Skill Premium and Preferential Policy: The Case of China*

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Abstract

We document a new fact about the wage structure in China: from 2009, the skill premium reverted its rising trend and started to decline. This paper interprets such change as a reflection of a long-lasting change in the structure of Chinese economy. That is, starting from 2009, government can offer its preferred firms with cheap credits. Since many of these preferred firms are unskilled labor intensive, with a lower financing cost, they increase investment and hire more unskilled workers, thereby reducing the skill premium. Our model can quantitatively account for China's economic transition over the last decade.

JEL Codes: E25, O16, O41, P23.

Keywords: Skill Premium; Preferential Policy; Misallocation; Economic Growth; Chinese Economy.

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1 Introduction

In 2009, China's skill premium, which is defined as the wage of skilled labor relative to that of unskilled labor, reversed its earlier trend and started to decline. Between 2000 and 2009, the wage premium of people with education levels of high school and above relative to people with education levels of middle school and below increased from 33% to 47%, but between 2009 and 2012, this premium decreased from 47% to 39%. A similar pattern is observed on the wage premium of people with education levels of college and above relative to people with education levels of high school and below.

We are the first to document this phenomenon of falling skill premium in China. By using Urban Household Survey (UHS) data from 2000 to 2012, our estimates of skill premium are consistent with those found in the literature (Ge and Yang, 2014; Sheng and Yang, 2017) for the pre-2008 period, but after extending our estimates to 2012, we find that the trend in skill premium after 2009 contrasts that observed before 2009.

What causes the observed decline in skill premium since 2009? In this paper, we emphasize the role of a long-lasting change in China's economic structure which was initiated by the government stimulus plan, that is, the strengthening of the preferential treatment to different firms. In response to the grave challenges of the global financial crisis, the Chinese government announced in November 2008 a stimulus package that includes plans to spend about 4 trillion yuan in the next two years, which is more than 11 percent of China's GDP in 2009. These expenditures are concentrated in a few government-preferred industries, in which firms can obtain cheap credits. Given that firms in most of these preferred industries, such as construction and transportation, hire relatively more unskilled workers than skilled ones, the demand for unskilled worker increases, thereby accelerating the growth of unskilled wage and reducing the skill premium.

This preferential treatment has important implications not only on the labor market

inequality, but also on many other aspects of the economy. For example, can this treatment help us reconcile the rising investment rate despite the global financial crisis? Can this treatment shed light on the high GDP growth despite the slump in foreign demand? What is the cost and benefit of this policy change? It is important to note that although the stimulus plan that initiates such treatment only lasts for two years, the preferential system stays afterward and hence has a long-lasting impact on the economy.

To understand the macroeconomic implications of this preferential treatment, we build a model in which firms are heterogeneous in terms of skill intensity and access to financial market. Firms in the government preferred industries are unskilled labor intensive and have better access to the financial market, i.e. government gives subsidy to interest payment of the loans taken by these preferred firms. Meanwhile, firms in non-preferred industries are skilled labor intensive and borrow from banks at the market interest rate. With a lower financing cost, the preferred industries increase their investment and hire more workers, thereby crowding out the resources in other industries and driving up the relative demand for unskilled labor. This prediction is consistent with the fact that the skill premium starts to decline since the implementation of the stimulus package. When calibrated to the Chinese data, first, the model can account for most of the decline in the skill premium from 2009 to 2012. Second, this model generates a sharp rise in investment rate from 2009, which matches the data well. Third, the model implies a rising aggregate output despite a large reduction in net exports.

We also document two pieces of evidence that support our model by using firm-level data from the national sample of Enterprise Taxation Surveys (ETS). First, we show that from 2009 those firms that employ workers with a lower education level face lower interest rates on bank loans. Second, we show that those firms that employ workers with a lower education level grow faster than other firms from 2009. We are the first to document these two patterns

by using firm-level survey data, thereby empirically contributing to the literature.

We then demonstrate that other potential explanations for the falling skill premium are not supported by the data. First, in the counterfactual exercise, we find that the increase of skilled labor supply cannot generate the surge in the investment rate and the accelerated growth of preferred sectors after 2008. Second, given the smooth progress of investment-specific technologies, capital-skill complementarity cannot be the major factor that drives the structural break of skill premium in 2009.

We emphasize that this preferential treatment differs from the previous treatments identified by the literature in several aspects. First, according to Bai, Hsieh, and Song (2016a), before 2008, local governments can only help their preferred firms by removing institutional obstacles, such as cutting red tapes. However, starting from 2008, the stimulus-related regulation changes have officially given local governments better access to financial resources and allow them to offer their preferred firms with easy, cheap capital. Second, this treatment differs from the well-known preferential treatment that the government gives to state-owned enterprises (SOEs). Those preferred firms selected by the government can very well be private. In fact, the change in skill premium cannot be explained by focusing on the two sector structure of SOEs and non-SOEs. As shown by the UHS data, the average education level of employees in SOEs is significantly higher than that of employees in non-SOEs. Therefore, if the government stimulus only manifests itself in the easy and cheap access to capital for SOEs, then we should expect an increase in the skill premium as a result of this stimulus.

Our paper is related to two strands of literature. First, there is a large literature investigating the changes in earning inequality in both developed and developing countries. For example, many studies, such as Katz and Murphy (1992), Autor, Katz, and Krueger (1998), Krusell, Ohanian, Rios-Rull, and Violante (2000), Acemoglu (2003), and He and Liu (2008), have investigated the evolution of skill premium in the US. See Autor, Katz, and

Kearney (2008) for an excellent survey. Two recent papers have also focused on the changes in skill premium in China. Ge and Yang (2014) document the evolution of the wage structure in China from 1992 to 2007 and identify capital accumulation, skill-biased technological progress, and rural to urban migration as the major drivers of these changes. Sheng and Yang (2017) examine the effect of offshoring through FDI on the skill premium in China's manufacturing sector from 1992 to 2008. However, these papers focus on the pre-2008 period. We are the first to document and explain the changes in the skill premium in China after 2008.

Second, some studies, such as Restuccia and Rogerson (2008), Guner, Ventura, and Xu (2008), and Hsieh and Klenow (2009), have examined government policies and related factor misallocations. Among these papers, our study is closed related to those that investigate government preferential treatment in China. Brandt, Tombe, and Zhu (2013) and Song, Storeletten, and Zilibotti (2011) study the well-known preferential treatment towards SOEs. Chung, Chen, Waggoner, and Zha (2016) explore the government preferential credit treatment towards heavy industries and its implication on the weak correlation between investment and consumption since the late 1990s. These heavy industries are different from our unskilled-intensive industries. Bai, Hsieh, and Song (2016a) focus on the preferential treatment where local governments help their preferred firms by cutting red tapes to explain the situation of Chinese economy before 2009. Complementary to their paper, we emphasize the effect of the strengthened preferential treatment where the government helps the preferred firms by subsidizing their use of capital, a practice that is highly relevant in the post-2009 Chinese economy. Ho, Li, Tian, and Zhu (2016) use bank loan data to show that the government policies in 2008 have resulted in the provision of excessive credit to the preferred industries, which echoes our finding. Bai, Hsieh, and Song (2016b) discuss the local government financing vehicles (LGFVs) that were set up during the 2008 stimulus plan and the implications

on investment and current account in a partial equilibrium model. Our model is the first general equilibrium model that attempts to understand the macroeconomic implications of the preferential treatment in the short run. In a companion work, Bai, Liu, and Yao (2016) evaluate the long run effects of the preferential treatment and its welfare implications by incorporating the externalities of infrastructure sector.

The rest of this paper is organized as follows. In Section 2, we present the empirical evidence and institutional background that motivate this paper. In Section 3, we describe the benchmark model, its key mechanism, and its solution. In Section 4, we discuss the calibration of the model and present the main results. In Section 5, we present alternative explanations for the decline in skill premium. Section 6 concludes the paper.

2 Empirical Evidence

This section describes the salient facts that motivate our paper. We begin by documenting the changes in the wage structure. Afterward, we describe the government stimulus plan and related preferential policy in detail. We also use cross-sectional data to illustrate the changes in the preferential policy and its impact.

2.1 Decline of Skill Premium

To summarize the basic changes in China's wage structure over the last decade, we draw on the national sample of UHS from 2000 to 2012. This survey is conducted by the National Bureau of Statistics in China and is equivalent to the Current Population Surveys being conducted in the US. The skill premium is defined as the wage of people with education levels of high school and above relative to that of people with education levels of middle school and below. We run the following regression to calculate the skill premium in each year

while holding the distribution of the worker's attributes fixed:

$$\ln w_i^t = \beta_0^t + \beta_1^t S_i^t + \beta_2^t X_i^t + \beta_3^t \left(X_i^t\right)^2 + \beta_4^t G_i^t + \sum_n \beta_n^t P_{in}^t + \varepsilon_i^t \tag{2.1}$$

where w_i^t is worker i's annual wage in year t, S_i^t is a dummy variable that denotes the high school education level and above (with middle school and lower level education being the base group), X_i^t and $\left(X_i^t\right)^2$ are the potential experience and its squared value,[1] G_i^t is the dummy variable for males, and P_{in}^t is the dummy variables for provinces.

Figure 1 Here

Figure 1 plots the evolution of skill premium, β_1^t, from 2000 to 2012. We observe a rise in skill premium from 2000 to 2009, peaking in 2009 with a premium of 0.47, which means that in 2009, when the other conditions are kept the same, people with education levels of high school and above earn 47% more than those people with an education level of middle school and below. The rise in skill premium before 2009 is consistent with the findings of other studies, such as Ge and Yang (2014) and Sheng and Yang (2017).

However, the focal point of the paper is the structural break in skill premium around 2009, during which the skill premium reverted its rising trend and started to decline. For instance, in 2012, the skill premium decreased to 0.39, which indicates a major change in China's labor market conditions.

2.2 Stimulus Plan and Preferential Policy

2.2.1 Stimulus Plan in 2008

After China's output growth decelerated as a result of the global financial crisis, the State Council announced a fiscal stimulus plan in November 2008 that specifically focused on a

[1] Experience is defined as min[(age - years of schooling - 6), (age - 16)]. More data details can be found in the appendix.

few priority areas. Table 1 lists the planned amounts of spending in these areas after the initial plan was modified in March 2009. These areas include Agriculture, Forestry, Animal Husbandry, and Fishery (A), Production and Supply of Electricity, Gas, and Water (D), Construction (E), Transport, Storage, and Post (F), Management of Water Conservancy, Environment, and Public Facilities (N), Health, Social Security, and Social Welfare (Q) and Culture, Sports, and Entertainment (R).[2] One important feature of these preferred industries is that they tend to hire more unskilled workers than skilled ones. By using the information from the 2005 National Census, we show that the average schooling year of employees in these preferred industries is 11 years, which is lower than the average schooling year of employees in the non-preferred industries (12 years).

Table 1 Here

When the local governments start to implement the stimulus, they find themselves not allowed to run budget deficits by law. To solve this problem, the Ministry of Finance issued a new regulation in 2009 which allows the local government to finance investment projects by using all sources of funds, including those borrowed by Local Government Financing Vehicles (LGFVs), which are companies set up by the local government that have explicit or implicit guarantees on their debts from the local government. According to Bai, Hsieh, and Song (2016b), about three quarters of the 4 trillion yuan in the stimulus plan is financed by LGFVs. Figure 2 illustrates the debt accumulation of LGFVs. Before the onset of the financial crisis in 2007, LGFVs were barely used as financing tool and the debt level is less than 1 trillion yuan. However, from 2008, given the increasing demand to finance investment projects in the preferred industries, the debts of LGFVs surged and reached 8.9 trillion yuan

[2]Given that some of the important data that we use are only available at the two-digit industry level according to China's industry classification, we choose those two-digit industries that are connected the closest to the priority areas of investment chosen by the State Council.

in 2009, and further to 10 trillion yuan in 2014. Once LGFVs are set up, it is very difficult for the central government to control them, hence the new regulation issued by the Ministry of Finance leads to a long-lasting change in the economy even after the stimulus plan is finished.

Figure 2 Here

Given that local governments offer more help to their preferred firms in terms of easy, cheap access to capital, the aggregate investment rate in China reached a record high as shown in Figure 3. In 2008, the investment rate was 0.41 and by the time the stimulus plan was fully implemented in 2010, the investment rate increased to 0.47.

Figure 3 Here

2.2.2 Credit Policy for Preferred Industries

In order to facilitate the spending on preferred industries, China's Banking Regulatory Commission (CBRC) announced the following guidance to banks in March, 2009:

> *Encourage local governments to attract and to incentivize banking and financial institutions to increase their lendings to the investment projects set up by the central government. This can be done by a variety of ways including increasing local fiscal subsidy to interest payment, improving rewarding mechanism for loans and establishing government investment and financing platforms compliant with regulations.*

Banks responded to this guidance by adjusting their credit policies. For example, the Industrial and Commercial Bank of China, as one of four major state-owned banks in China, changed its credit policy as stated in its 2009 Annual Report*:*

> *The bank accelerated the adjustment of credit policies and the product innova-*

tion, and increased the credit support to major customers in infrastructure area and the disbursement of quality medium to long-term project loans that are in line with the orientation of the state policy of boosting domestic demand.

The changes in the banks' credit policies are also reflected in the data. By using a national sample of ETS conducted by the State Administration of Taxation from 2007 to 2011,[3] we run the following regression to illustrate that banks provide lower interest rates to those firms who hire more unskilled workers:

$$R_{it} = \theta_0 + \theta_{1t} ASY_{it} \times year_t + \theta_{2t} year_t + controls + \varepsilon_{it} \tag{2.2}$$

where R_{it} is firm i's return to capital, ASY_{it} is the average schooling year of the employees in firm i, $year_t$ is the year dummy, *controls* include other factors (e.g., market concentration of the industry that the firm is in, firm size, and province fixed effect). We use the return to capital of firms to approximate the interest rate that they receive on their bank loans under the assumption of a perfect competitive market. We report the estimates of the relationship between return to capital and average schooling year in column (1) of Table 2. First, the positive coefficients θ_{1t} indicate that the firms with a lower average schooling year tend to have a lower return to capital from 2007 to 2011. In other words, those firms who hire more unskilled workers receive bank loans with lower interest rates. Second, the estimates significantly increase from 2009 onward. Specifically, the coefficient rises from 0.018 to 0.053 from 2008 to 2009 and remains at a high level afterwards. The increase in the coefficient reflects the preferential treatment, that is, government-preferred firms can secure an even lower interest rate than the non-preferred firms after 2008, which is consistent with aforementioned credit guidance issued by the CBRC.

[3] These data include approximately 700,000 firms each year and provides detailed information on the various taxes that a firm pays and on many other firm characteristics.

Table 2 Here

3 The Model

In this section, we present our benchmark model, which is a two-sector neoclassical growth model with credit policy that is biased to the preferred sector. We then characterize the optimality conditions for a competitive equilibrium, based on which we explore how the preferential policy affects factor prices, resource reallocation, and other key macroeconomic variables.

3.1 Model Setup

Time is discrete and the horizon is infinite. There exists a representative household with a constant-relative-risk-aversion preference. He chooses consumption c_t and saving a_{t+1} as well as provides skilled labor s_t and unskilled labor l_t at wage rates w_{Lt} and w_{St}, respectively. The household problem (HP) is formulated as

$$\max_{c_t, l_t, s_t, a_{t+1}} \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\rho}}{1-\rho}$$

$$\text{s.t. } c_t + a_{t+1} + \tau_{t+1} = w_{Lt} l_t + w_{St} s_t + (1 + r_{dt})\, a_t, \tag{3.1}$$

where r_{dt} is the interest rate and τ_{t+1} is a lump-sum tax.

There are two sectors, the preferred and non-preferred sectors, which produce intermediate goods by using Cobb-Douglas production technologies as follows:

$$Y_{it} = A_i \left(K_{it}\right)^{\gamma_i} \left(S_{it}\right)^{\beta_i} \left(L_{it}\right)^{\alpha_i}, \tag{3.2}$$

where $i = 1$ is the preferred sector and $i = 2$ is the non-preferred sector, K_{it}, S_{it}, and L_{it} are the capital, skilled labor, and unskilled labor used in sector i, and A_i is the sector-level

TFP.

The representative firm in sector i faces the decision (FP_i) as

$$\max_{K_{it},L_{it},S_{it}} \{p_{it}Y_{it} - r_{it}K_{it} - w_{Lt}L_{it} - w_{St}S_{it}\}, \tag{3.3}$$

where p_{it} is the price of intermediate good i and r_{it} denotes the capital rental rate in each sector.

Note that the two aforementioned sectors differ in the following aspects: (1) skill intensity: the preferred sector is more unskilled-labor-intensive than the non-preferred sector (i.e., $\alpha_1 > \alpha_2$); and (2) financing cost: firms in the preferred sector have access to cheap credit, which means that their effective capital rental rate is lower (i.e., $r_{1t} < r_{2t}$).

The final good is produced by combining two intermediate goods Y_{1t} and Y_{2t} via a CES aggregator. The firm chooses Y_{it} to maximize the profit as follows:

$$\max_{Y_{it}} Y_t - p_{1t}Y_{1t} - p_2Y_{2t}$$

$$s.t.\ Y_t = \left(\varphi\left(Y_{1t}\right)^{\frac{\sigma-1}{\sigma}} + (1-\varphi)\left(Y_{2t}\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}, \tag{3.4}$$

where the final good price is normalized to 1.

The banking sector is assumed to be fully competitive. There exists a representative bank that converts the household's savings into capital goods. For simplicity, we assume a one-for-one capital formation. In each period, the bank takes all the savings and converts them into capital goods. Afterward, the bank rents the capital to firms in both sectors at the market rate, r_t.

The preferential treatment takes the following form in the model: the government imposes a lump-sum tax on the household and uses the tax revenues to subsidize the loan rate being faced by the preferred sector. Therefore, the capital market is distorted so that the firms in the preferred sector gain access to cheap credits while those firms in the non-preferred sector

have to compete for loans. Specifically, $r_{1t} = r_t - \Delta r_t$ and $r_{2t} = r_t$.

We assume that the government runs a balanced budget every period as follows:

$$\tau_t = \Delta r_t K_{1t}. \tag{3.5}$$

3.2 Competitive Equilibrium

We focus on the competitive equilibrium that is defined as follows:

Definition 1 *Given an initial labor, capital endowment, L_{t_0}, S_{t_0}, K_{t_0}, a set of lump-sum tax τ_t, and sectoral productivity, A_{it}, a competitive equilibrium is a combination of a feasible allocation $(K_{ti}, L_{ti}, S_{ti}, K_t, Y_t)$ and a price system $(p_{it}, r_{it}, w_{Lt}, w_{St})$, $i = 1, 2$, for $t \geq 0$ such that: i) given the price system, the allocation solves both the household's problem (HP) and the firms' problem (FP_i); ii) all markets are clear; and iii) the government's budget constraint holds.*

The optimal choice of household requires the following:

$$\frac{U'(c_t)}{U'(c_{t+1})} = \beta (1 + r_{dt+1}). \tag{3.6}$$

The profit maximization of sector i implies the following:

$$w_{Lt} = \alpha_i p_{it} \frac{Y_{it}}{L_{it}};\ w_{St} = \beta_i p_{it} \frac{Y_{it}}{S_{it}};\ r_{it} = \gamma_i p_{it} \frac{Y_{it}}{K_{it}} \tag{3.7}$$

and the optimality conditions for the final good producer are expressed as follows:

$$\frac{Y_{1t}}{Y_{2t}} = \left(\frac{\varphi}{1-\varphi} \frac{p_{2t}}{p_{1t}} \right)^{\sigma} \text{ and} \tag{3.8}$$

$$\varphi^{\sigma} (p_{1t})^{1-\sigma} + (1-\varphi)^{\sigma} (p_{2t})^{1-\sigma} = 1. \tag{3.9}$$

Moreover, all markets are clear in the equilibrium, which requires the following:

$$\sum_{i=1}^{2} K_{it} = K_t; \ \sum_{i=1}^{2} L_{it} = L; \ \sum_{i=1}^{2} S_{it} = S, \tag{3.10}$$

$$C_t + I_t = Y_t, \text{ and} \tag{3.11}$$

$$K_{t+1} = I_t + (1-\delta) K_t. \tag{3.12}$$

3.3 Effect of the Preferential Policy

In this section, we explore the qualitative effects of the government preferential policy on factor prices, sectoral allocation of capital and labor, aggregate output, and consumption. When the government increases the interest rate subsidy, τ_{t+1}, to the preferred sector, this sector faces a lower effective capital rental rate r_{1t}, that is,

$$\frac{dr_{1t}}{d\tau_{t+1}} < 0, \tag{3.13}$$

where for any variable x_t, we use dx_t to denote the absolute deviation from its steady state x, and we use $d\widetilde{x}_t$ to denote the percentage deviation from its steady state.[4]

3.3.1 Crowding-Out Effect on Capital and Labor Allocation

We discuss in this session the implications on capital and labor market allocation.

Proposition 1 *The preferential policy that lowers r_{1t} has a crowing-out effect on both capital and labor market. Specifically, both the capital and labor are reallocated from the non-preferred sector to the preferred sector. Formally, we have*

$$i) \ \frac{d\tilde{k}_{1t}}{dr_{1t}} < 0, \frac{d\tilde{k}_{2t}}{dr_{1t}} > 0; \qquad ii) \ \frac{d\tilde{l}_{1t}}{dr_{1t}} < 0, \frac{d\tilde{l}_{2t}}{dr_{1t}} > 0.$$

[4] All proofs below are available in the technical appendix, which is available upon request.

From the market clearing condition (3.10) and the firm's optimal allocation conditions (3.7), we can derive

$$\frac{d\tilde{k}_{1t}}{dr_{1t}} = -\phi\left(1+\omega_{p_1}\right)\left[\alpha_1 + (1-\alpha_1)\,\sigma + (\alpha_2 + (1-\alpha_2)\,\sigma)\,\omega_{L_1}\right] < 0 \tag{3.14}$$

and

$$\frac{d\tilde{k}_{2t}}{dr_{1t}} = -\omega_{K_1}\frac{d\tilde{k}_{1t}}{dr_{1t}} > 0, \tag{3.15}$$

where $\omega_{p_1} = \varphi^{\sigma}\left(p_1/p_2\right)^{1-\sigma}$ is the relative price of intermediate goods, $\omega_{L_1} = L_1/L_2$ is the relative labor, $\phi > 0$ is a constant, and $\omega_{K_I} = \frac{K_1}{K_2}$ is the relative capital stock. When the government increases the interest subsidy, the capital rental rate for the preferred sector decreases, thereby increasing the capital stock in the preferred sector and decreasing the capital stock in the non-preferred sector. In other words, capital is crowded out from the non-preferred sector.

The labor market faces a similar effect. The optimal conditions for intermediate producers (3.7) yield the following:

$$\frac{d\tilde{l}_{1t}}{dr_{1t}} = -\phi\left(1+\omega_{p_{1t}}\right)(\sigma-1)\left[(1-\alpha_1) + \gamma_2\omega_{K_1}\right] < 0 \tag{3.16}$$

and

$$\frac{d\tilde{l}_{2t}}{dr_{st}} = -\omega_{L_{1t}}\frac{d\tilde{l}_{1t}}{dr_{st}} > 0, \tag{3.17}$$

which indicate that the preferential policy that depresses r_{1t} also crowds out the unskilled labor from the non-preferred sector. The intuition is straightforward. The firms in the preferred sector hire more unskilled workers as they increase their capital stock. Therefore, both capital and unskilled labor move from the non-preferred sector to the preferred sector. Panels B and C in Figure 4 illustrate the transitional dynamics of capital and labor allocations when the subsidy to the preferred firms is gradually increased till period T, and remains at

that level afterwards**.** Panel D shows that the aggregate investment rate increases during the transitional period.

The reallocation of capital and labor between sectors directly affects intermediate good production in the following way.

Lemma 2 *As the preferential policy lowers r_{1t}, the preferred sector expands while the non-preferred sector shrinks. When the initial share of the preferred sector is sufficiently high, the policy leads to a higher level of aggreaget output. Formally, we have*

$$i)\ \frac{d\tilde{y}_{1t}}{dr_{1t}} < 0, \frac{d\tilde{y}_{2t}}{dr_{1t}} > 0; \qquad ii)\ \frac{d\tilde{y}_t}{dr_{1t}} < 0, \textit{if } \omega_{Y_{1t}} > \underline{\omega}.$$

From production function (3.2), we can express the changes in sector output as follows:

$$\frac{d\tilde{y}_{it}}{dr_{1t}} = \gamma_i \frac{d\tilde{k}_{it}}{dr_{1t}} + \alpha_i \frac{d\tilde{l}_{it}}{dr_{1t}}. \tag{3.18}$$

Based on Proposition 1, we know immediately that the output in the preferred sector increases, $\frac{d\tilde{y}_{1t}}{dr_{1t}} < 0$, while the output in the non-preferred sector decreases, $\frac{d\tilde{y}_{2t}}{dr_{1t}} > 0$, as shown in Panel E of Figure 4. The change in aggregate output is expressed as a weighted average of the two sectors,

$$\frac{d\tilde{y}_t}{dr_{1t}} = \omega_{Y_1} \frac{d\tilde{y}_{1t}}{dr_{1t}} + (1 - \omega_{Y_1}) \frac{d\tilde{y}_{2t}}{dr_{1t}}, \tag{3.19}$$

where $\omega_{Y_1} = \varphi \left(Y_1/Y\right)^{\frac{\sigma-1}{\sigma}}$. We can also show that

$$\frac{d\tilde{y}_t}{dr_{1t}} < 0, \text{ if } \omega_{Y_1} > \underline{\omega}, \tag{3.20}$$

that is, if the share of the preferred sector is high enough, then the preferential policy is capable of promoting the aggregate output (as shown in Panel F in Figure 4). It is also interesting to note that, although the output increases, the investment increases more, leading

to a decline of the aggregate consumption (as shown in Panel G in Figure 4).[5]

3.3.2 Relative Goods Prices, Rental Rates, and Skill Premium

Proposition 3 *As more subsidies are provided to the preferred sector, the price of goods produced by the preferred sector, p_{1t}, decreases while the price of goods produced by the non-preferred sector, p_{2t}, increases.*

By combining (3.8), (3.9), and the previous results, we show that

$$\frac{d\tilde{p}_{1t}}{dr_{1t}} = \phi\left(1+\omega_{L_1}\right)\left[\left(1-\alpha_1\right)+\gamma_2\omega_{K_1}\right] > 0 \tag{3.21}$$

and

$$\frac{d\tilde{p}_{2t}}{dr_{1t}} = -\phi_0\frac{d\tilde{p}_{1t}}{dr_{1t}} < 0. \tag{3.22}$$

Proposition 4 *The preferential policy that depresses r_{1t} reduces the skill premium and increases the market rental rate of capital. Formally, we have:*

$$i)\ \frac{d\left(w_{st}/w_{Lt}\right)}{dr_{1t}} > 0; \quad ii)\ \frac{d\tilde{r}_{2t}}{dr_{1t}} < 0.$$

We derive from (3.7) that

$$\frac{d\left(w_{St}/w_{Lt}\right)}{dr_{1t}} = \frac{d\tilde{l}_{2t}}{dr_{1t}} > 0 \tag{3.23}$$

and

$$\frac{d\tilde{r}_{2t}}{dr_{1t}} = \frac{d\tilde{p}_{2t}}{dr_{1t}} + \alpha_2\left(\frac{d\tilde{l}_{2t}}{dr_{1t}} - \frac{d\tilde{k}_{2t}}{dr_{1t}}\right) - \beta_2\frac{d\tilde{k}_{2t}}{dr_{1t}}. \tag{3.24}$$

Under reasonable parameter values, we can prove that $\frac{d\tilde{r}_{2t}}{dr_{1t}} < 0$. The intuition is that the preferential policy that depresses r_{1t} have crowding-out effects on both capital and labor market. For the formal, such policy crowds out capital from the competitive rental market

[5] An interesting implication of our results is that a government that is interested in the short-run output level will have a strong incentive to implement such a distortionary policy in order to promote the output even though the policy does not lead to more consumption. In the long run, the output level decreases because of the distortions.

and thus increases its rental rate r_{2t} (as shown in Panel A of Figure 4). For the latter, given that the preferred sector uses unskilled labor intensively, its expansion drives up the relative demand for unskilled labor, thereby reducing the skill premium (as shown in Panel H of Figure 4).

Figure 4 Here

4 Quantitative Analysis

In this section, we take the model to the data and evaluate the quantitative effect of the preferential policy. We show that a calibrated version of the model can account for China's experience from 2008 to 2013. Specifically, our model captures the decline in skill premium, the high level of aggregate investment rate, the rise in aggregate investment rate, and the reallocation of resources between the preferred and non-preferred sectors. The algorithm for computing the steady state and the transitional dynamics is provided in the Appendix.

4.1 Calibration

We now choose the parameter values, setting some numbers based on prior information and setting others according to the steady-state conditions. One period in the model corresponds to one year.

Following the common practice, for the utility function parameters, the subjective discount factor is set to $\beta = 0.96$ and the risk aversion is set to $\rho = 2$. Meanwhile, for the production parameters, the annual depreciation rate of capital δ is set to 0.1. Given the data availability, we abstract from the changes in sectoral TFP and set both A_1 and A_2 to 1. We determine the capital income and labor income of preferred and non-preferred sectors according to the factor income data reported in the 2007 National Input-Output Table.[6] Therefore,

[6]The National Input-Output Table is available every five years, and 2007 is the closest available year to

we set the capital share of preferred sector, γ_1, to 0.4 and that of the non-preferred sector, γ_2, to 0.66. Given that no disaggregated data are available on the factor shares of skilled and unskilled labor, we assume that the unskilled labor share is three times larger than the skilled labor share in the preferred sector ($\alpha_1 = 0.45$, $\beta_1 = 0.15$) while we assume that the unskilled and skilled labor shares in the non-preferred sector are the same ($\alpha_2 = \beta_2 = 0.17$). We also experiment with other combinations of skilled and unskilled labor shares in the robustness analysis.

We use φ to match the fact that the preferred sector output is 27% of the total output in 2008. This implies a value of 0.42 for φ. The elasticity of substitution between the preferred sector and non-preferred sector goods, σ, is set to 2. For labor supply, we normalize the supply of skilled labor S to 1 and set the supply of unskilled labor L to 2.19 to match the skill premium of 0.47 in the data.[7]

4.2 Main Results

We analyze the quantitative implications of the preferential policy in this section. Specifically, the government implements the preferential policy from 2009 by gradually increasing the interest subsidy to the preferred sector. Although the interest subsidy, τ_t, is not directly observed in the data, its crowding-out effect should be reflected in the sector output share. If we look at the preferred sector output share data from 2004 to 2013, this share started to deviate from its trend from 2009.[8] Therefore, we can use τ_t to match the deviation of the preferred sector output share. For example, given that the output share of the preferred sector deviates from its trend by 0.7% in 2010, we set $\tau_{2010} = 0.069$ so that in the model,

2008.

[7] In the model, we assume that the wages are perfectly flexible. However, in the data, the wages react to shocks much slower than the other macroeconomic variables, such as output and investment. To capture the lagged response of wages, we match the steady state skill premium to that in 2009 rather than in 2008. Moreover, given that our focal point is the changes in the long-run trend, the initial level of skill premium is not crucial to our quantitative results.

[8] The data starts from 2004 because China initiated its first national economic census in that year which reports two-digit industry level value-added data.

the preferred sector output share increases from the trend by 0.7%. Panel A in Figure 5 shows the calibrated path of τ_t, which changes from 0 in 2008 to 0.254 in 2013 and remains unchanged afterward.[9]

Figure 5 Here

Panel B plots the changes in the output share of the preferred sector, where the starred line corresponds to the data and the solid line corresponds to the model. The increase in the preferred output share matches the data perfectly by construction, reflecting the crowding-out effect of the preferential policy.

Panel C reports the decline in skill premium, which is one of the key facts that we examine in this paper. Our simulation quantitatively shows that the crowding-out effect generated by the preferential policy can reduce the skill premium. Specifically, the skill premium declines from 0.47 in 2008 to 0.40 in 2012, thereby accounting for most of the changes in skill premium in the data.

Panel D shows that the aggregate investment rate in the model tracks both the level and trend in the data remarkably well. The investment rate initially stays at 41.6% in 2008 (42% in the data), rises to 46.7% in 2009 (46% in the data), remains around 45.5% to 47% from 2009 to 2012 (around 46.5% in the data), and reaches 47.5% in 2013 (47.8% in the data). Given that our model is not calibrated to the trend of aggregate investment rate, this result implies that our mechanism makes contribution to understanding the rising investment rate in China, which proves to be difficult for standard neoclassical growth model with decreasing marginal product of capital.

In sum, our quantitative exercise demonstrates that the preferential policy has crowding-

[9] As shown in the introduction, this preferential policy change is long-lasting. For simplicity, we assume that the policy remains the same after 2013. However, the quantitative results will not show much difference if the policy stops after several years.

out effects on both capital and labor market, which in turn generate quantitative outcomes that are broadly in line with the empirical facts in China. Given that our model is highly stylized, these results indicate that our theory is very important for understanding the Chinese economy over the last decade.

4.3 Robustness Analysis

In this section, we experiment with different skill-intensities for the two sectors and show the robustness of our model predictions. We experiment with two alternative parameterizations, namely, (1) $\alpha_1 = 0.4$, $\beta_1 = 0.2$, and $\alpha_2 = \beta_2 = 0.17$, in which the differences between the skill intensity of the two sectors are smaller than the benchmark; and (2) $\alpha_1 = 0.5$, $\beta_1 = 0.1$, $\alpha_2 = 0.1$, and $\beta_2 = 0.24$, in which the differences between the skill intensity of the two sectors are larger than the benchmark. In both cases, we maintain the assumption that the preferred sector is more unskilled-labor-intensive than the non-preferred sector. The other parameters are recalibrated to match the data.

Figure 6 Here

The simulation results in Figure 6 illustrate that the two alternative parameterizations deliver similar predictions as the benchmark. First, in Panel A, the model can always generate a reduction in skill premium even though the magnitude of the decline is sensitive to skill-intensity. When the preferred sector is more skill-intensive in experiment (2), the skill premium decreases further, from 0.47 in 2008 to 0.33 in 2012. By contrast, the skill premium only decreases to 0.42 in experiment (1).

Second, as shown in Panel B, both parameterizations generate roughly the same level and trend of the aggregate investment rate that are shown in the data, which means that the investment prediction is not very sensitive to skill-intensity. In experiment (1), the aggregate investment rate path generated by the model is similar to the benchmark. In experiment (2),

when the difference in the skill-intensity of the two sectors increases, the model generates a higher level of investment rate in response to the preferential policy.

4.4 Foreign Demand Shocks

In the benchmark model, to highlight the effects of the preferential policy, we abstract from the changes in foreign demand. However, because of the 2007 global financial crisis, China's net export to GDP ratio slumped from 8.6% in 2007 to 4.3% in 2009 and further to 2.4% in 2013. In this section, we introduce the foreign demand shock into the benchmark model and show that all of the aforementioned predictions in the benchmark model hold.

Households live in a small open economy, where they can choose to hold foreign assets. Therefore, the household's budget constraint becomes

$$c_t + a_{t+1} + \tau_{t+1} + \triangle B_t^* = w_{Lt} l_t + w_{St} s_t + (1 + r_{dt})\, a_t, \tag{4.1}$$

where $\triangle B_t^*$ is the net holdings of foreign assets.

Given that the economy is open to the world market, the goods market clearing condition is changed to

$$C_t + I_t + NX_t = Y_t, \tag{4.2}$$

where NX_t denotes net exports.[10]

In the equilibrium, we have

$$NX_t = \triangle B_t^*. \tag{4.3}$$

For simplicity, $\triangle B_t^*$ is assumed to be exogenously given.[11] Since the changes in $\triangle B_t^*$ transfer one-for-one into the change in net export, NX_t can be interpreted as foreign demand shocks. In the following exercise, we calibrate NX_t/Y_t to match the net export share in the

[10] In current version, we do not endogenously model the importing and exporting decisions.

[11] This assumption can be relaxed by endogenously modeling foreign asset holdings. Given that international goods and capital flow are not the focus of this paper, we simplify the model on this dimension. However, the key insights on skill premium and crowding-out effects still hold for more general models.

data from 2008 to 2013.[12]

In Figure 7, we compare the model predictions for two scenarios: (1) an economy without the preferential policy (i.e. $\tau_t = 0$); and (2) an economy with the preferential policy where τ_t is recalibrated the same way as in the benchmark.

Figure 7 Here

The results for these two scenarios are dramatically different. When there is no preferential policy as shown by the dash line, crowing-out effect is absent (Panel B), the model cannot generate the downward trend of skill premium (Panel C), and the aggregate investment rate does not increase (Panel D).

What is more interesting is the output response in Panel F. Without the preferential policy, the output drops persistently from 2009 to 2013 due to negative foreign demand shocks. However, when the preferential policy is implemented, the output rises temporarily from 2009 to 2011. Therefore, our model suggests that, at least in the short run, the preferential policy is capable of promoting output when the economy is subjected to negative foreign demand shocks.[13]

5 Alternative Explanations

In this section, we demonstrate that other potential explanations for the falling skill premium are not supported by the data.

[12] Note that the foreign demand shocks work in the similar way as productivity shocks in the model. In particular, the goods produced in exporting sectors are not substitute for domestic consumption goods. In other words, we want to capture the short-run effects of such demand shocks on the economy.

[13] This finding is consistent with the fact that the debt holdings of LGFVs accumulated rapidly after 2008. Given that the LGFVs are the major financing tools for the local governments, local governments borrow through LGFVs and subsidize the preferred sector, leading to a higher output growth.

5.1 Expansion of Skilled Labor Supply

One alternative explanation for the falling skill premium is the increase of skilled labor supply. Figure 8 shows a rapid increase in skilled labor in the data, that is, the ratio of unskilled labor to skilled labor declines from 2.32 in 2000 to 1.37 in 2015.

Figure 8 Here

We want to show that even though the rising skilled labor supply helps lower skill premium, its other implications are contrary to the data. To illustrate this argument, we conduct a counterfactual exercise where our demand side channel is shut down by removing the preferential policy. We then calibrate the changes in the skilled labor supply in the model (Panel A in Figure 9) so that the skill premium in the model matches that in data (Panel C in Figure 9).

Figure 9 Here

The simulation result reported in Panel B predicts a declining output share of the preferred sector, which contradicts the expansion in the data. Meanwhile, in Panel D, the model fails to produce a surge in aggregate investment rate after 2008. Therefore, the expansion of skilled labor supply cannot be the key factor behind the declining skill premium since 2009.

We also show additional firm-level evidence to support our benchmark model and reject the supply side story. By using ETS data, we explore the relationship between a firm's education level and its output growth rate by the following regression:

$$y_{it} = \gamma_0 + \gamma_{1t} ASY_{it} \times year_t + \gamma_{2t} year_t + controls + \varepsilon_{it}, \tag{5.1}$$

where y_{it} is the value-added growth of a firm and the independent variables are the same as those in regression (2.2). Column (2) of Table 2 illustrates the change in the relationship

between the firm's education level and output growth over time. Before 2008, the positive γ_{1t} indicates that firms with a higher average schooling year tend to expand faster. However, γ_{1t} becomes negative from 2009, which indicates that those firms that hire more unskilled workers tend to grow faster. This evidence is in line with our benchmark mode while contradicts the supply side story.

5.2 Capital-Skill Complementarity

Previous literature has shown that the technological advances in the production of new equipment triggers increases in accumulation of equipment. Given that skilled labor is complementary to equipment in the production, the demand for skilled labor increases, resulting in a rising skill premium.[14] We now examine if this capital-skill complementarity channel could contribute to the change of the skill premium since 2009. Figure 10 plots the equipment price in China from 2000 to 2012. The sustained decline of the equipment price indicates that there has been significant technological improvement in producing equipment. Given no slowdown of price decline in the data, the capital-skill complementarity channel cannot contribute to the falling skill premium.

Figure 10 Here

6 Conclusion

In this paper, we first document the following facts about the Chinese economy: i) the structural break in the trend of skill premium in China around 2009; ii) the rising aggregate investment rate from 2008 to 2013; iii) at the firm level, the firms with lower employee education level grow faster than the others after 2008, while the opposite is observed for their

[14] See Greenwood and Yorukoglu (1997), Greenwood, Hercowitz, and Krusell (1977), Autor, Katz, and Krueger (1998), Goldin and Katz (1998), Flug and Hercowitz (2000), and Krusell, Ohanian, Rio-Rull, and Violante (2000).

returns to capital. We believe that the preferential policy that biases towards unskilled-labor-intensive industries is the main driving force behind these facts. We then build a two-sector model and quantitatively evaluate the effects of such policies. The simulation results are consistent with China's transitional experience from 2008 to 2013.

We believe that our model has many important policy implications that can be explored in future research. First, the preferential policies, such as China's fiscal stimulus plan in 2008, are capable of promoting the output level but may sacrifice consumption or welfare in the long run. Therefore, if the governments' concern only focuses on short run output growth, then they will have a strong incentive to subsidize the preferred sectors, such as infrastructure and construction. This helps to explain the high local government debt in China during recent years. Second, this model implies that we cannot ascribe the falling skill premium to college enrollment expansion. Third, our results imply that the high investment rate in China is unsustainable, which generates large distortions in both capital and labor market and may result in nontrivial welfare loss.

References

[1] Acemoglu, Daron (2003) "Patterns of Skill Premia," *The Review of Economic Studies*, Vol. 70, No. 2, pp.199-230.

[2] Autor, David H., Lawrence F. Katz, and Melissa S. Kearney (2008) "Trends in U.S. Wage Inequality: Revising the Revisionists," *The Review of Economics and Statistics*, 90(2): 300–323.

[3] Autor, David H., Lawrence F. Katz, and Alan B. Krueger (1998) "Computing Inequality: Have Computers Changed the Labor Market?" *The Quarterly Journal of Economics*, Volume 113, Issue 4, Pages 1169–1213.

[4] Bai, Chong-En, Chang-Tai Hsieh, and Zheng Michael Song (2016a) "Institutional Foundations of China's Growth," Presentation Slides.

[5] Bai, Chong-En, Chang-Tai Hsieh, and Zheng Michael Song (2016b) "The Long Shadow of a Fiscal Expansion," *Brookings Papers on Economic Activity*, Fall: 129-165.

[6] Bai, Chong-En, Qing Liu, and Wen Yao (2016) "Investing Like China," Working Paper

[7] Brandt, Loren, Trevor Tombeb, and Xiaodong Zhu (2013) "Factor market distortions across time, space and sectors in China," *Review of Economic Dynamics 16 39–58.*

[8] Chun Chang, Kaiji Chen, Daniel F. Waggoner, Tao Zha (2016) "Trends and Cycles in China's Macroeconomy," *NBER Macroeconomics Annual*, volume 30, pages 1-84.

[9] Ge, Suqin, and Dennis Tao Yang (2014) "Changes in China's Wage Structure," *Journal of the European Economic Association 12(2):300–336.*

[10] Goldin, Claudia, and Katz, Lawrence F.(1998) "The origins of state-level differences in the public provision of higher education: 1890-1940," *American Economic Review*, Vol.88, No.2, pp.303-08.

[11] Greenwood, Jeremy, Hercowitz, Zvi, and Krusell, Per, (1997) "Long-Run Implications of Investment-Specific Technological Change," *American Economic Review*, American Economic Association, vol. 87(3), pages 342-362, June.

[12] Greenwood, Jeremy and Yorukoglut, Mehmet (1997) "1974," In Carnegie-Rochester conference series on public policy, Vol.46, pp.49-95, North-Holland.

[13] Guner, Nezih, Gustavo Ventura, and Yi Xu (2008) "Macroeconomic implications of size-dependent policies," *Review of Economic Dynamics 11 721–744.*

[14] He, Hui, and Zheng Liu (2008) "Investment-specific technological change, skill accumulation, and wage inequality," *Review of Economic Dynamics 11 314–334.*

[15] Ho, Chun-Yu, Dan Li, Suhua Tian, and Xiaodong Zhu (2016) "Government Intervention and Credit Misallocation: Evidence from a Fiscal Stimulus Plan in China," Unpublished manuscript.

[16] Hsieh, Chang-Tai, and Peter J. Klenow (2009) "Misallocation and Manufacturing TFP in China and India," *The Quarterly Journal of Economics*, Vol. 124, No. 4, pp. 1403-1448.

[17] Karnit, Flug, and Zvi, Hercowitz (2000) "Equipment investment and the relative demand for skilled labor: international evidence," *Review of Economic Dynamics*, Vol.3, No.3, pp.461-485.

[18] Katz, Lawrence F., and Kevin M. Murphy (1992) "Changes in Relative Wages, 1963-1987: Supply and Demand Factors," *The Quarterly Journal of Economics*, Vol.107, No.1, pp. 35-78.

[19] Krusell, Per, Lee E. Ohanian, Jose-Victor Rios-Rull, and Giovanni L. Violante (2000) "Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis," *Econometrica*, Vol. 68, No. 5, pp. 1029-1053.

[20] Restuccia, Diego, and Richard Rogerson (2008) "Policy distortions and aggregate productivity with heterogeneous establishments," *Review of Economic Dynamics 11 707–720.*

[21] Sheng, Liugang, and Dennis Tao Yang (2017) "Offshoring and Wage Inequality: Theory and Evidence from China," *Darden Business School Working Paper No. 3007876.*

[22] Song, Zheng, Kjetil Storesletten, and Fabrizio Zilibotti (2011) "Growing Like China," *American Economic Review 101: 196–233.*

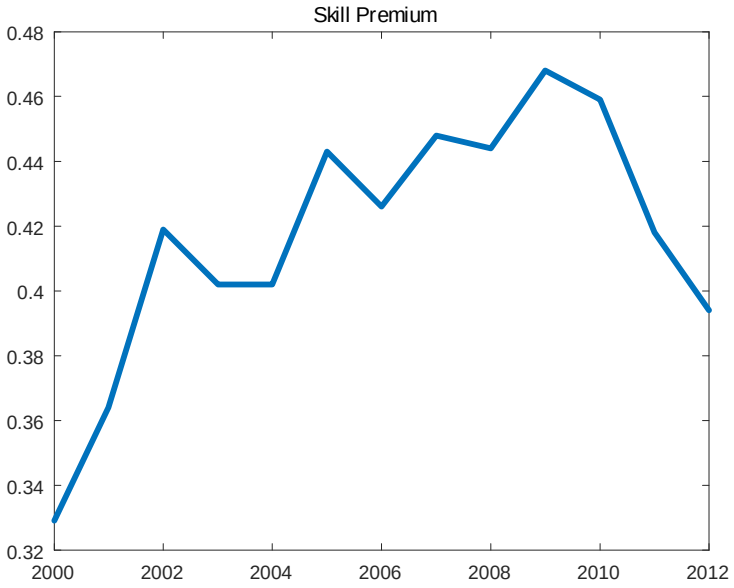

Figure 1: Skill Premium

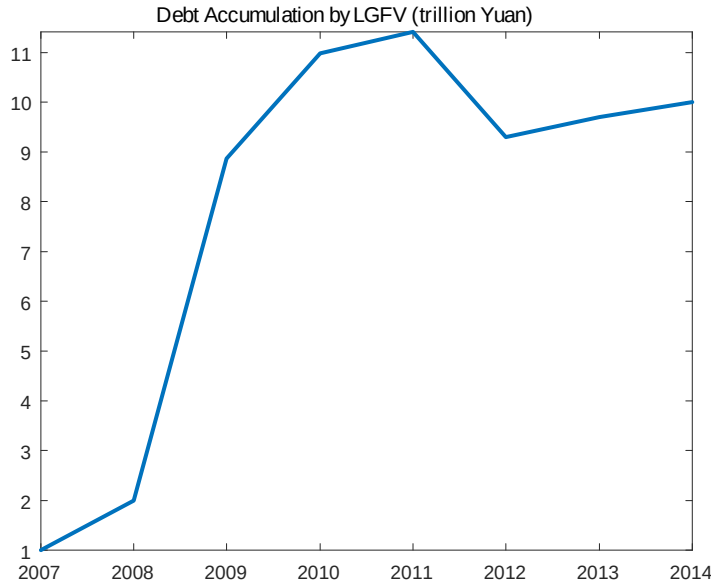

Figure 2: Debt Accumulation of LGFV

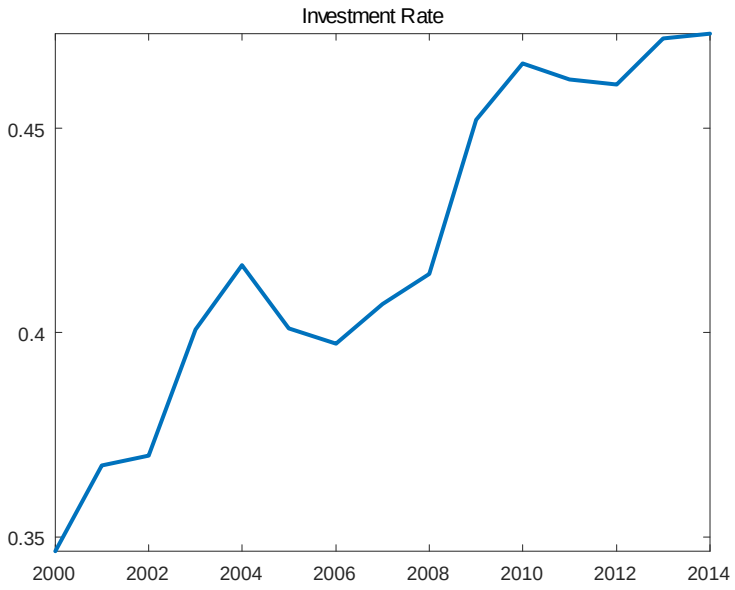

Figure 3: Aggregate Investment Rate

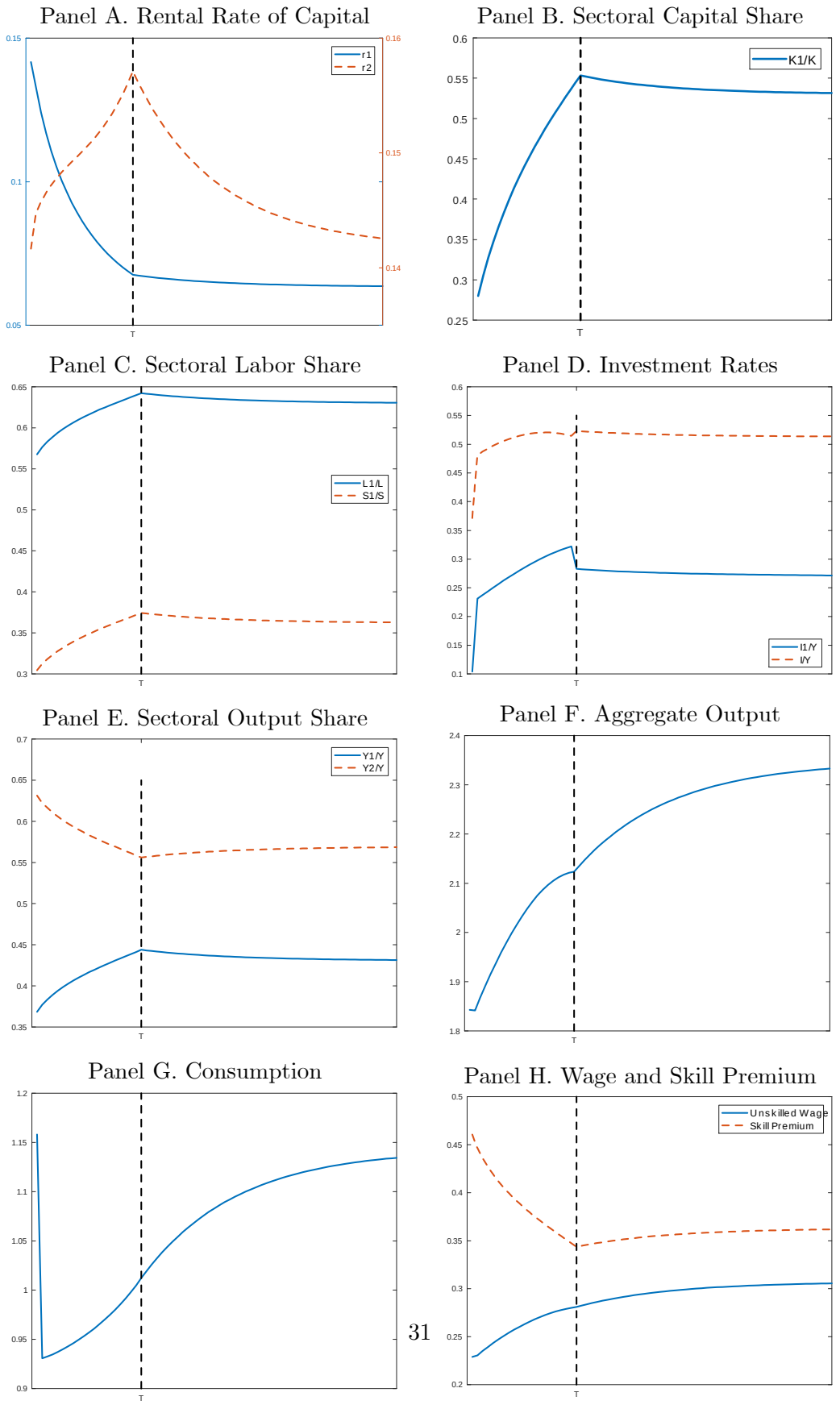

Figure 4. Transition in the Analytical Model

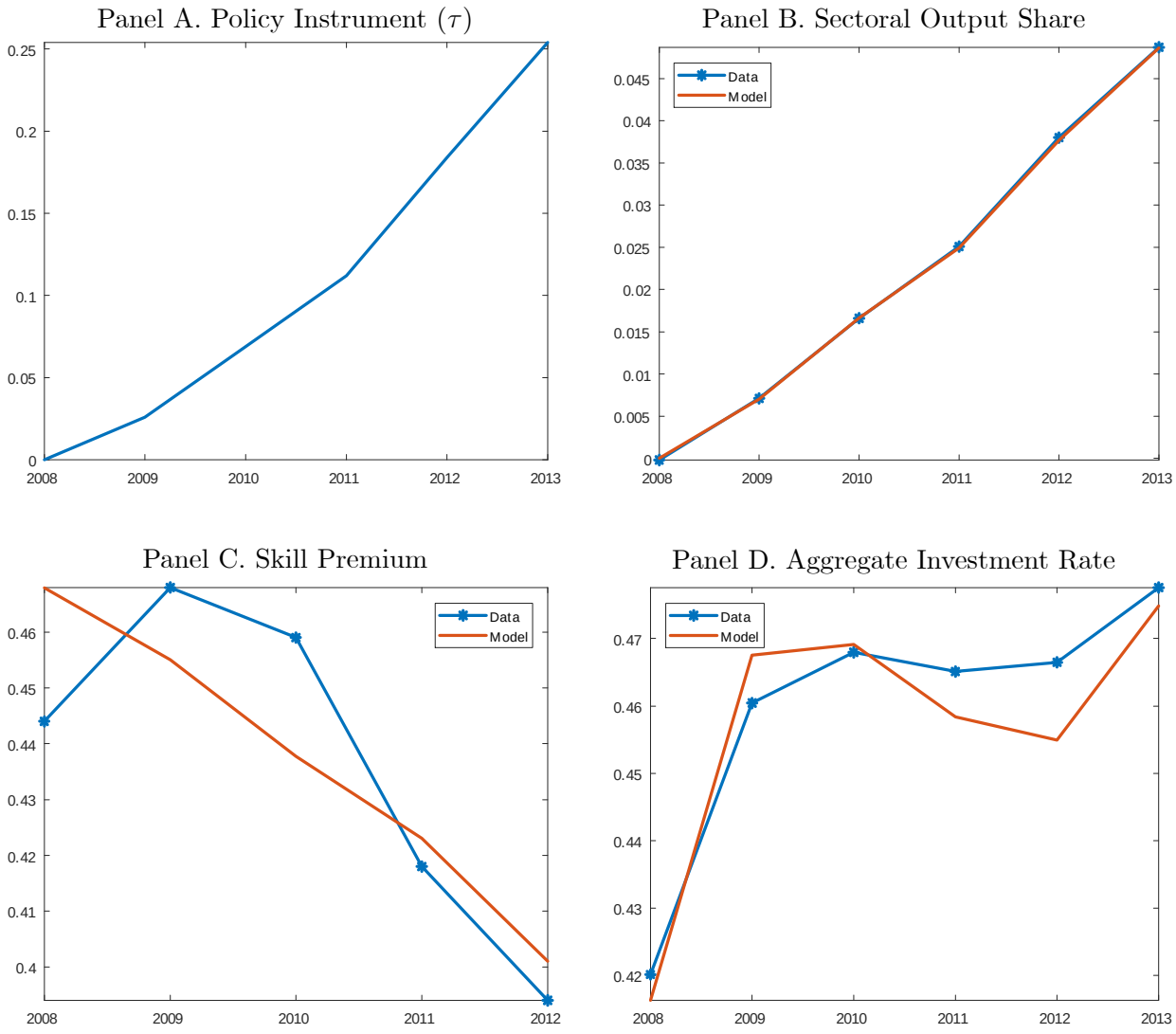

Figure 5. Benchmark Model: Transition in the Model and Data

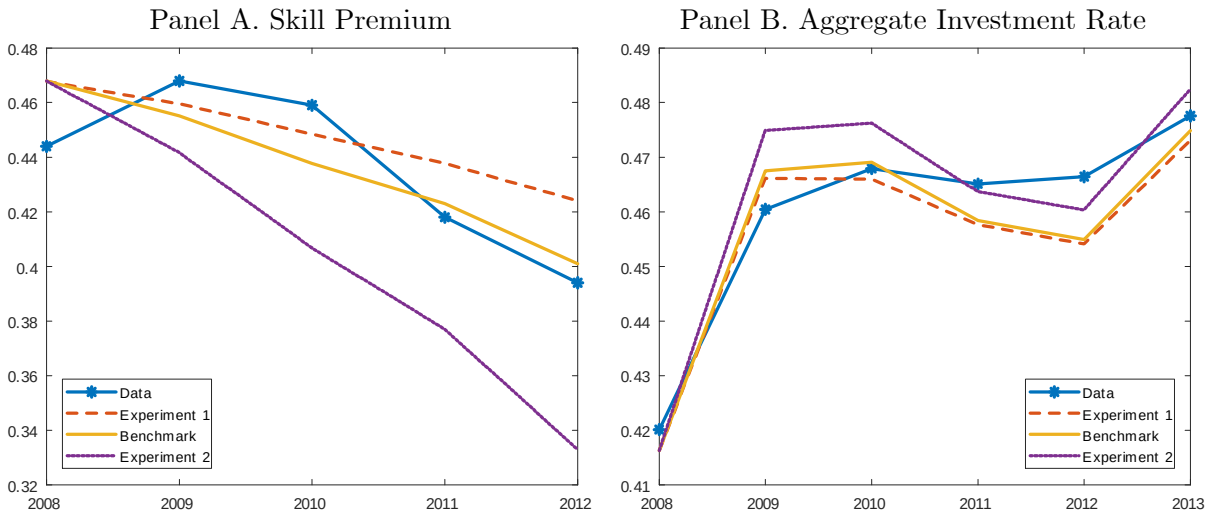

Figure 6. Robustness Analysis

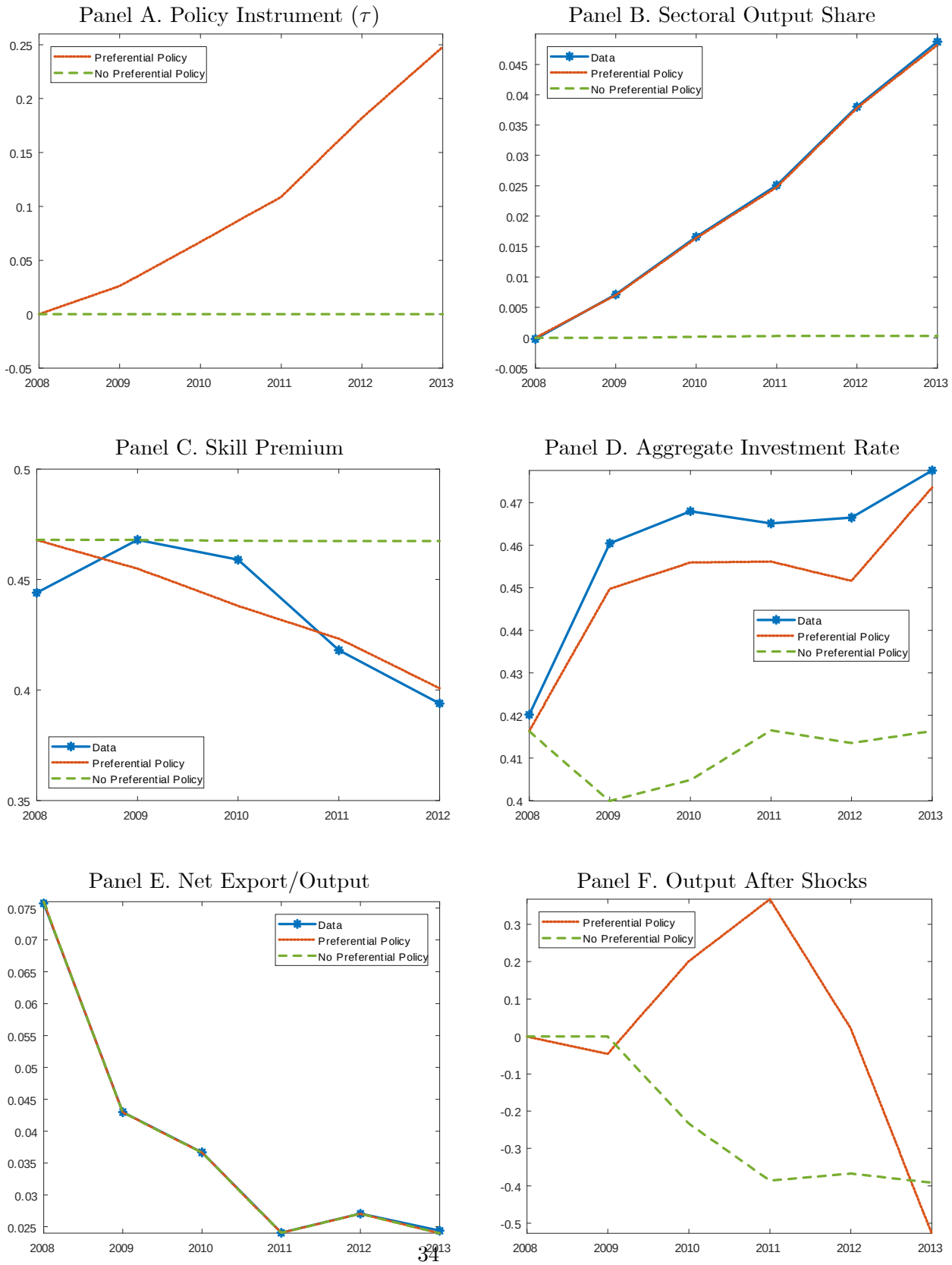

Figure 7. Economy with Foreign Demand Shocks: Transitions in the Model and Data

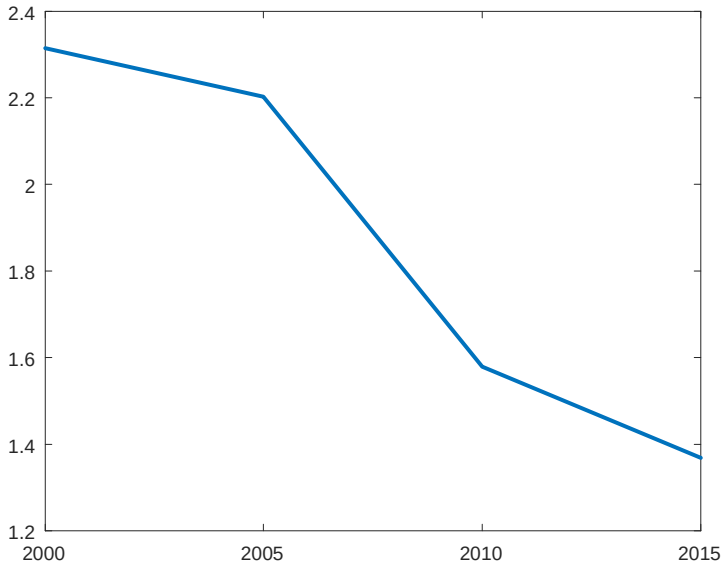

Figure 8: Ratio of Unskilled to Skilled Labor Supply

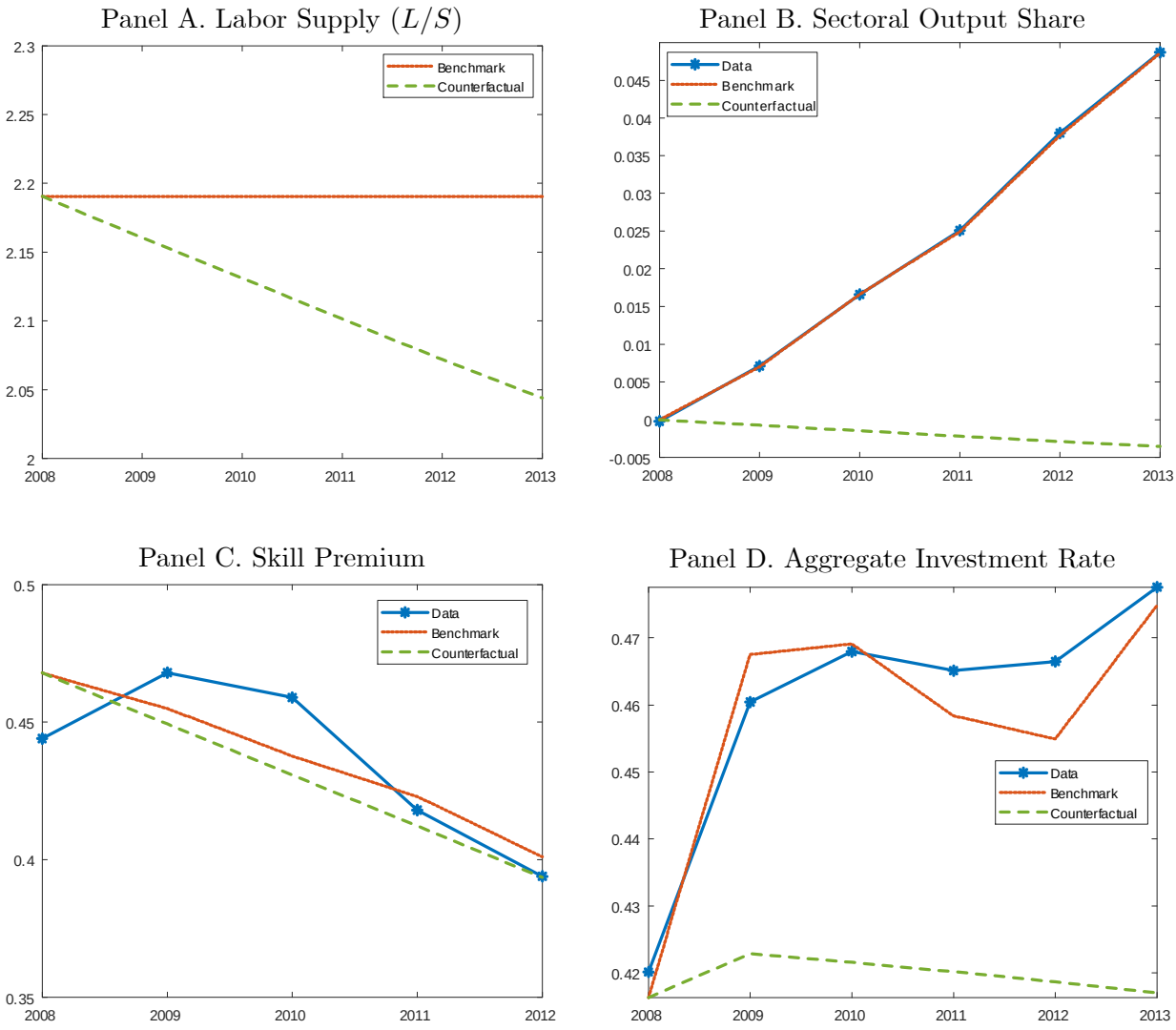

Figure 9. Conterfactual Exercise: Expansion of Skilled Labor Supply

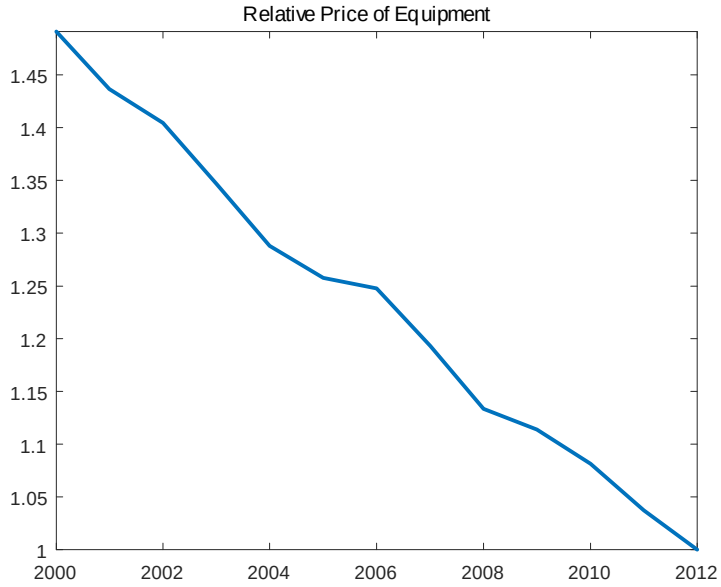

Figure 10: Relative Price of Equipment

Table 1:

Priority areas	Planned investment (in trillions of yuan)
Railways, roads, airports, water management, and urban power grids	1.5
Post-earthquake reconstruction	1
Welfare housing	0.4
Rural infrastructure and welfare housing	0.37
Self-independent innovation and structural adjustment	0.37
Environmental protection	0.21
Health, education, and culture	0.15

Table 2:

Dependent variables	Return to Capital	Output Growth
	(1)	(2)
$ASY \times 2007$	0.028	0.007
	(0.0008)	(0.0042)
$ASY \times 2008$	0.018	0.031
	(0.0007)	(0.0035)
$ASY \times 2009$	0.053	−0.032
	(0.0006)	(0.0023)
$ASY \times 2010$	0.064	−0.063
	(0.0006)	(0.0023)
$ASY \times 2011$	0.028	
	(0.0006)	
year 2008	0.073	−0.309
	(0.0113)	(0.0542)
year 2009	−0.260	0.619
	(0.0106)	(0.0475)
year 2010	−0.328	0.736
	(0.0105)	(0.0474)
year 2011	−0.030	
	(0.0103)	
Province dummy	Yes	Yes
Observations	2,987,528	1,107,791
R^2	0.07	0.01

Notes: Standard errors are in brackets.

Appendix

A Data

In this section, we describe the data we use in the regression.

A.1 Urban Household Surveys

- The wage income that we use is the annual wage of a full-time worker, which consists of basic wage, bonuses, subsidies, and other labor-related income. We can use weekly or hourly wage to be consist with the previous literature, but this information is not available for most of the survey years.

- Our sample includes full-time workers who are aged between 16 years and 55 years for females and between 16 years and 60 years for males.[15]

- Our sample excludes business employers, self-employed individuals, farm workers, retirees, students, those re-employed after retirement, and workers with annual wages of less than half of the minimum wage.

A.2 Enterprise Taxation Surveys

- R_{it} is defined as

$$\frac{\text{Operating Profit + Financial Expenses - Net Value - Added Tax - Net Vehicle and Vessel Tax}}{\text{Net Fixed Assets + Ending Inventory}}.$$

- The average schooling year of a firm is approximated by the average schooling year of its two-digit industry. National Census in 2005 reports the number of employees in each education level for two-digit industries. We weigh the schooling year of each education

[15] The official age for retirement in China is 55 years for women and 60 years for men, except for high-ranking officials and scholars.

level by the portion of employees in each category to back out the average schooling year for each industry.

- The herfindahl index is used to represent the degree of market concentration.

B Algorithm for Computing the Steady State

In the steady state, we have 18 variables $\{p_i, w_L, w_S, r_d, r_i, K_i, L_i, S_i, K, Y_i, Y, C, I\}$ and 18 equilibrium conditions as listed above. In the following derivation, we express all other 16 variables in terms of p_1 and w_S and then use the market clearing conditions of skilled labor and asset to pin down p_1 and w_S.

In particular, we solve the S.S. in the following steps:

1. Euler equation:
$$r_d = \frac{1}{\beta} - 1; \tag{B.1}$$

2. Choose p_1, and by price aggregate,
$$p_2 = \left[\frac{1-\varphi^\sigma (p_1)^{1-\sigma}}{(1-\varphi)^\sigma}\right]^{\frac{1}{1-\sigma}}; \tag{B.2}$$

3. Choose w_S,
$$\left(\frac{K_1}{S_1}\right) = \frac{w_S}{r_1}\frac{\gamma_1}{\beta_1}; \tag{B.3}$$

4. solve K_1/L_1,
$$\left(\frac{K_1}{L_1}\right)^{\alpha_1} = \gamma_1 \frac{p_1 A_1}{r_1}\left(\frac{K_1}{S_1}\right)^{-\beta_1}; \tag{B.4}$$

5. solve w_{Lt},
$$w_L = \alpha_1 p_1 A_1 \left(\frac{K_1}{L_1}\right)^{1-\alpha_1}\left(\frac{K_1}{S_1}\right)^{-\beta_1}; \tag{B.5}$$

6. using the optimal conditions for sector 2,
$$\left(\frac{K_2}{L_2}\right)^{\alpha_2 - \frac{(1-\alpha_2)(1-\beta_2)}{\beta_2}} = \beta_2 (\alpha_2)^{\frac{1-\beta_2}{\beta_2}} (p_2 A_2)^{\frac{1}{\beta_2}} (w_L)^{-\frac{1-\beta_2}{\beta_2}} (w_S)^{-1} \text{ and} \tag{B.6}$$
$$\left(\frac{K_2}{S_2}\right) = (\alpha_2 p_2 A_2)^{\frac{1}{\beta_2}} \left(\frac{K_2}{L_2}\right)^{\frac{1-\alpha_2}{\beta_2}} (w_L)^{-\frac{1}{\beta_2}}; \tag{B.7}$$

$$r_{2t} = (1 - \alpha_2 - \beta_2)\, p_{2t} A_{2t} \left(\frac{K_{2t}}{L_{2t}}\right)^{-\alpha_2} \left(\frac{K_{2t}}{S_{2t}}\right)^{-\beta_2}; \tag{B.8}$$

7. using the product function,

$$\frac{Y_1}{L_1} = A_1 \left(\frac{K_1}{L_1}\right)^{1-\alpha_1} \left(\frac{K_1}{S_1}\right)^{-\beta_1} \text{ and} \tag{B.9}$$

$$\frac{Y_2}{L_2} = A_2 \left(\frac{K_2}{L_2}\right)^{1-\alpha_2} \left(\frac{K_2}{S_2}\right)^{-\beta_2}; \tag{B.10}$$

8. optimal allocation across sectors,

$$\frac{L_1}{L_2} = \frac{\frac{Y_2}{L_2}}{\frac{Y_1}{L_1}} \frac{Y_1}{Y_2} = \frac{\frac{Y_2}{L_2}\left(\frac{\varphi}{1-\varphi}\frac{p_2}{p_1}\right)^{\sigma}}{\frac{Y_1}{L_1}}; \tag{B.11}$$

9. labor allocation, $L_1 + L_2 = L$;

$$L_2 = \frac{L}{1 + \frac{L_1}{L_2}} \text{ and} \tag{B.12}$$

$$L_1 = L - L_2; \tag{B.13}$$

10. capital allocation and output in each sectors:

$$K_1 = L_1 \left(\frac{K_1}{L_1}\right); \tag{B.14}$$

$$S_1 = K_1 \left(\frac{K_1}{S_1}\right)^{-1}; \tag{B.15}$$

$$K_2 = L_2 \left(\frac{K_2}{L_2}\right); \tag{B.16}$$

$$S_2 = K_2 \left(\frac{K_2}{S_2}\right)^{-1}; \tag{B.17}$$

$$Y_1 = L_1 \left(\frac{Y_1}{L_1}\right) \text{ and} \tag{B.18}$$

$$Y_2 = L_2 \left(\frac{Y_2}{L_2}\right); \tag{B.19}$$

11. total capital stock,

$$K = K_1 + K_2; \tag{B.20}$$

12. use the following conditions to pin down p_1 and w_S,

$$(1 + r_d) K = (1 - \delta + r_1) K_1 + (1 - \delta + r_2) K_2 \text{ and} \tag{B.21}$$

$$S_1 + S_2 = S; \tag{B.22}$$

13. aggregate output,

$$Y = \left(\varphi (Y_1)^{\frac{\sigma-1}{\sigma}} + (1 - \varphi) (Y_2)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \text{ and} \tag{B.23}$$

14. solve the consumption by:

$$C = Y - \delta K. \tag{B.24}$$

The household budget constraint is satisfied automatically.[16]

[16] Given that the non-arbitrage condition (3.5) and the resourse constraint are equivalent, only one of these is needed to pin down the equilibrium.

C Algorithm for Computing the Transition Path

We use the shooting method to solve the transitional dynamics. In particular, we compute a path where the economy starts from a given state and eventually goes back to the steady state. We assume that the economy take less than $T = 100$ periods to converge to its steady state. The shooting algorithm is described as follow:

1. The economy starts from an initial capital stock level K_1. We guess a range $\left[\underline{K}, \overline{K}\right]$ for the second period capital level K_2.

2. Let $K_2 = \left(\underline{K} + \overline{K}\right)/2$. Given K_1 and K_2, we can solve the system for T periods.

   (a) Given K_t, we can solve for the static variables $\{p_{it},\ L_{it},\ S_{it},\ K_{it},\ Y_{it}, Y_t,\ w_{Lt},\ w_{St},\ r_{2t},\ r_{dt}\}$ in period t.[17]

   (b) Similarly, we use K_{t+1} to solve for $\{p_{it+1},\ L_{it+1},\ S_{it+1},\ K_{it+1}, Y_{it+1}, Y_{t+1}, w_{Lt+1},\ w_{St+1},\ r_{2t+1},\ r_{dt+1}\}$.

   (c) After obtaining $\{w_{Lt}, w_{St}, r_{dt}, K_t, K_{t+1}\}$, c_t can be solved from the household's budget constraint (3.1).

   (d) We compute c_{t+1} from the Euler equation,

   $$\frac{U'(c_t)}{U'(c_{t+1})} = \beta\left(1 + r_{dt+1}\right). \tag{C.1}$$

   (e) Given $\{c_{t+1}, w_{Lt+1}, w_{St+1}, r_{dt+1}, K_{t+1}\}$, we solve for K_{t+2} from the household budget constraint (3.1).

   (f) Repeat (a)-(e) and solve for $K_{t+3}, K_{t+4}, \ldots K_T$.

3. If the value of K_2 we guessed above is higher than its true value, then the economy will accumulate more capital and eventually diverge with either $c_t \leq 0$ or $r_{dt} \leq 0$ at

[17] See Appendix D for details.

some point in the future. Similarly, if the guessed value of K_2 is too low, then the economy will consume too much and accumulate less capital. Eventually, the economy will diverge with $K_t \leq 0$. Therefore, in any period t,

(a) if $c_t \leq 0$ or $r_{dt} \leq 0$, then $\overline{K} = K_2$ and go back to step 2; and

(b) if $K_t \leq 0$, then $\underline{K} = K_2$ and go back to step 2.

4. If $|\overline{K} - \underline{K}| \leq 10^{-15}$ then stop the algorithm. Otherwise, go back to step 2.

We can repeat the shooting process at $K_3, K_4, ...$, to refine the transition path.

D Solving the Static Variables in a System of Transitional Dynamics

In our algorithm, step 2 is the key part for computing the transition path. Here, we describe in details how we solve the system.

After r_{1t} is given, the production side in our economy is static in the sense that the prices $\{p_{it}, w_{Lt}, w_{St}, r_{Lt}\}$, factor allocations, and outputs $\{K_{it}, L_{it}, S_{it}, Y_{it}, Y_t\}$ all are functions of r_{1t} and K_t. Therefore, given r_{1t} and K_t, we solve these variables as follows:

1. Choose p_{1t}, then
$$p_{2t} = \left[\frac{1-\varphi^{\sigma}\left(p_{1t}\right)^{1-\sigma}}{\left(1-\varphi\right)^{\sigma}}\right]^{\frac{1}{1-\sigma}}; \tag{D.1}$$

2. choose w_{St} and solve for K/S
$$\left(\frac{K_{1t}}{S_{1t}}\right) = \frac{w_{St}}{r_{1t}}\frac{\left(1-\alpha_{1t}-\beta_{1t}\right)}{\beta_{1t}}; \tag{D.2}$$

3. obtain K/L and w_L as
$$\left(\frac{K_{1t}}{L_{1t}}\right)^{\alpha_1} = \gamma_1\frac{p_{1t}A_1}{r_{1t}}\left(\frac{K_{1t}}{S_{1t}}\right)^{-\beta_1} \text{ and} \tag{D.3}$$
$$w_{Lt} = \alpha_1 p_{1t}A_1\left(\frac{K_{1t}}{L_{1t}}\right)^{1-\alpha_1}\left(\frac{K_{1t}}{S_{1t}}\right)^{-\beta_1}; \tag{D.4}$$

4. using the optimal conditions for sector 2,
$$\left(\frac{K_{2t}}{L_{2t}}\right)^{\alpha_2-\frac{(1-\alpha_2)(1-\beta_2)}{\beta_2}} = \beta_2\left(\alpha_2\right)^{\frac{1-\beta_2}{\beta_2}}\left(p_{2t}A_2\right)^{\frac{1}{\beta_2}}\left(w_{Lt}\right)^{-\frac{1-\beta_2}{\beta_2}}\left(w_{St}\right)^{-1}; \tag{D.5}$$
$$\left(\frac{K_{2t}}{S_{2t}}\right) = \left(\alpha_2 p_{2t}A_2\right)^{\frac{1}{\beta_2}}\left(\frac{K_{2t}}{L_{2t}}\right)^{\frac{1-\alpha_2}{\beta_2}}\left(w_{Lt}\right)^{-\frac{1}{\beta_2}} \text{ and} \tag{D.6}$$
$$r_{2t} = \gamma_2 p_{2t}A_2\left(\frac{K_{2t}}{L_{2t}}\right)^{-\alpha_2}\left(\frac{K_{2t}}{S_{2t}}\right)^{-\beta_2}; \tag{D.7}$$

5. using the product function in each sectors,

$$\frac{Y_{1t}}{L_{1t}} = A_1 \left(\frac{K_{1t}}{L_{1t}}\right)^{1-\alpha_1} \left(\frac{K_{1t}}{S_{1t}}\right)^{-\beta_1}; \tag{D.8}$$

$$\frac{Y_{2t}}{L_{2t}} = A_2 \left(\frac{K_{2t}}{L_{2t}}\right)^{1-\alpha_2} \left(\frac{K_{2t}}{S_{2t}}\right)^{-\beta_2}; \tag{D.9}$$

6. using the optimal allocation across sectors, we have

$$\frac{L_{1t}}{L_{2t}} = \frac{\frac{Y_{2t}}{L_{2t}}}{\frac{Y_{1t}}{L_{1t}}} \frac{Y_1}{Y_2} = \frac{\frac{Y_2}{L_2}}{\frac{Y_1}{L_1}} \left(\frac{\varphi}{1-\varphi} \frac{p_{2t}}{p_{1t}}\right)^{\sigma}; \tag{D.10}$$

7. from labor market clearing conditions,

$$L_{2t} = \frac{L}{1 + \frac{L_{1t}}{L_{2t}}} \text{ and} \tag{D.11}$$

$$L_{1t} = L - L_{2t}; \tag{D.12}$$

8. solve for the factor allocations, and outputs in each sectors:

$$K_{1t} = L_{1t} \left(\frac{K_{1t}}{L_{1t}}\right); \tag{D.13}$$

$$S_{1t} = K_{1t} \left(\frac{K_{1t}}{S_{1t}}\right)^{-1}; \tag{D.14}$$

$$K_{2t} = \frac{K_{2t}}{L_{2t}} L_{2t} \text{ and} \tag{D.15}$$

$$S_{2t} = K_{2t} \left(\frac{K_{2t}}{S_{2t}}\right)^{-1}; \tag{D.16}$$

9. use factor market clearing conditions to pin down (p_{1t}, w_{St})

$$K_{1t} + K_{2t} = K_t \text{ and} \tag{D.17}$$

$$S_{1t} + S_{2t} = S; \tag{D.18}$$

After solving for K_{1t} and K_{2t}, we can easily obtain r_{dt} as

$$r_{dt} = r_{2t} - \delta. \tag{D.19}$$

The other static variables $\{Y_{1t}, Y_{2t}, Y_t\}$ are given by the corresponding production functions (3.2) and (3.4).