Accounting for Rising Wages in China†

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Abstract

Between 1992 and 2006, average real wage in urban China increased by 196 percent. A decomposition analysis reveals that 77 percent of the total growth is attributable to higher pay for basic labor, increasing returns to human capital, and rising state-sector wage premiums. Using an aggregate labor market model with two sectors and two skill types, we explore a simple, explicit mechanism for understanding the determination of basic wage and wage premiums under globalization and economic transition. This framework provides a structural basis for studying sources of wage growth. Our empirical analysis shows that globalization factors, state-sector restructuring, capital deepening and skill-biased technological change are the major causes behind the recent wage explosion in China.

Keywords: wage growth, decomposition, skill premium, globalization, enterprise restructuring, China

1 Introduction

Between 1992 and 2006, average real wage in urban China increased by 196 percent. In the first ten years, the annual rate of wage growth was 6.1 percent; since 2001, the growth rocketed to 10.3 percent per annum.[1] It appears that higher wages have started to erode China's global advantage of cheap labor, the driving force behind its emergence as the world's workshop and the main attraction for foreign direct investments (FDI). China's rising labor costs may translate into higher commodity prices worldwide because its share of manufactured world exports already reached 13.2 percent in 2007. Policy makers and the public have paid increasing attention to this labor market phenomenon, but somewhat surprisingly, a systematic investigation of the trends, sources, and causes of rising wages in China has yet to be attempted.

In this paper, we use data from China's Urban Household Surveys (UHS) to document that the rise in general wage level occurred concurrently with several striking labor market trends, each of which may contribute to rising wages in China. First, both wage differentials by education and the schooling attainment of the labor force increased sharply. Second, the wage of men relative to women rose, while female labor force participation declined. Third, as the state sector shrank in size, its wage level grew rapidly over time, eventually surpassing other ownership categories. Fourth, the employment share of service sectors expanded gradually, while the share of manufacturing and construction fell. Finally, the high-income region experienced faster wage growth despite of significant labor inflows.

Dramatic changes in labor market conditions—including institutional transformations and globalization—occurred in China between 1992 and 2006. For instance, due to a policy initiative of expanding college enrollments, the annual supply of college graduates was more than quadrupled between 1999 and 2006. On the demand side, China's total volume of trade increased by eleven-fold from 1992 to 2006, the year when China also became the world's third largest recipient of FDI. During the same period, rapid technological changes, supported in part by fast increasing re-

[1]Wage and employment statsitics reported in the paper are based on the authors' own calculations using data from the comprehensive Urban Household Surveys collected by China's National Bureau of Statsitics (NBS). Section 2 and the Appendix provide descriptions of the data.

search and development (R&D) expenditures, raised the need for skilled labor. Amid these changes, labor market institutions were likewise transformed. Wage compression under central planning was replaced by more freedom in wage setting, and labor reallocation began to occur across industries and regions and towards growing non-state enterprises. The restructuring of state-owned enterprises (SOEs) in the late 1990s allowed SOEs to lay off massive redundant workers, ending the long protection of state employment. These profound social and economic transformations, perhaps unmatched in magnitude by the experience of other countries, offers a unique opportunity for examining the determination of relative wages and changes in wage levels.

To proceed, we first perform a decomposition analysis using a conditional mean wage regression function. This analysis reveals three main sources of wage growth in China: (1) the rise in the wage of basic labor, (2) increasing returns to human capital, and (3) a higher state-sector wage premium. Together these three factors account for 77 percent of the observed wage growth between 1992 and 2006. Other factors—such as the rise in labor quality, gender-related changes, and labor reallocation across regions, industries, and ownership classes—only make minor contributions.

Next, we formulate a labor market model based on aggregate production functions to explore a simple, explicit mechanism for understanding the determination of basic wage and wage premiums under globalization and economic transition. The model specifies skilled and unskilled labor as imperfect substitutes and they work in either the state or the private sector. Incorporated into the model are key features of the Chinese economy—globalization in forms of international trade and FDI; economic restructuring that loosens the protection of state employment; capital accumulation and skill-biased technological change; and changes in the supply of skilled and unskilled labor. Our empirical analysis of the model is still incomplete. The preliminary estimates show that globalization factors, state-sector restructuring, capital deepening and skill-biased technological change are among the key factors in fitting the trends of recent wage explosion in China.

This paper is closely related to the labor economics literature that explores demand, supply, and institutional factors for understanding wage structure changes [see e.g., Katz and Murphy (1992), Bound and Johnson (1992), Juhn, Murphy and Pierce (1993), and Katz and Auto (1999)]. Although this is an enormous literature covering extensive ground, we feel that our analysis makes several unique contributions. First, the two-sector labor market model allows us to explore explicit mechanisms through which forces of globalization and economic reforms impact both the wage level as well as relative wages. The framework provides a structural basis for studying sources of wage growth. Second, we build in capital-skill complementarity in the labor market model and present new estimates for China. Different from their findings, we separately identify the contributions to the rise in skill wage premiums made by capital-skill complementarity and skill-biased technological change. Last, but not least, this is the first attempt to investigate the trends, sources, and causes of rising wages in China. We believe each of these innovations adds significantly to our understanding of wage structure changes in a fast-growing developing country during a period of rapid globalization and economic transition.

The paper is organized as follows. Section 2 describes the UHS data, documents major changes in China's wage structures, and decomposes the sources of wage growth. Section 3 develops and estimates an aggregate labor market model that sheds light on the causes of rising wages in China. Section 4 presents conclusions.

2 Changes in China's Wage Structure, 1992-2006

2.1 The Data

The data we use in this paper come from 15 consecutive years of the Urban Household Surveys (UHS) conducted by China's National Bureau of Statistics (NBS). The starting year is 1992, when NBS began the use of standardized questionnaires. The latest data are from 2006 due to the NBS one-year-lag policy for releasing household data. The UHS data record basic conditions of urban households and detailed information on employment, wages, and demographic characteristics of all household members in each calendar year. We use the full sample covering all provinces except

Tibet because of missing surveys in certain years and the lack of representation from this autonomous region. Throughout the paper we focus on annual wages for adult workers engaged in wage employment. Wage income consists of basic wage, bonus, subsidies and other labor-related income from regular job. We deflate annual wages to 2006 yuan by province-specific urban consumption price indices.[2]

NBS adopts a sampling scheme such that in every 5 years they have a complete rotation of the urban household samples. Some changes to the questionnaires are also made along with the reshuffling of the samples. This survey design naturally breaks our samples into three 5-year periods: 1992-1996, 1997-2001, 2002-2006. The NBS attempted to select a national representative sample of cities over time, and it expanded sample coverage to include more cities since 2002.

Our sample for analysis include all workers who are aged 16-55 for females and 16-60 for males, excluding 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.[3] The choice of households in UHS is based on the principle of random and representative sampling, and the sampling method is consistent over all years. However, we discover that the response rates for workers of state-owned and collective firms are systematically higher than workers of other firms. Therefore, we deploy a resampling scheme which adjusts the sample distribution of workers by ownership type to the national distribution figures (see Data Appendix for details on resampling). Table 1 shows the sample distribution after resampling for three five-year subperiods and all years. After resampling, our sample cover 229,551 individuals for the period 1992-2006. In the first two subperiods, annual sample size is about 8,050 individuals, while the sample size increases to about 29,810 individuals per year for the last period.

[2] See Data Appendix for detailed descriptions of data sources, variable definitions and data adjustments.

[3] Provincial-level minimum wages are available only in 2006 from Ministry of Human Resources and Social Security. To impute minimum wages for the previous years, we calculate the ratios of the minimum wages to the mean wages for each province in 2006. We use the product of these ratios and annual mean wages in each province as our estimates for province-specific minimum wages in 1992-2005.

2.2 Major Wage Trends

Table 2 presents summary statistics on wage and employment distribution for 1992 and 2006. The basic story is that average real wage increased by 196.3 percent over the 15-year period, rising from 6,028 yuan to 17,858 yuan. Five striking patterns of labor market trends emerge and each of these structural changes may contribute to rising wages in China.

1. Wage differentials by education and the educational attainment of urban labor force increased substantially. Table 2 shows that wages increased across educational levels and the wage of workers with college and university education grew the fastest. In 1992, the wages of workers with middle school education or below and those with high or technical school education were essentially the same, and college and university graduates only earned 29.5 percent more than workers of middle school and below. By 2006, however, this wage gap increased to 81.6 percent, and the wage of high school graduates relative to middle school graduates also rose to 21.6 percent. At the same time, as Table 2 shows, the employment share of college graduates rose from 17.1 percent in 1992 to 36.0 percent in 2006, more than doubled in 15 years. The rise in the proportion of labor force with college education since 2001 reflects a policy initiative of expanding college enrollments started in the late 1990s. As a consequence, the annual supply of college graduates was more than quadrupled between 1999 and 2006, raising the total from 0.85 to 3.78 million. The rise in worker quality and a higher schooling premium create upward pressure on wages.

2. The wage of men relative to women rose sharply, while female labor market participation declined. The wages of both men and women soared during the period, but the wage of men increased by additional 28.5 percentage points relative to women (see Table 2). In the meantime, women lost their position of "holding half of the sky" in terms of contributions to employment. Women's share of employment declined from 49.7 percent in 1992 to 44.8 percent in 2006. The time trends of changes in employment share and average annual wages by gender reveal more details. While the decline in women's employment share occurred continuously over the entire period, the increase in male-female earnings gap has accelerated since 1999, when state-owned enterprises (SOEs) began massive layoffs. The combined effects of rising relative wage for male and the decline in female employment may also push up average wage.

3. As the state sector shrank in employment share, its wage level climbed rapidly, eventually surpassing other ownership categories. Table 2 shows that in 1992, while there was clustering of wages across the state and private-collective sectors, workers of joint-venture, stockholding and foreign firms (JSF) earned a 57.9% premium over state workers. In fact, during the entire 1990s, wages of JSF firms were about 40 percent higher than that of SOEs and about the double of private and collective firms. This was the period when talents left state sector to seek jobs in JSF firms. However, the state-sector wage shows impressive increases, especially after 1997, the year when massive restructuring efforts began. Eventually state-sector wages surpassed wages of all other sectors in 2004. Coinciding with the wage trend, the employment share of the state sector declined precipitously since 1997. The shrinking of the state sector and the expansion of JSF employment private sector almost offset each other. State-sector employment share declined from 72.7% to 44.5% between 1992 and 2006, with the pace of decline accelerated since the late 1990s. JSF firms employed only 1.9% of the workforce in 1992 but they accounted for 28.8% of the employment in 2006.

The decline in the share of state-sector employment reflects continued privatization and state-sector restructuring during the reforms. Under China's planned economy, most jobs were assigned by government agencies at various levels. Workers in the state and collective sectors have the "iron rice bowl" (permanent employment) to secure their jobs, but it was also difficult to change jobs across enterprises. The years after 1992 witnessed much progress toward making the employment system more flexible. Firms were given more autonomy in setting wages, and in deciding on employment contracts. Workers, too, were given more freedom to change jobs. The labor market reform was accelerated in the late 1990s with major economic restructuring. In 1997, the Chinese government launched a drastic urban labor market reform, known as *xiagang*, to reduce inefficiency in SOEs by laying off a quarter or more of SOE workers within 4 years (1997-2000) (Appleton et al. 2002). A welcoming attitude from the government toward private and JSF firms has led to employment growth in the non-state sectors.

4. The employment share of basic services expanded gradually, while the share in manufacturing and construction declined over time. Table 2 presents wage and employment distribution over the years 1992 to 2006 by three broadly defined industries: manufacturing and construction, basic services, and advanced services. Over time we observe all industries experienced rapid wage growth but wage levels diverged across industries. Wages of the advanced service sector increased the fastest among the three industries. Wages in the manufacturing sector, which has contributed to nearly 90% of China's total exports, increased only modestly before 2001, but then accelerated in later years after China's entry into the WTO. In spite of major contributions made by the manufacturing sector to China's exports, its share of employment declined by 8.2 percentage points between 1992 and 2006. Since China's entry into the WTO, trade to GDP ratio increased from 38 percent in 2001 to 67 percent in 2006 (author's calculation from China Statistical Yearbook), and Foreign Direct Investment (FDI) reached 200 billion US dollars in 2006. Intense globalization may directly affect China's wage structure.[4]

5. The high income region experienced faster wage growth despite significant labor inflows. As Table 2 shows, the Eastern region, which has the highest initial income, also experienced the fastest wage growth at 204.5% during the 15-year period. The wage growth of the other three regions ranged between 154.2 to 179.5%. Consequently we see the wage level of the East pulls away from all other areas, which remain rather clustered during the entire period. The higher earnings of the East have also attracted labor inflows; its employment share increased from 35 percent in 1992 to 45.7 percent in 2006.

The wage trends reported above are based on simple wage averages. A more informative way of documenting wage changes is to compute relative wage changes conditional on schooling attainment, gender, ownership category, industry and region.

We specify the following regression function that provides average wage estimates

[4] See Goldberg and Pavcnik (2007) for a recent survey on effects of globalization on wages in developing countries, and Zhao (2001) for a study on China.

for individuals with different schooling attainment, experience, gender, the ownership type of employer, industry of employment, and geographic location of work:

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

More specifically, S_{ik}^t are dummy variables for schooling levels, where $k \in \{midsch, highsch, col\}$ corresponding to middle school and below, high and technical school, and college and university education, as defined before; EXP_i^t and $EXP_i^{t^2}$ are potential experience and experience squared, respectively.[5] GEN_i^t is a dummy variable for male. O_{il}^t are dummy variables for ownership, where $l \in \{state,\ JSF\}$, leaving private and collective sectors as the reference group. I_{im}^t are dummy variables for industry, where $m \in \{manu,\ advserv\}$ corresponding to manufacturing and construction as well as the advanced service sectors, leaving basic services as the reference group. R_{in}^t are dummy variables for regions, where $n \in \{central, west, east\}$ with the northeastern region being used as the reference.

Equation (1) will provide conditional mean estimates for the base wage and various wage premiums. Since the basic reference group in equation (1) are female workers who have middle school education or below, work in a private or collective firm in basic service industries located in the low-income northeastern region, the estimated parameter β_{midsch} is therefore interpreted as the base wage for raw labor without work experience. Other parameters would represent wages premiums for high school and college graduates ($\beta_{highsch} - \beta_{midsch}, \beta_{\text{col}} - \beta_{midsch}$), being a male ($\beta_g$), working in the state and JSF sectors ($\beta_{state}, \beta_{JSF}$), with employment in manufacturing and construction or advanced services ($\beta_{manu}, \beta_{advserv}$), and being located in richer regions of the middle, west and east ($\beta_{middle}, \beta_{west}, \beta_{east}$). The two experience coefficients are intended to capture the concave schedule of average returns to experience.

[5] Potential experience is calculated as min(age - years of schooling - 6, age - 16) where age is the age at the survey date.

We run this conditional mean regression for the cross-section data for each of the individual years between 1992 to 2006. Figures 1 and 2 provide the time series plot of the computed changes in base wage and various wage premiums over the entire time period. These estimated parameters are average wages of workers conditional on individual characteristics, location and sectors. The selection of these control variables reflect our desire to capture the five major labor market trends documented above.

Figures 1 and 2 show that: (1) The base wage increased substantially between 1992 to 2006; (2) the schooling premiums, especially the college wage premiums, increased significantly during the same period; (3) the gender wage gap widened by roughly 12 percentage points with most change taking place after 1999; (4) The state sector had a 15.9 percent wage premium over the collective-and-private sector in 1992, and this premium increased to 35.3 percent in 2006. The JSF sector had a 60.6 percent wage premium over the collective-and-private sector in the initial year, but that advantage declined to 23.9 percent in the ending year; (5) With regard to industrial wage premiums, the manufacturing sector had lower pays than the basic service sector until 2001, but experienced a 12.9 percentage points gain relative to basic services between 2001 and 2006, which is likely driven by the increasing manufacturing exports after China's accession into the WTO. On the other hand, the wage of the advanced service sector appeared to be suppressed initially, but the premium rose in later years; and (6) the Eastern region maintained its high wage premiums relative to the reference Northeastern region throughout the period. These structural changes form the fundamental forces behind fast wage increases in China.

2.3 Decomposition of Wage Growth

We analyze the sources 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 sources: 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 function form:

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

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 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

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

where $\overline{\ln w^{\tau_0}}$ and $\overline{\ln w^{\tau}}$ are the average log wage 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

$$\overline{\ln w^{\tau}} - \overline{\ln w^{\tau_0}} = \sum_j \widehat{\beta}_j^{\tau} (\overline{X}_j^{\tau} - \overline{X}_j^{\tau_0}) + \sum_j \overline{X}_j^{\tau_0} (\widehat{\beta}_j^{\tau} - \widehat{\beta}_j^{\tau_0}) \ . \qquad (4)$$

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 structure of wage premiums, when the distribution of individual characteristics is held fixed at the initial level. This formulation can be considered as an application of the Oaxaca-Blinder decomposition analysis (Oaxaca 1973; Blinder 1973).

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 equations (1) and (4), we can obtain βs based on data from individual years, 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 sources of the wage change.

The last two columns of Table 2 present the distribution of worker characteristics ($\overline{X}$) for 1992 and 2006. Recall from the last section, the fraction of college workers rose from 17.1 percent to 36.0 percent between 1992 and 2006, reflecting an increase in the supply of skilled labor. Male employment share increased from 50.3 percent to 55.2 percent. The state sector shrank from employing 72.7 percent of the labor force to 44.5 percent, while JSF's employment share expanded from 1.9 percent to 30.7 percent. Manufacturing employment share declined by 8.1 percentage points, while the employment of the basic service sector increased. Also noticeable is the expansion in the share of the labor force from 35 percent to 45.7 percent in the Eastern region, which had the highest income in both periods and apparently attracted inflows of labor over the 15-year period.

The average wage level for 1992 is 6,028 yuan. It increased by 196 percent from 1992 to 2006 and reached 17,858 yuan in 2006. The corresponding mean log wage differential between the two years is 0.965. In what follows, we use the conditional mean estimates of the wage function in (1) to perform decomposition analysis based on equation (4).

Table 3 presents the decomposition results using equation (4) for the years over 1992 and 2006. The change in base wage accounts for 30.86 percent of the log wage change, or 0.298 of the mean log wage differential. It is estimated that approximately 0.13 or 13.45 percent of the log wage difference is due to the improvement in the human capital of the labor force and labor reallocation towards highly-paid sectors. Changes in returns to characteristics and sector premiums contribute to 55.69 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 the 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 77 percent of the observed wage increase between 1992 and 2006. Overall, the rise in labor quality, labor reallocation across ownership types and industries, the widening gender wage gap and the decline in female labor force participation and labor mobility across regions only make relatively minor contributions to wage growth.

Explaining what factors have contributed to the three largest sources of wage growth—higher base wage, increasing returns to human capital, and rising wage premium for the state sector—is the task to which we now turn.

3 The Sources of Wage Growth

Previous studies have used supply-demand-institution (SDI) frameworks to investigate wage structure changes (*e.g.*, Bound and Johnson,1992). Their emphasis is to examine the causes of wage inequality, or the skill premium, defined as the wage of skilled labor relative to that of unskilled labor. The basic framework is built on an aggregate production function consisting of different demographic groups–identified by sex, education, and experience–which are treated as distinct labor inputs. Demand shifts are mainly measured through compositional changes in employment across industries and through changes in certain variables (e.g., trade imbalance in manufacturing goods) over time.

To explain the changes in wage structures in China, we attempt to 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, and these two sectors may also have differences in accessing both domestic and foreign capital and new technologies; (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 by incorporating into the model key factors such as capital-skill complementarity and globalization. This model provides an analytical framework to directly assess the quantitative importance of various economic forces behind rising wages in China.

3.1 A Simple 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 consider a two-level CES production function with two types of labor: high-skilled labor $\left(N^h\right)$ and low-skilled labor $\left(N^l\right)$. The production technology in sector j is given by:[6]

$$\begin{aligned} Y_{jt} &= A_{jt}F(K_{jt}, N_{jt}^l, N_{jt}^h) \\ &= A_{jt}\{\mu(N_{jt}^l)^\sigma + (1-\mu)\left[\lambda(K_{jt})^\rho + (1-\lambda)\left(N_{jt}^h\right)^\rho\right]^{\frac{\sigma}{\rho}}\}^{\frac{1}{\sigma}}. \end{aligned} \tag{5}$$

In this specification, A_j is the neutral technological efficiency in sector j. μ and λ are parameters that govern income shares. The elasticity of substitution between low-skilled labor and capital is $1/(1-\sigma)$, and the elasticity of substitution between high-skilled labor and capital is $1/\left(1-\rho\right)$, where $\sigma, \rho < 1$. If $\sigma > \rho$, the production technology 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: $N_t^l = \psi_t^l n_t^l$ and $N_t^h = \psi_t^{hs} n_t^{hs} + \psi_t^c n_t^c$, where n_t^l, n_t^{hs}, n_t^c are numbers of middle school, high school, and college workers, 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 skill-specific technology level. They are assumed to be equal across sectors.

The major institutional factor we consider is the employment protection in the state sector under central planning and its loosening during economic restructuring.

[6]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), 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.

Under central planning, one of the government's goals is to keep "full employment." 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, $\overline{n^l}$. 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 with 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. Government has less incentive to protect high-skilled workers since they are less likely to be unemployed. Therefore the market for high-skilled labor is assumed to be more competitive.

In the state sector, the production function becomes

$$Y_{st} = A_{st}\{\mu(\overline{N_t^l})^\sigma + (1-\mu)\left[\lambda(K_{st})^\rho + (1-\lambda)\left(N_{st}^h\right)^\rho\right]^{\sigma/\rho}\}^{1/\sigma}$$

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. Real wages of high-skilled labor and low-skilled labor in the state sector are determined by marginal productivities, and so are the real wages in the private sector.

Mobility of high-skilled labor equalizes the wage premiums of high-skilled labor across sectors:

$$\frac{w_{st}^{hs}}{w_{st}^l} = \frac{w_{pt}^{hs}}{w_{pt}^l} \quad \text{and} \quad \frac{w_{st}^c}{w_{st}^l} = \frac{w_{pt}^c}{w_{pt}^l}.$$

The equilibrium high-skilled labor in the state sector at date t, N_{st}^h, is therefore determined by the following implicit function:

$$[\lambda(\frac{K_{st}}{N_{st}^h})^\rho + (1-\lambda)]^{\sigma/\rho-1}(\frac{N_{st}^h}{\overline{N_t^l}})^{\sigma-1} = [\lambda(\frac{K_{pt}}{N_t^h - N_{st}^h})^\rho + (1-\lambda)]^{\sigma/\rho-1}(\frac{N_t^h - N_{st}^h}{N_t^l - \overline{N_t^l}})^{\sigma-1}, \tag{6}$$

where N_t^h and N_t^l are the total efficiency units of high-skilled labor and low-skilled labor given by the size of the workforce.

Consistent with the decomposition results, we define the base wage as the real wage of low-skilled labor in the private sector, w_{pt}^l, and

$$w_{pt}^l = \mu A_{pt}^{\sigma} Y_{pt}^{1-\sigma} (N_t^l - \overline{N_{st}^l})^{\sigma-1} \psi_t^l. \tag{7}$$

To illustrate the driving forces of the base wage growth, we log-linearize equation (7) and differentiate with respect to time. Denoting the growth rate of variable x as g_x, we obtain

$$g_{w_{pt}^l} = \sigma g_{A_{pt}} + g_{\psi_t^l} + (1-\sigma) g_{Y_{pt}} + (\sigma - 1) g_{N_t^l - \overline{N_t^l}}. \tag{8}$$

Equation (8) decomposes the growth rate of the base wage into various components that have specific economic interpretations. For instance, the growth of base wage depends on the growth rates of general technological efficiency and specific technological efficiency of low-skilled labor–*the efficiency effect*. It also depends on the supply of low-skilled labor in the private sector–*the supply effect*. Since $\sigma < 1$, increase in supply of low-skilled labor reduces the base wage.

We define skill premiums as the relative wages between high-skilled and low-skilled labor. We have high school premium as

$$\frac{w_{pt}^{hs}}{w_{pt}^l} = \frac{\eta}{\mu} \left[\lambda \left(\frac{K_{pt}}{N_t^h - N_{st}^h} \right)^{\rho} + (1-\lambda) \right]^{\sigma/\rho - 1} \left(\frac{N_t^h - N_{st}^h}{N_t^l - \overline{N_{st}^l}} \right)^{\sigma - 1} \frac{\psi_t^{hs}}{\psi_t^l}, \tag{9}$$

and college premium as

$$\frac{w_{pt}^{c}}{w_{pt}^l} = \frac{\eta}{\mu} \left[\lambda \left(\frac{K_{pt}}{N_t^h - N_{st}^h} \right)^{\rho} + (1-\lambda) \right]^{\sigma/\rho - 1} \left(\frac{N_t^h - N_{st}^h}{N_t^l - \overline{N_{st}^l}} \right)^{\sigma - 1} \frac{\psi_t^{c}}{\psi_t^l}, \tag{10}$$

where $\eta = (1-\mu)(1-\lambda)$. Log-linearization and differentiation with respect to time yield the growth rate of college premium

$$\begin{aligned} g_{w_{pt}^c / w_{pt}^l} \simeq \; & (\sigma - 1)(g_{N_t^h - N_{st}^h} - g_{N_t^l - \overline{N_t^l}}) + (g_{\psi_t^c} - g_{\psi_t^l}) \\ & + \lambda(\sigma - \rho)(\frac{K_{pt}}{N_t^h - N_{st}^h})^{\rho} (g_{K_{pt}} - g_{N_t^h - N_{st}^h}). \end{aligned} \tag{11}$$

Equation (11) decomposes the growth rate of college premium into three components. The first component, $(\sigma - 1)(g_{N_t^h - N_{st}^h} - g_{N_t^l - \overline{N_t^l}})$, depends on the growth rate of high-skilled labor input relative to the growth rate of low-skilled labor input–*the relative supply effect*. Since $\sigma < 1$, relative faster increase in high-skilled labor reduces the college premium. The second component, $(g_{\psi_t^c} - g_{\psi_t^l})$, is the difference in the growth rates of labor efficiency between college labor and low-skilled labor–*the relative efficiency effect.* A relative improvement in the quality of college labor increases the college premium. The third component, $\lambda(\sigma - \rho)(\frac{K_{pt}}{N_t^h - N_{st}^h})^\rho (g_{K_{pt}} - g_{N_t^h - N_{st}^h})$, is *the capital-skill complementarity effect.* If $\sigma > \rho$, 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 state and private sector:

$$\frac{w_{st}^l}{w_{pt}^l} = \frac{{A_{st}}^\sigma Y_{st}^{1-\sigma} (\overline{N_{st}^l})^{\sigma-1}}{{A_{pt}}^\sigma Y_{pt}^{1-\sigma} (N_t^l - \overline{N_{st}^l})^{\sigma-1}}, \tag{12}$$

and the growth rate of state-sector wage premium is determined by

$$g_{w_{st}^l/w_{pt}^l} = \sigma(g_{A_{st}} - g_{A_{pt}}) + (1-\sigma)(g_{Y_{st}} - g_{Y_{pt}}) + (\sigma - 1)(g_{\overline{N_t^l}} - g_{N_t^l - \overline{N_t^l}}).$$

Therefore 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 private sectors. In particular, if SOE restructuring reduces the relative growth rate of low-skilled labor in the state sector, state-sector wage premium increases.

3.2 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 2006. Therefore we focus our attention on these wage and wage premiums. As is shown in Panel A of Figure 1, base wage (in log) increased from 7.62 to 8.36 between 1992–2006. Panel B shows high school and college premiums relative to middle school workers. High school premium increased from 11 percent to 19 percent from 1992 to 1998, and somewhat stabilized and even declined slightly ever since. On the other hand, college premium rose sharply and continuously from 25 percent to 53 percent. Panel A of Figure 2 shows three patterns in the state sector wage premium over this period: a sharp increase between 1992–1994, a decline over much of 1994–1999, and another surge since 1999. Overall, the state sector wage premium increased from 16 percent to 35 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 for real GDP, the stocks of physical capital, low-skilled labor and high-skilled labor inputs in both state and private sectors. Following the same aggregation for ownership category as for the UHS sample, we combine the collective sector and the domestic 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 less than twice of private output by 2006. The average output growth rate of the state sector is 7 percent between 1992–2006, and that of the private sector is 12 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 1999–2006. Data for both GDP and capital are in constant 2006 Yuan. 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 40 percent and the ratio of college labor input to middle school labor input increased by 168 percent over the 1992–2006 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 consistently over the entire 1992–2006 period. As we discussed in the theory, this ratio affects the skill premiums through capital-skill complementarity. Finally, we also construct proxies for technological change, FDI, and sector-specific exports data to analyze the impact of skill-biased technological change (SBTC) and globalization.[7]

3.3 Quantitative Analysis

In this section we use the two-sector model to investigate quantitatively the driving forces of changes in the base wage and wage premiums. With values of production function parameters, equations (7) to (12) can be used to assess how base and relative wages are affected by various forces. We estimate the parameters of the model using simulated method of moments. Then we run counterfactual simulations to study the effects of different mechanisms on wage levels and relative wages by comparing wages from each simulation with those in the benchmark.

3.3.1 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. It is probably not too surprising that the introduction of new technology into the labor market is particularly beneficial to high-skilled workers.[8] Therefore we specify the efficiency of each type of worker as a stochastic process influenced by technological change:

[7] See Data Appendix B for details in the construction of aggregate variables.

[8] Many researchers (Bound and Johnson 1992; Juhn, Murphy and Pierce 1993; Berman, Bound and Griliches 1994) have argued that skill-biased technological change is an important contributor to the increase in wage inequality in the United States.

$$\psi_t^l = \psi_0^l + \gamma^l X_t + \omega_t^l, \tag{13}$$
$$\psi_t^{hs} = \psi_0^{hs} + \gamma^{hs} X_t + \omega_t^{hs}, \tag{14}$$
$$\psi_t^c = \psi_0^c + \gamma^c X_t + \omega_t^c. \tag{15}$$

Each type k labor input has an initial level of efficiency given by ψ_0^k, which might be determined by school quality and the initial technological level. Technological advances can be achieved by both domestic research and development (R&D) and by learning new technology from abroad. We consider domestic R&D expenditure, imported machinery, and FDI as proxies for SBTC.[9] These SBTC measures are introduced in X_t, which affect the efficiency of each type of workers at different rates γ^l, γ^{hs}, and γ^c. $\omega_t' s$ 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 (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

[9] There is some debate over the measure of SBTC that one can correlate with the changes in the wage structure. Recent studies of the link between technological change and wages include Doms, Dunne and Troske (1997), Machin and Van Reenen (1998), Bartel and Sicherman (1999), Bresnahan, Brynjolfsson and Hitt (2002), Autor, Levy and Murnane (2003). A review of the literature is given by Acemoglu (2002).

school and college premiums, and state-sector wage premium:

$$
\begin{aligned}
(w_{pt}^{l})^{UHS} &= w_{pt}^{l}(Z_t;\theta), && (16)\\
(\frac{w_{pt}^{hs}}{w_{pt}^{l}})^{UHS} &= \frac{w_{pt}^{hs}}{w_{pt}^{l}}(Z_t;\theta),\ (\frac{w_{pt}^{c}}{w_{pt}^{l}})^{UHS} = \frac{w_{pt}^{c}}{w_{pt}^{l}}(Z_t;\theta), && (17)\\
(\frac{w_{st}^{l}}{w_{pt}^{l}})^{UHS} &= \frac{w_{st}^{l}}{w_{pt}^{l}}(Z_t;\theta), && (18)
\end{aligned}
$$

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 SBTC. The parameter vector θ contains following parameters: the curvature parameters σ and ρ, which govern the elasticities of substitution; parameters that govern income shares, λ and μ; 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 domestic R&D expenditure, imported machinery and FDI as measures of SBTC but found that the impact of imported machinery on labor efficiency was near zero. Thus we kept domestic R&D expenditure and FDI as proxies for SBTC for the rest of analysis. In total, the parameter vector θ includes 14 parameters and they are estimated with $4 \times 15 = 60$ moments.

3.3.2 Findings from the Benchmark Model

The model is estimated using simulated method of moments (SMM).[10] Estimates of the parameters and bootstrapped standard errors are reported in Table 4. The parameter estimates show that $\sigma > \rho$, that is, production is characterized by capital-skill complementarity. The elasticity of substitution between capital and low-skilled labor is $1/(1-\sigma) = 2.01$. This implies that they are substitutes for one another in the production process. The elasticity of substitution between capital and high-skilled

[10] See the Appendix C for details.

labor is $1/(1-\rho) = 1.43$, which implies the substitutability between capital and high-skilled labor is lower than that between capital and low-skilled labor. Both estimates are well within the reasonable range found in the empirical literature reviewed in Hamermesh (1993) and are close to those reported from a cross-country study in 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 .[11]

Figure 3 shows that 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. The model high school and college premiums track the actual school premiums closely even though it cannot capture all the period by period fluctuations. Perhaps the only exception is that the model under-predicts the state premium between 1992–1999 even though it matches the state premium in the data quite well after 2000. This failure might be explained by the fact that there existed some wage protection in the state sector prior to state-sector restructuring in the late 1990s. Starting from a system of permanent employment and wage grid under central planning, the SOEs tend to protect both the employment and the wage of low-skilled workers until the restructuring in the late 1990s. Since our model simplifies from wage protection, the predicted wages of low-skilled workers are below those in the data in the early 1990s. After SOE restructuring started in 1999, wage protection dies out and the predicted state premiums closely track the actual ones.

[11] Factor-neutral technological efficiencies, A_{st} and A_{pt}, can be backed out using observed inputs and outputs data and the estimated paramters. They are not equivalent to the TFP concept widely used in the growth accounting literature because of the separate labor efficiency component in our model. When we compute the Solow residual both in primary measure using factor quantities and in dual measure using factor prices following Hsieh (2002), TFP growth rates are found to be 2.4-2.6% and 1.8-2.0% in the state sector and in the private sector, respectively, between 1992-2005, which are close to those reported in Young (2003).

3.3.3 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 the shocks. For example, capital investment might respond to concurrent wage. The only way of dealing with this problem explicitly would be to extend the model to a dynamic general equilibrium setting, in which one could solve for the decision rules for capital accumulation along with labor supply. This would be 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 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 use a two-stage SMM. 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. We construct capital stock sequences using the fitted investments from this first-stage regression.

Similarly, labor force participation might also respond to concurrent wage. Therefore we use cohort size for women aged 16–55 and men aged 16–60 as instrument and project total employment onto a constant, its lagged value, a trend, and cohort size. Then we use the instrumented values of capital stock and total employment in stead of those observed from the data in a second-stage SMM procedure as described in Appendix C. We find that the parameter estimates are not sensitive to the implementation of a first-stage IV estimation.

3.3.4 Counterfactual Analysis

In the benchmark economy, changes in wage levels and wage premiums over time are caused by the exogenous changes in capital stocks, labor supply, technological levels, and employment restriction. We run counterfactual simulations to decompose the effects of different mechanisms on wage growth.

Capital Deepening Effects: China has one of the highest investment rates in the world. Capital investment increased from 26 percent of GDP in 1992 to 45 percent in 2005 based on our data. In this experiment, we reduce capital investment by one-third in the state sector and the private sector over the period 1992–2006. Then we reconstruct the capital stock sequences and re-simulate the model. Figure 4 shows the counterfactual of capital deepening effects. Since capital and labor are substitutes in the production function, the substitution effect indicates that firms will increase labor demand when capital input is lower, holding output constant. In the meantime, lower capital stock implies lower output. The scale effect indicates that firms will decrease labor demand as production shrinks. Under our model estimates, scale effect dominates and lower capital implies lower demand and thus lower wages for all types of labor. The impact on high school and college workers is larger because capital and high-skill labor are less substitutable (or relatively more complementary) and therefore the substitution effect is less important for these workers. In the counterfactual, base wage would be 0.16 lower in log points, and school premiums would be 0.07 lower in log points by 2006.

WTO and Accelerated Trade Effects: China has enjoyed double-digit output growth through most of the last three decades in part because of rapid expansion of exports. From 1992 to 2006, China's total volume of trade increased by eleven-fold. Exports to output ratio in the state sector was more or less stable between 22–26 percent between 2002–2006, but in the private sector, it grew dramatically from less than 1 percent in 1992, and eventually reached 41 percent in 2006. Exports grew at faster pace in both sectors after 2001, when China became a member of the World Trade Organization (WTO). In the state sector, annual exports growth rate was 7.0% between 1992–2001 and 12.2% between 2002–2006. In the private sector, average exports growth rate increased from 46.2% between 1992–2000 to 58.0% between 2001–2006. To quantify the WTO accession and accelerated trade effects, in this experiment, we assume state exports growth rates to be 7.0% instead of 12.2% and private exports growth rates to be 46.2% instead of 58.0% between

2002–2006.

The results are shown in Figure 5. When exports grow at a lower rate, base wage drops by 0.14 log points, or about 14 percent between 2002–2006 compared to the benchmark. Lower exports decrease both the output demand and the labor demand, thus lower the base wage. Therefore, expansion of exports is an important source of the increase in base wage. Since lower exports reduce the demand and wages of all skill type, it has no impact on schooling 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's exports to output ratio is higher after 2001 and the counterfactual lowers exports growth rate in the private sector more. Without the accelerated trade effects, the state premium would be 0.12 higher in log points in 2006.

SBTC Effects: R&D expenditure and FDI are used as proxies for SBTC. Our skill-type-specific estimates of their impact on labor efficiency indicate that they are indeed biased towards well-educated workers. Annual growth rate of R&D expenditure was 1.6% between 1992–1998. Since 1999, annual growth rate jumped to 16.9%. In the counterfactual, we assume annual growth rate of R&D expenditure is lowered by one-third since 1999. Figure 6 shows the impact of R&D expenditure. When R&D expenditure is lower, there are two effects on skill premiums. First, because efficiency units decrease more for high school and college workers, the relative efficiency effect implies that schooling premiums would decline. Second, the decrease in the relative supply of high-skilled labor in efficiency units would push up schooling premiums. Overall, reduced R&D expenditure implies that high school premium is 0.04 log points lower and college premium is 0.08 log points lower in 2006.

China's booming economy has attracted large FDI inflows since the early 1990s and FDI growth accelerated after 2001. Since the FDI to the state and the private sectors has been accounted in the capital stocks, we focus on the FDI in the other JSF sector. FDI introduces new technology and managerial skills to the JSF firms. With market competition and learning-by-doing, it also has spillover effect on the entire economy. To see the impact of FDI on wages, we run an experiment which reduce the annual growth rate of FDI (15.3%) between 2001–2006 by one-third. The results are presented in Figure 7. Overall its influence on wages are very small.

State-Sector Restructuring Effects: The restructuring of SOEs in the late 1990s allowed SOEs to lay off massive redundant workers, ending the long protection of state employment. We consider a scenario in which the pace of state-sector restructuring is slower. The decline in low-skilled workers in the state sector since 1999 is reduced by one-third, i.e. state sector would retain more low-skilled workers. In the meantime, the number of low-skilled workers in the private and JSF sectors are reduced. The results are shown in Figure 8. When more redundant low-skilled workers are kept in the state sector, the low-skilled wages decline. State premium drops by 0.33 log points in 2006. In the private sector, the number of available low-skilled workers is reduced, pushing up the base wage. One consequence of the state sector restructuring seems to push down wage rate of raw labor and therefore assist the growth of the private sector.

Increasing College Supply Effects: Annual growth rate of supply of college workers was 2% between 1992–2001. Since 2002, when the first cohort affected by the policy initiative to expand higher education entered the labor market, the number of college workers increased by 8.4% every year. In the counterfactual, we assume the supply of college workers grows at a constant rate of 2% instead of 8.4% between 2002–2006 while keeping the total size of employment as in the benchmark. We split those workers who would otherwise have college education into middle school and high school workers using observed proportions. Figure 9 shows the increasing college supply effects. Lower supply of college workers increases school premiums by 0.10 log points. As the number of low-skilled labor increases, their marginal product decreases, pressing down low-skilled wage. State premium increases because its number of low-skilled workers is fixed.

Finally we summarize the causes of changes in base wage and wage premiums in Table 5. In column (1)–(4), we compare the changes in base wage, high school and college premiums, and state premiums between 1992–2006 in the data, in the benchmark model, and in each counterfactual simulation. For example, the benchmark predicts the base wage to increase 0.8 log points between 1992–2006. If we lower capital investment, the base wage would increase only by 0.636 log points, or 0.164 log points lower compared to the benchmark. According to results in Table 5, the most important forces of base wage growth is capital deepening and expanded exports. Capital deepening and growth in R&D expenditures are most important to account for the increase in schooling premiums. Lastly, state-sector restructuring is the driving force of the increase in state-sector premium.

Recall that the total change in log wages is equal to

$$\overline{\ln w^{06}} - \overline{\ln w^{92}} = \sum_{j=1}^{K} \widehat{\beta}_j^{06} (\overline{X}_j^{06} - \overline{X}_j^{92}) + \sum_{j=1}^{K} \overline{X}_j^{92} (\widehat{\beta}_j^{06} - \widehat{\beta}_j^{92}),$$

where $\ln w_i^t$ is determined by Equation (1). Now we rewrite the decomposition formula into the three most important sources of wage growth (base wage, school premiums, state premium) and the rest variables including gender, industry, region:

$$\begin{aligned}
\overline{\ln w^{06}} - \overline{\ln w^{92}} &= \sum_{j=1}^{K} \widehat{\beta'}_j^{06} (\overline{X'}_j^{06} - \overline{X'}_j^{92}) + \sum_{j} \overline{X'}_j^{92} (\widehat{\beta'}_j^{06} - \widehat{\beta'}_j^{92}) \\
&\quad + \sum_{k} \overline{S}_k^{92} (\widehat{\beta}_k^{06} - \widehat{\beta}_k^{92}) + \sum_{k} \widehat{\beta}_k^{06} (\overline{S}_k^{06} - \overline{S}_k^{92}),
\end{aligned}$$

where $k \in \{Midsch, Highsch, Col, State\}$.

The two-sector model predicts the base wage, school premiums, and state premium. Let us denote these predicted wages as $\widetilde{\beta}_k^t (Z^t; \theta)$, where Z^t is a vector of exogenous variables which determine the wages and θ is the parameter vector of the model. The overall wage growth accounted for by the benchmark model is determined by

$$\sum_{k} \overline{S}_k^{92} [\widetilde{\beta}_k^{06} \left(Z^{06}; \theta\right) - \widetilde{\beta}_k^{92} \left(Z^{92}; \theta\right)] + \sum_{k} \widetilde{\beta}_k^{06} \left(Z^{06}; \theta\right) (\overline{S}_k^{06} - \overline{S}_k^{92})$$

plus the contribution of all other variables. Each counterfactual simulation accounts for the impact of change in one variable in Z. The predicted change in $\widetilde{\beta}$ will quantify the direct effects of this one variable on base wage and wage premiums. In the last column of Table 6, we translate these impact back to the changes in the overall average wages. Capital deepening, accelerated trade, R&D expenditure, FDI, and state-sector restructuring all contributed to the overall wage growth. In total, they can account for about 40% of the total wage growth between 1992–2006.

4 Conclusions

[To be completed]

We find evidences that capital deepening, exports expansion, state-sector restructuring, and skill-biased technological change are important forces behind the wage growth in China.

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.

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 has imposed strict limit on individuals changing their permanent place of residence since it was instituted in the 1950s. 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. They were initially absorbed by the rural non-agricultural sector because rural-to-urban migration was tightly controlled until the middle 1980's. In the mean time, the demand for rural labor in the urban areas continued to increase due to the development of urban private and informal sectors. Both supply and demand factors pushed national and local authorities to loosen restrictions on rural-to-urban migrations. As a result, the number of rural migrant workers in urban areas began to increase dramatically since the late 1980s and the early 1990s.

Households that live in urban areas but have no urban registrations were not sampled 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. Census-based urban population estimates for 2002 was 502 million. Experts have estimated rural migrants, who are registered in a village but work temporarily in urban areas, to be in the range of 90 to 110 million. Therefore rural migrants account for at least 20% of the urban workforce. However, out of 149,051 workers observed in our sample, only 683 of them were reported to be 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.

Survey-based studies show evidence that migrant workers are discriminated against in the urban labor market and earn lower wages than their urban counterparts (Meng and Zhang, 2001). However, the average wages of the identified 683 migrant workers are higher than those of other workers. This is likely due to following reasons. Most of the millions of rural migrant workers spend some time in a city to earn money but still have a significant income from farming. They regularly go back during harvest times. They usually earn low income in urban areas and do not have regular housing. In fact, many migrant workers stay in a factory dormitory or a shack on construction sites. Therefore they have no formal address and are unlikely being surveyed by the NBS. The rest of migrant workers are in different stages of actual migration. They more or less permanently live in urban areas and 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. The migrant workers observed in UHS sample seem to be among these semi-permanent migrants, the relatively wealthy and educated ones.

Data Resampling. According to survey administrators at the NBS, the over-sampling of workers from state and collective enterprises are likely due to several explanations. First, self-reporting might introduce error. When a state-owned enterprise (SOE) is restructured and becomes a stock-holding firm or a joint venture, its employees may continue to classify its 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. Based on "Comprehensive Statistical Data and Materials on 55 Years of New China" and various years of China Statistical Yearbook published by NBS, we first compile aggregate annual employment shares of three ownership categories – state-owned firms, collective firms, and other ownership firms including joint-venture, stock-holding, and foreign firms – for the provinces in our sample. Under the assumption that survey participation of workers within an ownership type is random, we keep the workers in private firms and other ownership firms, and randomly re-sample workers in state firms and collective firms such that their numbers relative to the number of workers in other ownership firms are consistent with the aggregate statistics.

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," "technical and high school" where technical school usually require 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 four ownership categories for their employers: individually-owned private firms, collectively owned firms, state-owned enterprises (SOEs), or other ownership firms which include various joint-venture companies, stock-holding firms, and foreign firms (JSF). While maintaining SOE and JSF categorization, we combine collective and private firms into a "collective and private" group because worker characteristics across these two 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 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 private firms as a separate ownership group.

(c) *Industry:* We group manufacturing and construction together as representing the secondary sector. Basic services include transportation, storage, postal services, whole sale, 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.

B. Aggregate Data

Real GDP

GDP data for industrial and tertiary sectors are collected from China Statistical Yearbooks and Industrial Statistical Yearbooks. However, the estimation of the two-sector model requires GDP data for each ownership category. Industrial value-added output are available for each ownership category between 1999–2006. From 1992 to 1998, value added by ownership category were not reported but the total output were. Since value added as a fraction of total output above designated size in each ownership category showed clear trend from 1999 to 2006, we estimate industrial value added as proportions of total output for each ownership category in earlier years using a linear in time projection. These estimated ratios are then combined with total outputs to compute ownership-specific value added for those years.[12] We compute the shares in industrial value-added (or industrial GDP) for the state sector and the private sector. Finally we apply ownership-specific shares of value added to industrial and tertiary total GDP to construct ownership-specific output.[13] All

[12] We estimated the total ouput above designated size in each ownership category for 1992 since they were missing. We also noticed some anomally high output in the collective sector between 1994-1997, and we adjusted them using an interpolation between 1993 and 1998.

[13] Since no information is available on value added across ownership category in the tertiary sector,

nominal output are deflated by urban CPI to 2006 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, total investment and investment in three categories: "construction and installation" (construction), "purchase of equipment, tools and instruments" (equipment), and "others" are reported separately. "Others" 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 2000–2002, 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 live is not yet expired. The weights are the relative efficiency of capital investment of different vintage. In formula:

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

of which:

A_t = gross capital stock in time t,

I_t = gross capital investment in year t,

d_τ = relative efficiency of capital investment of vintage τ,[14]

T = expected service life.

If relative efficiency of capital investment declines geometrically, gross capital stock at time t can be estimated by

we assume the distribution to be the same as in the industrial sector.

[14]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 $t \geq T$.

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

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 (2005)'s 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 2006 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

China Statistical Yearbooks provide the total number of urban employed workers by each ownership category. However, workers' education distribution is unknown from the aggregate data source. We construct the series for high-skilled (high school and college) and low-skilled (middle school and below) labor input in three steps. In the first step, we calculate the proportion of workers of each education level in the state sector and in the private sector from the national UHS sample. In the second step, we use the employment ratio by education and total employment in each sector to compute the number of workers who have different education attainment in each sector. Finally, 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 private sectors.

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 2006 yuan using annual exchange rate and CPI.

R&D Expenditure: Annual data on "Expense on science and technology promotion" are collected from Statistical Yearbooks and we construct a two-year moving average.

Imports: Annual data on "Imports value of machinery and transport equipment " are collected from Statistical Yearbooks and we construct a two-year moving average.

FDI: Annual data on "Total amount of foreign capital actually utilized" are collected from Statistical Yearbook. In our model specification, we allow for capital-skill complementarity and also allow FDI to affect labor efficiency. To avoid double counting, we subtract from the total FDI the portion of equipment investment coming from foreign capital to construct the relevant FDI variable in the labor efficiency equations. Again a two-year moving average is used.

C. SMM Estimation Procedure

Let m_j be moment j in the data, which is from the LHS of Equations (16) to (18). 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 (16) to (18). 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 $J = 60$ (4 moments $\times$ 15 years). We minimize following objective function with respect to θ

$$L(\theta) = g(\theta)' W g(\theta),$$

where the weighting matrix W is the identity matrix. The steps in more details are as follows:

1. Make initial guesses for the parameter vector $\theta = \{\sigma, \rho, \lambda, \mu, \psi_0^l, \psi_0^{hs}, \psi_0^c, \gamma^l, \gamma^{hs}, \gamma^c, \eta_\omega\}$.

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

3. Use Equations (13) to (15) and 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, $\overline{n_t^l}$.

4. Compute equilibrium high-skilled labor allocation, N_{st}^h, using Equation (6).

5. Back out the neutral technology efficiencies in both sectors, A_{st} and A_{pt}, using the production function specified in (5).

6. Simulate the wages of all labor types and compute base wage and wage premiums for each year.

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

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

9. Adjust parameters, repeat step 2–6 until the optimum is reached.

Even though the two-sector model is estimated using aggregate time series data, the empirical moments are estimated from the UHS micro sample and therefore their distributions are known. Standard errors are computed by bootstrapping: Firstly, generate a random sample of base wage and wage premiums from their distributions, m_j^i; Secondly, estimate the model using the sample m_j^i and store the estimates θ^i; Finally, implement $B = 500$ times of bootstrap replications and the bootstrap standard errors of the parameter vector θ is

$$\sigma_{boot} = \sqrt{\frac{1}{B-1} \sum_{i=1}^{B} |\theta^i - \overline{\theta}|^2}$$

where $\overline{\theta} = \frac{1}{B} \sum_{i=1}^{B} \theta^i$.

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Table 1: Distribution of the Sample by Ownership Type

Year	Total	Employment shares (%)			
		State	Collective	Private	JSF
Period 1 (1992-1996)	40,763	72.1	21.5	2.0	4.3
Period 2 (1997-2001)	39,737	65.6	13.7	7.9	12.8
Period 3 (2002-2006)	149,051	48.8	6.5	18.5	26.3
All years	229,551	55.8	10.4	13.7	20.0

JSF: Joint-venture, stock holding and foreign-invested firms

Table 2: Changes in Wage and Employment Structures in China, 1992-2006

	Wage level (2006 yuan)		Wage growth (%)	Employment share (%)		Emploement change (%)
Classification of Group	1992	2006	1992-2006	1992	2006	1992-2006
Whole sample	6,028	17,858	196.3	100	100	100
By education:						
Middle school and below	5,589	12,935	131.4	40.4	23.8	-16.5
Vocational and high schoo	5,959	15,728	163.9	42.6	40.2	-2.4
College and university	7,237	23,488	224.6	17.1	36.0	18.9
By gender:						
Male	6,560	20,022	205.2	50.3	55.2	4.9
Female	5,490	15,192	176.7	49.7	44.8	-4.9
By ownership:						
Collective and private	4,985	11,995	140.6	25.4	24.8	-0.6
State	6,291	20,462	225.3	72.7	44.5	-28.3
JSF	9,931	18,824	89.5	1.9	30.7	28.8
By industry:						
Manufacturing	5,753	17,506	204.3	46.0	37.9	-8.0
Basic services	5,803	16,448	183.4	24.7	35.9	11.2
Advanced services	6,649	20,310	205.5	29.3	26.1	-3.2
By region:						
Northeast	4,844	13,266	173.9	16.5	12.0	-4.5
Central	5,349	14,950	179.5	23.0	19.0	-4.0
West	5,868	14,916	154.2	25.5	23.3	-2.3
East	7,150	21,771	204.5	35.0	45.7	10.7

Table 3: Decomposition of Log Wage Differentials between 1992 and 2006

Sources of wage differential	Change in log wage	Contribution to total change (%)
Observed total change	0.965	100.00
Base wage	0.298	30.86
Due to worker characteristics and reallocations	0.130	13.45
Schooling and experience:	0.113	(11.74)
Middle School	-1.382	
High School	-0.205	
College	1.683	
Experience	0.018	
Gender	0.011	(1.18)
Ownership:	-0.031	(-3.19)
State	-0.100	
JSF	0.069	
Industry:	-0.005	(-0.51)
Manufacturing	-0.003	
Advanced Service	-0.002	
Region:	0.041	(4.24)
Central	-0.002	
West	-0.002	
East	0.045	
Due to factor returns and sector premiums	0.538	55.69
Schooling and experience:	0.313	(32.41)
High school	0.344	
College	0.173	
Experience	-0.204	
Gender	0.062	(6.39)
Ownership:	0.134	(13.86)
State	0.141	
JSF	-0.007	
Industry:	0.028	(2.89)
Manufacturing	0.021	
Advanced Service	0.007	
Region:	0.001	(0.13)
Central	-0.005	
West	-0.021	
East	0.028	

Note: Numbers in parentheses are percentage contributions made by subgroups of variables.

Table 4. SMM Parameter Estimates

Parameters	Estimates	Standard errors
Curvature parameters		
σ	0.5027	0.0005
ρ	0.3030	0.0003
Income shares		
μ	0.6138	0.0003
λ	0.6618	0.0023
Initial efficiency units		
ψ_0^{l}	13.5020	0.1146
ψ_0^{hs}	52.2116	0.6404
ψ_0^{c}	57.8043	0.8240
SBTC proxies (middle school)		
R&D expenditure	0.0077	0.0004
FDI	0.0138	0.0002
SBTC proxies (high school)		
R&D expenditure	0.4342	0.0021
FDI	0.2455	0.0075
SBTC proxies (college)		
R&D expenditure	0.6678	0.0040
FDI	0.3019	0.0100
St.d. of efficiency shocks		
η_ω	0.0718	0.0007

Note: Standard errors are calculated based on 500 bootstraps.

Table 5: Contributions to the Total Change in Average Wages

	Base wage	High school premiium	College premium	State sector premium	Total change in log(wage)
Benchmark: change in log(wage)	0.800	0.098	0.327	0.294	1.107
(1) Lower investment	-0.164	-0.068	-0.068	-0.005	-0.218
(2) Lower exports	-0.136	0	0	0.118	-0.084
(3) Lower R&D growth	-0.053	-0.040	-0.075	0.007	-0.093
(4) Lower restructuring	0.046	0.098	0.098	-0.329	-0.025
(5) Lower supply of col grads	-0.073	0.101	0.101	0.068	0.035
(6) (1)-(4)	-0.308	-0.010	-0.045	-0.207	-0.421

Figure 1: Estimated Base Wage, Schooling and Male Wage Premiums

Figure 2: Estimated Wage Premiums by Ownership Type, Industry, and Region

Figure 3: Goodness of Fit, Base Wage and Wage Premiums, 1992-2006

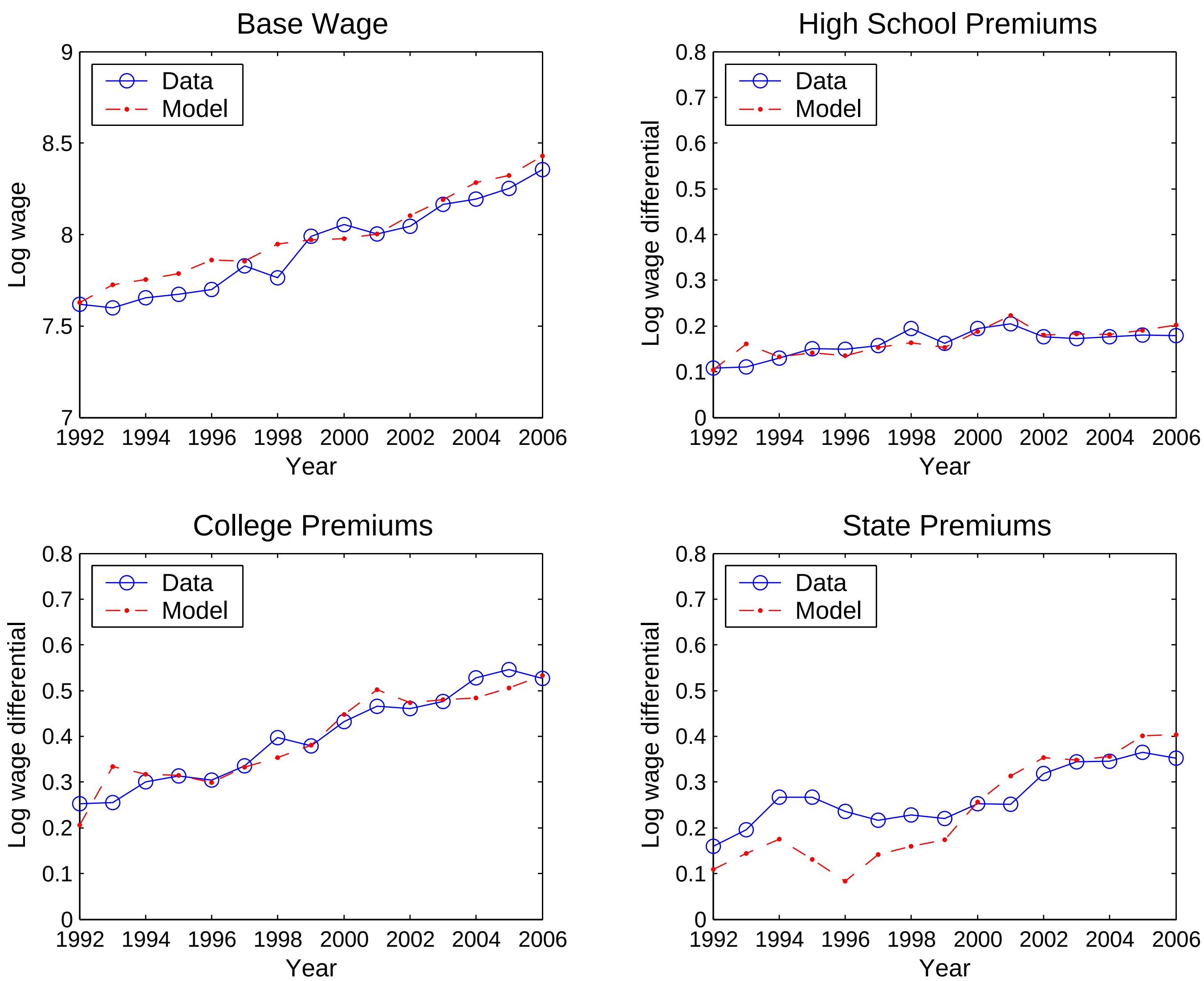

Figure 4: Counterfactual, Capital Deepening Effects

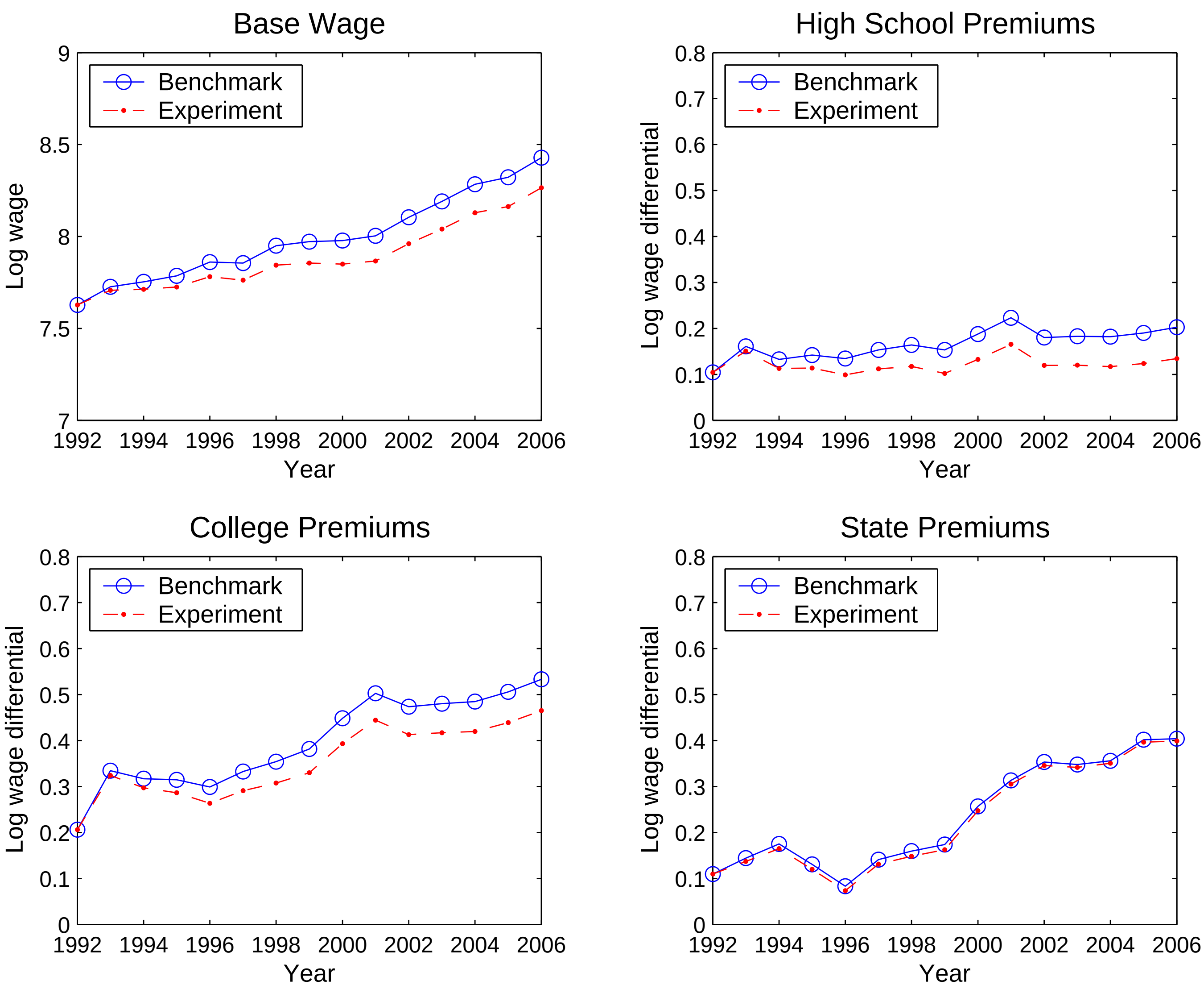

Figure 5: Counterfactual, WTO and Accelerated Trade effects

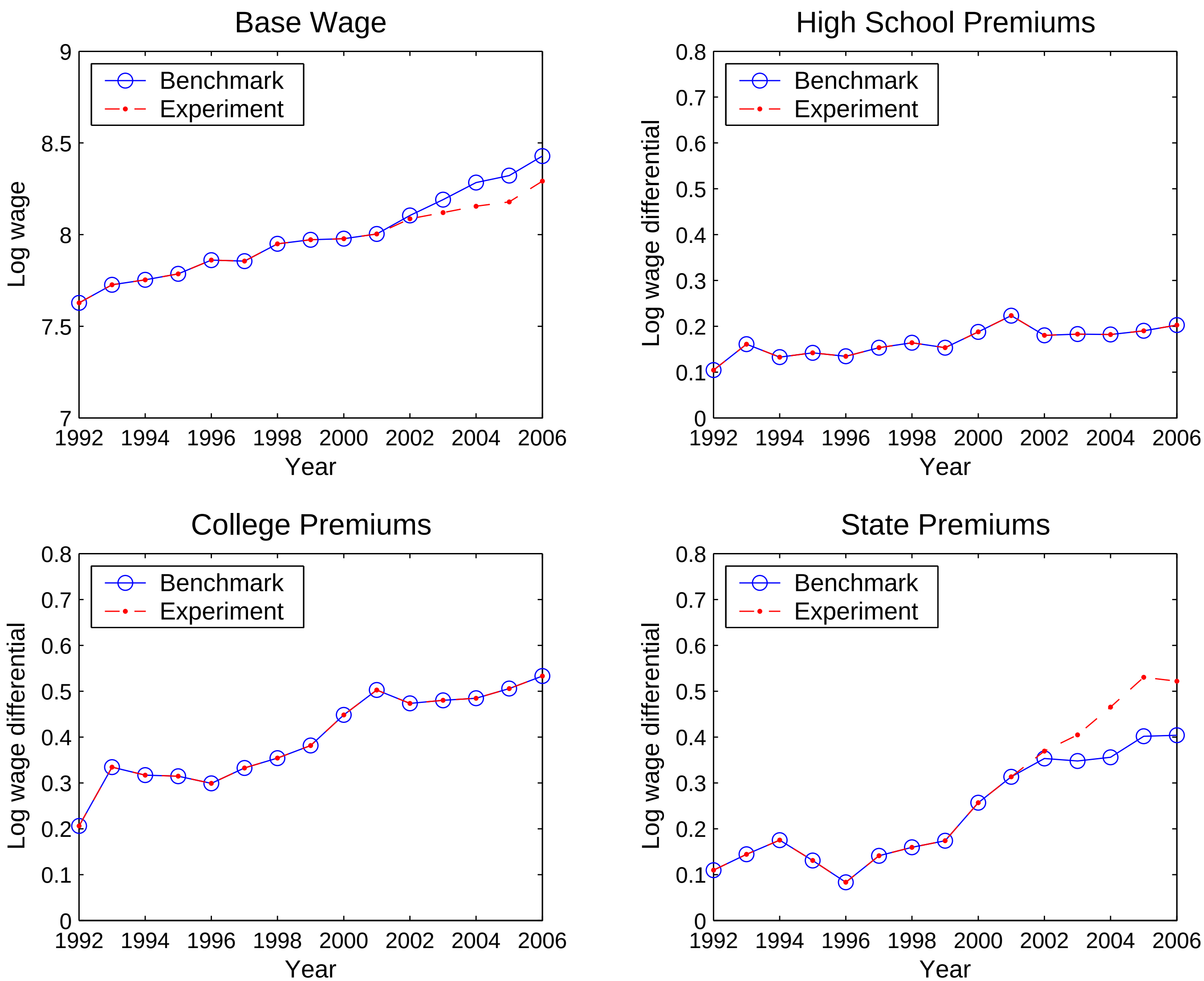

Figure 6: Counterfactual, R&D Expenditure Effects

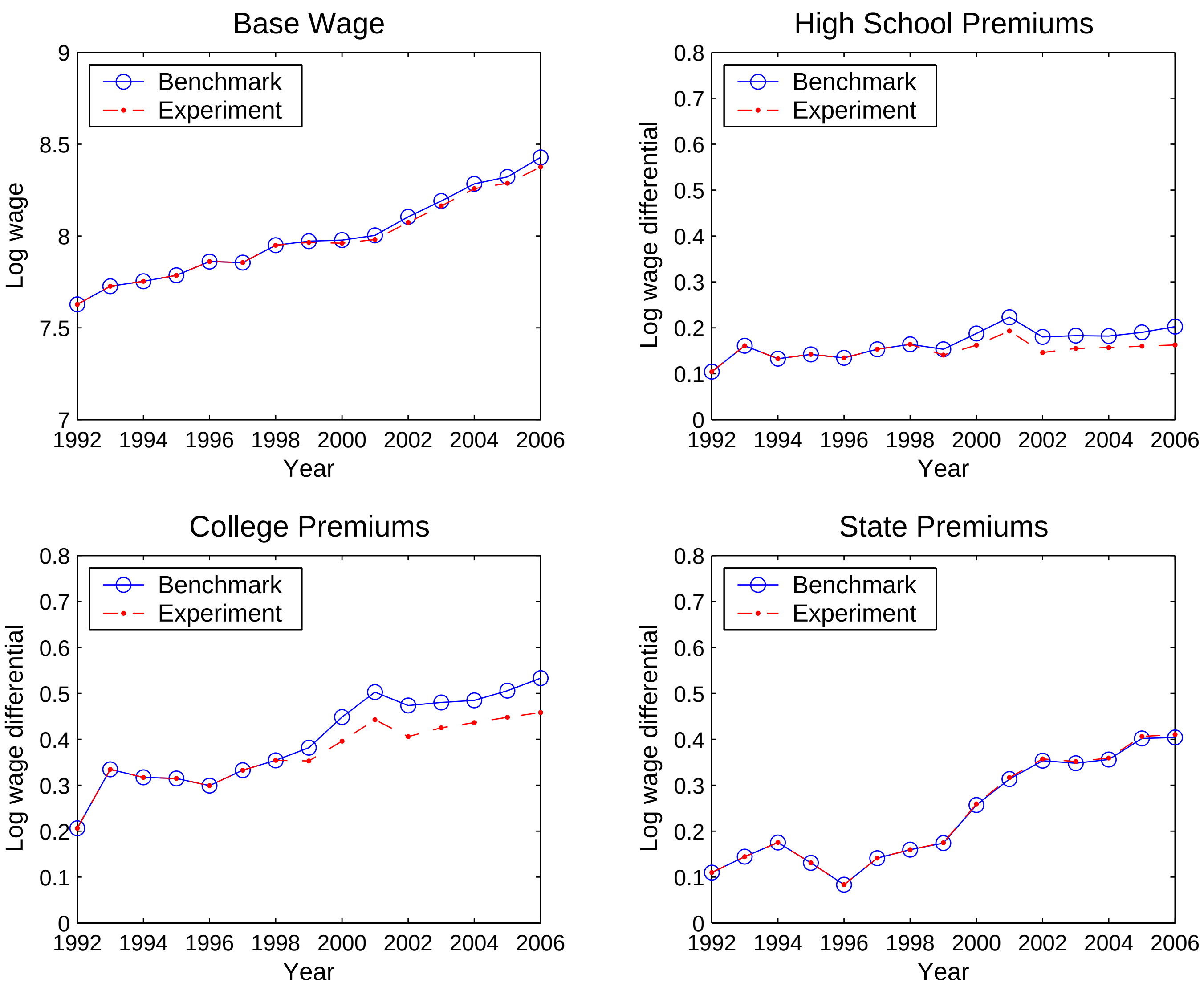

Figure 7: Counterfactual, State-Sector Restructuring Effects

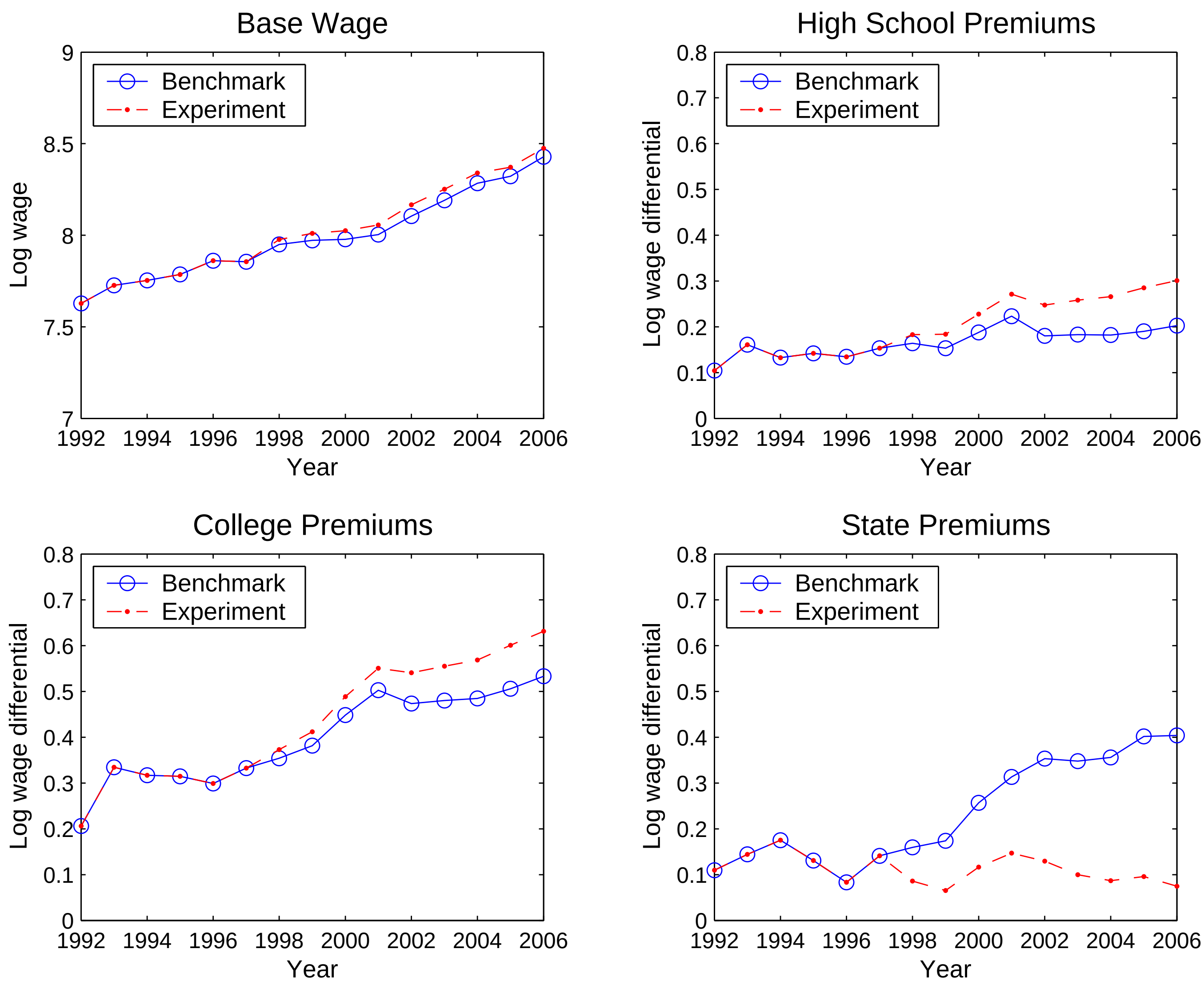

Figure 8: Counterfactual, Increasing College Supply Effects