well for the evolving wage structure in China.

There is a vast body of literature on wage structure changes in both developed and developing countries.[5] This research has focused largely on earnings inequality because, relative to the substantial earnings divergence, wage growth has been modest in many economies. However, as rising wages is a key feature of an emerging economy, we jointly examine the determinants of wage growth and wage inequality. Our research builds upon two aspects of the existing literature. First, we closely follow the supply-demand-institution framework (e.g.,

existing literature.

[5] See Katz and Autor (1999) for a comprehensive review of the literature on the wage structure in advanced economies, and Goldberg and Pavcnik (2007) for a discussion of income inequality in developing countries with a focus on the effects of globalization.

Bound and Johnson, 1992; Katz and Murphy, 1992; Juhn, Murphy and Pierce, 1993) and apply the key wage determinants posited in the literature to investigate China's changing labor market. Second, the specification of aggregate production functions with capital-skill complementarity highlighted by Fallon and Layard (1975) and Krusell et al. (2000) is central to both our model construction and empirical estimation.[6]

This paper also contributes to the burgeoning literature on labor market developments in China. Existing research in this area typically focuses on the investigation of one aspect of the labor market in certain regions during specific survey periods.[7] Instead, we conduct a comprehensive assessment of the nationwide evolution of the wage structure over an extended period. Our coherent framework allows us to demonstrate that the changes in several components of the wage structure are inter-related, that is, they are influenced by a common set of forces arising from economic transition and rapid growth. Our empirical findings reveal a multifaceted process of economic development through the lens of the labor market.

The remainder of the paper proceeds as follows. Section 2 outlines the labor market conditions in China, describes the UHS data, documents the major trends in wages and employment, and decomposes the sources of wage growth. Section 3 develops and estimates a two-sector labor market model to investigate the driving forces behind rising wages and widening wage inequality in China, and Section 4 concludes the paper.

2 Wage and Employment Structural Changes

2.1 Labor Market Conditions

China's economic reforms began in 1978. In 1992, after a period of economic and political instability, then Chinese leader Deng Xiaoping took his famous "southern tour" during which he reasserted the continuity of these reforms. Five years later, the Chinese government's announcement of a massive privatization program involving the sale, merger, or closure of the vast majority of inefficient state-owned enterprises (SOEs) took the country a step closer

[6] We also draw on useful features from other studies that estimate lifecycle decisions in a dynamic general equilibrium framework and account for the effects of demand and supply factors on wage inequality (e.g., Heckman, Lochner and Taber, 1998; Lee and Wolpin, 2010).

[7] Important topics already studied include wage differentials between state and non-state sectors, the consequences of enterprise restructuring, wage discrimination, consumption and residual wage inequality, as well as returns to education. See Zhao (2002), Giles, Park and Zhang (2005), Gustafsson and Li (2000), Meng and Kidd (1997), Fleisher and Wang (2005), Yang (2005), and Zhang et al. (2005) for studies covering these topics. In particular, Cai, Chen and Zhou (2010) analyze the 1992 to 2003 UHS national sample, but they focus on household income and consumption inequality. Xing and Li (2012) examine wage inequality attributable to unobserved worker characteristics, a topic we do not investigate here, but their findings complement our study.

to a fully fledged market economy. The resulting economic restructuring led to a precipitous decline in state employment and concurrent expansion of the private sector. China's accession to the WTO in 2001 was yet another milestone in the country's integration into the world economy that dramatically expanded external demand for Chinese goods. From 1992 to 2007, China's GDP grew by 10.7 percent per year. Against this backdrop of rapid economic growth, labor market conditions in urban China experienced a number of profound changes.

The demand for labor is strongly influenced by the accelerated accumulation of capital stock in China. In the 1992–2007 period, total investment in fixed assets jumped from 0.81 to 13.73 trillion yuan (NBS, 2008).[8] As a result, the capital-output ratio in China increased from 1.36 to 1.72 over this 16-year period (Bai, Hsieh and Qian, 2006). Capital accumulation raises the marginal product of labor. If production technology exhibits capital-skill complementarity, then a rise in capital stock should raise the marginal product of skilled labor more than it raises that of unskilled labor, thus leading to a greater disparity in relative wages.

Technological change is another driving force behind China's evolving wage structure. Advances in technology can be achieved by domestic investments in R&D and by learning new technology from industrialized economies. In China, total R&D expenditures rocketed from 22.4 to 178.4 billion yuan between 1992 and 2007. China also became the second largest recipient of FDI in this period, with utilized investment reaching US$74.8 billion in 2007, up from US$11.0 billion in 1992. FDI is likely to be an important channel for the diffusion of ideas and technologies (e.g., Barrell and Pain, 1997), and thus a source of demand for skilled labor (Feenstra and Hanson, 1997). The upgrading of technologies can be particularly beneficial to highly skilled workers because SBTC has been found to boost their wages relative to their unskilled counterparts.

On the supply side, college enrollment and the number of college graduates has continued to increase since the inception of reforms. Although the rise held steady throughout the 1980s and much of the 1990s, a new policy of nationwide college expansion took effect in 1999. In that year alone, college admissions surged by nearly 50 percent to reach 1.60 million. As a result of this initiative, the number of college graduates jumped more than five-fold in less than a decade: from 0.85 million in 1999 to 4.48 million in 2007 (NBS, 2008). At the same time, urban China experienced an influx of rural migrants. Although China's centrally planned economy greatly restricted labor mobility, rural-urban migration grew rapidly following the series of deregulation measures that began in the late 1980s. Analysis of the 2005 population census reveals that about three-quarters of rural migrants

[8] The lion's share of fixed assets was invested in urban China, accounting for 0.61 and 11.75 trillion yuan, respectively, in the two years.

had an educational attainment of middle school or below (middle school hereafter) in that year. Overall, the educational attainments of the urban workforce increased over the study period.

Along with changes in demand and supply, labor market institutions were likewise transformed. Under the central planning regime, government labor bureaus assigned workers to state and collective enterprises, where they enjoyed secure employment, known as the "iron rice bowl," and wages were determined by a grade system. Labor market reforms made progress toward a market-oriented system with flexible wage determination, employment contracts, and increased job mobility. Since the mid-1980s, urban wage reforms have made it possible for wages to reflect firm profitability and worker productivity. By the early 1990s, skilled workers were already searching for better-paid jobs in the non-state sector, whereas the disguised unemployment of low-skilled labor prevailed in SOEs because of the government's political objective to reduce unemployment and ensure social stability (e.g., Dong and Putterman, 2003). In 1997, however, the mounting losses of SOEs prompted the Chinese government to launch a drastic state-sector restructuring program known as *xiagang* (or "leaving the current position"). The objective was to shut down loss-making SOEs, establish modern forms of corporate governance, and de-link the provision of social services from individual employers. These aggressive reforms led to the layoffs of 40 million workers from the public sector between 1996 and 2002 (e.g., Giles, Park and Zhang, 2005), effectively ending protectionism in state employment. These profound changes in labor market conditions provide a unique opportunity to investigate the major forces behind the determination of the wage structure amid rapid economic growth.

2.2 The Data

The primary data source for this paper is the 16 consecutive years of UHSs conducted by the NBS for the 1992–2007 period.[9] This repeated cross-sectional dataset records the basic socioeconomic conditions of Chinese urban households, including detailed information on employment, earnings and expenditures as well as the demographic characteristics of household members. The survey design of the UHS is similar to that of the Current Population Surveys (CPS) in the U.S. and the information on employment and earnings is comparable to that of the March CPS, which is widely used in the study of the U.S. wage and employment structure. The UHS is the only nationally representative household dataset in China that

[9] Although UHS data are available from 1988, we take 1992 as the starting year for two reasons. First, the survey questionnaires became reasonably consistent and comparable starting in 1992. Second, domestic private firms as well as joint-venture, stockholding, and foreign firms were nearly non-existent between 1988 and 1991, thus making meaningful empirical analysis by ownership type impossible.

encompasses all provinces and contains yearly information dating back to the early 1990s. This is the first study to employ the national UHS sample to analyze the evolution of the Chinese labor market over an extended period of time.[10]

The wage measure that we employ throughout the paper is the average annual wage of representative workers with a strong labor market attachment. Wage income consists of the basic wage, bonuses, subsidies, and other labor-related income from a regular job. We deflate annual wages to 2007 yuan by province-specific urban consumption price indices (CPI).[11] Ideally, we would focus on the weekly or hourly wages of full-time workers for consistency with previous studies of the wage structure (e.g., Bound and Johnson, 1992; Katz and Murphy, 1992; Juhn, Murphy and Pierce, 1993). However, information on working hours is unavailable in the UHS for most of the survey years. Between 2002 and 2006, when working hours were reported for the month prior to the survey, the average number of monthly hours in the sample fluctuated within the narrow range of 180 to 184, thus suggesting that actual working hours held steady over time. Hence, there appear to be limited measurement errors in the annual wage measure due to possible changes in the intensity of labor supply.[12] Our sample for analysis includes all female workers aged 16-55 and male workers aged 16-60 as 55 and 60 are the official retirement ages in China for women and men, respectively. Moreover, consistent with standard studies of the wage structure, we exclude from our sample business employers, self-employed individuals, farm workers, retirees, students, those re-employed after retirement, and workers whose wages are less than one half the minimum wage.[13] The resultant sample contains 655,372 individuals in the 16 years of repeated cross-sectional data. In the 1992-2001 period, the annual sample size ranges from 22,418 to 30,306 workers. After 2002, it increases to more than 62,206 per year.

The UHS adopts a framework of the stratified random sampling of urban households, and this survey method has remained consistent over the years. However, we note two

[10] The NBS has various regulations restricting data access. The Chinese University of Hong Kong enjoys a long-standing collaborative relationship with the NBS and was able to acquire UHS data for much of the 1990s. We were able to expand this data usage to all provinces and up to 2007 for this project.

[11] CPI have slightly higher values than the GDP deflator. When we use the province-specific GDP deflator to deflate wage income, the real wage growth rate between 1992 and 2007 increases by around 15 percent, but the patterns of the wage structure change remain the same.

[12] To track changes in working hours over time, we also examined data from China Health and Nutrition Surveys (CHNS) for select years between 1991 and 2006. Hours of work remained rather steady during this period, except for a noticeable decline in weekly hours between 1993 and 1997. This decline was mostly driven by the fact that China switched from the arrangement of six working days per week to five days per week in 1995. None of the changes should systematically affect the rising skill premiums (or gender gap) documented in this paper. See the not-for-publication Appendix for more detailed facts and discussions on changes in working hours.

[13] As a result, 8.6 percent of the original sample are excluded from our analysis, comprising 6.1 percent of the individuals who are either business employers or self-employed, 0.9 percent of farm workers, and 1.6 percent of workers who earn less than half of the minimum wage.

data caveats that are addressed carefully in subsequent analyses. First, prior to 2002, the UHS sampled only households with official urban household registration status (*hukou*), thus excluding rural migrants without legal registration, who are considered the "floating population" in China (e.g., Chan and Zhang, 1999). Although UHS coverage was expanded in 2002 to include all households with a residential address in an urban area, regardless of registration status, rural-to-urban migrant workers remain under-represented because many of them live on the periphery of cities, in employer-provided dormitories, or in their workplaces such as construction sites. In Section 3, in which we perform empirical estimation of wage determination, we impute the size of the rural-to-urban migrant workforce and treat these individuals as part of the aggregate urban labor supply. Second, UHS data are known to over-represent workers from state and collective enterprises whose survey response rates are systematically higher than those of workers employed in private sector firms. We deploy an elaborate re-sampling scheme that adjusts the sample distribution of workers by ownership type to the more reliable figures of national worker distributions based on firm-level surveys. Appendix A provides detailed descriptions of the UHS sample restrictions, data adjustments, and variable definitions.

2.3 Trends in Wages and Employment

Table 1 describes the structural changes in China's wages and employment between the first and last years of the study period, 1992 and 2007. The most prominent change is that the average real wage increased by 201.9 percent, from 6,193 to 18,695 yuan, which translates to an annual growth rate of 7.6 percent over this 16-year period. Other striking labor market trends also emerge from the table. We first place emphasis on documenting employment changes, followed by more elaborate analysis of the evolving wage structure.

The top parts of the table show changes in the real wage and employment composition by education level and sex. For empirical analysis, "college workers" are defined as individuals with all kinds of post-secondary education, including those who attended formal colleges and universities (with and without obtaining a degree), as well as those who attended specialized two-year or three-year colleges (with and without a successful graduation) or received post-secondary education from college-equivalent training programs (with and without obtaining a diploma). As such, our definition of college workers is an inclusive classification.[14] From 1992 to 2007, the employment share made up of college workers rose from 16.7 to 33.6 percent, more than doubling in 16 years, whereas that of workers with a middle school education

[14]This definition reflects the fact that the UHS surveys do not contain sufficient information to separate college graduates from those who dropped out or to differentiate individuals who received various kinds of post-secondary education.

declined by a similar percentage. This upsurge in educational attainment partially reflects the policy effects of expanding college enrollment in the late 1990s. The popularity of obtaining college-equivalence diplomas among adults also contributed to the rise in worker quality.[15] However, despite the large increase in the supply of college workers, their real wage climbed 240 percent, an annual growth rate of 8.5 percent over this period, growing at a much higher rate than that of high school and middle school workers.

Parallel to this rise in educational attainment, women's employment share declined from 49.8 percent in 1992 to 46.1 percent in 2007, with women gradually losing their historical legacy of "holding half of the sky" from the central planning era. Indeed, the rate of labor market participation by women between the prime ages of 16 and 55 dropped by 11 percentage points during the 16-year period under study, declining to 81.2 percent by 2007. Although the real wage soared for both men and women in this period, the growth of men's wage outpaced that of women by 30.6 percentage points, thus widening the initial male-female earnings gap in the early 1990s.

The middle section of Table 1 shows that the wages of state-sector employees grew at a much faster rate (259.8 percent or 8.9 percent annually) than those employed in collective-individual-private enterprises (CIP; 178.2 percent or 7.1 percent annually) and joint-venture, stockholding, and foreign firms (JSF; 99.2 percent or 4.7 percent annually). Coinciding with this steep upward trend in earnings, the employment share of the state sector dropped precipitously from 69.7 percent in 1992 to 32.6 percent in 2007, as a result of ongoing privatization and state-sector restructuring since the late 1990s. The mass exodus of SOE workers was largely absorbed by the growing non-state sectors. In 1992, JSF firms employed only 1.8 percent of the urban workforce, whereas it employed 23.7 percent in 2007. Likewise, the CIP share of this workforce grew over the period from 28.5 to 43.7 percent, with these firms replacing state firms as the largest employer of urban Chinese workers in recent years.

The bottom portions of the table present wage growth and employment distribution by industry and region. Industries are reported in three broad categories: manufacturing, basic services, and advanced services. Although wages grew significantly in all industries, basic services saw the slowest growth while experiencing rapid expansion in employment numbers. Wage growth in both the manufacturing sector, which contributed more than 90 percent of

[15] Three other reasons can also help explain the seemingly high percentage of workers with college education. First, we consider an urban sample, where workers are better educated than the national average. Second, the full-time employees in our sample are usually better educated than an average worker in the labor force also comprising part-time employees. Third, we use a sample of working-age population, who belong to relatively young cohorts. In the not-for-publication Appendix, we use aggregate statistics of college enrollment and the size of the urban labor force to verify the reliability of the educational composition of our household sample. The findings suggest that the educational attainment of workers in the UHS sample is broadly consistent with aggregate statistics.

China's total exports, and the advanced service sector, which employed the most educated labor force, was above the national average. With regard to location, the eastern, coastal region experienced the fastest wage growth during the 16-year period despite having the highest level of initial income. It appears that the large labor inflows into the region helped maintain its wage growth not far over the national average.

Table 1: Changes in Wage and Employment Structures in China, 1992-2007

	Wage level (2007 yuan)		Wage growth* (%)	Employment share (%)		Employment change (%)
Classification of Group	1992	2007	1992-2007	1992	2007	1992-2007
Whole sample	6,193	18,695	201.9 (7.6)	100	100	100
By education						
Middle school and below	5,764	13,547	135.0 (5.9)	41.9	25.7	-16.2
Vocational and high schools	6,135	16,590	170.4 (6.9)	41.4	40.7	-0.7
College and university	7,414	25,208	240.0 (8.5)	16.7	33.6	16.9
By sex						
Male	6,754	21,111	212.6 (7.9)	50.2	53.9	3.7
Female	5,628	15,868	182.0 (7.2)	49.8	46.1	-3.7
By ownership						
Collective, individual and private	5,067	14,096	178.2 (7.1)	28.5	43.7	15.2
State	6,550	23,565	259.8 (8.9)	69.7	32.6	-37.1
Joint-venture, stockholding and foreign	10,291	20,501	99.2 (4.7)	1.8	23.7	21.9
By industry						
Manufacturing	5,910	18,345	210.4 (7.8)	46.5	34.4	-12.1
Basic services	5,950	15,368	158.3 (6.5)	24.9	39.1	14.2
Advanced services	6,864	24,076	250.8 (8.7)	28.6	26.5	-2.1
By region						
Northeast	4,993	14,027	180.9 (7.1)	16.6	12.1	-4.6
Central	5,467	15,874	190.4 (7.4)	23.6	18.1	-5.5
West	6,088	15,945	161.9 (6.6)	26.1	24.1	-2.0
East	7,373	22,497	205.1 (7.7)	33.7	45.8	12.1

Note. *Annual growth rates are in parentheses.

2.4 Changes in Conditional Mean Wages

The wage trends reported in the previous section, which are categorized by one worker characteristic at a time, do not control for changes in wage levels arising from shifts in the educational, gender, firm ownership, industry, or regional composition of the labor force. A more informative documentation of the wage structure would show relative wage changes over time, holding the distribution of worker attributes fixed. Thus, we specify the following regression function.

$$\begin{aligned} \ln w_i^t &= \sum_k \beta_k^t S_{ik}^t + \beta_1^t X_i^t + \beta_2^t X_i^{t^2} + \beta_g^t G_i^t + \\ & \sum_l \beta_l^t O_{il}^t + \sum_m \beta_m^t I_{im}^t + \sum_n \beta_n^t R_{in}^t + \varepsilon_i^t, \end{aligned} \tag{1}$$

where S_{ik}^t are dummy variables for schooling levels with $k \in \{midsch, \ highsch, col\}$ corresponding to middle school, high school and college workers; X_i^t and $X_i^{t^2}$ are potential experience, computed as $min[(age - years\ of\ schooling - 6), (age - 16)]$, and experience squared, respectively; and G_i^t is a dummy variable for male. O_{il}^t are dummy variables for ownership, where $l \in \{state, \ JSF\}$, leaving the CIP sector as the reference group. Similarly, I_{im}^t are dummy variables for industry, where $m \in \{manu, \ advserv\}$ corresponding to the manufacturing and advanced services sectors, leaving basic services as the reference group. R_{in}^t are dummy variables for regions, with $n \in \{central, west, east\}$ and the northeast left as the reference region.

In studies of wage structural change, demographic breakdowns of the data are typically based on sex, education, and experience to control for demographic changes. In China, because of the institutional setting and economic transition, there are large variations in wages by ownership type, industry, and region. These variations are essential to understanding the wage structural change, and we therefore include them as additional classifications to compute the conditional mean wages.[16]

Equation (1) provides conditional mean estimates for the base wage and various wage premiums. In this study, we define the base wage as the log real annual wage of the basic reference group, which refers to female workers with a middle school education and no experience working in a CIP firm in the basic service sector in the low-income northeastern region. Hence, the parameter β_{midsch} provides an estimate for the base wage. Other parameters in the equation correspond to log wage premiums for high school and college workers, being male, working in the state or JSF sectors, employment in the manufacturing or advanced services, and working in the wealthier central, western or eastern regions. These

[16] We could potentially introduce paired interaction terms between the worker characteristics and sector affiliations in Equation (1), but the sample size would then become a constraint. Dividing workers into 216 groups by sex, schooling level, ownership type, industry, and region leaves many cells empty, and close to 40 percent of them have fewer than 30 observations for the years before 2002. When paired interactions are allowed, more than 80 percent of the regression coefficients are statistically insignificant.

wage premiums are computed with the control for experience profiles.[17] We run this conditional mean regression using the UHS cross-sectional data for each of the 16 consecutive years under study.[18]

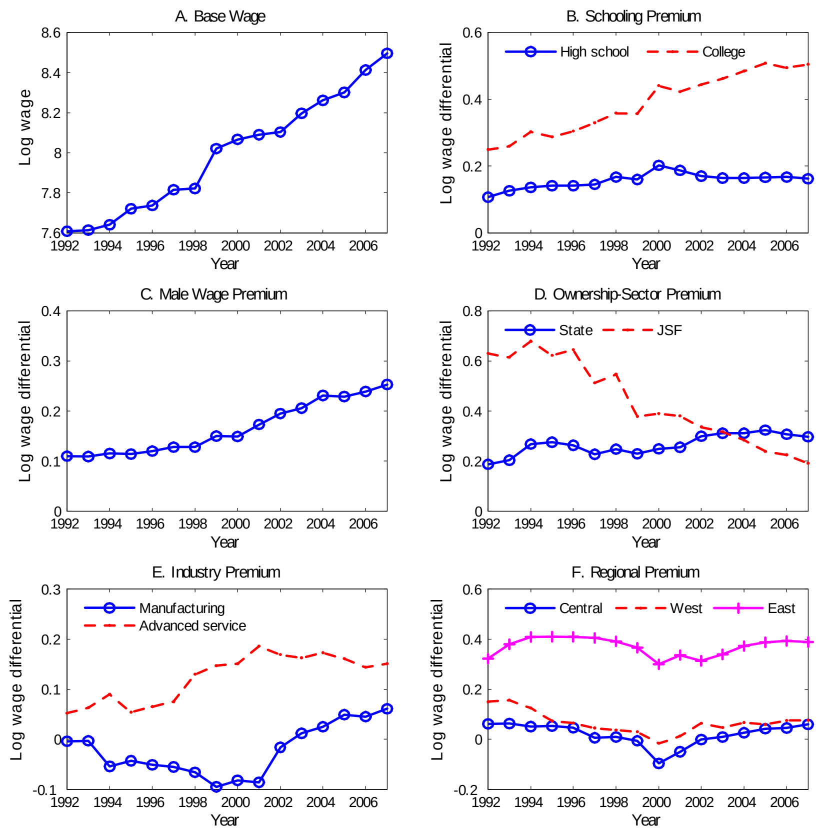

Figure 1: Changes in Conditional Mean Wages, 1992–2007

Figure 1 illustrates the major changes in China's wage structure from 1992 to 2007. Panel A plots the estimated mean log real base wage for each of the 16 years, whereas Panels B–F provide estimates of the wage premiums measured by the log wage differentials between

[17] The choice of reference group reflects the fact that workers in this group received the lowest average earnings in 2007. With this setup, in order to compute the average earnings of other worker groups, we can simply add to the base wage their corresponding wage premiums estimated from the conditional mean regression. Thus, the wage structure can be conveniently analyzed as comprising the base wage and various premiums.

[18] Admittedly, the schooling coefficients in Equation (1) do not disentangle the effect of education on earnings from the influence of unobserved personal traits (e.g., innate ability) that are correlated with schooling. Similarly, the wage premiums revealed through other coefficients may reflect the selection of workers into different sectors. Although these ability and selection biases may not be significant in the Chinese context, given that our estimates are broadly consistent with existing studies that control for such biases, we should interpret the estimated wage premiums as simple conditional mean wages of workers with different personal and work characteristics.

specific worker groups and their respective reference groups. Panel B, for example, presents the log wage differentials between college and middle school workers (the reference group) and between high school and middle school workers, holding constant the distribution of the labor force by sex, ownership, industry, and region. Several striking wage change patterns can be observed, and are summarized in the following.

1. The base wage of raw labor increased persistently and rapidly between 1992 and 2007 (Panel A). Significant wage increases occurred in the 1990s, with the log base wage rising from 7.608 in 1992 to 7.822 in 1998. Over the next 10 years, the growth of the base wage accelerated. The log base wage climbed to 8.496 in 2007, an increase of 67.4 percent in a decade. The continued wage growth for the unskilled labor force after 1992 appears to reject the notion that the Lewis turning point has recently arrived in China.[19]

2. The schooling premium, particularly the college wage premium, rose sharply (Panel B). The log wage differential between college and middle school workers doubled during the 16-year period examined here, rising from 0.25 in 1992 to 0.505 in 2007. The increase in the college wage premium occurred primarily before 2004 and, since then, has plateaued out. The high school wage premium also experienced steady increases in the early part of the period, but has remained stable since 2000. Increasing returns to education is a prominent feature of the Chinese labor market during economic transition. In fact, using the UHS data the estimated rate of return to education in 1992 was just over 40 percent of the U.S. level using CPS data (4.2 percent versus 9.7 percent), based on Mincer earnings regression with controls for schooling, potential experience, and sex. By 2004, returns to education in China had fully converged with the U.S. level (11.0 percent versus. 11.1 percent) and remained comparable thereafter.

3. The wage of men relative to women increased during the study period (Panel C). Although the wages of both men and women saw substantial increases, their log wage differential increased from 0.11 in 1992 to 0.253 in 2007, a level comparable to the U.S. gender earnings gap in recent years (e.g., Mulligan and Rubinstein, 2008). The data show a steady increase in the Chinese male-female earnings gap in the 1992-1998 period, with the disparity rapidly accelerating since the late 1990s, a period that coincides with the mass layoffs that

[19] The classical two-sector Lewis model predicts wage stagnation when a developing country has a pool of surplus rural labor and wage rises when redundant labor is depleted. As Ge and Yang (2011) describes, the media and several empirical studies based on surveys of rural migrants posited the arrival of the Lewis turning point in China in 2003-04 or 2007-08, when wages began to grow faster than in earlier periods. These claims appear to be inconsistent with the national data presented here because steady wage growth had occurred since the early 1990s. On the other hand, despite continuous wage growth between 1992 and 2007, real wage growth (at an annual rate of 7.6 percent) is significantly lower than the growth rate of real GDP per capita (at an annual rate of 9.7 percent), which is consistent with the fact that China has a large pool of rural labor to support industrialization.

took place during the restructuring of the state sector.

4. The wage of the state sector rose relative to that of the CIP and JSF sectors (Panel D). In the 1992-1998 period, the average wage of the JSF sector was about 40 percent and 60 percent higher than that of the state and CIP sectors, respectively. During this period, many better educated SOE workers began to actively search for new jobs in the non-state sector, a phenomenon known as "jumping into the sea" (Li, 1998). However, in the interests of social stability, SOEs were forbidden from laying off redundant workers, who were usually less educated and had less adaptive ability to switch jobs. The SOE restructuring that took place in the late 1990s had dramatic effects on employment and wages. Coinciding with the aforementioned sharp decline in state employment, the wage level of this sector registered impressive gains, eventually surpassing that of the JSF sector in 2004. A new phrase—"coming back to shore"—has been coined to describe the phenomenon of Chinese professionals working in the non-state sector being lured to the state sector through attractive incentives.

5. Wage inequality across basic services, manufacturing and advanced services has widened over time (Panel E). Wages across industries remained clustered in the early 1990s, after which the average wage for the skill-intensive advanced service sector surpassed that of labor-intensive industries in the manufacturing and basic service sectors. By 2007, the average wage in the advanced service sector was about 15.1 percentage points higher than that in the basic service sector. Manufacturing wages declined relative to those of basic services throughout the 1990s, but this trend was reversed beginning in 2001 after China's WTO entry. The log wage differential between the tradable manufacturing sector and the non-tradable basic service sector increased by 0.147 during the 2001-2007 period.

6. The eastern regions in the coastal provinces of China maintained high wage premiums relative to other regions from 1992 to 2007 (Panel F). The wage level of the eastern region was about 30 to 40 percent higher than that of the other three regions, whose wage levels remained rather closely clustered throughout the period. Thanks in part to high wages, the eastern region has attracted a significant inflow of labor, raising its employment share by 12.1 percentage points according to the UHS data.

In addition to the six major wage change patterns, we also find evidence that returns to work experience has been declining in urban China, which confirms the findings of Zhang et al. (2005) covering the trend up to 2001. More specifically, the linear coefficient estimated for experience was approximately 4.5 percent in 1992, decreased continuously to approximately 3 percent in 1999, and then fluctuated around an average of 3.2 percent for the 2000 to 2007 period. The rises in the base wage and wage premiums, along with systematic changes in employment distributions, such as the increase in the proportion of workers with a college education, the decline in female labor force participation, and large labor flows to regions with high earnings, appear to be the major sources of wage growth in China. Assessing the relative contributions of these factors to rising wages is the task to which we now turn.

2.5 Decomposition of Wage Growth

We deploy a decomposition framework that employs the aforementioned conditional mean wages. The earnings function posits that the average wage for a working sample reflects workers' characteristics and the labor market prices of individual characteristics. Consequently, changes in the wage level over time result from two components: changes in the distribution of individual characteristics and changes in the wage premiums for different worker characteristics. Consider a wage equation in the following semi-log functional form.

$$\ln w_i^t = \sum_j \beta_j^t X_{ij}^t + \varepsilon_i^t \ , \tag{2}$$

where w_i^t is the annual wage for individual i in year t, X_{ij}^t is the individual's jth characteristic (e.g., educational attainment or ownership category), β_j^t is the market price for the jth characteristic, and ε_i^t represents a random error.

For wage growth from an initial year τ_0 to an ending year τ, the difference in the log wage over the two years can be written as

$$\overline{\ln w^{\tau}} - \overline{\ln w^{\tau_0}} = \sum_j \widehat{\beta}_j^{\tau} \overline{X}_j^{\tau} - \sum_j \widehat{\beta}_j^{\tau_0} \overline{X}_j^{\tau_0} \ , \tag{3}$$

where $\overline{\ln w^{\tau_0}}$ and $\overline{\ln w^{\tau}}$ are the average log wages for years τ_0 and τ, respectively. $\{\overline{X}_j^{\tau_0}, \overline{X}_j^{\tau}\}$ are the mean values of the jth regressor, and $\{\widehat{\beta}_j^{\tau_0}, \widehat{\beta}_j^{\tau}\}$ are the estimated wage premiums for the corresponding worker characteristics. Rearranging equation (3) gives us

$$\overline{\ln w^{\tau}} - \overline{\ln w^{\tau_0}} = \sum_j [\alpha_j \widehat{\beta}_j^{\tau} + (1-\alpha_j)\widehat{\beta}_j^{\tau_0}](\overline{X}_j^{\tau} - \overline{X}_j^{\tau_0}) + \sum_j [\alpha_j \overline{X}_j^{\tau_0} + (1-\alpha_j)\overline{X}_j^{\tau}](\widehat{\beta}_j^{\tau} - \widehat{\beta}_j^{\tau_0}), \tag{4}$$

where α_js are weights with $0 \leq \alpha_j \leq 1$. This equation decomposes the change in the average of the log wage between the two years into two components. The first term on the right-hand side of equation (4) represents the portion of the log wage change that is due to changes in worker characteristics ($\overline{X}$), and the second is that due to changes in returns to characteristics (β) or changes in the wage structure. Using equation (1), we can obtain βs for the individual years, as shown in Figure 1. Then, by combining them with the sample values of $\overline{X}$, we can decompose the change in the log wage over two specific years into the various components of wage change.

Table 2: Decomposition of Log Wage Differentials between 1992 and 2007

Sources of wage differential	Change in log wage	Contribution to total change (%)
Observed total change	0.989	100.00
Base wage	0.372	37.58
Due to factor returns and sector premiums	0.554	55.96
Schooling and experience	0.352	(35.56)
Gender	0.072	(7.26)
Ownership	0.069	(7.00)
Industry	0.058	(5.87)
Region	0.003	(0.26)
Due to worker characteristics and reallocations	0.064	6.46
Schooling and experience	0.091	(9.17)
Gender	0.009	(0.91)
Ownership	-0.068	(-6.88)
Industry	-0.011	(-1.06)
Region	0.043	(4.32)

Table 2 presents the decomposition results of wage growth from 1992 to 2007. During this period, the average real wage jumped 201.9 percent, corresponding to a 0.989 increase in the log wage differential. Setting the distribution of individual characteristics to the initial level, i.e., $\alpha_j = 1$, the rise in the base wage alone accounts for 37.58 percent of total wage growth. Among the other sources of wage growth, 55.96 percent is attributable to changes in factor returns and sector premiums, and 6.46 percent is attributable to improvements in worker characteristics and reallocations to highly paid sectors. In the first category of changing factor returns and sector premiums, the rise in human capital returns (35.56 percent) and in the ownership premium (7 percent, of which 7.8 percent arises from an increase in the state-sector wage premium and -0.8 percent comes from a decline in the JSF wage premium), are the two major components. Increases in the base wage of unskilled labor, returns to human capital, and state-sector wage premiums constitute the three largest contributors, together accounting for 80 percent of the observed wage growth between 1992 and 2007.[20] Such

[20] This decomposition result is not sensitive to alternate values of α_j. When setting $\alpha_j = 0.5$, as in Reimers (1983), the three factors jointly account for approximately 75 percent of the observed wage growth. When setting $\alpha_j = 0$, i.e., holding the distribution of individual characteristics at the ending level, the three factors still account for 70 percent of the wage growth during the study period.

factors as the rise in labor quality, labor reallocation across ownership type and industry, labor mobility across regions, and changes in wage premiums across industry and region only make relatively minor contributions to the documented wage growth.

3 Accounting for Wage Growth and Wage Inequality

Drawing on the foregoing decomposition results, in this section we investigate the driving forces behind the three major components of wage growth, namely, the rising base wage, increasing returns to education, and the higher wage premium for the state sector.[21] Given the importance of capital accumulation to enhancing labor productivity, and thus to wage determination, we adopt an aggregate production function that employs three factor inputs: capital, skilled labor, and unskilled labor. We follow Krusell et al. (2000) in allowing for capital-skill complementarity, and we expand the existing model: (a) to explore the determination of the base wage, in addition to the skill premium; (b) to develop a two-sector model comprising a state and a private sector, thereby capturing a key feature of China's economic transition; and (c) to construct proxies for SBTC and to incorporate their role in wage determination. We estimate the parameters of the model structurally by matching wages from the model-implied marginal product schedules to observed wages in the data. Hence, the estimation deploys aggregate time-series input-output data by ownership type and the corresponding wage information from the UHS. Our counterfactual analysis reveals both the explicit mechanisms of wage determination and the relative importance of different economic forces in shaping wage changes in China.[22]

[21] As Table 2 shows, the widening gender earnings gap is another significant source of wage growth. We leave this topic for future research, as the study of gender roles and possible discrimination in the labor market is beyond the scope of this paper. Our framework can be applied to address industry/regional premiums, but the main obstacle is that aggregate data on output, employment, and capital stock are not available for sectors categorized based on ownership type, industry, and region.

[22] There are alternative approaches to empirical estimation, which differ in terms of data requirements and emphases. One alternative is to estimate a life-cycle labor supply model under a dynamic general equilibrium framework, similar to Heckman, Lochner, and Taber (1998) and Lee and Wolpin (2010). However, the estimation of this framework requires individual panel data similar to those in the National Longitudinal Survey of Youth (NLSY), which are not available in China. Another alternative is to adopt a regression-based approach along the lines of Katz and Murphy (1992), which treats major occupational categories of gender-education groups among broadly defined industries as the basic unit of analysis. Their study examines approximately 1.4 million U.S. workers, whereas the sample size of the UHS data is too small to implement similar analysis. The lack of Chinese data on industry-level capital stock is an additional limitation.

3.1 Two-Sector Model

Consider a model with a state sector ($j = s$) and a private sector ($j = p$). The aggregate output Y_{jt} for sector j at time t is generated by a two-level constant-elasticity-of-substitution (CES) production function with three inputs: physical capital (K_{jt}), high-skilled labor $\left(N^h\right)$, and low-skilled labor $\left(N^l\right)$:

$$\begin{aligned} Y_{jt} &= A_{jt}F_j(K_{jt}, N^l_{jt}, N^h_{jt}) \\ &= A_{jt}\{\mu_j(N^l_{jt})^{\sigma_j} + \left(1-\mu_j\right)[\lambda_j(K_{jt})^{\rho_j} + (1-\lambda_j)(N^h_{jt})^{\rho_j}]^{\sigma_j/\rho_j}\}^{1/\sigma_j}, \end{aligned} \tag{5}$$

where A_{jt} is an efficiency parameter, and $\{\mu_j, \lambda_j\}$ are parameters that govern income shares. In this specification, the elasticities of substitution between capital and low-skilled labor, and between high-skilled labor and low-skilled labor, are the same, with a value of $1/(1-\sigma_j)$,[23] whereas that between high-skilled labor and capital is $1/\left(1-\rho_j\right)$, with $\{\sigma_j, \rho_j\} < 1$. If $\sigma_j > \rho_j$, then the production technology exhibits capital-skill complementarity.

The labor input of each skill type is measured in efficiency units. We define the skill level of labor input by workers' educational attainment, with low-skilled labor matched to middle school graduates and high-skilled labor requiring a high school or college education. Following Krusell et al. (2000), we define the efficiency labor units of each type as a product of worker numbers and their efficiency index: $N^l_{jt} = \psi^l_t n^l_{jt}$ and $N^h_{jt} = \psi^{hs}_t n^{hs}_{jt} + \psi^c_t n^c_{jt}$, where $\{n^l_{jt}, n^{hs}_{jt}, n^c_{jt}\}$ are the numbers of middle school, high school, and college workers in sector j at date t, and $\{\psi^l_t, \psi^{hs}_t, \psi^c_t\}$ constitute the unmeasured quality of workers of each type. The $\psi's$ can be interpreted as education-specific labor-augmenting technology levels, which are assumed to be equal across sectors.

A major institutional factor that is incorporated into our analysis is employment protection under the central planning regime and the subsequent relaxation of control during the economic transition. Prior to reform, with the government's goal to achieve full employment, SOEs served as guarantors of their employees' job security and welfare. During the initial period of reform, employment protection for low-skilled workers remained pervasive because it was thought that mass layoffs from inefficient SOEs might lead to social instability. To model overstaffing in the state sector in the early years of reform, we assume that the observed number of low-skilled workers subject to protection $(\overline{n^l})$ exceeded the employment level that would prevail under competitive conditions. Beginning in 1997, however, when China launched its restructuring program to privatize SOEs, state-protected employment $\overline{n^l}$

[23] This specification is supported by recent studies on capital-skill complementarity, including those of Krusell et al. (2000) and Duffy, Papageorgiou, and Perez-Sebastian (2004). The alternative specification of setting the same elasticities of substitution between N^h and N^l and N^h and K appears to be inconsistent with empirical estimates (see Hamermesh, 1993).

gradually declined, eventually converging to the competitive level.[24] Given the social burden of the state sector, its production function becomes

$$Y_{st} = A_{st}\{\mu_s(\overline{N_{st}^l})^{\sigma_s} + (1-\mu_s)\left[\lambda_s(K_{st})^{\rho_s} + (1-\lambda_s)\left(N_{st}^h\right)^{\rho_s}\right]^{\sigma_s/\rho_s}\}^{1/\sigma_s}, \tag{6}$$

where $\overline{N_{st}^l} = \psi_t^l \overline{n_t^l}$ is the state-managed level of low-skilled labor in efficiency units.

By contrast, the Chinese government has directly intervened in the market for high-skilled labor to a very limited extent. Workers with a high level of schooling often boast strong social networks, good information skills, and the ability to switch jobs, and therefore are more mobile and less vulnerable to layoffs during periods of transition.[25] Hence, we assume that high-skilled workers are mobile across the state and private sectors. In earlier empirical analyses, when paired interaction terms are added to Equation (1) for all years under study, most of the coefficients for the interaction between schooling levels and the state-sector dummy variables are statistically insignificant, thus suggesting equal skill premiums across the state and CIP sectors. Guided by this empirical result, we specify equal skill premiums for high school and college workers across the state and private sectors.[26] Therefore, given that the capital markets across the two sectors are segmented (Bai, Hsieh and Qian, 2006; Song, Storesletten and Zilibotti, 2011) and that capital stocks are determined exogenously by long-term accumulations, the equilibrium allocation of high-skilled labor in the state sector

[24] The layoffs resulting from SOE restructuring primarily affected low-skilled workers, with the fraction of employees with a middle school education declining from 33.8 percent in 1992 to 13.3 percent in 2007 in the state sector. This skill composition shift was driven only partially by the skill-upgrading of the urban workforce, as the fraction of low-skilled workers in the overall urban workforce decreased at a much slower pace (see Table 1).

[25] Knight and Yueh (2004) find that the mobility rates of urban residents increase with their education. Empirical evidence also supports that labor markets for engineers and managers were developed more than those for production workers in the 1990s (Lee, 1999).

[26] An alternative specification is to assume an equal level of high-skilled wages across the two sectors. However, this assumption would imply a lower skill premium in the state sector because the wage level for low-skilled workers in the state sector is higher than that in the private sector. This alternative specification would violate the empirical finding of equal skill premiums revealed in the data. Equal skill premiums across the two sectors could be an outcome of wage setting or negotiation within the state sector. For simplicity, we decided not to go deeper into the mechanisms behind this apparent feature of the data, but instead to take a reduced-form approach. Our assumption of equal skill premiums across the two sectors is consistent with the practice that the government uses time-varying skill premiums in the private sector as references for setting skill premiums in the state sector. Similar practices of wage setting in government sectors also exist in other economies.

N_{st}^h at date t is determined by the following implicit function.

$$\frac{\eta_s}{\mu_s}\left[\lambda_s\left(\frac{K_{st}}{N_{st}^h}\right)^{\rho_s}+(1-\lambda_s)\right]^{\frac{\sigma_s}{\rho_s}-1}\left(\frac{N_{st}^h}{\overline{N_{st}^l}}\right)^{\sigma_s-1} \tag{7}$$

$$= \frac{\eta_p}{\mu_p}\left[\lambda_p\left(\frac{K_{pt}}{N_t^h-N_{st}^h}\right)^{\rho_p}+(1-\lambda_p)\right]^{\frac{\sigma_p}{\rho_p}-1}\left(\frac{N_t^h-N_{st}^h}{N_t^l-\overline{N_{st}^l}}\right)^{\sigma_p-1},$$

where $\eta_j=(1-\mu_j)(1-\lambda_j)$ and $\{N_t^h,N_t^l\}$ are the total efficiency units of high and low-skilled labor in the workforce. Combined with the allocation of capital and low-skilled labor across the two sectors, this condition helps to pin down all of the aggregate factor inputs used in the production functions.

Reforms were carried out within the state and private sectors as early as the mid-1980s to align wages with worker productivity. The implementation of incentive schemes suggests that workers' wages can be assessed on the basis of marginal product conditions. Consistent with earlier empirical analysis, we define the base wage as the earnings of low-skilled labor in the private sector w_{pt}^l, which can be derived as

$$w_{pt}^l=\mu_p A_{pt}^{\sigma_p} Y_{pt}^{1-\sigma_p}(N_t^l-\overline{N_{st}^l})^{\sigma_p-1}\psi_t^l. \tag{8}$$

Equation (8) shows that the base wage is determined by several factors. Because $\sigma_p<1$, greater output in the private sector (Y_{pt}), through capital deepening for instance, may push up the wages of the unskilled. As expected, the base wage is also positively dependent on the efficiency parameter (A_{pt}), the quality of low-skilled labor (ψ_t^l), and its factor share parameter (μ_p). By contrast, *ceteris paribus*, an increase in the supply of low-skilled labor in the private sector ($N_t^l-\overline{N_{st}^l}$) reduces the base wage.

The skill premium is defined as the wage of high-skilled labor relative to that of low-skilled labor. Given that skill premium levels do not differ statistically across the two sectors, the college premium can be expressed as

$$\frac{w_{pt}^c}{w_{pt}^l}=\frac{\eta_p}{\mu_p}\frac{\psi_t^c}{\psi_t^l}\left(\frac{N_t^h-N_{st}^h}{N_t^l-\overline{N_{st}^l}}\right)^{\sigma_p-1}\left[\lambda_p\left(\frac{K_{pt}}{N_t^h-N_{st}^h}\right)^{\rho_p}+(1-\lambda_p)\right]^{\sigma_p/\rho_p-1}. \tag{9}$$

The high school premium can be defined similarly. Aside from income share parameters $\{\eta_p,\mu_p\}$, equation (9) explicates three determinants of the college premium. First, this premium depends positively on the efficiency of college workers relative to middle school workers, $\left(\psi_t^c/\psi_t^l\right)$. Second, it is determined by the ratio of high-skilled labor to low-skilled labor, $\left(N_t^h-N_{st}^h\right)/(N_t^l-\overline{N_{st}^l})$. As $\sigma_p<1$, the relative growth of high-skilled labor reduces the skill premium. Third, capital deepening is another important factor driving the relative wage. When there is capital-skill complementarity ($\sigma_p > \rho_p$), a rise in capital to high-skilled labor ratio $K_{pt}/(N_t^h - N_{st}^h)$ raises the college premium.

Finally, we define the state-sector wage premium as the ratio of low-skilled wages (or, equivalently, the ratio of high-skilled wages) in the state sector relative to those in the private sector:

$$\frac{w_{st}^l}{w_{pt}^l} = \frac{\mu_s \left(A_{st}\right)^{\sigma_s} \left(Y_{st}\right)^{1-\sigma_s} (\overline{N_{st}^l})^{\sigma_s - 1}}{\mu_p \left(A_{pt}\right)^{\sigma_p} \left(Y_{pt}\right)^{1-\sigma_p} (N_t^l - \overline{N_{st}^l})^{\sigma_p - 1}}. \tag{10}$$

Hence, given the economy's capital stock and labor force in period t, the state-sector wage premium depends on three relative quantities across the state and private sectors: technological efficiency, output levels, and the allocation of low-skilled labor. In particular, when SOE restructuring slashes the number of low-skilled workers in that sector, *ceteris paribus*, the state wage premium increases accordingly.

3.2 Quantitative Analysis

We now employ the two-sector model to analyze quantitatively the driving forces behind the observed changes in the base wage and wage premiums. With the estimates obtained for the production function parameters, equations (8), (9), and (10) can be used to assess the way in which various economic forces affect the base wage and wage premiums. We proceed with this analysis in four steps: (A) specification of the empirical model, (B) variable measurement using supplemental aggregate data, (C) parameter estimation with robustness checks, and (D) counterfactual analysis of wage determination.

A. Empirical Specification

The efficiency of a worker with education level $k \in \{l, hs, c\}$ is given by index ψ_t^k. Although unobservable to the econometrician, we specify this index as a linear function of an initial efficiency level at the beginning of the sample (ψ_0^k), labor-augmenting technological change ($\gamma^k X_t$), and a stochastic factor (ω_t^k):

$$\psi_t^k = \psi_0^k + \gamma^k X_t + \omega_t^k, \tag{11}$$

where the education-specific coefficient γ^k captures the idea that technological change may exert differential (or biased) effects on the efficiency of different skill types.[27] We con-

[27] We treat technological change as skill biased yet exogenous, as in Krusell et al. (2000). An alternative view is that the process of technology adoption is endogenously skill biased (Gancia and Zilibotti 2009; Gancia, Müller and Zilibotti forthcoming). In a developing country such as China that is abundant in low-skilled labor, low-skilled technologies would be first adopted if technology transfers are costly. This condition

sider domestic R&D and capital flows from abroad as two sources of technological advances (Griliches, 1979; Feenstra and Hanson, 1997). Following the methods first proposed by Griliches (1979), we adopt the perpetual inventory method (PIM) to construct the stocks of domestic R&D and FDI as proxies for X_t, as explained in Appendix B.[28] The $\omega_t^k s$ are assumed to be normally distributed i.i.d. shocks with zero mean, zero covariance, and identical variances, which implies that covariance matrix $\Omega = \eta_\omega^2 I_3$, where η_ω^2 is the common innovation variance and I_3 is the 3×3 identity matrix. Given the small sample size with which we are working, these restrictions are necessary to reduce the number of parameters to be estimated.

The econometric model comprises four structural wage equations derived from the two-sector model. These four equations represent the base wage, the high school and college premiums, and the state-sector wage premium:

$$\left(w_{pt}^l\right)^{UHS} = w_{pt}^l(Z_t;\theta), \tag{12}$$

$$\left(\frac{w_{pt}^{hs}}{w_{pt}^l}\right)^{UHS} = \frac{w_{pt}^{hs}}{w_{pt}^l}(Z_t;\theta), \quad \left(\frac{w_{pt}^{c}}{w_{pt}^l}\right)^{UHS} = \frac{w_{pt}^{c}}{w_{pt}^l}(Z_t;\theta), \tag{13}$$

$$\left(\frac{w_{st}^{l}}{w_{pt}^l}\right)^{UHS} = \frac{w_{st}^{l}}{w_{pt}^l}(Z_t;\theta), \tag{14}$$

where $Z_t \equiv \{Y_{st}, Y_{pt}, K_{st}, K_{pt}, n_t^l, n_t^{hs}, n_t^c, \overline{n_t^l}, X_t\}$ is the vector of exogenous variables including by-sector output, by-sector capital stock, total number of workers by type, state-managed low-skilled labor, and measures of technological change. The parameter vector θ has 18 components: curvature parameters σ_j and ρ_j, which govern the elasticities of substitution; income share parameters, λ_j and μ_j; the initial values of labor efficiencies, ψ_0^k; labor efficiency coefficients γ^k; and the variance of labor efficiency shocks η_ω^2.

The left-hand sides of the structural equations are the empirical base wage and wage

implies a low initial skill premium. Considering that barriers are removed over time, technology adoption would accelerate and shift toward high-skilled content, which induces an increase in skill premiums. Although this alternative theory can potentially shed light on the changes in relative wages in China, a systematic investigation goes beyond the scope of the current paper.

[28]Unlike Katz and Murphy (1992), we do not model skill-biased technological change by a simple time trend in the efficiency level of high-skilled labor. Instead, we use two specific variables to proxy technological advances and allow them to have different effects on the efficiency of different skill types. Both domestic R&D and FDI have increased over the sample period, but follow very different patterns. Domestic R&D was relatively flat between 1992 and 1999, but increased exponentially since 2000. The time series of FDI resembles a linear trend, although its growth accelerated after 2002. When we tried a specification where a linear time trend is present in Equation (11), the coefficients on the time trend are not well identified and close to zero. This result is likely due to the fact that FDI grows almost linearly. Our data may not be sufficient to identify separately the effects of FDI from its fluctuations rather than the trend, but the effects of R&D appear well identified from its fluctuations.

premiums estimated from the UHS sample, and the right-hand sides are their theoretical counterparts from the model. We employ the simulated method of moments (SMM) to estimate the 18 parameters, relying on $4 \times 16 = 64$ moments generated from the 16-year period. The weighted average distance between the sample moments from the UHS and simulated moments from the model is minimized with respect to the model parameters. The not-for-publication Appendix provides details of the SMM estimation including the weighting procedure.

B. Measurement of Aggregate Variables

Although the empirical moments of the base wage and wage premiums in equations (12)-(14) can be computed using the UHS data, the model-generated moments require aggregate time-series data on Z_t from 1992 to 2007, which comprise output values, factor inputs, and the proxies of technological change in both the state and non-state sectors. For empirical analysis, we define the non-state sector (or private sector) as comprising collective enterprises and all domestic individual and private enterprises, which is the same as the CIP group in earlier analysis. Using data from the Statistical Yearbook of China (SYC), we measure output (Y_{jt}) as real GDP in 2007 yuan in each of the two sectors. The state sector's output share of GDP declines over time, consistent with the trend in employment documented in Table 1. The output value of this sector was larger than that of the private sector by more than three fold in 1992, but by 2007 it was just 38 percent larger. During the study period, the average output growth rate of the private sector hovered around 12.6 percent per year, far exceeding the 6.2 percent annual growth rate of the state sector.

The construction of the capital stock series (K_{jt}) in real prices is based on the PIM approach and uses a long series of capital investment data from published sources, including the "Statistical Yearbook of Fixed Assets Investments." As Appendix B explains, our construction of capital stock figures builds on the well-regarded work of Sun and Ren (2005), who take into account capital investment by type and adopt depreciation schedules suitable to the Chinese economy. Our constructed data series reveals the rapid growth of capital stocks in the state sector during the 1992–1998 period. However, following the subsequent state-sector restructuring beginning in the late 1990s, the growth rate of capital stocks in the private sector surpassed that in the state sector during the 1999–2007 period.

With regard to labor inputs $\{n_t^k\}$, the basic data are urban employed workers by ownership category. However, additional information is needed to implement the estimation: (a) the distribution of urban workers by educational attainment, and (b) the number of rural-to-urban migrants, as they are part of the urban labor supply but their size is under-represented in the UHS. We employ the national sample of the UHS to impute the proportion of workers in each of the educational categories and estimate the size of the rural-to-urban migrant workforce based on the 2000 and 2005 Population Censuses. Our estimates reveal a strong upward trend in the supply of high-skilled workers relative to that of low-skilled workers over the 1992–2007 period. The ratio of workers with a high school education to those with a middle school education increased by 54 percent during the period, and that of employees with a college education to those with a middle school education increased by 215 percent. Moreover, despite increases in both skilled labor and capital inputs, the capital to high-skilled labor ratio grew continuously over the study period. The rise in capital intensity raised the skill premium through capital-skill complementarity, as suggested by equation (9). Finally, we also compile stock measures of domestic R&D and FDI to approximate technological change (X_t), as previously discussed. Appendix B provides more detailed descriptions of the construction of these aggregate variables.

Table 3: SMM Estimates of Key Model Parameters, Benchmark and IV Specifications

	Benchmark		IV	
Parameters	Estimates	(SE)	Estimates	(SE)
Curvature parameters				
σ_s	0.596	(0.001)	0.596	(0.001)
ρ_s	0.307	(0.009)	0.307	(0.011)
σ_p	0.567	(0.002)	0.565	(0.002)
ρ_p	0.338	(0.027)	0.339	(0.030)
Efficiency effect of X on middle school workers				
$\gamma^l_{R\&D}$	0.006	(0.001)	0.007	(0.001)
γ^l_{FDI}	0.016	(0.002)	0.014	(0.003)
Efficiency effect of X on high school workers				
$\gamma^{hs}_{R\&D}$	0.102	(0.036)	0.102	(0.019)
γ^{hs}_{FDI}	0.127	(0.047)	0.139	(0.029)
Efficiency effect of X on college workers				
$\gamma^c_{R\&D}$	0.155	(0.055)	0.173	(0.033)
γ^c_{FDI}	0.168	(0.062)	0.171	(0.035)

C. Parameter Estimates

The estimation of the benchmark model takes the stocks of capital and labor variables in Z_t as exogenous, which is a standard assumption in growth accounting. However, because date t capital investment and the participation of skilled and unskilled labor may respond to date t realizations of technology and labor quality shocks, the capital and labor variables are potentially endogenous. We first present the findings from the benchmark model and then examine the sensitivity of the results to an alternative instrumental variable (IV) procedure.

Table 3 reports the estimates of the key model parameters and their standard errors (SE). The results show that $\sigma_j > \rho_j$, i.e., production exhibits capital-skill complementarity in both sectors. More specifically, the estimated substitution elasticities between low-skilled labor and capital (and, by symmetry, high-skilled labor) are $1/(1-\sigma_s) = 2.48$ in the state sector and $1/(1-\sigma_p) = 2.31$ in the private sector, whereas those between high-skilled labor and capital are $1/(1-\rho_s) = 1.44$ and $1/(1-\rho_p) = 1.51$, respectively, in the two sectors. There appears to be no substantial differences in the estimated elasticities across the two sectors. Moreover, these estimates for China are well within the reasonable range found in the empirical literature (Hamermesh, 1993) and are close to those reported in cross-country studies (Duffy, Papageorgiou and Perez-Sebastian, 2004). With regard to worker quality, technological change, as measured by R&D expenditures and inflows of FDI, is found to enhance the efficiency of labor significantly, and the size of this effect increases with educational attainment. In other words, technological change in China is indeed biased toward high-skilled labor.

Given the parameter estimates, we can derive the predictions of the benchmark model and compare them with the base wage and wage premiums observed in the data. Figure 2 shows the estimated model to perform well in predicting all four key variables. Panel A illustrates the model's ability to capture the upward trend in the base wage: the predicted increase in the log wage from 7.61 in 1992 to 8.50 in 2007 closely matches the rise in the observed data from 7.60 to 8.48. Admittedly, the model cannot track all short-period fluctuations effectively. For example, immediately after Deng Xiaoping's southern tour in 1992, private sector output expanded significantly for two consecutive years, effecting a jump in the base wage in the model. In contrast, the increase in the actual base wage was steady and smooth. For the years since China's entry into the WTO in 2001, both the data and the model exhibit accelerated wage growth.

Panels B and C indicate that the predicted high school and college wage premiums closely track the actual school premiums over time. More specifically, the predicted versus actual increases in the high school premium are 0.038 versus 0.055 log points from 1992 to 2007, whereas those for the college premium are 0.287 versus 0.255. There is a minor mismatch between the two series in that the college premium implied by the model exceeds the actual observations in most years in the 1990s, a pattern consistent with the view that the rate of returns to education was systematically suppressed during the early years of reform. An interesting emerging trend is that the college premium plateaued in both the data and the model in the last several years of the sample, a period that coincides with the increased supply of college workers to China's labor market following the dramatic expansion of college enrollment in the late 1990s.

In Panel D, the model predictions for the state-sector wage premium are broadly consistent with the data, although the predicted series exhibits greater fluctuation than the actual changes. More specifically, the model under-predicts the state-sector wage premium from 1992 to 1999, and over-predicts it from 2000 to 2003. The result in the first period is consistent with the view that the government provided systematic wage subsidies to SOE workers in the 1990s.[29] The subsequent restructuring led to the closure of many loss-making SOEs and mass layoffs in those that continue to operate. This process is revealed by the drastic increase in the predicted state-sector wage premium in Panel D, whereas the actual wage adjustment appears to be steadier and smoother. After 2003, with diminished wage subsidies from restructuring, the model and the data converge into a tight fit, thus implying that the ratio of state-sector to private-sector wages reflects relative labor productivity.

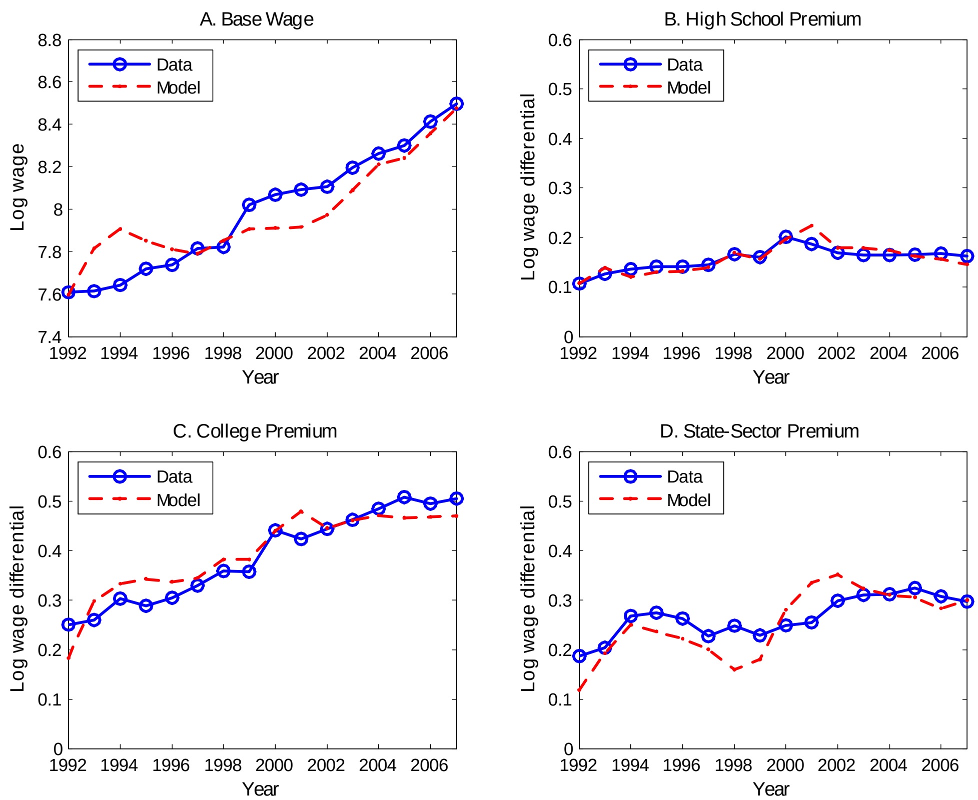

Figure 2: Actual and Predicted Base Wage and Wage Premiums, 1992–2007

We have thus far presented the parameter estimates and model fit based on the assumption that capital stocks and labor supplies are exogenous. Before we proceed to counterfac-

[29]SOEs carried several kinds of policy burdens during the transition. When the government and state firms have wage, employment, and profits in their objective functions, the wage is set above the marginal product of labor (Lee, 1999).

tual analysis, it seems prudent to first check the robustness of our results by relaxing the assumption of exogenous factor inputs. It is true that the capital stocks carried over from earlier periods can be treated as exogenous, but date t capital investment may respond to changing wage conditions and technology shocks, and thus is potentially endogenous. Similarly, labor force participation may also respond to concurrent economic conditions, such as the realization of the technology and labor quality shocks.

To take these potential endogeneity issues into account, we adopt a two-step procedure along the lines of an IV approach. In the first step, we project annual capital investment onto lagged capital stocks and a set of IVs, including military spending, administrative expenditure, and world oil prices, that are correlated with concurrent investment but independent of civilian non-agricultural production. This is essentially the approach taken in Heckman, Lochner and Taber (1998). Then, we construct capital stock series based on the fitted investment values. Moreover, as in Lee and Wolpin (2010), we employ cohort size as an IV for total employment. More specifically, we use the cohort size for women aged 16-55 and that for men aged 16-60, which reflect the rules on mandatory retirement and regulations on working age in China. In the second step, the fitted values for labor supply and the constructed capital stock series are used in the SMM estimation of the parameters. Estimates from this two-step procedure are reported in the last two columns of Table 3. The differences between the benchmark and two-step estimates are negligible. It is evident that the parameter estimates in the benchmark model are not sensitive to alternative IV specifications.

D. Accounting for Wage Structural Changes

Profound changes in labor market conditions, characterized by capital accumulation, technological advances, enterprise restructuring, and shifts in the quantity and quality of labor, have influenced China's wage structure. The relative contributions of these factors to the rising base wage and wage premiums can be assessed quantitatively employing the estimated benchmark model. In what follows, we first focus on the effects of changes in factor inputs on wage growth, and we then extend the analysis to explore the labor market consequences of China's rural-urban migration.

To isolate the quantitative effect of each factor on wage changes over the 1992–2007 period, we perform the following counterfactual analysis. We set 1992 as the base year and hold all factor inputs and technological parameters at their initial levels. With this setup, we analyze how the Chinese wage structure would evolve under alternative scenarios in which some of these factors changed as they did in reality and others underwent no change from their initial levels.

We consider five counterfactual scenarios in which we allow each variable to move from its 1992 base to the 2007 level while holding all other variables at their initial conditions: (1) capital stock accumulates; (2) the numbers of middle school, high school, and college workers evolve; (3) the employment protection of unskilled labor declines; (4) the factor-neutral technological level changes; and (5) skill-biased technological change occurs. Table 4 presents the results of these counterfactual experiments for wage changes over the 1992-2007 period. The first row reports observed changes in the data in log points for the base wage, schooling premiums, and state wage premium, which serve as a basic reference for comparisons. All of the counterfactual experiments in rows (1)–(5) examine the relative contribution to wage changes of one factor at a time, whereas the last row represents the benchmark outcomes resulting from simultaneous changes in all five factors.

Table 4: Accounting for the Rise in the Base Wage and Wage Premiums

	Base wage	High school premium	College premium	State premium
	1992-2007	1992-2007	1992-2007	1992-2007
Log wage change in data	0.888	0.055	0.255	0.111
Changes in				
(1) Capital accumulation	0.834	0.386	0.386	-0.333
(2) Supply of labor	0.018	-0.157	-0.157	-0.012
(3) SOE restructuring	-0.206	-0.225	-0.225	0.610
(4) Skill-neutral technological change	0.292	0	0	-0.114
(5) Skill-biased technological change	0	0.038	0.287	0
Benchmark with (1)-(5)	0.878	0.038	0.287	0.182

Between 1992 and 2007, the measured capital stocks increased by 2.8 times in the state sector and by 6.9 times in the private sector. Combining these figures, the share of capital investment in GDP increased from 26.4 percent to 51.9 percent. To assess the effects of capital deepening, the first experiment in row (1) allows these changes in capital stocks in each sector while keeping all of the other variables at their 1992 levels. Capital accumulation by itself would have led to a 0.834 log-point increase in the base wage, a 0.386 such increase in the high school and college premiums, and a 0.333 such decrease in the state wage premium. Capital deepening enhances the marginal product of labor when employment is held constant, causing wages to rise for all types of labor. Moreover, an increase in the capital-labor ratio raises the school premiums, as shown in equation (9), because capital is more complimentary to high-skilled labor ($\sigma_j > \rho_j$). However, the state wage premium declines because capital accumulated at a faster pace in the private than state sector during the sample period.

The employment share of workers with a middle school education declined persistently, as the urban workforce continually upgraded its skills from 1992 to 2007. At the same time, the number of low-skilled rural migrants has increased gradually since the early 1990s, offsetting the reduction in comparable workers in cities. In total, the number of low-skilled workers declined only slightly over the sample period, from 70.9 million in 1992 to 69.7 million in 2007. The number of employed workers with a high school education increased up to 1997 and then declined thereafter, whereas the number of college-educated workers continued to increase throughout the period. In row (2) of Table 4, we allow for these actual changes in the composition of the workforce over time, while holding the other variables at their 1992 base values. Because the number of low-skilled workers declined slightly, the base wage would rise marginally. The high school and college premiums would have declined by 0.157 log points because of the increase in the supply of high-skilled workers.

Economic restructuring in the late 1990s led to large-scale layoffs of redundant workers in the state sector. The experiment in row (3) considers the relaxation of state employment protection. Holding the other factors constant, the observed decline in state employment $(\overline{n^l})$ is associated with the release of low-skilled workers into the private sector, which would have led to a -0.206 log-point reduction in the base wage. Lower wages would have facilitated private sector growth, and the allocation of high-skilled labor across the two sectors would have adjusted to restore the equilibrium. In equation (9), both the high to low-skilled labor ratio and the capital to high-skilled labor ratio undergo adjustment, and the net effect is to reduce the skill premium by -0.225. In our model, economic restructuring plays a major role in boosting labor productivity in China's SOEs, and is a major driving force of the rise in the state wage premium.[30]

Technological change in the model is characterized by the efficiency parameters $(A's)$ as well as by FDI and domestic R&D expenditures $(X's)$, which serve as proxies for technological innovations. The parameters, A_{st} and A_{pt}, are computed as residuals using the estimated production parameters and observed input and output data based on the aggregate produc-

[30] An alternative explanation for the increasing state premium draws on the housing provision and health-care subsidies accruing to SOE workers in the early 1990s (see Zhao, 2002; Wang, 2011). As reform progressed, these subsidies are likely to have been converted into monetary wages over time, thus raising the wages of SOE workers relative to their counterparts in the CIP sector. Although data on non-wage subsidies in the state sector are sparse, we find no supporting evidence for this alternative hypothesis using indirect UHS data. First, workers in the CIP sector are likely to have received similar housing subsidies as state workers because: (1) municipalities allocated funds to develop public housing for workers employed in small and street-level enterprises, amounting to 27 percent of the total public housing budget in 1988, and (2) some collective enterprises, especially large ones controlled by the state, did provide housing to their employees (Wu, 1996). Second, using the UHS data, we find state and CIP-sector workers to have almost the same time-series patterns of expenditure on housing and health care, conditional upon household income. There is no evidence of state-sector workers receiving more subsidies than their CIP-sector counterparts. These results are available from the authors upon request.

tion functions. These parameters are influenced by both technological innovations and the efficiency of resource allocation (Hsieh and Klenow 2009). Table 3 reveals that the enhancing effects of R&D expenditures and inflows of FDI on labor efficiency vary across educational attainment. Thus, overall technological advances can be specified as comprising a skill-neutral and a skill-biased component. Accordingly, we can assess the individual effects of the two components on the base wage and wage premiums. The skill-neutral technological change combines the changes in $A's$ and $X's$ that are neutral to all skill types. Row (4) shows that skill-neutral technological change alone would have led to a 0.292 log-point increase in the base wage. Given that such technological advancement is skill neutral, it has no effect on school premiums, whereas its effect on state-sector wage premium is negative. Parameter estimates in Table 3 suggest that the changes in $X's$ have more significant efficiency effects on high school workers than on their middle school counterparts ($\gamma^{hs} > \gamma^{l}$), and their efficiency effects are even larger for college workers ($\gamma^{c} > \gamma^{hs}$). Therefore, skill-biased technological change creates forces to raise schooling premiums. As shown in row (5) of Table 4, SBTC alone would have resulted in a 0.038 log-point increase in the high school premium and a significant 0.287 increase in the college premium.[31]

The last row of Table 4 presents the changes in the wage level and relative wages in the benchmark model by combining the effects of all five factors considered in these experiments. Overall, capital accumulation through the mechanism of capital-skill complementarity and SBTC are the two major forces driving up the base wage and skill premiums, whereas changes in the labor supply and enterprise reform exert downward pressure on these premiums. SOE restructuring is the main driving force behind the rise in the state wage premium.

Thus far, our counterfactual experiments have explored the effects of aggregate factor input changes on wage growth. We now apply the same framework to explore the wage effects of massive rural-to-urban migration, which is a defining feature of China's labor market in the past two decades. Despite rapid growth in the number of rural migrants since the early 1990s, the majority of migrating workers still possess limited schooling attainment. Therefore, we treat rural migrants as part of low-skilled urban labor supply, competing for jobs with urban workers with middle school education.[32]

We examine the effects of migration on urban wage structural changes in two counterfactual scenarios. First, we hold the size of rural migrants at its 1992 level, i.e., blocking

[31] These results are consistent with empirical findings based on firm-level data showing that R&D has significant and positive effects on productivity in Chinese industries (Hu, Jefferson and Qian, 2005). These authors also find evidence of complementarity between R&D and both domestic and foreign technology transfer variables.

[32] Appendix B presents more detailed descriptions on how we estimate the size of rural-to-urban migration relevant to our study.

the inflow of rural workers to cities over time while allowing other variables to take their observed values in each year. For the 1992 to 2007 period, the total number of low-skilled rural migrants working in cities almost quintupled. By removing this source of labor supply, we derive the predicted base wage and wage premiums using the structural model and compare them with the wage moments predicted under the benchmark scenario in which migration increased over time. Panel A of Figure 3 shows that the base wage would have increased significantly faster with no migration growth since 1992. More specifically, the predicted increase in base wage under the counterfactual scenario is 1.075 log points, which is significantly higher than the benchmark increase of 0.878 from 1992 to 2007. Since China's accession to the WTO in 2001, the demand for manufacturing jobs rose because of the rapid expansion in Chinese export. Our counterfactual experiment suggests that the base wage of low-skilled labor would have been 0.176 to 0.198 log points higher if no continuous inflow of rural migrants into cities occurred during this period. Therefore, the large pool of rural labor in China is indeed a crucial factor that helps contain rising labor costs and sustain export growth. Admittedly, these findings are based on partial equilibrium analyses that do not consider any endogenous responses by firms and labor market participants.

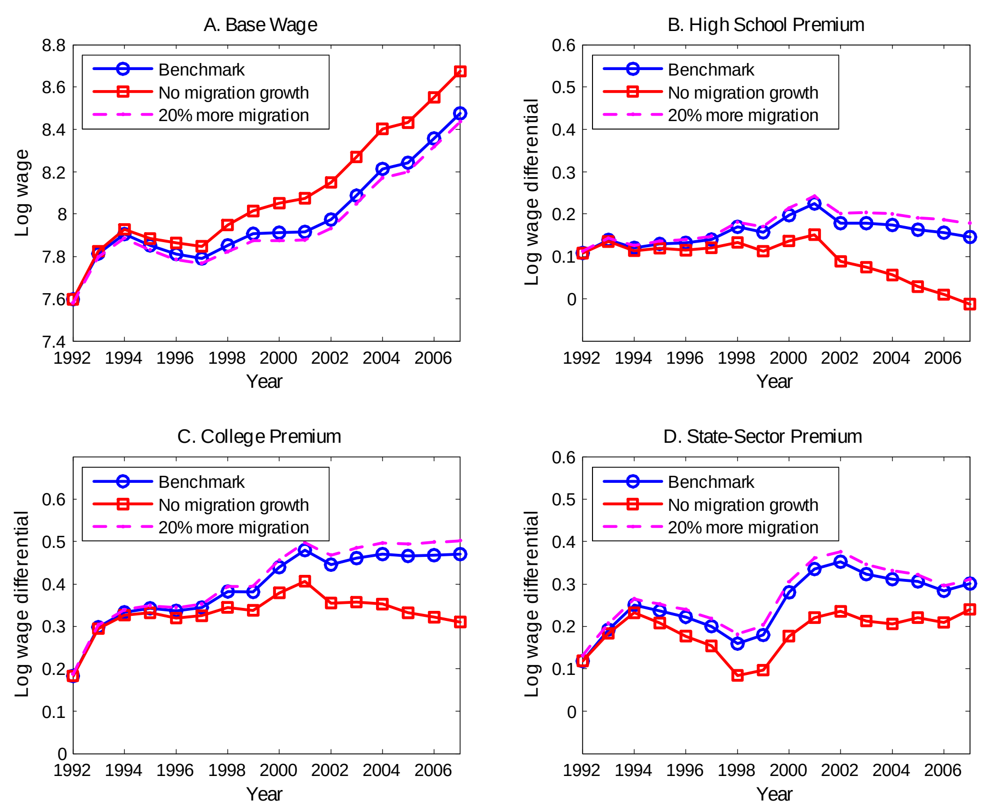

Figure 3: Effects of Rural-to-Urban Migration on the Wage Structure

Results in Panels B and C suggest that rural-urban migration is another major factor behind the rise in skill premiums during the study period. Without growth in rural-urban migration, the predicted changes in school premiums would have been 0.159 log points lower than the benchmark case. That is, if the number of low-skilled rural migrants remained at the 1992 level, while other variables continued to evolve as observed, an abundant supply of high-skilled labor would be available, which would reduce the skill premiums. In reality, the massive inflow of rural migrants helped contain the wage growth of the unskilled, thus pushing up the skill premium in China, as revealed in the benchmark case. A noticeable trend emerging from the counterfactual case is that both high school and college premiums reached their peaks in 2001 and then declined in the last few years. This finding is consistent with the dramatic expansion in college enrollment that started in the late 1990s and the subsequent increase in the supply of college workers.

Panel D illustrates that the state-sector wage premium in the counterfactual case would have been 0.067 log points lower than the benchmark average for the years between 1992 and 2007. This result reflects the fact that rural migrants are five times more likely to work in the CIP sector than in the state sector, as revealed in the data. Thus, when rural-urban migration is prohibited, the decline in the supply of low-skilled labor would have been more severe in the CIP sector than the state sector, resulting in the predicted outcome. This result suggests the importance of rural-urban migration in explaining the rise in the state-sector wage premium given the hiring practices of the state sector.

In the second counterfactual scenario, we examine the wage effects of rural-urban migration at levels higher than the actual experience. This exercise is meaningful because economists commonly believe that the *hukou* household registration system continues to obstruct labor mobility despite the significant relaxation of government controls during the sample period. To assess the potential impact of deepening the reform, we simulate a counterfactual scenario in which the number of migrant workers is 20 percent higher than what is revealed in the data.[33] These additional migrants are distributed across sectors based on their observed proportions in individual years. The dashed lines in Figure 3 illustrate the predictions of the base wage and wage premiums under this experiment. All four panels show that the potential increase in rural-urban migration appears to have limited impact on the base wage, skill premiums, and the state-sector premium with estimated average yearly effects falling in the range of 0.016 to 0.031 log points. These findings indicate that, although the base wage and relative wages were strongly influenced by the occurrence of rural-urban migration, the observed wage structure would be rather stable and not sensitive to further relaxation of *hukou* controls.

[33] Experiments raising the migration flows to 10, 30, and 40 percent above the actual experience are also conducted, but the conclusions are not sensitive to these alternative specifications.

4 Conclusion

In this paper, we document the fundamental changes in China's wage and employment structures during a period of extraordinary economic growth. Our empirical findings suggest that persistent increases in the base wage, rising returns to human capital, and a higher state-sector wage premium are the major components of the country's wage growth. Other factors, such as changes in worker characteristics, the gender composition of the labor force, and the reallocation of workers across industries and regions, have made relatively minor contributions to such growth. The major driving forces behind both wage growth and rising wage inequality in China are capital accumulation, SBTC, and rural-urban migration. Combined with capital-labor and capital-skill complementarity, demand factors have more than offset the effect of an increased supply of unskilled and skilled labor, thereby pushing up wages.

Our analysis illustrates the multi-faceted nature of labor market adjustments in China. Over the past two decades, rising returns to education have been associated with greater college enrollment and an increase in the quality of the labor force. Interestingly, women's relative earnings have declined in this period, as has their labor market participation. Along with rapid economic growth, the employment share of the service sector has risen, whereas that of the manufacturing sector has fallen, despite China's emergence as the workshop of the world. Moreover, during this process, the non-state sector has expanded, and labor has flown continuously to the high-productivity and high-wage regions. Viewed through the lens of the labor market, these structural changes reveal vivid details of the process of economic growth.

The present study focuses on the operation of the labor market in China. However, other emerging economies have also undergone fast-paced economic growth amid economic transition and globalization. Although the institutional conditions of these countries may exhibit marked differences from their counterparts in China, many of the fundamental forces governing the growth process are likely to be similar. Whether the driving forces of wage growth identified in the Chinese context can explain wage structure changes in other fast-growing economies remains an important topic for future research.

Appendix: Description of Data

A. Urban Household Surveys

Sample Inclusion Criteria. Our wage sample includes full-time wage and salary workers aged 16-55 (females) and 16-60 (males), the lower and upper limits of the official working ages in China. Excluded from the sample are employers, self-employed individuals, farm workers, retirees, students, those re-employed after retirement, and workers with real annual wages less than half the real minimum wage. Province-level minimum wages are compiled from data released by China's provincial or municipal Ministries of Human Resources and Social Security.

Aggregation of Worker Groups. The UHS record detailed information on school completion levels, enterprise ownership class, industry coding, and residential location by province. To conduct the analysis carried out in this paper, we perform the following aggregation.

(a) *Education:* Workers are grouped into the categories of "middle school and below," "vocational and high school," with vocational school usually requiring two years of post middle school education in China, and "college and university," which consists of attendees and graduates of four-year universities, two-year or three-year specialized colleges, and those who obtained government-recognized college-equivalence diplomas by taking post-secondary night classes or online courses or participating in other remote training programs.

(b) *Ownership type:* Workers in the sample report various ownership categories for their employers: individually owned, private, collectively owned, state-owned enterprises (SOEs), or other ownership categories, including joint-venture companies, stock-holding firms, and wholly foreign-owned firms (JSF). While maintaining the SOE and JSF categorization, we combine collective, individual, and private firms into a CIP group because worker characteristics across these firm types are almost identical, and the average wages and wage growth patterns are similar. Another reason for this aggregation is that very few people worked in individual/private firms in the early years of the data, accounting for only about 2 percent of the labor force in the 1992-1996 period. It would be difficult to conduct meaningful econometric studies in subsequent analysis if these firms were treated as a separate ownership group.

(c) *Industry:* We group manufacturing and construction together to represent the secondary sector, and we classify them as the manufacturing industry. Basic services include transportation, storage, postal services, wholesale, retail, food services, real estate, and social services. Advanced services include finance and insurance, health, sports, social welfare, education, cultural services, media, scientific research, miscellaneous technical services, government administrations, and social organizations.

(d) *Region:* The Northeast consists of three provinces: Liaoning, Jilin, and Heilongjiang. Central China comprises six provinces: Shanxi, Anhui, Jiangxi, Henan, Hubei, and Hunan. The West consists of 11 provinces and autonomous regions and a municipality: Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Inner Mongolia, Guangxi, Ningxia, Xinjiang, and Chongqing. Finally, the East comprises 10 provinces and municipalities: Hebei, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan, Beijing, Tianjin, and Shanghai. Tibet is excluded because of missing surveys in certain years.

Data Resampling. According to the NBS survey administrators, there are several likely explanations for the oversampling of workers from state and collective enterprises. First, self-reporting may introduce error. For example, when a SOE is restructured and becomes a stock-holding firm or a joint venture, its employees may continue to classify their employer as a SOE, failing to recognize the change in ownership for some time. Second, SOE workers usually work a regular eight-hour day, and thus may have more free time in which to respond to surveys than their private-sector counterparts. Third, the NBS seeks help from employers to persuade workers to participate in the surveys to reduce the nonresponse rate. SOEs and their labor union usually provide more help than other types of firms.

To correct this sampling bias, we randomly resample the data such that the employment share of each ownership category is consistent with the aggregate statistics compiled in "Comprehensive Statistical Data and Materials on 55 Years of New China" and various years of the SYC published by the NBS. More specifically, we denote the annual employment shares of three ownership categories—state-owned firms (SOE), collective and individual/private firms (CIP), and firms with other types of ownership, including joint-venture, stock-holding, and foreign firms (JSF)—as S_t/L_t, C_t/L_t, and J_t/L_t, where the capital letters represent the aggregate numbers of workers, and L_t is the size of the labor force. We denote the sample proportions of workers as s_t/l_t, c_t/l_t, and j_t/l_t, where the small letters represent the workers in the sample, and $s_t/l_t > S_t/L_t$, $c_t/l_t < C_t/L_t$, and $j_t/l_t < J_t/L_t$.

Table A1: Percentage Distribution of Sample by Ownership Type

	Before resampling			
	Total	State (%)	CIP (%)	JSF (%)
1992–1996	143,094	83.0	15.8	1.2
1997–2001	123,819	82.1	13.8	4.1
2002–2007	388,459	70.6	16.1	13.2
All years	655,372	75.5	15.6	8.9
	After resampling			
	Total	State (%)	CIP (%)	JSF (%)
1992–1996	143,094	66.9	29.2	4.0
1997–2001	123,819	56.3	32.7	11.1
2002–2007	388,459	39.1	39.9	21.1
All years	655,372	48.4	36.2	15.4

Based on the assumption that the survey participation of workers within an ownership type is random, we randomly resample workers and adjust the number of those in each ownership category as follows. (1) Adjusting s_t down by $[(s_t/l_t - S_t/L_t)/(s_t/l_t)] \times s_t$; (2)

Adjusting c_t up by $[(C_t/L_t - c_t/l_t)/(c_t/l_t)] \times c_t$; (3) Adjusting j_t up by $[(J_t/L_t - j_t/l_t)/(j_t/l_t)] \times j_t$. We can show that

$$\frac{C_t/L_t - c_t/l_t}{c_t/l_t} c_t + \frac{J_t/L_t - j_t/l_t}{j_t/l_t} j_t = \frac{s_t/l_t - S_t/L_t}{s_t/l_t} s_t.$$

The resampled data have the same number of observations for each individual year as they did before the resampling, but the employment share of each ownership category is now consistent with the aggregate statistics. Table A1 presents the sample distribution by ownership type before and after resampling.

B. Aggregate Data

Real GDP. We combine industrial and tertiary sector GDP collected from the SYC and Industrial Statistical Yearbooks as an estimate of the non-agricultural urban GDP, although these data are not separately available for the state, private, and other sectors for certain time periods. Between 1999 and 2007, industrial value-added outputs are reported by ownership type, whereas only the total outputs by ownership type are available prior to 1999. For the state and private sectors, we compute the share of industrial value-added output in total output above a designated size from 1999 to 2007, and then employ a linear in time projection to impute the fractions for earlier years. These estimated ratios, and total industrial output, are then combined to calculate the ownership-specific industrial value-added between 1992 and 1998. Because no information is available on ownership-specific GDP or value-added output in the tertiary sector, we apply the state and private sector's shares of total industrial value-added output to both industrial and tertiary GDP to construct ownership-specific output. All nominal outputs are deflated by the urban CPI in 2007 yuan.

Capital Stock. Our main data sources for capital stock are the SYC and the Statistical Yearbook of Fixed Assets Investments. Capital investment data can be obtained for the whole economy, for urban areas, and for the state-owned, collective, and private ownership categories. For each ownership category, investments in three categories, "construction and installation" (construction), "purchase of equipment, tools and instruments" (equipment), and "others," are reported separately. The "others" category has no specific definition and consists of a relatively small fraction (between 10 and 16 percent) of total investments and so we split it into construction and equipment using the corresponding shares of each. Construction and equipment investment data for the private sector are missing for the 2000-2002 period, and so we adopt a linear interpolation using data for 1999 and 2003.

We adopt the PIM to construct capital stock time series using the capital investment data. Employing the PIM, gross capital stock is calculated as the weighted average of gross fixed capital formation in previous years, of which the service life has not yet expired. The weights constitute the relative efficiency of capital investments of different vintage. In the formula, $A_t = \sum_{\tau=0}^{T} d_\tau I_{t-\tau}$,where A_t denotes gross capital stock at time t, I_t represents gross capital investment, d_τ is the relative efficiency of a capital investment of vintage τ, and T denotes the expected service life. If the relative efficiency of capital investment declines geometrically, then gross capital stock at time t can be estimated by $A_t = (1 - \delta)A_{t-1} + I_t$, where δ is the capital depreciation rate.

Although fairly reliable statistics on capital investment are available, statistics on capital retirement are rare. Based on estimates from other countries and suggestions from NBS experts, we assume the service life of equipment to be 16 years and that of construction to be 40 years. Given these assumptions, the depreciation rates for equipment and construction are 17% and 8%, respectively. Sun and Ren's (2005) estimates of capital stocks in 1992 are adopted as our base-year figures. Price indices of investments in construction and equipment are available from the SYC. All nominal units are deflated by type-specific price indices to 2007 values. We construct time series of capital stocks of construction and equipment using their separate depreciation rates for each ownership category. Finally, construction and equipment capital stocks are summed to obtain the total capital stock in the state and private sectors.

Labor Input. To estimate employment size by skill type in China's urban labor market, we first collect SYC data on the total number of urban employed workers in each ownership category. However, workers' education distribution cannot be ascertained from the aggregate data source. Therefore, we calculate the proportion of workers at each education level (middle school and below, vocational and high school, and college and university) in the state and private sectors from the national UHS sample. Then, we use the employment share by education level and total employment in each sector to compute the number of workers with different levels of educational attainment in each sector. Finally, the total high and low-skilled labor inputs are generated by aggregating the number of middle school, high school, and college workers across the state and private sectors.

One caveat concerning our labor input measure is that the SYC aggregate urban employment statistics exclude rural-to-urban migrant workers. The NBS did not sample households in urban areas that lacked urban registrations before 2002. In that year, it expanded the sample coverage of the UHS to include more cities and rural migrant households. However, we discovered migrant workers to be under-represented in the sample. Of the 388,459 workers observed in our sample between 2002–2007, slightly more than 1 percent (4,456) were identified as migrant workers, a number that is much lower than reality.

To rectify this under-representation, we made an effort to estimate the size of the migrant workforce using alternative data sources. Some highly skilled migrant workers live in urban areas on a long-term basis and are able to meet the legal requirements of a "stable source of income" and "stable place of residence," which are necessary to obtain public services such as health care and schooling for their children. This type of migrant is likely to be included in the UHS sample. However, most rural migrant workers have few skills, and they compete with urban residents for low-income jobs. Many of these migrants live on the periphery of cities, residing in employer-provided dormitories or at their workplaces such as construction sites. Without a formal urban address, they have little chance of being covered by the UHS. Because of these factors, we estimate the size of the low-skilled rural migrant workforce and add these estimates to that of the low-skilled urban labor force.

The best data source for estimating the number of rural-to-urban migrants is the Chinese census. Since 2000, each individual covered in the census has reported his or her resident status. Hence, using the 2000 census and a 1 percent sample of the 2005 census, we estimate the size of the low-skilled rural migrant workforce. For the other years between 2000 and 2007, we estimate the size of this workforce by assuming a linear time trend over the time interval. We extrapolate migrant numbers between 1992 and 1999 by combining the estimates of Cai, Park and Zhao (2008) and our own estimates from the 2000 census. Finally, migrant workers are split into the state and the private sectors using the proportions observed in the 2002-2007 UHS data.

R&D Expenditure: Annual data on "expenses on science and research" since 1978 are collected from the SYC, and we employ them as a measure for domestic R&D investment. Following the methods first proposed in Griliches (1979), we adopt the PIM to construct the stocks of domestic R&D in 2007 prices. Following Hu, Jefferson and Qian (2005) and Fleisher and Zhou (2010), we assume the depreciation rates to be 15 percent.

FDI: Annual data on the "total amount of foreign capital actually utilized" since 1979 are drawn from the SYC. Again, we employ the PIM with a 15 percent depreciation rate to construct foreign capital stocks in 2007 price.

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Appendix: Not for Publication

A. Changes in Working Hours

Considering that the UHS does not report information on hours of work for most of the survey years, we have relied on another data source, China Health and Nutrition Surveys (CHNS), to investigate changes in hours of work over time. The CHNS covers nine provinces: Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou. A multistage, random cluster process was used to draw the samples surveyed in each of the provinces, covering both rural and urban areas. The first round of the CHNS was collected in 1989, and six additional panels were collected in 1991, 1993, 1997, 2000, 2004, and 2006. Liaoning did not participate in the 1997 survey, and Heilongjiang was added to the survey only after 1997. To maintain a comparable sample, we exclude these two provinces and restrict our analysis to the remaining seven provinces. We use the urban sample and deploy the same sample selection criteria as those used for the UHS sample. More specifically, our sample includes all workers aged 16–55 for females and 16–60 for males, excluding employers, self-employed individuals, independent operators (including farmers), students, and workers whose real annual wages were below half of the real minimum wage.

Table 1 presents the changes in average hours per week for all workers and separately by gender and education from 1991 to 2006 using the CHNS data. Hours of work remained rather steady during this period, except for a noticeable decline in weekly hours between 1993 and 1997. This decline was mostly driven by the fact that China switched from the arrangement of six working days per week to five days per week in 1995. Therefore, hourly wage growth rate is likely to be faster than annual wage growth between 1993 and 1997. Between 2000 and 2004, hours per week slightly increased by approximately two hours, implying a lower hourly wage growth compared with annual wage growth.

Although changes in working hours may introduce a deviation of hourly wage estimates from annual wage rates, we find no evidence that the male wage premium or education premiums are driven by changes in hours worked by different groups. Male and female workers spend almost the same amount of time working in all years, with a gap never exceeding one hour per week. Therefore, the difference in working hours should have a limited effect on the changes in the gender earnings gap. On average, more educated workers have less working time than the less educated workers, and the difference in their working hours appears to have increased between 2000 and 2006. Therefore, if school premiums are defined according to hourly wages, the growth of the skill premium would be higher than those defined in annual wages in recent years.

Table 1: Changes in Average Weekly Hours: 1992-2006

	1991	1993	1997	2000	2004	2006
All	48.2	47.3	41.8	41.6	43.6	43.5
By gender						
Male	48.5	47.2	42.2	41.5	43.6	43.7
Female	47.9	47.3	41.3	41.7	43.6	43.3
By education						
Middle school	48.6	48.2	42.7	42.1	45.6	46.0
High school	47.6	46.3	40.8	41.3	43.3	42.7
College	47.8	45.2	39.9	40.4	40.2	41.4

B. Educational Attainment of the Urban Labor Force

In the UHS sample, "college workers" defined as wage employees with any forms of post-secondary education comprised 33.6 percent of the urban labor force in 2007. To verify the representativeness of the sample in terms of workers' educational distribution, we collect and analyze aggregate statistics on college enrollment from the China Statistics Yearbook (CSY). Students with post-secondary education are categorized into four groups of school enrollment in the CSY: (1) postgraduate doctor's or master's degrees; (2) regular students in four-year universities or two-year or three-year colleges; (3) adult students in four-year universities or two-year or three-year colleges; (4) other degree programs of higher education, including part-time arrangements, studies relying on radio, TV and internet instructions, and various examination programs towards a diploma based on self-learning. Our definition of "college workers" differs from the standard definition of "college graduates" because college workers in our sample consist of all individuals who participated in the above four types of educational programs, with or without a successful graduation. According to official statistics, there were 0.42 million of new enrollments in 2007 in post-graduate degree programs, 5.66 million in regular universities or colleges, 1.91 million of adult students in universities or colleges, and another 1.36 million in all other forms of higher educational programs and institutions (CSY, 2008). Therefore, student enrollments in regular universities and colleges accounted for approximately 60.5 percent of total new enrollments in higher educational programs and institutions in 2007.

The preceding calculations are needed to estimate the total number of college workers in 2007. Historic numbers on enrollments are not available for all four categories of higher education discussed above. However, reports on annual student enrollments in regular universities and colleges are available since 1978, with a total of 36.3 million new enrollments recorded between 1978 and 2005. Assuming that the shares of student enrollments in regular universities and colleges in all forms of higher education are constant over time, the estimate for the total new enrollments in all higher educational programs would add up to 60.0 million (= 36.3/60.5%) during the 1978-2005 period. Because an overwhelming majority of college attendees would stay in cities, those attendees between 1978 and 2005 were presumably in the urban labor force in 2007, as they were mostly within the working age of 16-55 for females and 16-60 for males. We consider all new college enrollments for years before 2005 because students enrolled in two-year colleges in 2005 would have joined the labor force by 2007, and students engaging in part-time graduate education, adult training programs and studies through multimedia channels were already in the labor force by 2007. Conceptually, 60.0 million is a close estimate of urban college workers as defined in the UHS sample because it includes all individuals who have some exposure to various kinds of post-secondary schooling. Even if some of the newer college attendees may not have entered the labor force, those who enrolled in higher education before 1978 may continue to work in 2007, thus counter balancing the counts for college workers.

Given the number of urban workers exclusive of rural migrants of 196.9 million in 2007 (CSY, 2008), we estimate that college workers constitute approximately 30.5 percent (= 60.0/196.9×100) of the urban workforce in that year. Therefore, the educational distribution of workers in our UHS sample is broadly consistent with aggregate statistics, although we cannot completely dismiss the possibility that college workers have a higher response rate than workers with lower educational attainment.

C. SMM Estimation Procedure

Let m_j be moment j in the data presented on the left-hand side of equations (12) to (14). The corresponding simulated moment is denoted by $m_j^S(\theta)$, which is obtained from 500 simulations, $m_j^S(\theta) = \frac{1}{500}\sum_{s=1}^{500} m_j^s(\theta)$; $m_j^s(\theta)$ is computed as the right-hand side of equations (12) to (14). Our task amounts to finding a parameter vector θ that renders the model-simulated base wage and wage premiums $(m_j^S(\theta))$ as close as possible to the empirical ones (m_j). The vector of moment conditions is

$$g(\theta)' = [m_1 - m_1^S(\theta), \cdots, m_j - m_j^S(\theta), \cdots, m_J - m_J^S(\theta)],$$

where $J = 64$ is the number of moments used (4 moments × 16 years). We minimize the following objective function with respect to θ

$$L(\theta) = g(\theta)' W g(\theta), \tag{15}$$

where W is a weighting matrix.

Following Lee and Wolpin (2010), we make two assumptions in forming the weighting matrix W: (1) W is diagonal and (2) $E[g_j(\theta)^2] = \sigma_j^2/N_j$, where N_j is the number of individuals that comprise the jth moment. We employ a two-step procedure to compute the diagonal elements of W. First, we set $\sigma_j^2 = 1$ and weight each sample moment by N_j. We estimate θ by minimizing (15) and allow $\widehat{\theta}$ to be the first-stage estimate of θ. Second, we update σ_j^2 according to $\sigma_j^2 = E[g_j(\widehat{\theta})^2]$. Then, we weight each moment j by N_j/σ_j^2 and estimate θ according to (15).

In each step, the solution to the aggregate labor market model is used as the inputs of the estimation procedure. The detailed procedure is as follows.

1. Make an initial guess for the parameter vector $\theta = \{\sigma_j, \rho_j, \lambda_j, \mu_j, \psi_0^l, \psi_0^{hs}, \psi_0^c, \gamma^l, \gamma^{hs}, \gamma^c, \eta_\omega\}$.

2. Randomly draw shocks to labor efficiency $\omega_t' s$ from the normal distribution $N\left(0, \eta_\omega^2\right)$.

3. Use equation (11) and the observed number of workers at each educational level to calculate total labor efficiency units of each type. The observed employment of middle school workers in the state sector is adopted as the government employment restriction of low-skilled labor, $\overline{n_t^l}$. Compute equilibrium high-skilled labor allocation, N_{st}^h, using equation (7).

4. Compute the technology parameters in both sectors, A_{st} and A_{pt}, using the production functions specified in (5).

5. Simulate the wages of all labor types and compute the base wage and wage premiums in each year.

6. Run 500 simulations by repeating steps 2–5, and then take their average to construct simulated moments, $m_j^S(\theta)$.

7. Compute the objective function $L\left(\theta\right)$.

8. Adjust the parameters and repeat steps 2–5 until the optimum is reached.

The variance-covariance matrix of the parameter estimates is given by $\left(A'WA\right)^{-1}$, where A is the matrix of the derivatives of the moments with respect to the parameters and W is the inverse of the variance-covariance matrix of the moments.