Accounting for Rising Wages in China†

Highly Preliminary Draft

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Abstract

Using a unique national sample of Urban Household Surveys, we document several profound changes in the wage structure in China 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 that 80 percent of this wage growth is attributable to higher pay for basic labor, rising returns to human capital, and increases in the state-sector wage premium. Employing an aggregate production function framework, we account for the sources of wage growth and wage inequality in China in the face of rapid globalization and economic transition. We find capital accumulation, export expansion, and skill-biased technological change to be the primary forces behind the recent wage explosion in China.

Keywords: wage growth, wage premium, capital accumulation, trade expansion, technological change, China

JEL code: J31, E24, O40

1 Introduction

Over the past two decades, China's gross domestic product has grown by more than 10 percent per year, turning the country into the world's fastest growing economy. Against this backdrop of rapid economic growth, this paper documents the profound changes in China's wage structure using a unique national sample Urban Household Surveys (UHS). Although there is a burgeoning body of literature focusing on specific aspects of the Chinese labor market, we take a different approach that provides a more comprehensive picture. We document a rise in the basic wage for unskilled workers and trace the changing wage premiums to 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 have also occurred in other East Asian economies, such as Japan in the 1950s and 1960s and Korea in the 1970s and 1980s.[1] However, little is known about the wage and employment structural changes that took place during these episodes. The current study is intended to fill this void in the literature by illuminating the facts and mechanisms of wage determination during China's process of rapid development.

Between 1992 and 2007, the average real wage in urban China increased by 202 percent.[2] 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 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 made remarkable gains. The 260 percent wage growth enjoyed by these employees far surpassed that for workers in collective, individual, and private enterprises (CIP). Another interesting labor market trend in the 1992–2007 period was the sharp rise in men's wages relative to women's and the decline in female labor force participation. Some of these observations are novel findings, and others corroborate the results of existing studies covering select regions and shorter periods. 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 which posits a sudden increase in the basic wage after a long period of wage stagnation. Phenomena also not well

[1] 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 roughly tripled in the 1971–1986 period (Kim and Topel, 1995), and also grew rapidly in postwar Japan, climbing by 180 percent between 1952 and 1965 (JIL, 1967).

[2] 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. Section 3 and the Appendix provide detailed descriptions of the data.

documented in the literature are the rising wage premium for the state sector, the long-term increase in the gender earnings gap, and the decline in female labor market participation. An important goal of this paper is to bring these facts to the fore and explore the forces of wage determination within 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 observed wage growth 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 this 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 who work in the state or private sector, and posits that skills complement capital. Incorporated into the model are key features of the Chinese economy: globalization in the form of trade and foreign direct investment (FDI), economic restructuring that loosens the protection of state employment, capital accumulation, skill-biased technological change, and changes in the relative skill supply. Taking these potential driving forces of wage trends as given, we solve the model for the base wage, schooling premium, and state-sector wage premium on the basis of marginal product conditions, while allowing for labor mobility across the two sectors. 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 that capital accumulation and skill-biased technological change are the most important contributors to the rise in the base wage and skill premium. The restructuring of the state sector has played an essential role in raising the state-sector wage premium. Moreover, this empirical framework allows us to assess the labor market consequences of major events, such as China's accession to the World Trade Organization (WTO). Indeed, the resulting expansion in exports has pulled up the base wage, although the continuous flow of rural labor has partly mitigated the upward wage pressure. Overall, our estimated model accounts well for the recent wage explosion in China.

There is a vast body of literature on wage structure changes in both developed and developing countries.[3] This research has focused largely on earnings inequality because, relative to the substantial and widespread earnings divergence seen within many economies in recent

[3] 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.

decades, wage growth has been modest. In a fast-growing economy, however, a rise in the wage level is a distinctive feature of the labor market; therefore, we examine the determination of wage growth and wage inequality jointly, an emphasis that builds upon two aspects of the existing literature. First, we closely follow the supply-demand-institution framework (e.g., Bound and Johnson, 1992; Katz and Murphy, 1992; Juhn et al., 1993; Freeman and Katz, 1994; DiNardo et al., 1996; Autor et al., 1998) and apply the key wage determinants posited in the literature to investigate China's fast-growing economy. Second, the specification of aggregate production functions with capital-skill complementarity highlighted by Fallon and Layard (1975), Goldin and Katz (1998), and Krussell et al. (2000) is central to both our model construction and empirical estimation.[4]

This paper also contributes to the burgeoning literature on labor market developments in China. Existing research has typically focused on such topics as wage differentials between the state and non-state sectors (e.g., Zhao, 2002), the consequences of enterprise restructuring (e.g., Giles et al., 2005), wage discrimination and inequality (e.g., Gustafsson and Li, 2000; Knight and Song, 2003), and returns to education (e.g., Meng and Kidd, 1997; Fleisher et al., 2005; Yang, 2005; Zhang et al., 2005). Instead of investigating one aspect of the labor market in certain regions during specific survey periods, we conduct a comprehensive assessment of the nationwide evolution of the wage structure over an extended period. By developing a coherent framework, we demonstrate that changes in several components of the wage structure are inter-related; that is, they are influenced by a common set of forces arising from globalization, economic transition, and rapid growth.

The remainder of the paper proceeds as follows. Section 2 outlines the economic and institutional background of China during the study period. Section 3 describes the UHS data, documents major trends in wages and employment, and decomposes the sources of wage growth. Section 4 develops and estimates a two-sector labor market model to investigate the driving forces behind rising wages in China, and Section 5 concludes.

2 Economic and Institutional Background

Market economic reforms in China began in 1978. Momentum for further reforms accelerated in 1992, after the Chinese leader Deng Xiaoping took his famous "Southern Tour." Since then, China has moved towards a full-fledged market economy. In 1997, China reached another milestone in its reform efforts, when the role of the private sector was re-defined from "a

[4] 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 et al., 1998; Lee and Wolpin, 2010).

necessary and beneficial supplement to the public economy" to "an important component part" of the national economy. China's accession to the World Trade Organization (WTO) in 2001 was a watershed in its integration to the world economy and contributed to its export-led growth. The post-1992 Chinese economy is characterized by fast and stable growth under globalization and rapid transition to the market economy. Both economic growth and transition have produced profound changes in China's urban labor market conditions.

China's output growth is largely driven by its high investment rate. Total urban investment in fixed assets increased from 0.66 to 11.75 trillion yuan from 1992 to 2007.[5] As a result, capital output ratio increased from 1.36 to 1.72 from 1992 to 2005 (Bai et al. 2006). Capital deepening increases the marginal product of labor. If the production technology features capital-skill complementarity, increases in the capital stock will increase the marginal product of skilled labor more than the marginal product of unskilled labor.

Export expansion has contributed significantly to China's rapid economic growth in the last deacde. The entry into the WTO in 2001 was a turning point in its integration into the world economy and allowed China to capitalize fully on its large supply of labor. Before 2001, the share of exports in GDP hovered around 15 to 20 percent. Since then, exports to GDP ratio has increased rapidly to more than 36 percent in 2007. Manufactured goods have contributed to nearly 95% of China's total exports in recent years, and China has become the world's largest manufacturing exporter. The booming manufacturing industry not only leads to the fast pace of industrialization, but also fosters demand for workers with basic skills.

Technological change is another important source of economic growth. Technological advances can be achieved by both domestic research and development (R&D) and by learning new technology from abroad. Domestically, expense on science and research more than tripled between 1992 and 2007. In the meantime, China has become the second largest recipient of foreign direct investment (FDI). The utilized FDI reached 74.8 billion US dollars in 2007, up from 11.0 billion in 1992. FDI is likely to be an important channel for the diffusion of ideas and technologies (Barrell and Pain, 1997) and correlated with the relative demand for skilled labor (Feenstra and Hanson, 1997). Technological change may also be induced by trade in the form of increased imports of machines, equipment and other capital goods (Acemoglu, 2002). The introduction of new technology into the labor market may be particularly beneficial to high-skilled workers. Many researchers (e.g., Bound and Johnson, 1992; Juhn et al., 1993; Berman et al., 1994) have argued that skill-biased technological change is an important contributor to the increase in wage inequality.

On the supply side, the number of college students and college graduates kept increasing

[5] Data are taken from various years of China Statistical Yearbook of Fixed Assets Investment.

ever since the beginning of the reforms. The increase in the 1980s and most of the 1990s was only modest. In 1999, a policy initiative of expanding college enrollments took effect. As a result, the number of college enrollment increased by almost 50% from 1.08 million in 1998 to 1.60 million in 1999. The number of college graduates increased by more than fivefold between 1999 and 2007, rising from 0.85 to 4.48 millions (NBS, 2008). In the meantime, the urban labor market has experienced an influx of rural migrants. During the centrally planned regime, labor mobility was restricted by the household registration system. After the deregulation on rural-urban migration in the late 1980s, the size of rural to urban migration increased rapidly and exploded in recent years. The majority of migrant workers are less-skilled. According to the 2005 Chinese census, 76% of the migrants have an education level at middle school or below (Duan et al. 2008). The employment share of less-educated workers decreased over time as the urban workforce becomes more educated, but this decline is partially offset by inflows of less-educated migrant workers.

Along with these evolving conditions, labor market institutions were likewise transformed. Under central planning, government labor bureaus assigned workers to state and collective enterprises, where all workers had secure employment, known as the "*iron rice bowl*," and wages were determined by a grade system. Labor market reforms made progress towards a market-oriented system with flexible wage determination, employment contracts, and increased job mobility. Since the mid 1980s, urban wage reforms made it possible for wages to reflect firm profitability and worker productivity (Zhang et al. 2005). Beginning in the early 1990s, skilled workers already searched for jobs of higher pay in the non-state sector, whereas disguised unemployment of low-skilled labor was prevalent in the SOEs because the government had an political objective to reduce unemployment and ensure social stability (e.g., Dong and Putterman, 2003). In 1997, pressed by the mounting losses of the SOEs, the Chinese government launched a drastic state-sector restructuring program, known as *xiagang* (or *leaving the current positions*). 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 from 1996 to 2002 (e.g., Appleton et al., 2002; Giles et al., 2005), ending protectionism in state employment. These profound labor market transformations, perhaps unmatched in magnitude by the experience of other countries, provide an unusual opportunity for investigating major forces behind the evolving wage structures.

3 Wage and Employment Structural Changes

3.1 The Data

The primary data source for this paper is 16 consecutive years of Urban Household Surveys (UHS) conducted by China's National Bureau of Statistics (NBS) for the period 1992–2007. This repeated cross-sectional data set records basic socioeconomic conditions of Chinese urban households including detailed information on employment, earnings, expenditures and demographic characteristics of household members. The survey design of the UHS is similar to the Current Population Surveys (CPS) in the US, and the information on employment and earnings is comparable to those of the March CPS, which has been widely used for studying the US wage and employment structure. The UHS is the only national representative household dataset in China that covers all provinces and contains yearly information dating back to the early 1990s. This is the first study that uses the national UHS sample to analyze the evolution of the Chinese labor market for an extended period of time.[6]

The wage measure that we use throughout the paper is the average annual wage of representative workers with a strong labor market attachment. Wage income consists of basic wage, bonus, subsidies and other labor-related income from the regular job. We deflate annual wages to 2007 yuan by province-specific urban consumption price indices (CPI).[7] Ideally we would like to focus on weekly wages or hourly wages for full-time workers as in previous studies of the wage structure (e.g., Bound and Johnson, 1992; Katz and Murphy, 1992; Juhn et al., 1993). However, information on working hours are not available in the UHS in most of the survey years. Between 2002 and 2006, when working hours were reported for the month prior to the survey, the average monthly hours of the sample fluctuated within a narrow range of 180 to 184, suggesting that actual working hours were rather stable over time. Hence, there appears to be limited measurement errors in the annual wage measure due to possible changes in the intensity of labor supply. Our sample for analysis includes all workers who are aged 16–55 for females and 16–60 for males as 55 and 60 are the official retirement ages for women and men in China, respectively. Moreover, consistent with standard studies of the wage structure, we exclude from the sample business employers, self-employed individuals, farm workers, retirees, students, those re-employed after retirement, and those workers whose wages were below one half of the minimum wage.

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

[7]CPI is slightly above GDP deflator. When we use the province-specific GDP deflator to deflate the wage income, the real wage growth rate between 1992 and 2007 increases by around 15%. But the patterns of wage structure change stay the same.

Using these inclusion criteria, the resultant sample contains 655,372 individuals in the 16 years of repeated cross-sectional data. In the 1992-2001 period, annual sample size ranges from 22,418 to 30,306 workers; and after 2002, the sample size increases to above 62,206 per year.

The UHS adopts a framework of stratified random sampling of urban households and the survey method is consistent over the years. However, we note two data caveats that will be addressed carefully in subsequent analyses. First, before 2002, the UHS only sampled households in cities with official urban household registration (*hukou*), thus excluding rural migrants without legal registration, those considered as "floating population" in China (e.g., Chan and Zhang, 1999). Although the UHS coverage was expanded in 2002 to include all households with a residential address in urban areas, rural-to-urban migrant workers were still under-represented because many of them lived in the periphery of cities, employer provided dormitories, or in workplaces such as construction sites. In Section 4, where we conduct empirical estimation on wage determination, we will impute the size of rural-to-urban migrants and treat them as part of the aggregate urban labor supply. Second, the UHS data is known to have over representation of workers from the state and collective enterprises because their survey response rates are systematically higher than workers from private sector firms. We have deployed an elaborate resampling scheme which 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.

3.2 Trends in Wage and Employment

Table 1 describes structural changes in wage and employment in China between the first and the last years of the study period, 1992 and 2007. The most prominent facts is that average real wage increased by 201.9 percent from 6,193 to 18,695 yuan over the 16-year period. Other striking labor market trends also emerge from the table. We first give emphasis to documenting employment changes, which will be followed by more elaborate analysis on the evolving wage structure.

The top parts of the table show changes in real wage and employment composition by education level and gender. From 1992 to 2007, the employment share of college and university workers (college graduates, thereafter) rose from 16.7 percent to 33.6 percent, more than doubled in 16 years, whereas the employment share of workers with middle school education and below (middle school graduates, thereafter) declined by similar percentage points. This upsurge in educational attainment 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.[8] However, despite the large increase in the supply of college graduates, their real wage climbed 240 percent over this period, growing at a much higher rate than those of high school and middle school graduates.

Parallel to the rise in schooling attainment, the employment share of women declined from 49.8 percent in 1992 to 46.1 percent in 2007. Therefore, the females gradually lost their historical legacy of "holding half of the sky" in employment from the central planning era. Indeed, for prime aged women between 16 and 55, the rate of labor market participation dropped by 11 percentage points during the 16-year period, lowering to 81.2 percent in 2007. While the wage soared for both men and women, the growth of men's wage outpaced that of women by 30.6 percentage points, which enlarged the initial male-female earnings gap in the early 1990s.

The middle part of Table 1 indicates that wages of state-sector employees grew at a much faster rate (259.8 percent) than those of collective-individual-private enterprises (CIP; 178.2 percent) and joint-venture, stockholding and foreign firms (JSF; 99.2 percent). Coincided with the 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. This decline in state employment was a result of continuous privatization and state-sector restructuring since the late 1990s. The massive exodus of SOE workers were largely absorbed by the growing non-state sectors. In 1992 the JSF firms employed only 1.8 percent of the urban workforce, but the proportion rose to 23.7 percent in 2007. Likewise the share of CIP's employment also grew from 28.5 percent to 43.7 percent, replacing state firms as the largest employer of urban Chinese workers in recent years.

The bottom parts of the table present wage growth and employment distributions by industry and region. Industries are reported in three broad categories: manufacturing, basic services, and advanced services. While wages in all industries grew significantly, the slowest growth occurred in basic services, a sector that experienced rapid expansion in employment. The wage growth in the manufacturing sector, which contributed more than 90 percent of China's total exports, and in the advanced service sector, which employed the most educated labor force, were both above the national average. In regard to location, the Eastern, coastal region experienced the fastest wage growth during the 16-year period despite its highest level

[8] Our classification of "college worker" consists of workers with any post-secondary education. In UHS data, we cannot separate college graduates from college attendees or differentiate individuals who acquire formal education in regular college/university from those that study towards college-equivalent diplomas by attending informal night classes or training programs. According to China Health and Nutrition Surveys (CHNS), 24% of the urban labor force have graduated and received diploma from either a regular three-year specialized college or a four-year university in 2006, indicating that a significant number of college workers as we classify them never graduated from college.

of initial income. It appears that large labor inflows to the region was just sufficient to keep its wage growth roughly in line with the national average.

3.3 Changes in Conditional Mean Wages

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

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

where S_{ik}^t are dummy variables for schooling levels with $k \in \{midsch,\ highsch, col\}$ corresponding to middle school, high school and college graduates; EXP_i^t and $EXP_i^{t^2}$ are potential experience, computed as $min[(age - years\ of\ schooling - 6),\ (age - 16)]$, and experience squared, respectively; and GEN_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 manufacturing and the advanced services sector, using basic services as the reference group. R_{in}^t are dummy variables for regions with $n \in \{central, west, east\}$, leaving northeast as the reference region.

In studies of wage structural change, demographic breakdown of data are typically based on gender, education, and experience to control for demographic changes. In China, because of the institutional setting and economic transition, there are large variations in wages across ownership types, industries, and regions. They are very important to understand the wage structural change. Therefore we include them as additional classification to compute the conditional mean wages.[9]

Equation (1) will provide conditional mean estimates for the base wage and various wage

[9] In the specification presented in Equation (1), it is implicitly assumed that all interaction terms across worker characteristics and sector affilications are equal to zero. This assumption is made because of the limited sample size available. For example, once we divide the data into 216 groups, distinguished by gender, education (middle school, high school, and college), ownership type (CIP, state, JSF), industry (manufacturing, basic services, advanced services), and region (northeast, central, west, east), many cells are empty and close to 40% of the cells have less than 30 observations before the sample was expanded in 2002. If we allow these variables to be fully interacted, less than 20% of the regression coefficients are significant.

premiums. In this study, we define base wage as the log real annual wage of the basic reference group, which refers to female workers with middle school education, no experience, working in a CIP firm in the basic service sector and in the low-income northeastern region. Hence, the parameter β_{midsch} provides an estimate for this base wage. Other parameters in the equation correspond to log wage premiums for high school and college graduates, being a male, working in the state and JSF sectors, employment in manufacturing and advanced services, and working in the richer central, western and eastern regions. These wage premiums are computed with the control for experience profiles. We run this conditional mean regression using the UHS cross-sectional data for each of the 16 consecutive years under study.

A graphical illustration of the major changes in the wage structure in China from 1992 to 2007 is provided in Figure 1. While Panel A plots the estimated mean log real base wage for each of the 16 years, Panels B–F provide estimates of wage premiums measured in log wage differential between specific worker groups and their respective reference groups. In Panel B, for example, the log wage differentials between college and middle school graduates (the reference group) and between high school and middle school graduates are presented, holding constant the distributions of the labor force by gender, ownership, industry and region. Several striking patterns of wage changes in China can be summarized as follows.

1. The base wage of raw labor increased persistently and rapidly between 1992 and 2007 (Panel A). Significant wage increases already occurred in the 1990s, when the log base wage rose from 7.608 in 1992 to 7.822 in 1998. In the next 10 years, beginning with China's anticipation into the WTO, 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. This accelerated wage growth points to a potential link between China's dramatic trade expansion and the wage growth of unskilled labor, who are heavily recruited by exporting manufacturing firms. Over a long period after 1992, the continued wage growth of unskilled labor appears to reject the notion that the Lewis turning point has just arrived in China.[10]

2. The schooling premium, especially the college wage premium, rose sharply (Panel B). The log wage differential between college graduates and middle school graduates was doubled during this 16 year period, rising from 0.25 in 1992 to 0.505 in 2007. The increase in college wage premium occurred mostly before 2004, and since then the premium plateaued out. In comparison, the high school wage premium also experienced steady increases in the early

[10]The Lewis model predicts wage stagnation when a developing country has a pool of surplus rural labor, and that wage rises when the redundant labor is depleted. Using survey data on rural migrants, Cai and Du (2010) and Zhang et al. (2010) suggest the arrival of the Lewis turning point in China in 2003-04, when wages began to grow after a long period of stagnation. This claim appears to be inconsistent with the national data presented here.

period and stayed stable after 2000. The rise in the returns to education is a prominent feature of the Chinese labor market during economic transition. In fact, the estimated rate of returns to education using the UHS data was just above one third of the US level using the CPS data in 1988 (3.6 percent vs. 8.9 percent). By 2004, the schooling returns in China had fully converged to the US level (11.1 percent vs. 10.9 percent) and stayed at comparable levels thereafter (Ge and Yang, 2011).

3. The wage of men relative to women increased during the study period (Panel C). While the wages of men and women both experienced substantial increases, their log wage differential increased from 0.11 in 1992 to 0.253 in 2007, a level comparable to the gender earnings gap in the US in recent years (e.g., Mulligan and Rubinstein, 2008). The data show a steady increase in male-female earnings gap in 1992-1998, but the widening of the disparity accelerated since the late 1990s, which coincides with the massive layoffs during the state sector restructuring.

4. The wage of the state sector rose relative to the CIP sector and JSF firms (Panel D). In the 1992-1998 period, the average wage of the JSF sector was about 40 percent higher than that of the state sector and about 60 percent higher than the CIP firms. During that period, many better educated SOE workers actively searched for new jobs in the non-state sector, a phenomenon known as "jumping into the sea." However, in the interest of social stability, the SOEs were not allowed to lay off redundant workers, who were usually less educated with low adaptive ability of switching jobs. The SOE restructuring in the late 1990s had dramatic effects on employment and wages. Coincided with the sharp decline in state employment documented earlier, its wage level registered impressive gains and eventually surpassed that of the JSF sector in 2004. A new phrase—"coming back to shore"— has been coined to refer to the phenomenon that Chinese professionals working in the non-state sector have felt strong incentives luring them to work for the state sector.

5. The wage inequality across basic services, manufacturing and advanced services has widened over time (Panel E). Wages across industries stay clustered in the early and mid 1990s, but then the average wage for the skill-intensive advanced service sector climbed passing the wage levels in labor-intensive industries of manufacturing and basic services. By 2007, the average wage of the advanced service sector was about 15.1 percentage points higher than that of the basic service sector. Manufacturing wages declined relative to that of basic services throughout the 1990s; however, this trend is reversed beginning in 2001 after China's entry into the WTO. 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 percent to 40 percent higher than the other three regions, where their wage levels remained rather clustered during the entire period. Due in part to high wages, the eastern region has attracted significant inflow of labor raising its employment share by 12.1 percentage points in the UHS data.

The rise in base wage and wage premiums, along with systematic changes in employment distributions, such as the increase in the proportion of workers with college education, the decline in female labor force participation, and large labor flows to regions with high earnings, are suggestive of the major sources of wage growth in China. Assessing the relative contributions of these factors to rising wages is the task we now turn.

3.4 Decomposition of Wage Growth

We analyze the components of wage growth in China using a decomposition framework that relies on the conditional mean wages reported above. The basic wage function posits that the average wage for a working sample reflects the characteristics of the workers and the labor market prices to various individual characteristics. Consequently, changes in the wage level over time come from two components: changes in the distribution of individual characteristics and changes in the wage premiums to worker characteristics. For year t, consider a wage equation in the 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 individual i's jth characteristic (such as schooling attainment or ownership category of his/her employer), β_j^t is the market price for the jth characteristic, and ε_i^t represents a random error.

To examine wage growth from an initial year τ_0 to an ending year τ, the difference in 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 year τ_0 and τ, respectively. $\{\overline{X}_j^{\tau_0}, \overline{X}_j^{\tau}\}$ are mean values of the jth regressor, and $\{\widehat{\beta}_j^{\tau_0}, \widehat{\beta}_j^{\tau}\}$ are estimated wage premiums for the corresponding worker characteristics. Rearranging equation (3) gives

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

where α_js are weights between 0 and 1 and satisfy $\sum_j \alpha_j = 1$. This equation decomposes the change in the average of log wage between the two years into two parts. The first term on the right-hand side of equation (4) represents the part of the log wage change due to changes in worker characteristics, and the second term is the part of log wage change due to changes in returns to characteristics, or changes in the wage structure. This formulation can be considered as an application of the Oaxaca-Blinder decomposition analysis.

Our decomposition analysis builds on the fact that changes in the composition of the work force as measured in $\overline{X}$ and changes in various wage premiums as measured in βs may contribute to changes in $\ln w$ over time. Using equation (1), we can obtain βs based on data from individual years as illustrated in Figure 1, then by combining the parameter values with sample values of $\overline{X}$, we can decompose the change in log wage over any two specific years into various components of the wage change.

In general, contributions of worker characteristics and returns to characteristics to the log wage change depend on the choice of weights in $\alpha_j s$. Since we are more interested in wage growth due to changes in wage structure, we assume the distribution of individual characteristics to be fixed at the initial level and set $\alpha_j = 1$.

The average wage level for 1992 is 6,193 yuan. It increased by 202 percent from 1992 to 2007 and reached 18,695 yuan in 2007. The corresponding mean log wage differential between the two years is 0.989. In what follows, we use the estimates of the wage function in (1) to perform decomposition analysis. Table 2 presents the decomposition results using equation (4) for the years over 1992 and 2007. The change in base wage accounts for 37.58 percent of the log wage change, or 0.372 of the mean log wage differential. Changes in returns to characteristics and sector premiums contribute to 55.96 percent of the wage changes, in which the rising returns to human capital and changes in ownership premium especially the rising state-sector wage premium are two major components. Together, increases in the base wage of unskilled labor, rising returns to human capital, and changes in state-sector wage premium are the three more important factors, together accounting for 80 percent of the observed wage increase between 1992 and 2007.[11] It is estimated that approximately 0.064 or 6.46 percent of the log wage difference is due to the improvement in the human capital of

[11] Neither employment or wage structure is fixed over time. Following Reimers (1983), we have chosen $\alpha_j = 0.5$ for our wage decomposition as robustness check and find that the three factors, including the base wage of unskilled labor, rising returns to human capital, and changes in state-sector wage premium, can still account for 75 percent of the observed wage growth between 1992 and 2007.

the labor force and labor reallocation towards highly-paid sectors. Overall, the rise in labor quality, labor reallocation across ownership types and industries, the decline in female labor force participation, labor mobility across regions, and wage premiums across industry and region only make relatively minor contributions to wage growth.

4 Accounting for Wage Growth and Wage Inequality

In this section, we turn to investigate the driving forces of the three major components of wage growth—higher base wage, increasing returns to schooling, and rising wage premium for the state sector.[12] Conceptually we adopt a supply-demand-institution framework. Taking into consideration the rapid economic growth under globalization and economic transition, we develop a two-sector model that incorporates all of the major explanations of wage structural changes in China. We specify and estimate aggregate production functions with differentiated labor similar to Krusell et al. (2000). We expand the existing framework along several directions: (a) to formulate a two-sector model consisting of a state and a private sector, which are subject to various institutional constraints during economic transition; (b) to build in state-sector restructuring as a key aspect of economic transition that affects wages; (c) to explore an explicit mechanism for understanding the determination of basic wage and wage premiums in a fast growing economy by incorporating into the model key factors such as capital deepening and technological change.[13] This model provides a coherent framework to directly assess the quantitative importance of various economic forces behind rising wages and wage inequality in China.

4.1 A Two-Sector Model

We begin with a simple stylized model of two sectors: a state sector ($j = s$) and a private sector ($j = p$). Consider a CES production function for aggregate output Y_{jt} in sector j at time t with capital and labor as inputs. We specify a two-level CES production function with two types of labor: high-skilled labor $\left(N^h\right)$ and low-skilled labor $\left(N^l\right)$ in each sector j

[12] As shown in Table 2, increasing gender wage premium is another major source of overall wage growth. We decide to leave it for future research because this phenomenon might be caused by changes in labor market discrimination, which is not the focus of this study.

[13] An alternative approach is to specify a dynamic general equilibrium model similar to Heckman et al. (1998) and Lee and Wolpin (2010). However, we cannot estimate a lifecycle labor supply model like theirs because individual panel data similar to NLSY are not available in China. In addition, there are many structural breaks during economic transition in China, and therefore, it is difficult to specify the forecast rule for skill rental prices in a dynamic general equilibrium model.

as follows:[14]

$$
\begin{aligned}
Y_{jt} &= A_{jt}F_j(K_{jt}, N_{jt}^l, N_{jt}^h) \\
&= A_{jt}\{\mu_j(N_{jt}^l)^{\sigma_j} + \left(1-\mu_j\right)\left[\lambda_j(K_{jt})^{\rho_j} + (1-\lambda_j)\left(N_{jt}^h\right)^{\rho_j}\right]^{\frac{\sigma_j}{\rho_j}}\}^{\frac{1}{\sigma_j}}. \qquad (5)
\end{aligned}
$$

In this specification, A_j is the neutral technological efficiency in sector j. μ_j and λ_j are parameters that govern income shares. The elasticity of substitution between low-skilled labor and capital is $1/(1-\sigma_j)$, and the elasticity of substitution between high-skilled labor and capital is $1/\left(1-\rho_j\right)$, where $\sigma_j, \rho_j < 1$. If $\sigma_j > \rho_j$, the production technology in sector j exhibits capital-skill complementarity.

The labor input of each skill type is measured in efficiency units, following Krusell et al. (2000). It is standard in the literature to define the skill level of labor input based on workers' education level. We define high-skilled labor as requiring high school or college education. Each labor input type is a product of the raw number of workers and an efficiency index: $N_{jt}^l = \psi_t^l n_{jt}^l$ and $N_{jt}^h = \psi_t^{hs} n_{jt}^{hs} + \psi_t^c n_{jt}^c$, where n_{jt}^l, n_{jt}^{hs}, n_{jt}^c are numbers of middle school, high school, and college workers in sector j, ψ_t^l, ψ_t^{hs}, ψ_t^c are the unmeasured quality per worker of each type at date t. The unmeasured quality $\psi's$ can be interpreted as human capital or a education-specific labor-augmenting technology level. They are assumed to be equal across sectors.

The major institutional factor in the Chinese labor market we consider is the employment protection in the state sector under central planning and its loosening during economic transition. Under central planning, one of the government's goals is to keep "full employment," and one of SOEs' traditional roles is to guarantee job security. To reach this goal, we assume, the employment of low-skilled workers in the state sector is constrained by the government to be greater than or equal to a fixed minimum employment, $\overline{n^l}$.[15] If $\overline{n^l}$ is below the competitive level, it has no effect on the competitive equilibrium. If $\overline{n^l}$ is above the competitive level, we shall be dealing with the case in which the employment of low-skilled workers in the state sector $n_s^l = \overline{n^l}$. Since economic restructuring starts, the limit on $\overline{n^l}$ is lowered until it reaches the competitive level. Because the SOE restructuring primarily affected the low-skilled workers, the fraction of low-skilled employees with middle school or below education dropped by 60.7% in the state sector, from 33.8% to 13.3% between 1992

[14]The two-level CES specifications have been used in recent literature to examine the evolution of skill premiums and the consequences of the capital-skill complementarity hypothesis. There are three permutations of the two-level CES function, Fallon and Layard (1975), Caselli and Coleman (2002) and Duffy et al. (2004) all prefer to work with the specification we choose, where the elasticities of substitution between capital and low-skilled labor and between high-skilled labor and low-skilled labor are the same.

[15]Based on panel data of 681 SOEs, Dong and Putterman (2003) estimate that 68% of SOEs had redundant workers in 1992.

and 2007.[16] Given the employment constraint, the production function in the state sector becomes

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

where $\overline{N_t^l} = \psi_t^l \overline{n_t^l}$ is the minimum efficiency units of low-skilled labor employed in the state sector.

The government has less incentive to protect high-skilled workers since they are less likely to be unemployed. High-skilled labor generally has better access to market information and social network and therefore is more mobile.[17] If the labor market is perfect competitive with no frictions, free mobility implies wage equalization across the sectors. However, employment protection in the state sector restricts the mobility of low-skilled workers and generates wage differentials for low-skilled workers across sectors. If high-skilled wages are equal between the state and the private sectors, skill premiums will differ across sectors, an outcome inconsistent with our empirical results.[18] Therefore we assume that mobility of high-skilled labor equalizes the wage premiums of high-skilled labor across sectors. The equilibrium high-skilled labor in the state sector at date t, N_{st}^h, is thus determined by the following implicit function:

$$\begin{aligned} & \frac{\eta_s}{\mu_s}\left[\lambda_s\left(\frac{K_{st}}{N_{st}^h}\right)^{\rho_s} + (1-\lambda_s)\right]^{\frac{\sigma_s}{\rho_s}-1}\left(\frac{N_{st}^h}{\overline{N_t^l}}\right)^{\sigma_s-1} \\ = & \frac{\eta_p}{\mu_p}\left[\lambda_p\left(\frac{K_{pt}}{N_t^h - N_{st}^h}\right)^{\rho_p} + (1-\lambda_p)\right]^{\frac{\sigma_p}{\rho_p}-1}\left(\frac{N_t^h - N_{st}^h}{N_t^l - \overline{N_t^l}}\right)^{\sigma_p-1}, \end{aligned} \tag{7}$$

where $\eta_j = (1-\mu_j)(1-\lambda_j)$, and N_t^h and N_t^l are the total efficiency units of high-skilled labor and low-skilled labor determined by the size of the workforce.

China's urban wage reform started in the mid 1980s, and by the 1990s wages more or less reflect worker productivity in both sectors. We derive real wages of high-skilled labor and low-skilled labor in each sector by using marginal product conditions. Consistent with the previous empirical analysis, the base wage is defined as the real wage of low-skilled labor

[16] This shift in skill composition may partially driven by the fact that the urban workforce becomes more educated over time. However, the fraction of low-skilled workers among the total workforce declined only by 38.5% in the same time period.

[17] Knight and Yueh (2004) find that the mobility rates of urban residents increase in education. In a somewhat related study, Li (1998) discusses the phenomenon that state officials quit their government positions to join the business community, known as *xiahai* (i.e., "jumping into the sea") since the late 1980s and majority of these people have higher education.

[18] We find little evidence that schooling premiums are different across the state and the CIP sectors. When we systematically add interaction terms between any two worker characteristics in Equation (1), most of the regression coefficients on the interaction terms between school levels and a dummy variable for the state sector are insignificant.

in the private sector, w^l_{pt}, and

$$w^l_{pt} = \mu_p A^{\sigma_p}_{pt} Y^{1-\sigma_p}_{pt} (N^l_t - \overline{N^l_{st}})^{\sigma_p - 1} \psi^l_t. \tag{8}$$

Equation (8) illustrates the determinants of the base wage. Changes in the right-hand side variables are the driving forces of the base wage growth, and each component has specific economic interpretations. The base wage is determined by output growth. Since $\sigma_p < 1$, fast output growth in the private sector (Y_{pt}) implies rising base wage. If capital deepening and export expansion drive up output growth, they will also have a positive effect on the base wage. The growth of base wage also depends on the growth rates of general technological efficiency (A_{pt}) and specific technological efficiency of low-skilled labor $\left(\psi^l_t\right)$. On the other hand, increase in the supply of low-skilled labor in the private sector $(N^l_t - \overline{N^l_{st}})$ reduces the base wage.

Skill premiums are defined as the relative wages between high-skilled and low-skilled labor. We have college premium as

$$\frac{w^c_{pt}}{w^l_{pt}} = \frac{\eta_p}{\mu_p} \frac{\psi^c_t}{\psi^l_t} \left(\frac{N^h_t - N^h_{st}}{N^l_t - \overline{N^l_{st}}} \right)^{\sigma_p - 1} \left[\lambda_p \left(\frac{K_{pt}}{N^h_t - N^h_{st}} \right)^{\rho_p} + (1 - \lambda_p) \right]^{\sigma_p/\rho_p - 1}. \tag{9}$$

High school premium is defined similarly. Equation (9) demonstrates three driving forces of the growing college premium. First, the college premium depends on the relative labor efficiency between college labor and low-skilled labor $\left(\psi^c_t/\psi^l_t\right)$. A relative improvement in the quality of college labor increases the college premium. Second, the college premium is affected by the growth rate of high-skilled labor input relative to the growth rate of low-skilled labor input, $\left(N^h_t - N^h_{st}\right)/(N^l_t - \overline{N^l_{st}})$. As $\sigma_p < 1$, relative faster increase in high-skilled labor reduces the college premium. In addition, capital deepening is an important determinant of the college premium. If $\sigma_p > \rho_p$, that is, high-skilled labor is more complementary with capital than is low-skilled labor, and if capital grows faster than efficiency units of high-skilled labor input, capital deepening tends to increase the college premium as it increases the relative demand for high-skilled labor.

Finally we define state-sector wage premium as the relative low-skilled wage between the state and the private sectors,

$$\frac{w^l_{st}}{w^l_{pt}} = \frac{\mu_s \left(A_{st}\right)^{\sigma_s} \left(Y_{st}\right)^{1-\sigma_s} (\overline{N^l_{st}})^{\sigma_s - 1}}{\mu_p \left(A_{pt}\right)^{\sigma_p} \left(Y_{pt}\right)^{1-\sigma_p} (N^l_t - \overline{N^l_{st}})^{\sigma_p - 1}}. \tag{10}$$

The growth rate of state-sector wage premium depends on the relative technological efficiency, relative output demand, as well as relative supply of low-skilled labor between the state and the private sectors. In particular, if SOE restructuring reduces the relative growth rate of low-skilled labor in the state sector, state-sector wage premium will increase.

4.2 Aggregate Data

From our previous decomposition analysis, the rises in base wage, school premiums, and state-sector wage premium together account for a majority of the observed wage growth between 1992 and 2007. As is shown in Figure 1, base wage (in log) increased from 7.61 to 8.50 between 1992–2007. High school premium increased from 11 percent to 20 percent from 1992 to 2000, declined in the next three years, and somewhat stabilized ever since. On the other hand, college premium rose sharply and continuously from 25 percent to 51 percent. The state sector wage premium exhibits a sharp increase between 1992–1994, a decline over much of 1994–1999, another surge between 1999 and 2005, and a small decline since 2005. Overall, the state sector wage premium increased from 19 percent to 30 percent.

In order to account for these changes in base wage and wage premiums, we estimate the two-sector model of wage determination. The estimation requires data on real GDP, capital stocks, low-skilled labor and high-skilled labor inputs in both state and private sectors. Following the same aggregation of ownership category as for the UHS sample, we combine the collective sector and the domestic individual and private sector and refer them as the private sector thereafter. We obtain GDP data from China's Statistical Yearbooks (CSY). The output share of the state sector in total GDP declines over time, which is consistent with the employment trend documented earlier. State output was more than 3-fold of private output in 1992, but it was only 38% more than private output by 2007. The average output growth rate of the state sector is 6.2 percent between 1992–2007, and that of the private sector is 12.6 percent. We construct data for capital stock using investment data from CSY and the perpetual inventory method. Capital stock shows stronger growth in the state sector between 1992–1998, but the growth rates in the private sector are higher between 1999–2007. Data for both GDP and capital are in constant 2007 Yuan. As for the labor inputs, since rural-to-urban migrants are under-represented in the UHS, we impute the size of rural-to-urban migrant workers based on the 2000 and 2005 Population Censuses and treat rural migrants as part of the aggregate urban labor supply. Our education-based measures show a strong secular increase in the stock of high-skilled relative to low-skilled labor input. The ratio of high school employment to middle school employment increased by 54 percent and the ratio of college labor input to middle school labor input increased by 215 percent over the 1992–2007 period. Even though both skilled labor input and capital input increased dramatically, we find that the ratio of quantity of capital to the quantity of high-skilled labor input has grown continuously over the entire 1992–2007 period. As we discussed in the theory, this ratio affects the skill premiums through capital-skill complementarity. Finally, we also construct proxies for technological advances, FDI, and sector-specific exports data to analyze the impact of technological change and globalization. Data Appendix B provides details in the construction of the aggregate variables.

4.3 Quantitative Analysis

In this section we use the two-sector model to investigate quantitatively the driving forces of changes in base wage and wage premiums. With the values of the production function parameters, equations (8), (9) and (10) can be used to assess how base wage and wages premiums are affected by various forces.

A. The Benchmark Model

The efficiency of a worker with education level $k \in \{l, hs, \text{col}\}$ is given by the exogenous index ψ_t^k. These efficiency indices are determined by factors like school quality and technological advances. They are in principle unobserved by the econometrician. We specify the efficiency of each type of worker as a stochastic process influenced by technological change:

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

$$\psi_t^{hs} = \psi_0^{hs} + \gamma^{hs} X_t + \omega_t^{hs}, \tag{12}$$

$$\psi_t^c = \psi_0^c + \gamma^c X_t + \omega_t^c. \tag{13}$$

Type k labor input has an initial level of efficiency given by ψ_0^k, which is determined by school quality and the initial technological level. Labor augmenting technological change are introduced in X_t, and they may be biased to certain skill type, as reflected by the type-specific labor efficiency growth rates, γ^l, γ^{hs}, and γ^c. Technological advances can be induced by domestic research and development or by globalization through learning ideas from abroad. Following the methods first proposed in Griliches (1979), we use a perpetual inventory method to construct the stocks of domestic R&D, imported machinery, and FDI as variables in X_t.[19] $\omega_t' s$ are normally distributed *i.i.d.* shocks to the efficiency of labor with mean zero and covariance matrix Ω. In the benchmark specification, we impose the condition that the shocks had zero covariance and identical variances. This implies that we can rewrite the covariance matrix $\Omega = \eta_\omega^2 I_3$, where η_ω^2 is the common innovation variance and I_3 is the

[19] The depreciation rates are assumed to be 15% following Hu et al. (2005) and Fleisher and Zhou (2010). See Appendix B for the details.

3×3 identify matrix. Given the small sample size we are working with, these restrictions are necessary to reduce the number of parameters to be estimated.

The econometric model consists of four structural wage equations which are derived from the two-sector models. These four equations are the base wage, high school and college premiums, and state-sector wage premium:

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

$$\left(\frac{w_{pt}^{hs}}{w_{pt}^{l}}\right)^{UHS} = \frac{w_{pt}^{hs}}{w_{pt}^{l}}(Z_t;\theta),\quad \left(\frac{w_{pt}^{c}}{w_{pt}^{l}}\right)^{UHS} = \frac{w_{pt}^{c}}{w_{pt}^{l}}(Z_t;\theta), \tag{15}$$

$$\left(\frac{w_{st}^{l}}{w_{pt}^{l}}\right)^{UHS} = \frac{w_{st}^{l}}{w_{pt}^{l}}(Z_t;\theta), \tag{16}$$

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 outputs by sector, factor inputs, and measures of technological change. The parameter vector θ contains following parameters: the curvature parameters σ_j and ρ_j, which govern the elasticities of substitution; parameters that govern income shares, λ_j and μ_j; the initial values of labor efficiencies, ψ_0^k, $k \in \{l, hs, \text{col}\}$; labor efficiency growth rates, γ^l, γ^{hs} and γ^c; and η_ω^2, the variance of the labor efficiency shocks.

The LHS of these structural equations are the empirical base wage and wage premiums estimated from UHS sample and the RHS of these equations are comprised of the theoretical counterparts from the model. Initially we use stocks of domestic R&D expenditure, imported machinery and FDI as measures of technological change but find that the impact of imported machinery on labor efficiency is close to zero. Thus we keep domestic R&D expenditure and FDI as proxies for technological change in the rest of analysis. In total, the parameter vector θ includes 18 parameters and they are estimated with $4 \times 16 = 64$ moments. We estimate the parameters of the model using simulated method of moments (SMM). In particular, a weighted average distance between sample moments from the UHS and simulated moments from the model is minimized with respect to the model parameters. We discuss the details of the SMM estimation including the weighting procedure in Appendix C.

B. Findings from the Benchmark Model

Estimates of the parameters and their standard errors are reported in the second and third columns of Table 3. The parameter estimates show that $\sigma_j > \rho_j$ $(j = s, p)$, that is, production is characterized by capital-skill complementarity in both sectors. In the state sector, the elasticity of substitution between capital and low-skilled labor is $1/(1-\sigma_s) = 2.48$. This implies that they are substitutes for one another in the production process. The elasticity of substitution between capital and high-skilled labor is $1/(1-\rho_s) = 1.44$, indicating that the substitutability between capital and high-skilled labor is lower than that between capital and low-skilled labor. In the private sector, the elasticity of substitution between capital and low-skilled labor is $1/(1-\sigma_p) = 2.31$, and the elasticity of substitution between capital and high-skilled labor is $1/(1-\rho_p) = 1.51$. Therefore, capital is slightly more complementary with high-skilled labor and more substitutable with low-skilled labor in the state sector. These estimates are well within the reasonable range found in the empirical literature (Hamermesh, 1993) and are close to those reported from cross-country studies (Duffy et al., 2004). The parameter estimates of labor efficiency show that labor efficiency increases in education level. Both R&D expenditure and FDI improve the efficiency of better-educated workers more than the less-educated workers. That is, they exhibit bias towards high-skilled labor.

Factor-neutral technological efficiencies, A_{st} and A_{pt}, can be backed out as residuals using the estimated parameters and the observed input and output data based on the production functions. Solow residual or TFP can be computed by combining the factor-neutral and the labor augmenting technological efficiencies. Following Hsieh (2002), TFP are estimated both in primary measure using factor quantities and in dual measure using factor prices, and we find TFP growth rates to be 2.5-3.0% in the state sector and 2.0-2.1% in the private sector between 1992-2007. These estimates are close to those reported in Young (2003).

Figure 2 shows the goodness of fit of the model. Overall, predictions of the estimated benchmark model are broadly consistent with the data along all four dimensions. The model is able to capture the overall trend in the change of base wage level. In the data, base wage (in log points) increased from 7.61 in 1992 to 8.50 in 2007. The model predicts that base wage increases from 7.60 to 8.48, very close to the data observations. However, the model is not able to capture all the period by period fluctuations. For example, right after Deng Xiaoping's southern tour in 1992, the private sector expanded quickly in 1993 and 1994, which led to a jump in base wage in the model. But the actual labor adjustment was probably slower and more smooth, as indicated by the continuous growth in base wage in the data. Both the data and the model prediction show an accelerated growth in base wage after 2001, which coincides with China's entry to WTO.

The model-predicted high school and college premiums track the actual school premiums closely. In particular, high school premium increased by 0.055 log points and college premium increased by 0.255 log points between 1992 and 2007 based on UHS data. The model-predicted increases in high school and college premiums are 0.038 and 0.287, respectively. Again, the model is not able to reproduce all the year to year fluctuations observed in the data. The simulated college premium flattened out in 2003, when the initial cohorts of students admitted to college after enrollment expansion graduated from school and entered the labor market.

The model captures the overall upward trend in the state premium, but the state premium is under predicted for the 1992–1999 period. One possible explanation is that wage setting in the state sector was not perfectly competitive and the government subsidized the state workers in the 1990s.[20] Therefore, the actual observed state premium with subsidy appears greater than the model prediction based on the marginal product of labor. Employment protection and wage subsidy impose heavy burdens to the government and the state sector. Most of SOEs were having losses and eventually SOE restructuring started in the late 1990s. The government allowed the SOEs to lay off redundant workers and reduced direct wage subsidy to state firms. During this process, inefficient firms were more likely to go bankruptcy, and within each firm marginal product of labor rose as the number of worker decreased. Both forces pushed up labor productivity. Even though state subsidy declined during the reform, the increase in labor productivity more than compensated the declining subsidy. After the reform, wage setting in the state sector becomes more competitive, and our model is therefore able to predict the state wage better.[21]

C. Sensitivity Analysis

Capital stocks are kept fixed as those observed in the data throughout the simulation, while in equilibrium they will tend to respond to shocks. For example, capital investment may respond to concurrent wage. The only way of dealing with this problem explicitly is to extend the model to a dynamic general equilibrium setting, in which one can solve for the decision rules for capital accumulation along with labor supply. This involves a much more complicated model with no analytical solution and with many more parameters. However, our model set-up suggests that the scope of the problem may not be very large. First, the disturbance terms are *i.i.d.*, so that shocks today to labor efficiency are not expected to persist. Second, while shocks may affect investment, which is a flow, the overall effect on the stock of capital will be relatively small. Third, the estimated innovation variance of the

[20] SOEs carry many types of policy burdens in a transitional economy (Lin and Tan, 1999). Lee (1999) shows that when the government and state firm have both wage, employment and profits in their objective functions, wage is above the marginal product of labor. There is also evidence that, corporatization of state firms led to lower wages because there is stronger profit motivation from corporatization.

[21] On the supply side, workers from the private sector may prefer state jobs before the reform because state sector pays more. However, there were many restrictions to secure a state job (for example, one's parent has to be a state employee), because the state firm has to pay their workers above marginal productivity and provide them permanent jobs. Some workers may willingly choose to work in the private sector despite its lower wages because they expect that it is not sustainable for the state sector to run on losses.

shocks is fairly small, and this will tend to limit the range of values the shocks can take.

To formally treat the potential endogeneity of capital investment, we treat annual capital investments as endogenous, and we project these variables onto a constant, lagged capital stock, military expenditure, administrative expenditure, and world oil price, following Heckman et al. (1998). We construct capital stock sequences using the fitted investments from this first-stage regression.

Similarly, labor force participation may also respond to concurrent wage. As argued by Lee and Wolpin (2010), cohort size is a valid instrument for labor input level. Therefore, we use cohort size for women aged 16–55 and men aged 16–60 as instruments and project total employment onto a constant, its lagged value, a trend, and cohort size.

We use the instrumented values of capital stock and total employment in stead of those observed from the data in a second-stage SMM estimation as before. Estimates from this two-stage instrumental variable procedure are reported in the last two columns of Table 3. The parameter estimates are not sensitive to the implementation of a first-stage IV estimation.

4.4 Counterfactual Analysis

In the benchmark economy, the rising base wage and wage premiums are driven by the profound changes in China's urban labor market conditions produced by rapid economic growth. Important changes include factor inputs such as capital deepening, technological advances, and economic restructuring on employment protection. To quantitatively assess the relative importance of these factors in accounting for wage growth over the 1992–2007 period, we perform the following thought experiment. Suppose the economy had stopped growing after 1992 in terms of all factors of inputs, that is, there was no new capital formation, no further neutral or labor-augmenting technological change, no further changes in labor supply or in employment restriction. Compared to that world (the 1992 "zero growth" base), how would the Chinese labor market have evolved under alternative scenarios in which some of these factors changed as they did in reality and others did not change, and how would those new worlds differ from what actually happened (as predicted by our benchmark model).

We consider five counterfactual scenarios relative to the "zero growth" base: (1) capital stock changes; (2) there is labor-augmenting technological change; (3) the numbers of middle school, high school and college workers change; (4) state sector employment restriction changes; (5) residuals not captured by (1)–(4) change. Table 4 shows the results of these counterfactual experiments over the period of 1992 to 2007.

The row on data serves as the norm for the counterfactual experiments. As capital stocks (K), labor-augmenting technological change as proxied by R&D expenditure and FDI (X), type-specific labor supply (n), and employment restriction in the state sector ($\overline{n^l}$) all varied over time, base wage increased by 0.888, high school premium by 0.055, college premium by 0.255, and state premium by 0.111 between 1992 and 2007, where wage growth is measured in log points. All of counterfactual experiments in rows (1)–(5) as well as the benchmark (the last row) are simulated using the estimated parameters and used to investigate relative contribution of each force to the wage growth in log points since 1992.

Capital investment increased from 26.4 percent of GDP in 1992 to 51.9 percent in 2007 based on our data. To assess the effects of capital deepening, the first experiment (row (1)) allows changes in capital stocks in both sectors while keeping all other variables at 1992 levels. We show that capital accumulation by itself would have led to a 0.834 log points increase in base wage, a 0.386 log points increase in school premiums, and a 0.333 log points decrease in state premium between 1992 and 2007. Capital deepening increases marginal product of labor when employment is held constant, and thereby wages are higher for all types of labor. The effects on high school and college workers are larger because capital and high-skilled labor are more complementary. State premium declines because capital stock increases by 6.9 times in the private sector whereas it increases only by 2.8 times in the state sector between 1992–2007.

R&D expenditure and FDI are used as proxies for labor-augmenting technological change. Our education-specific estimates of their impact on labor efficiency indicate that they are indeed biased towards well-educated workers. In the second experiment (row (2)), both R&D expenditure and FDI are allowed to change as observed in the data whereas all other variables are held constant. These changes would have led to a 0.659 log points increase in base wage because of the increase in labor quality. As the efficiency coefficients increase more for the high school and college workers, the relative efficiency effect implies that schooling premiums will rise. However, total efficiency units increase in the efficiency coefficients; thus, the relative supply effect implies that schooling premium will decline. Overall, increasing R&D expenditure and FDI alone would have led to a 0.038 log points increase in the high school premium, and a 0.287 log points increase in college premium.[22]

The employment share of low-skilled labor declined from 1992 to 2007 as the urban labor force become more educated. In the meantime, the number of low-skilled rural migrant workers in urban areas began to increase since the early 1990s, offsetting the decline. In total, the number of low-skilled workers with middle school or below education only changed slightly from 70.9 million in 1992 to 69.7 million in 2007. The number of high school workers

[22] Using firm-level data, Hu and Jefferson (2004) and Hu et al. (2005) find that R&D has significant and positive effects on productivity within Chinese industry. Furthermore, when a production function is estimated using firm-level data, Hu et al. (2005) find strong evidence of complementarity between R&D and both domestic and foreign technology transfer variables.

increased before 1997 and declined afterwards, whereas the number of college workers continued increasing throughout the period. In row (3) of Table 4, we allow for actual changes in both the total number of low-skilled workers and high-skilled workers. As the number of low-skilled workers declined slightly, base wage rose slightly accordingly. Both high school and college premiums went down because of the increasing supply of high-skilled workers.

The restructuring of SOEs in the late 1990s allowed SOEs to lay off massive redundant workers. The fourth experiment (row (4)) considers the loosening of state sector employment protection alone. The actual change in state sector restructuring ($\overline{n^l}$) while holding everything else constant implies a release of low-skilled worker to the private sector, thus pushing down the wage of low-skilled worker in the private sector, i.e. the base wage, and pushing up the state premium. One perhaps unexpected consequence of the state sector restructuring is to push down wage rate of raw labor and therefore assist the growth of the private sector. In our model, the SOE restructuring and the consequent productivity improvement in SOEs are the major driving forces of the increasing state premium.[23]

In row (5), we consider the effects of factors not measured by observed capital, labor, and technology on wage growth. In the last row of Table 4, we present the changes in wage level and relative wages in the benchmark model by combining the effects of capital deepening, technological changes, and labor supply. As seen in Table 4, capital deepening and technological change can account for the increase in base wage and skill premiums, whereas changes in labor supply put downward pressure on skill premiums. SOE restructuring, i.e. reduction of employment protection in the state sector, is the main driving force of increase in the state premium.

The counterfactual experiments in Table 4 account for the effects of input growth such as capital accumulation and increases in labor quantity and quality on wage growth. Next, we will pay close attention to China's WTO accession and investigate how this event affects wage growth by driving up input growth.

[23] An alternative explanation for increasing state premium is that SOE workers were provided with housing and health care subsidies (Zhao, 2002) in the early 1990s, and these subsidies were converted to monetary wages following reforms in the SOE compensation system over time. Direct data on non-wage subsidy (e.g. housing and health subsidy) in the state sector are sparse, but we do not find evidence for this alternative hypothesis. First, workers in the private sector, which corresponds to the CIP sector in the data, may have received similar housing subsidy as state workers because (1) municipalities allocate their housing budgets to municipal housing bureaus to develop public housing for the workers of small and street-level enterprises (27% of total public housing in 1988); (2) some collective enterprises, at least the large ones, are controlled by the state, and provide work-unit housing (Wu, 1996). More formally, using UHS data on household expenditure on housing and health care, we find that conditional on household income, state sector workers and CIP sector workers have almost the same time-series patterns of expenditures on housing and health care. In the early 1990s, however, their expenditure levels were below those from JSF, indicating a likely subsidy to both state and CIP workers relative to those in the JSF sector. These results are available from the authors.

Export expansion is one major driving force of China's rapid growth in recent decades. Exports grew at faster pace after China's entry to WTO in 2001, especially in the private sector. To analyze the effects of exports expansion after WTO accession, we consider a counterfactual scenario where exports were at the 2001 level in 2007, and we compute how base wage and wage premiums change. As exports drop, the external demand, as part of the total output, will decline. Assuming everything else being constant, we can generate the following expression for the change in log base wage over time from Equation (8):

$$\begin{aligned} \ln w^l_{pt+1} - \ln w^l_{pt} &= (1-\sigma_p)\left(\ln Y_{pt+1} - \ln Y_{pt}\right) \quad (17) \\ &= (1-\sigma_p)\left\{\ln\left[x_{pt+1}Y_{pt+1} + (1-x_{pt+1})Y_{pt+1}\right] - \ln\left[x_{pt}Y_{pt} + (1-x_{pt})Y_{pt}\right]\right\} \end{aligned}$$

where (x_{pt}, x_{pt+1}) denote shares of export in total output. Suppose output produced by state and non-state firms are homogeneous, then the shares of export influenced by trade can be computed as:

$$x_{pt} = x_{st} = \frac{X_{pt} + X_{st}}{Y_{pt} + Y_{st}}, \quad (18)$$

where X_{jt} is exports in sector j. This expression encompasses the idea that the influence of trade spreads into the two sectors, i.e., if one sector exports more, the other sector will take up the slack in the domestic market.

Between 2001 and 2007, the increase in export can be measured as $\Delta X = x_{p07}Y_{p07} - x_{p01}Y_{p01}$.Therefore, the changes in log base wage due to export expansion can be assessed numerically as:

$$\Delta \ln w^l_p(\Delta X) = (1-\sigma)\left\{\ln\left[x_{p07}Y_{p07} + (1-x_{p07})Y_{p07}\right] - \ln\left[x_{p01}Y_{p01} + (1-x_{p07})Y_{p07}\right]\right\}, \quad (19)$$

where we fix the domestic demand as in 2007, but reduce exports demand from 2007 level to 2001 level. When exports are reduced to 2001 level while all else are held constant at those observed in 2007, base wage would be 0.124 log points lower in 2007 compared to the benchmark. Lower exports decrease the output and labor demand, thus lower the base wage. Therefore, expansion of exports is an important driving force of the increase in base wage.

Using a similar approach, we can also compute the effect of trade expansion on the state wage premiums. Even though lower exports reduce low-skilled wages in both private and state sectors, it has a larger impact on the private sector because the private sector experience a faster expansion in exports after WTO entry. Without the accelerated trade effects, the state premium would be 0.041 higher in log points in 2007. Since lower exports reduce the demand and wages of all skill type, it would lower the wages of all workers by the same amount and, therefore, it has no impact on schooling premiums.[24]

Processing exports have accounted for more than 50% of total exports in China since 1996 (Koopman et al. 2008). Imported raw materials and intermediate inputs used in the production for exports reduce the share of value added generated by domestic Chinese firms. We compute domestic value added in total exports in both sectors using the estimated shares of domestic content from Koopman et al. (2008),[25] and replace changes in total exports by changes in domestic value added in total exports in Equation (17) to (19). Therefore we measure the WTO induced external demand change by domestic value added embedded in exports. When domestic value added in exports are reduced to 2001 level, base wage would be 0.093 log points lower and state premium would be 0.028 log points higher in 2007 compared to the benchmark.

Along with export expansion, China's import growth has been equally extraordinary. Before 2004, import growth followed closely to exports, and the current account surplus stayed at around 2 percent of GDP. However, exports started growing at a faster pace than imports since 2005, and the current account surplus reached close to 8 percent of GDP in 2007. An alternative measure for trade-induced external demand is net exports, or current account surplus. When total exports are replaced by net exports in Equation (17) to (19), we find that base wage would be 0.027 log points lower and state premium would be 0.004 log points higher in 2007 if net exports are reduced to 2001 level. According to calculations by Koopman et al. (2008), close to 80% of Chinese imports are intermediates, 40% are capital goods, and final consumption only consists of less than 2% of total imports. Therefore the effects on domestic demand due to import replacement is small. We shall interpret the net exports effects as the lower bound of the trade-induced effects on wages, while the total exports effects can be considered as the upper bound.

The number of rural migrant workers in urban areas began to increase dramatically since the early 1990s when the government started to loosen restrictions on rural-to-urban migration. The demand for rural labor in the urban areas continued to increase due to China's accession to WTO and expansion of manufacturing exports. In the next counterfactual, the migrant size is fixed at 2001 level, while all other variables are held as those observed in 2007. If there were fewer rural migrants, base wage would be 0.075 higher in log points in 2007 whereas school premiums would be pushed down by 0.061 log points. Since majority of

[24] In the Stolper-Samuelson model, international trade affects the relative output price and thereby skill premiums. There is only one final good in our model; the direct trade effect is thus skill neutral.

[25] By combining information from detailed trade statistics with input-output tables, Koopman et al. (2008) estimate the share of domestic content in China's exports to be at about 50%. In particular, the share of domestic value added is about 80% in private firms, 70% in state owned firms, 44% in joint venture firms, and 30% in foreign firms. These ratios are relative constant over time.

rural migrants work in the private sector, 2001 migrant size implies much fewer low-skilled workers in the private sector compared with the state sector. Therefore low-skilled wage in the state sector would increase less than that in the private sector and state premium would decline by 0.021 log points.

5 Conclusion

In this paper, we have documented the fundamental changes that have taken place 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 in China. 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 a relatively minor contribution. The major driving forces behind both wage growth and rising wage inequality in China are capital accumulation, skill-biased technological change, and the expansion in external demand for exports. 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 shows that labor market adjustments in China have constituted a multifaceted process. 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 economic growth process.

The present study focuses exclusively on China. However, globalization and economic transition have seen many other emerging economies experiencing fast-paced economic growth. 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.

6 Appendix

A. Urban Household Surveys

Sample Inclusion Criteria. Our sample for analysis include all workers who are aged 16-55 for females and 16-60 for males, where 55 and 60 are the official retirement ages for female and male workers in China. We exclude from our sample employers, self-employed individuals, farm workers, retirees, students, those re-employed after retirement, and those workers whose real annual wages were below one half of the real minimum wage. Province-level minimum wages are collected from provincial or municipal Ministry of Human Resources and Social Security. In the early 1990s, minimum wage information in some provinces was not available. We impute the missing minimum wages by using the ratio between minimum wage and average wage in each province. For example, if 1992 minimum wage is missing in a province, we multiply the ratio of minimum wage to mean wage in that province in 1993 with 1992 annual mean wage and use the product as our estimate for the 1992 minimum wage. Our results are not sensitive to the exclusion criteria based on the minimum wage.

Data Resampling. According to survey administrators at the NBS, the oversampling of workers from state and collective enterprises are likely due to several reasons. First, self-reporting might introduce error. 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 of ownership immediately. Second, SOE workers usually have regular working schedule of eight hours, and they might have more free time to respond to the surveys. Third, NBS seeks help from employers to persuade workers to participate in the surveys to reduce nonresponse rate. SOE and its labor union usually provide more help.

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

Under the assumption that survey participation of workers within an ownership type is random, we randomly re-sample workers and adjust the number of workers in each ownership category as follows:

(1) Adjusting down s_t by:

$$\frac{s_t/l_t - S_t/L_t}{s_t/l_t} s_t;$$

(2) Adjusting up c_t by:

$$\frac{C_t/L_t - c_t/l_t}{c_t/l_t} c_t;$$

(3) Adjusting up j_t by:

$$\frac{J_t/L_t - j_t/l_t}{j_t/l_t} j_t.$$

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 before the resampling, but employment share of each ownership category is now consistent with aggregate statistics. Table A1 presents the sample distribution by ownership type before and after resampling.

Table A1: Percentage Distribution of the Sample by Ownership Type

	Before re-sampling			
	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 re-sampling			
	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

Aggregation of Worker Groups. UHS records detailed information on school completion levels, ownership class of enterprises, coding of industries, and residential location by province. For purpose of analysis we perform the following aggregation.

(a) *Education:* Workers are grouped into "middel school and below," "vocational and high school" where vocational school usually requires two years of post middle school education in China, and "college and university" which consists of attendees and graduates of four-year universities, three-year specialized colleges, and those who have government recognized college-equivalence diplomas by attending post-secondary night classes, online courses and 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 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 there were very few people working in individual/private firms in the early years of data coverage, accounting for about 2 percent of the labor force for the 1992-1996 period. It would be difficult to conduct meaningful econometric studies in subsequent analysis if treating these firms as a separate ownership group.

(c) *Industry:* We group manufacturing and construction together as representing the secondary sector, and 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 fiance and insurance, health, sports, social welfare, education, cultural services, media, scientific research, miscellaneous technical services, government administrations, and social organizations.

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

B. Aggregate Data

Real GDP

We combine industrial and tertiary sector GDP collected from China Statistical Yearbooks and Industrial Statistical Yearbooks as an estimate for the non-agricultural urban GDP, but these data are not separately available for the state, the private, and other sectors. Between 1999 and 2007, industrial value-added outputs were reported by ownership type, whereas only the total outputs by ownership type were available before 1999. In the state and the private sectors, we compute industrial value-added output's share in total output above designated size from 1999 to 2007 and use a linear in time projection to impute the fractions in the earlier years. These estimated ratios and total industrial output are then combined to calculate the ownership-specific industrial value added between 1992 and 1998.[26] In the tertiary sector, no information is available on ownership-specific GDP or value-added output, we apply the state sector and the private sector's shares in total industrial value-added output to both industrial and tertiary GDP to construct ownership-specific output. All nominal output are deflated by urban CPI to 2007 yuan.

Capital Stock

Our main data sources for capital stock are various years of China Statistical Yearbook and Statistical Yearbook of Fixed Assets Investment. Capital investment data can be obtained for the whole economy, for urban areas, and by ownership categories: state-owned, collective, and private. For each ownership category, investment 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 relatively small fraction (between 10-16%) of the total investment, so we split it into construction and equipment using their corresponding shares. Between 2000 and 2002, construction and equipment investment data in the private sector were missing, so we adopt a linear interpolate using data on 1999 and 2003.

We adopt the Perpetual Inventory Method (PIM) to construct time series of capital stock using data on capital investment. Using the PIM, gross capital stock is calculated as the weighted average of gross fixed capital formation in previous years, of which the service life is not yet expired. The weights are the relative efficiency of capital investment of different vintage. In formula,

$$A_t = \sum_{\tau=0}^{T} d_\tau I_{t-\tau},$$

where

$A_t =$ gross capital stock in time t,

$I_t =$ gross capital investment in year t,

$d_\tau =$ relative efficiency of capital investment of vintage τ,[27]

$T =$ expected service life.

If relative efficiency of capital investment declines geometrically, gross capital stock at

[26] We noticed some anomally high output in the collective sector between 1994-1997, and they were adjusted using an interpolation between 1993 and 1998.

[27] Normally it is assumed that the relative efficiency of new capital is 1, and that of retired capital is equal to 0. That is, $d_0 = 1$ and $d_t = 0$ for $t \geq T$.

time t can be estimated by

$$A_t = (1 - \delta)A_{t-1} + I_t,$$

where δ is the capital depreciation rate.

Even though fairly reliable statistics on capital investment are available, statistics on retirements are rare. Based on estimates of other countries and suggestions from experts in NBS, we assume the service life of equipment to be 16 years and the service life 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 used as base year capital stocks. Price indices of investment in construction and investment in equipment are available from Statistical Yearbooks. 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 are summed up to obtain total capital stock in the state sector and in the private sector.

Labor Input

In order to estimate employment size by skill type in China's urban labor market, we first collect data from Statistical Yearbooks on the total number of urban employed workers by each ownership category. However, workers' education distribution is unknown from the aggregate data source. Therefore we calculate the proportions of workers of each education level (middle school and below, vocational and high school, college and university) in the state sector and in the private sector from the national UHS sample. Then we use the employment shares by education level and total employment in each sector to compute the number of workers who have different education attainment in each sector. Finally, total high-skilled and low-skilled labor inputs are generated by aggregating the number of middle school, high school, and college workers across the state and the private sectors. One caveat of the labor input measure is that the aggregate urban employment statistics from Statistical Yearbooks exclude rural-to-urban migrant workers (Yue, 2005).

Prior to the recent tide of migration, China had isolated rural and urban labor markets for decades. Such segregation was mainly implemented through a strict Household Registration (*hukou*) System (HRS). HRS imposes strict limit on individuals changing their permanent place of residence. A rural worker was very difficult to live in urban areas without urban *hukou* because employment and the allocation of housing, food, and other necessities were all contingent on urban *hukou*. Beginning with the economic reform in the late 1970s, millions of rural workers were released from agricultural sector, but rural-to-urban migration was tightly controlled until the middle 1980's. Since the late 1980s and the early 1990s, the demand for rural labor in the urban areas continued to increase due to the development of urban private and informal sectors, and national and local authorities started to loosen restrictions on rural-to-urban migrations. As a result, the number of rural migrant workers in urban areas began to increase dramatically.

Households that live in urban areas but have no urban registrations were not sampled in UHS by the NBS before 2002. The NBS expanded sample coverage in 2002 to include more cities as well as rural migrant households. However, we discover that migrant workers in the sample are under-represented, at least for those we can identify. Out of the 388,459 workers observed in our sample between 2002–2007, slightly more than 1% (4,456) of them were identified as migrant workers. We cannot distinguish whether this is due to the under-sampling of migrant workers or because the survey has missing information on residency status for most of the people in the sample.

Since migrant workers are under-represented in UHS, we try to estimate their size separately. Among migrant workers, those with high skills more or less permanently live in urban areas and are able to meet legal requirements for a "stable source of income" and a "stable place of residence" to obtain public services such as health care and schooling for their children on an equal basis with other residents. This type of migrants are likely already included in the sample. Most of the rural migrant workers, however, have low skills and compete with urban residents for low-income jobs. Many of them live in the periphery of cities, employer-provided dormitory, or in workplace such as construction sites. Without formal urban address, they have low chance to be surveyed. Therefore we will expand the employment size for low-skilled labor by adding the number of low-skilled migrant workers.

The best source to estimate the size of rural to urban migration is the Chinese census. Since 2000, each individual reports his/her resident status. We compute from 2000 census and 1% census in 2005 the proportion of rural to urban migrants in the urban labor force and the fraction of workers with middle school and below education among the migrant workers. Then the size of low-skilled migrant workers is estimated by multiplying urban employment size with the proportion of rural-to-urban migrants and the fraction of low-skilled worker among migrants. For the rest of years between 2000 and 2007, we estimate migrant size by assuming a linear time trend in the number of migrant workers. We extrapolate migrant size between 1992 and 1999 by combining the estimates from Cai et al. (2008) and our own estimates from 2000 census. Finally migrant workers are split into the state and the private sectors by using proportions observed from UHS in 2002–2007.

Other Variables

Exports: China's Ministry of Commerce publishes exports data by ownership category since 1994. For 1992 and 1993, we extrapolate exports in the state sector and the private sector using estimated exports/output ratio. Total exports in each sector are converted to 2007 yuan using annual exchange rate and CPI.

R&D Expenditure: Annual data since 1978 on "expense on science and research" are collected from Statistical Yearbooks and we use them as a measure for domestic R&D investment. Following the methods first proposed in Griliches (1979), PIM is used to construct the stocks of domestic R&D in 2007 price. The depreciation rates are assumed to be 15% following Hu et al. (2005) and Fleisher and Zhou (2010).

Imported Machinery: Annual data since 1980 on "imports value of machinery and transport equipment " are collected from Statistical Yearbooks. We use PIM with a 15% depreciation rate to construct stocks of imported machinery in 2007 price.

FDI: Annual data since 1979 on "total amount of foreign capital actually utilized" are collected from Statistical Yearbook. Again, we use PIM with a 15% depreciation rate to construct stocks of foreign capital in 2007 price.

C. SMM Estimation Procedure

Let m_j be moment j in the data, which is from the LHS of equations (14) to (16). The corresponding simulated moment is denoted by $m_j^S(\theta)$, and it is obtained across 500 simulations, $m_j^S(\theta) = \frac{1}{500}\sum_{s=1}^{500} m_j^s(\theta)$. The $m_j^s(\theta)$ elements are in turn computed as the RHS of equations (14) to (16). Our task amounts to finding a parameter vector θ, which makes 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 is the number of moments used and $J = 64$ (4 moments $\times$ 16 years). We minimize following objective function with respect to θ

$$L(\theta) = g(\theta)' W g(\theta), \tag{20}$$

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, (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 use a two-step procedure for computing the diagonal elements of W. First, we set $\sigma_j^2 = 1$ and weight each sample moment by N_j. Estimate θ by minimize (20) and let $\widehat{\theta}$ 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 (20).

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

1. Make 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 equations (11) to (13) and the observed number of workers at each school level to calculate the total labor efficiency units of each type. The observed employment of middle school workers in the state sector is used 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. Back out the neutral technology efficiencies in both sectors, A_{st} and A_{pt}, using the production function specified in (5).

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

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

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

8. Adjust parameters, repeat step 2–5 until the optimum is reached.

The variance-covariance matrix of the parameter estimates is given by $(A'WA)^{-1}$ 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.

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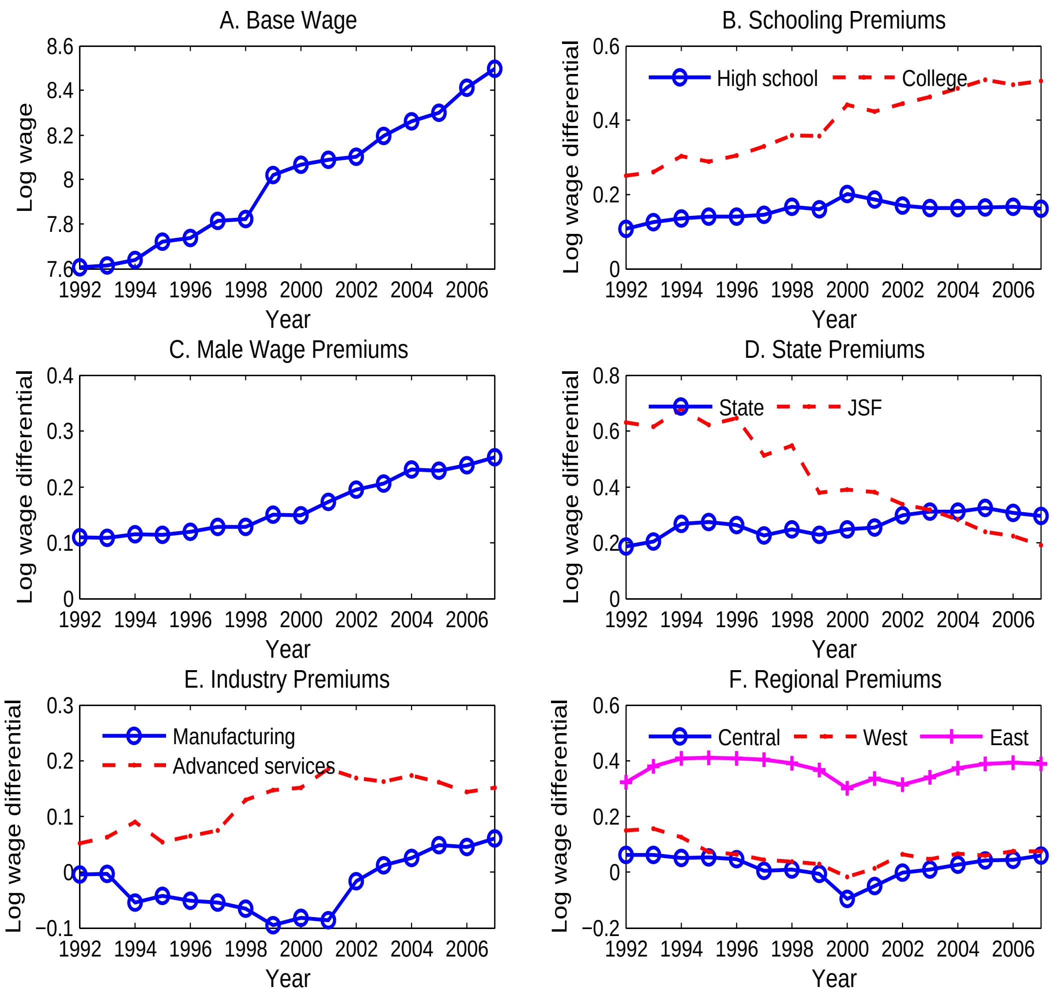

Figure 1: Changes in Conditional Mean Wages, 1992–2007

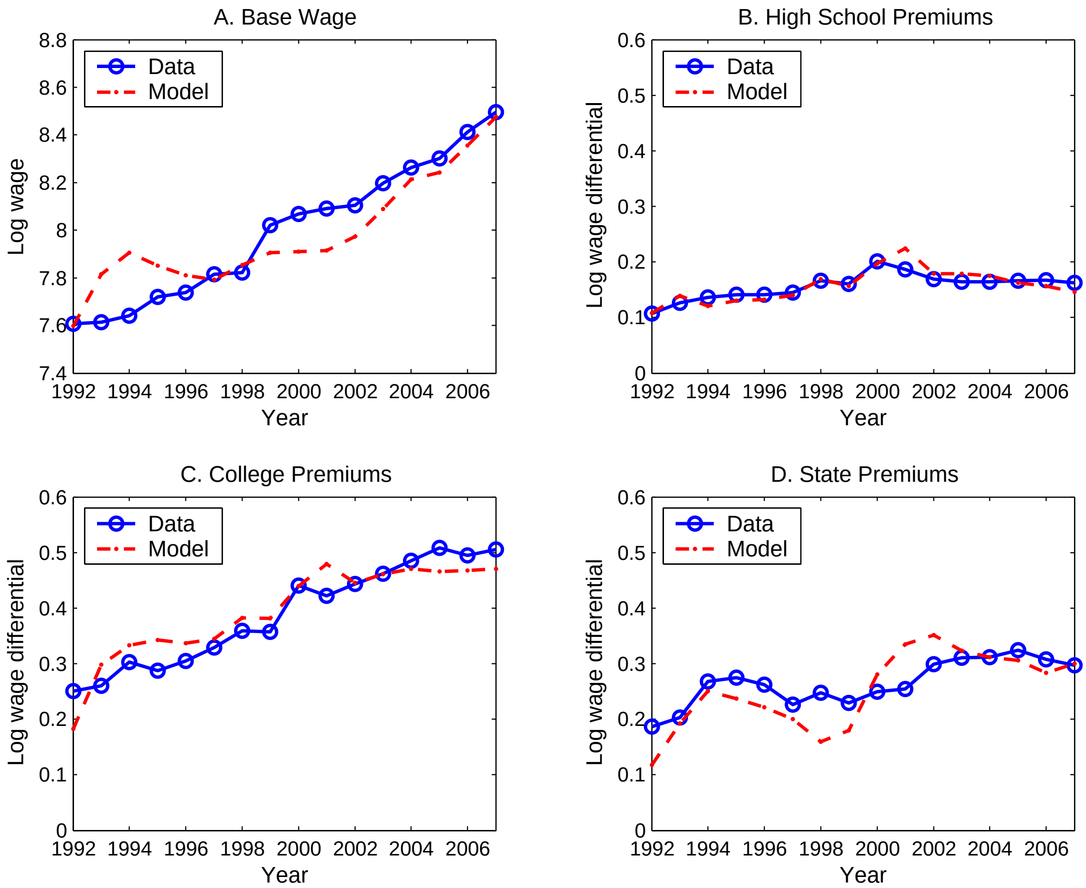

Figure 2: Goodness of Fit, Base Wage and Wage Premiums, 1992–2007

Table 1: Changes in Wage and Employment Structure 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	100	100	100
By education						
Middle school and below	5,764	13,547	135.0	41.9	25.7	-16.2
Vocational and high schools	6,135	16,590	170.4	41.4	40.7	-0.7
College and university	7,414	25,208	240.0	16.7	33.6	16.9
By gender						
Male	6,754	21,111	212.6	50.2	53.9	3.7
Female	5,628	15,868	182.0	49.8	46.1	-3.7
By ownership						
CIP	5,067	14,096	178.2	28.5	43.7	15.2
State	6,550	23,565	259.8	69.7	32.6	-37.1
JSF	10,291	20,501	99.2	1.8	23.7	21.9
By industry						
Manufacturing	5,910	18,345	210.4	46.5	34.4	-12.1
Basic services	5,950	15,368	158.3	24.9	39.1	14.2
Advanced services	6,864	24,076	250.8	28.6	26.5	-2.1
By region						
Northeast	4,993	14,027	180.9	16.6	12.1	-4.6
Central	5,467	15,874	190.4	23.6	18.1	-5.5
West	6,088	15,945	161.9	26.1	24.1	-2.0
East	7,373	22,497	205.1	33.7	45.8	12.1

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

	Benchmark		IV	
Parameters	Estimates	(St. Err.)	Estimates	(St. Err.)
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)
Income shares				
μ_s	0.655	(0.024)	0.653	(0.023)
λ_s	0.694	(0.029)	0.694	(0.019)
μ_p	0.632	(0.021)	0.631	(0.022)
λ_p	0.756	(0.027)	0.758	(0.026)
Initial efficiency units				
ψ_0^l	41.834	(3.606)	43.420	(4.229)
ψ_0^{hs}	120.834	(42.247)	122.351	(23.306)
ψ_0^c	130.221	(81.105)	129.394	(51.371)
LATC proxies for middle school workers				
γ_1^l : R&D effect	0.006	(0.001)	0.007	(0.001)
γ_2^l : FDI effect	0.016	(0.002)	0.014	(0.003)
LATC proxies for high school workers				
γ_1^{hs} : R&D effect	0.102	(0.036)	0.102	(0.019)
γ_2^{hs} : FDI effect	0.127	(0.047)	0.139	(0.029)
LATC proxies for college workers				
γ_1^c : R&D effect	0.155	(0.055)	0.173	(0.033)
γ_2^c : FDI effect	0.168	(0.062)	0.171	(0.035)
St.d. of efficiency shocks				
η_ω	0.094	(0.111)	0.097	(0.083)

Note–LATC represents labor-augmenting technological change.

Table 4: Accounting for the Increase in Base Wage, School Premiums, and State Premium

	Base wage	High school premium	College premium	State premium
	1992-2007	1992-2007	1992-2007	1992-2007
Data	0.888	0.055	0.255	0.111
Actual change in				
(1) capital accumulation (K)	0.834	0.386	0.386	-0.333
(2) labor-augmenting technical change (X)	0.659	0.038	0.287	0.016
(3) supply of labor (N^l, N^h)	0.018	-0.157	-0.157	-0.012
(4) SOE restructuring $(\overline{n^l})$	-0.206	-0.225	-0.225	0.610
(5) residuals	-0.367	0	0	-0.130
Benchmark (1)-(5)	0.878	0.038	0.287	0.182