Skill Premium and Preferential Policy: The Case of China*

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Abstract

Using the national sample of Urban Household Surveys, we document a new stylized fact in China: the skill premium was rising over the past decades until 2008, but started to decline substantially after 2009. What is the cause of this abrupt decline? This paper interprets this change as a reflection of a long-lasting change in the structure of the Chinese economy. That is, starting from 2009, the government offered its preferred firms cheap credit. 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. A calibrated version of the model accounts for most of the decline of the skill premium in the data. Moreover, the model also predicts a surge in the aggregate investment rate, which is also in line with the data.

JEL Codes: E25, O16, O41, P23.

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

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1 Introduction

In recent decades, there have been profound changes in wage inequality between workers with different education levels in China. This paper documents the evolution of China's skill premium, defined as the wage of skilled labor relative to unskilled labor, using the unique national sample of Urban Household Surveys (UHS) from 2000 to 2012. Our empirical study indicates that the skill premium of people with a high school education or above relative to those with a middle school education or below rose from 33% in 2000 to 47% in 2008;[1] however, this trend reversed itself after 2009.

What has caused the observed decline in skill premium in China after 2009? In this paper, we emphasize the role of the government's preferential policy; that is, the government began offering cheap credit to preferred firms in 2009. This preferential policy was first introduced in China in 2009 in the form of stimulus plan; however, the policy continued afterwards, and had a long-lasting impact on the Chinese economy. In 2008Q4, China's State Council announced a stimulus package to boost China's domestic demand during the global financial crisis. This package included plans to spend about 4 trillion yuan in the next two years, roughly 12 percent of China's annual GDP. The plan was concentrated in a few preferred industries and was mainly implemented by Local Government Financing Vehicles (LGFVs), which are firms that borrow and spend on behalf of local government. Since these firms have explicit or implicit guarantees on their debts from the government, they can borrow at lower cost. Given that firms in most of these preferred industries, such as construction and transportation, hire more unskilled workers than skilled, the demand for unskilled workers increased, thereby accelerating the growth of unskilled wages and pushing down the skill premium. After the stimulus plan ended in 2010, local governments continued to use these firms to borrow and spend, facilitating access to capital for government-preferred industries. This implies that

[1] The rising skill premium before 2008 is consistent with previous literature (Ge and Yang 2014; Sheng and Yang 2017).

the preferential policy remained after the stimulus plan, leading to a permanent change in China's economic structure.

This preferential policy has not only impacted the labor market inequality, but also has important implications for many other aspects of the economy. For example, in the data, we observe that despite the global financial crisis, China's aggregate investment rate rose rapidly from 0.41 in 2008 to 0.47 in 2010 and remained around 0.47 afterwards. Moreover, China sustained a high GDP growth rate, which was above 10% even during the financial crisis. To understand the macroeconomic implications of this preferential policy quantitatively, we build a model in which firms are heterogeneous in terms of skill intensity and access to the financial market. Firms in the government-preferred industries are unskilled labor intensive and have better access to the financial market, i.e. the government subsidizes interest payments on 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. The model is calibrated to the Chinese data and we find that the simulation results are consistent with several interesting facts in the past decade. First, the model can account for the decline in the skill premium from 2009 to 2012. Second, the model generates a sharp rise in the aggregate investment rate from 2008 to 2009, which matches the data well. Third, given this permanent policy change, the model predicts that the investment rate remains around at a high level even after 2010, which is also in line with the data. Fourth, the model implies a rising aggregate output during the global financial crisis, which is consistent with the high output growth in the data. The counterfactual exercise shows that without such preferential policy, the aggregate output would decline.

Our preferential policy is related to the recent study by Restuccia and Rogerson (2008),

Guner, Ventura, and Xu (2008), and Hsieh and Klenow (2009), which examine government policies and related factor misallocations. Among these papers, our study is closed related to those that investigate government preferential treatment in China. However, it is worthwhile emphasizing that the type of preferential policy we study in this paper differs from the previous preferential treatments documented in the literature. First, Bai, Hsieh, and Song (2016a) argue that local governments pick their preferred firms and help them by removing institutional obstacles, such as exempting them from official rules. However, we focus on the post-2008 period in this paper, when local governments gained the financial resources to offer their preferred firms cheap capital. This was the first time in history that the local government could distort the capital market towards their preferred firms. Second, there is a large literature on preferential treatment of state-owned enterprises (SOEs), such as Song, Storeletten, and Zilibotti (2011) and Brandt, Tombe, and Zhu (2013). However, the existence of SOEs cannot account for the decline in the skill premium observed in the data, because that the average education level of employees in SOEs is significantly higher than that of employees in non-SOEs as shown by the UHS data. Therefore, if the government's preferential policy only manifests itself in easier access to capital for SOEs, then we should expect an increase in the skill premium as a result. Third, Chung, Chen, Waggoner, and Zha (2016) explore preferential government treatment of strategic industries since 1996 and its implication for the weak correlation between investment and consumption in China. These strategic industries are "heavy industries" in the sense that they are capital intensive, which differs from our preferred industries which are unskilled labor intensive.

We make three distinctive contributions in this paper. First, we document the phenomenon of the falling skill premium since 2009; this is the first paper to document this pattern. Using UHS data from 2000 to 2012, we obtain skill premium estimates consistent with those found in the literature for the pre-2008 period, but after extending our estimates to 2012, we

find that the trend in the skill premium after 2009 contrasts with that observed before 2009. In addition, we use two other pieces of indirect evidence to show that this falling trend in the skill premium persists after 2012.[2] First, data at the one-digit industry level shows that from 2003 to 2008 the wages of industries with more educated workers grew faster than those of industries with less educated workers. However, this relationship has reversed since 2009. From 2009 to 2015, the wages of industries with more educated workers grew slower than those of industries with less educated workers. Second, we show the evolution of the income inequality in China. China's Gini coefficient rose from 2003 to 2008; however, it started to decline from 2009 to 2015. Since wage income constitutes the majority of household income, this suggests that the skill premium continues to decline after 2012. From this perspective, our paper contributes to the large literature investigating changes in wage inequality in both developed and developing countries. 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; while Ge and Yang (2014) and Sheng and Yang (2017) have investigated the changes in China's skill premium before 2008.

A second contribution of this paper is to provide firm-level evidence of the government's preferential policy. Specifically, we use firm-level data from the national sample of Enterprise Taxation Surveys (ETS) to show that beginning in 2009, firms with less educated workers have faced lower financing cost. We are the first to document this fact, thereby empirically contributing to the literature. In a related study, Ho, Li, Tian, and Zhu (2016) use bank loan data to show that government policies in 2008 resulted in the provision of excessive credit to the preferred industries, which echoes our finding.

[2] Before 2012, the National Bureau of Statistics collected the Urban Household Survey and Rural Household Survey separately. Since 2013, the NBS has combined these two surveys into a National Household Survey with unified survey content. Unfortunately, the National Household Survey from 2013 onward is currently not accessible for academia.

A third contribution of this paper is to advance a theory to explain the declining skill premium and rising investment rate in China during the last decade. Our paper is related to Bai, Hsieh, and Song (2016b), who discuss the LGFVs that were set up during the 2008 stimulus plan and their implications for investment and current account using a partial equilibrium model. We present the first general equilibrium model that aims to understand the macroeconomic implications of preferential treatment in the short run. In a companion work, Bai, Liu, and Yao (2016) evaluate the long run effects of the preferential policy and its welfare implications by incorporating the externalities of the 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 demonstrate that other potential explanations for the falling skill premium are not supported by the data. Section 6 concludes the paper.

2 Empirical Evidence

This section describes the stylized facts that motivate our paper. We begin by documenting the changes in the wage structure. We then describe in detail the government's preferential policy and its relation to the stimulus plan. Finally, we use firm-level evidence to illustrate the implementation of the preferential policy.

2.1 Decline of the Skill Premium

To summarize the basic changes in China's wage structure over the last decade, we draw on the national sample of Urban Household Surveys (UHS) from 2000 to 2012. This survey is conducted by the National Bureau of Statistics (NBS) in China and is equivalent to the Current Population Surveys conducted in the US, which have detailed information on household

education levels, income, expenditures and other demographic information. The UHS data have been frequently used in the empirical literature.

We document the evolution of the skill premium during the sample period by computing the conditional skill premium for each year, which is defined as the wage of people with a high school education or above relative to that of people with middle school education or below, holding the distribution of worker attributes fixed, such as sex, experience, and province. That is, for each year we run the following regression:

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

where w_i^t is worker i's annual wage in year t, S_i^t is a dummy variable that denotes a high school education or above (with middle school or lower being the base group), X_i^t and $\left(X_i^t\right)^2$ are experience and its squared value, G_i^t is the dummy variable for males, and P_{in}^t is the dummy variable for province.[3] In this regression, the coefficient β_1^t reflects the conditional skill premium, which is shown in Figure 1. [4]

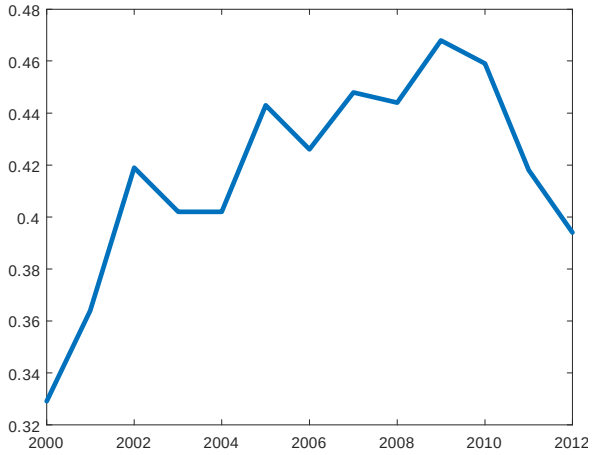
We observe a continuous rise in the skill premium from 2000 to 2009, peaking in 2009 with a level of 0.47, which indicates that in 2009, when the other conditions are kept the same, people with a high school education levels or above earned 47% more than those with a middle school education or below. The rising skill premium before 2009 is consistent with empirical findings in other studies, such as Ge and Yang (2014) and Sheng and Yang (2017).

However, the skill premium exhibits a structural break around 2009, during which the skill premium reversed its rising trend and started to decline. Within three years, the skill premium fell sharply from 0.47 in 2009 to 0.39 in 2012, which indicates a major change in

[3] Experience is defined as min[(age - years of schooling - 6), (age - 16)]. More details about the data are described in the appendix.

[4] Following Ge and Yang (2014), we choose middle school or lower education level as the base group and focus on the high school premium in this paper. This differs from the literature on developed economies which focuses on the college premium. As it will become clear in Section 2.2.1, our choice is motivated by the fact that the preferential policy has important effect on wages for the workers with middle school or lower (9-year or less) education.

Figure 1: Skill Premium



China's labor market conditions. It is worthwhile emphasizing that the change in the skill premium around 2009 is not a temporary phenomenon. Given that we only have three years' data after 2009, we draw on two other pieces of evidence with a longer time span to support our argument.

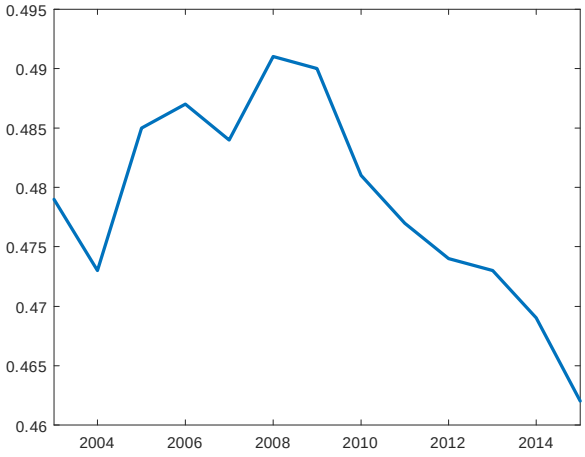
The first piece of evidence uses data on income inequality, which is the Gini coefficient. Given that wage income constitutes 67% of household income, a decline of the skill premium could lead to a decline of income inequality.[5] Figure 2 plots China's Gini coefficient from 2003 to 2015 from the NBS.[6] We can see that the Gini coefficient follows a similar pattern to the skill premium; that is, it rises from 2003 to 2008 and starts to decline afterwards. More importantly, the Gini coefficient continues to fall even after 2012, all the way to 2015. The persistent and significant decline of income inequality after 2012 indicates that the decline of the skill premium is likely not a temporary phenomenon.

The second piece of evidence uses sector wage data to support the argument of persistent

[5] According to the China Yearbook of Household Survey, household income is divided into the following four parts: wage income, operational income, asset income and transfers. Their average share in total household income from 2000 to 2015 are 67%, 7%, 3%, and 22% respectively.

[6] The China Yearbook of Household Survey reports the Gini coefficient from 2003 onward.

Figure 2: Gini Coefficient



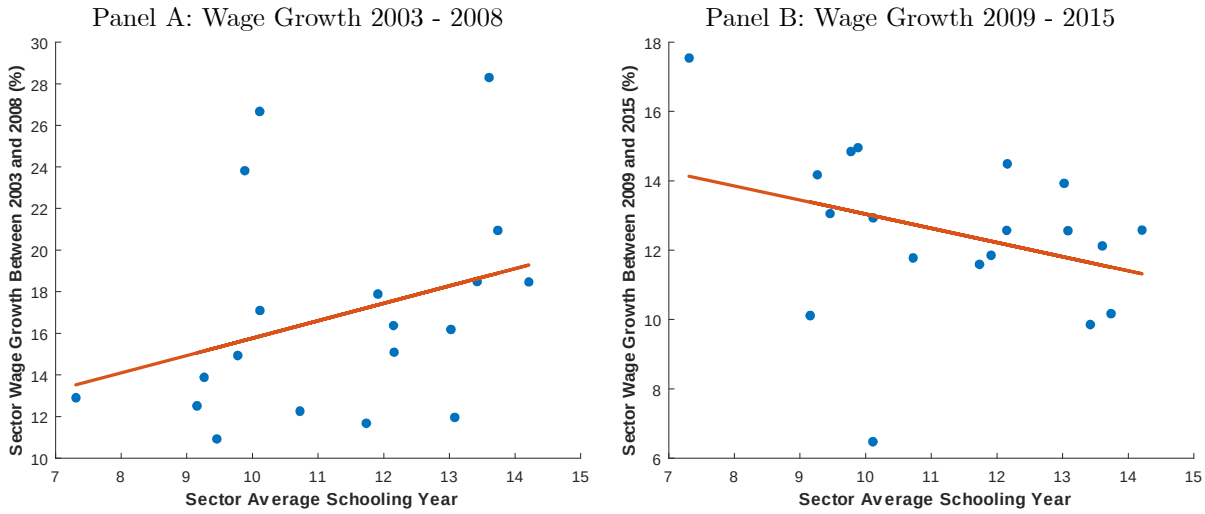
decline in the skill premium. We examine the relationship between skill intensity and the wage growth rate across sectors before and after 2008. Specifically, we use information from the 2005 Population Census of China to compute the average schooling year (ASY) of workers in each one-digit sector,[7] using it as a measure of sector skill intensity. We then compute the real wage growth for each sector from 2003 to 2008 (shown in Panel A in Figure 3) and from 2009 to 2015 (shown in Panel B in Figure 3).[8] Suppose there is a rise of the skill premium; then the wage of the skilled labor intensive sector will grow faster than that of the unskilled labor intensive sector; while if the skill premium declines, the wage of the skilled labor intensive sector will grow more slowly than that of the unskilled labor intensive sector. Hence, the positive relationship between the ASY and wage growth rate between 2003 and 2008 and the negative relationship between 2009 and 2015 indicate that there is indeed a structural break in the skill premium around 2009. As a robustness check, we repeat this exercise for each year and get consistent findings: the annual wage growth rate is positively

[7] According to China's industrial classification 2002 standard, all national economic activities can be divided into 20 sectors which are labelled from (A) to (T). For the purpose of our study, we exclude the sector International Organization (T), which gives us 19 sectors in total.

[8] The China Statistic Yearbook has reported the average wage in each one-digit sector since 2003.

related to the ASY for each year between 2004 and 2008, while this relationship becomes negative beginning in 2009. To save space, we do not include the graphs here.

Figure 3: Sector Wage Growth and Average Schooling Year



To sum up, we present empirical evidences that indicate that the skill premium was rising before 2008 and started to decline in 2009. Moreover, the decline of the skill premium is likely to have persisted till 2015.

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 stimulus plan in November 2008 that specifically focused on several 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 Fisheries (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).[9] One important feature of these preferred sectors is that they tend to hire more unskilled workers than skilled ones: the ASY of employees in these preferred sectors is 8.6 years, while that of the non-preferred sectors is 10.7 years.

Table 1: Stimulus Plan

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
Independent innovation and structural adjustment	0.37
Environmental protection	0.21
Health, education, and culture	0.15

As the local governments started to implement the stimulus and spend in the priority areas, they found themselves prevented from running a budget deficit by the 1994 Budget Law. To get around this problem, the Ministry of Finance issued a new regulation in 2009 which allowed local governments to finance investment projects by using more 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. This regulation states:

> *... local government is allowed to finance the investment projects by essentially all sources of funds, including budgetary revenue, land revenue and funds borrowed by local government financing vehicles.*[10]

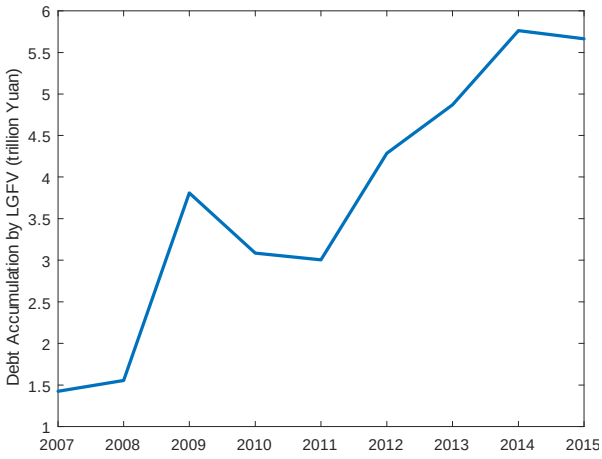
According to calculations by Bai, Hsieh, and Song (2016b), about 3/4 of the 4 trillion yuan in the stimulus plan was financed by LGFVs. We collect information from the annual

[9] Given that some of the important data are only available at the one-digit sector level, we choose those one-digit sectors that are most closely connected to the priority areas of spending chosen by the State Council.

[10] Document 631, Department of Construction, Ministry of Finance, Oct 2009.

financial statements of LGFVs that issued bonds and compute the total amount of debt they issued.[11] Figure 4 shows the debt accumulation by LGFVs, which is defined as change in debt stocks of LGFVs. Before the onset of the financial crisis in 2007, LGFVs were barely used as a financing tool and the debt issued in that year was only 1.5 trillion yuan.[12] However, given the increasing demand for financing investment projects in the preferred industries, the debt accumulation by LGFVs surged to 3.8 trillion yuan in 2009, and further to 5.7 trillion yuan in 2015.

Figure 4: Debt Accumulation by LGFVs



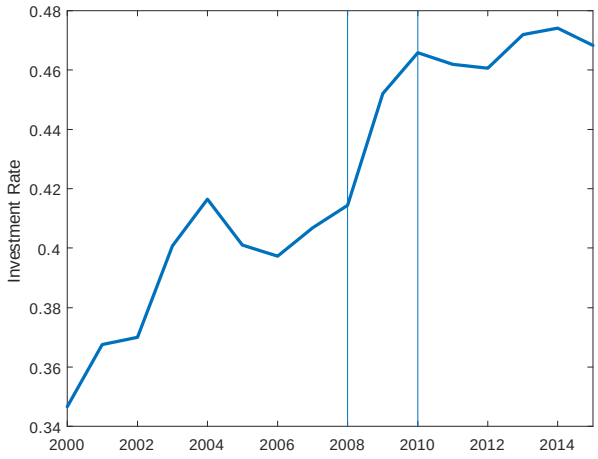
It is interesting to note that the debt accumulation by the LGFVs did not stop after the stimulus plan ended in 2010: the level of debt accumulation continued to rise from 2010 to 2015. This phenomenon indicates that local governments have used the LGFVs as a regular tool to circumvent financial constraints on their budgets since 2009. Hence, this change in local governments' financing methods has had a long run impact on the economy even after the stimulus plan finished. The permanent change in government financing methods is also

[11] These data are available on WIND database, which is the Chinese version of Bloomberg. WIND publishes the annual financial statements of all companies that issue bonds. WIND defines an LGFV as a company whose business covers "infrastructure and utilities" and whose major shareholder is a local government or a subsidiary of a local government.

[12] LGFVs exist before 2009 but were highly restricted.

reflected in the rising investment rate shown in Figure 5. The aggregate investment rate rose sharply from 0.41 in 2008 to 0.47 in 2010 when the stimulus plan was fully implemented. Moreover, it remained at a very high level around 0.47 till 2015, which is consistent with the high debt accumulation by LGFVs after 2010 shown in Figure 4.

Figure 5: Aggregate Investment Rate



2.2.2 Government's Preferential Policy

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

> We *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 payments, improving reward mechanisms for loans, and establishing government investment and financing platforms compliant with regulations.*[13]

[13] Document 92, China's Banking Regulatory Commission, March 2009.

Banks responded to this guidance by adjusting their credit policies. For example, the Industrial and Commercial Bank of China, the largest one among 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 product innovation, and increased the credit support to major customers in infrastructure areas 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.*

These favorable changes of credit policy towards government-preferred firms indicate that they could probably borrow at a lower interest rate than other firms. We test this relationship using a national sample of Enterprise Taxation Surveys (ETS) conducted by the State Administration of Taxation from 2007 to 2011.[14] We run the following regression to test whether banks provided lower interest rates to firms that hired more unskilled workers:

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

where R_{it} is firm i's return to capital, ASY_i is the average schooling year of employees in firm i, $year_t$ is the year dummy, and *controls* include other factors (e.g., market concentration of the industry that the firm belongs to, firm size, and province fixed effect). We use the return to capital to approximate the interest rate at which the firm borrows under the assumption of a perfect competitive market.[15] Table 2 reports the estimates of the relationship between return to capital and average schooling year. First, the positive θ_{1t} from 2007 to 2011 indicate that the firms with a lower average schooling year tend to have a lower return to capital. In other words, firms that hired more unskilled workers received bank loans with lower interest

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

[15] Unfortunately, the data quality of interest rate payment is low, which prevents us from using it as a direct measure of firm's financing cost.

rates. Second, this estimate increases significantly from 0.018 in 2008 to 0.053 in 2009. The increase of the coefficient reflects the preferential policy; that is, government-preferred firms could secure an even lower interest rate than other firms after 2008, which is consistent with the credit guidance issued by China's Banking Regulatory Commission.

Table 2: Firm Level Regression

Dependent variables	Return to Capital
$ASY \times 2007$	0.028
	(0.0008)
$ASY \times 2008$	0.018
	(0.0007)
$ASY \times 2009$	0.053
	(0.0006)
$ASY \times 2010$	0.064
	(0.0006)
$ASY \times 2011$	0.028
	(0.0006)
year 2008	0.073
	(0.0113)
year 2009	-0.260
	(0.0106)
year 2010	-0.328
	(0.0105)
year 2011	-0.030
	(0.0103)
Province dummy	Yes
Observations	$2,987,528$
R^2	0.07

Note: The dependent variable is return to capital in each firm. We control for market concentration, firm size, and province fixed effect in each regression. Standard errors are in brackets.

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 across sectors, 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. The household chooses consumption c_t and savings a_{t+1}, and 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.[16]

There are two sectors, the preferred and non-preferred sectors, that produce intermediate goods with 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 $i = 1$ denotes the preferred sector and $i = 2$ the non-preferred sector. K_{it}, S_{it}, and L_{it} are the capital, skilled labor, and unskilled labor used in sector i, respectively. A_i is the

[16] In China, the government's revenue mainly comes from (a) indirect taxes (Value-added Tax and Business Tax, etc.); (b) seigniorage revenue; (c) relatively high level of reserve requirement; (d) land finance and the resulting high housing prices, etc. The preferential policies are essentially financed by such revenues, which are indeed beared by the private sector. In our model, we use the lump-sum tax, τ, as a shortcut to capture these implicit tax burdens on consumers.

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 preferred and non-preferred 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 they face lower effective capital rental rate (i.e., $r_{1t} < r_{2t}$).

The final good is produced by combining the 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 in our model takes the following form: the government imposes a lump-sum tax on the household and uses the tax revenues to subsidize bank loans to firms in the preferred sector. Therefore, the capital market is distorted in the way that firms in the preferred sector gain access to cheap credit while those 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 level, capital endowment, L_{t_0}, S_{t_0}, K_{t_0}, a set of lump-sum tax scheme 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 clear; and iii) the government's budget constraint holds.*

The optimal choice of a 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 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.[17]

3.3.1 Crowding-Out Effect on Capital and Labor Allocation

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

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

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

[17] 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 level, $\phi > 0$ is a constant, and $\omega_{K_1} = \frac{K_1}{K_2}$ 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 similar effects. 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 unskilled labor from the non-preferred sector. The intuition is straightforward. 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 6 illustrate the transitional dynamics of capital and labor allocation 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 aggregate 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 6). It is also interesting to note that, although the output increases, the investment increases more, leading

to a decline in aggregate consumption (as shown in Panel G in Figure 6).[18]

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} has crowding-out effects on both the capital and labor markets. For the former, such policy crowds out capital from the competitive rental market

[18] 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 to promote 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 6). 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 6).

4 Quantitative Analysis

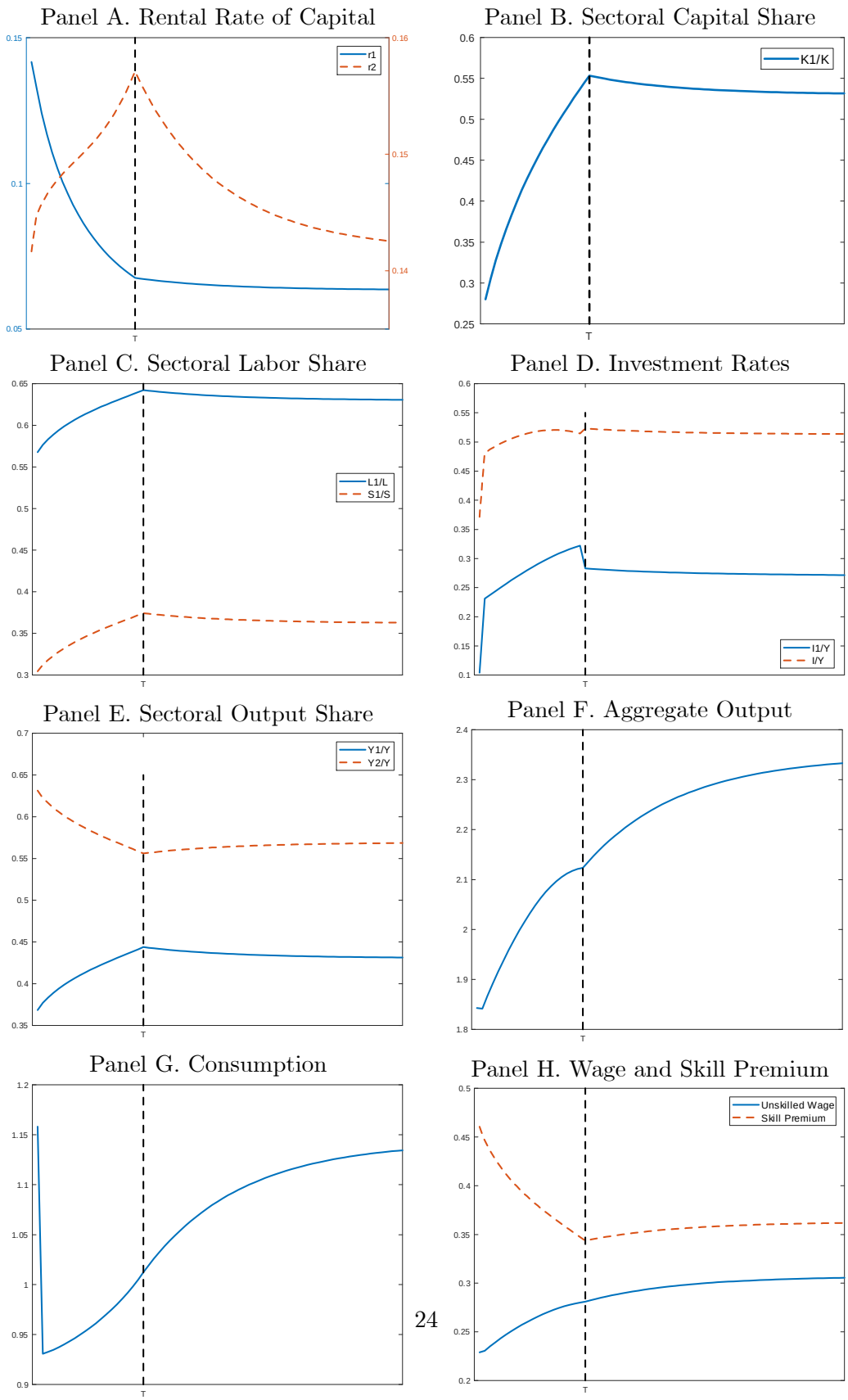
In this section, we bring our model to the data and evaluate the quantitative effects of the preferential policy. We show that a calibrated version of the model can account for China's experience from 2008 to 2015. Specifically, our model captures the decline in skill premium, the rise in aggregate investment 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 preference parameters, the subjective discount factor β is set to 0.96 and the risk aversion ρ is set to 2. Meanwhile, on the production side, the annual depreciation rate of capital δ is set to 0.1. Given the lack of disaggregated sector employment data, we abstract from the changes in sector TFP and set both A_1 and A_2 to 1. We choose φ to match the fact that the preferred sector output is 27% of the total output in 2008, which implies a value of 0.49 for φ. For labor supply, we normalize the supply of skilled labor S to 1 and set the unskilled labor supply L to 0.92 to match the skill premium of 0.47 in the data.[19]

[19] 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 changes in the long-run trend, the initial level of the skill premium is

Figure 6: Transition in the Analytical Model



We calibrate the capital and labor income share of the preferred sector and non-preferred sector using information from the 2005 National Input-Output (IO) Table.[20] The IO Table decomposes the value added of a sector into four parts: compensation of employees, net production tax, profits, and depreciation of fixed assets. We aggregate the factor income data of 42 disaggregated sectors from the IO Table into preferred and non-preferred sectors, and define the labor income share as compensation of employees over total value added. This gives us the labor income share of 0.59 and capital income share of 0.41 for the preferred sector, while for the non-preferred sector, labor income share is 0.34 and capital income share is 0.66.

Given the total labor income share in each sector, we want to further divide it between skilled and unskilled labor. To calibrate the skilled and unskilled labor income shares for the preferred and non-preferred sectors, α_i and β_i, we draw information from the 2005 Population Census, along with the 2005 National IO Table. We first divide the 42 disaggregated sectors from the IO Table into preferred and non-preferred sectors. We then assume that the skilled to unskilled labor income ratio is the same for all disaggregated sectors within the preferred sector. The same assumption applies to the non-preferred sector. Under these assumptions, we use the labor income for each disaggregated sector and the number of skilled and unskilled workers in each disaggregated sector to backout the skilled and unskilled labor income shares for the preferred and non-preferred sectors. This gives us $\alpha_1 = 0.42$, $\beta_1 = 0.17$; and $\alpha_2 = 0.06$, $\beta_2 = 0.28$.[21]

Following Acemoglu and Guerrieri (2008) and Chang, Chen, Waggoner, and Zha (2015), we estimate the elasticity of substitution between the preferred and non-preferred sectors, σ, by the following relationship between the value ratio and the quantity ratio of the two

not crucial to our quantitative results.

[20] We need information from both National IO Table and the National Census to pin down capital income share, skilled labor income share, and unskilled labor income share. These data are available for years ending with 0 or 5 and 2005 is the closest year to 2008.

[21] The details are in the technical appendix, available upon request.

sectors, which is derived from equation (3.8):

$$\log \frac{p_{1t}Y_{1t}}{p_{2t}Y_{2t}} = \log\left(\frac{\varphi}{1-\varphi}\right) + \frac{\sigma-1}{\sigma}\log\frac{Y_{1t}}{Y_{2t}}. \tag{4.1}$$

The variables used in the regression are first HP-filtered. Since the data are in annual frequency, we follow Backus and Kehoe (1992) to set the smoothing parameter for the HP-filter to 100. The regression gives us $(\sigma-1)/\sigma = 0.703$ with the t-statistic 2.15, implying σ to be 3.37 and significantly greater than 1. Since there is less consensus in the literature on the smoothing parameter when moving to frequencies other than quarterly, we also experiment with other values of the smoothing parameter in the robustness analysis. In particular, following Ravn and Uhlig (2002), we set the smoothing parameter of the HP-filter to 6.25 in the robustness analysis.

4.2 Main Results

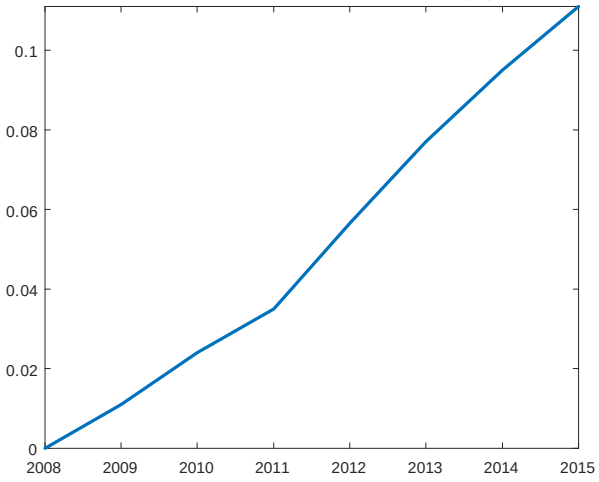
We analyze the quantitative implications of the preferential policy in this section. Specifically, the government has implemented the preferential policy by providing more cheap credit to the preferred sector since 2009. Although the policy instrument, τ_t, is not directly observed in the data, its crowding-out effects are tightly linked to the changes in the sectoral output shares. If we look at the preferred sector output share data from 2004 to 2015, it began to deviate from its trend from 2009.[22] Hence, we 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 1.74% in 2010, we set τ_{2010} to 0.024 so that the preferred sector output share rises above the trend by 1.74% in the model. Panel A in Figure 7 shows the calibrated path of τ_t, which changes from 0 in 2008 to 0.111 in 2015 and remains unchanged afterward.[23]

[22] The data start from 2004 because China initiated its first national economic census in that year which reports one-digit industry level value-added data. This series stopped after 2015.

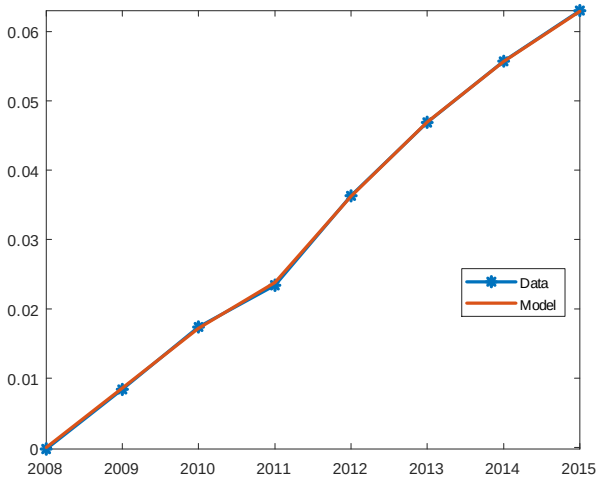
[23] As shown in Section 2, this preferential policy change has been long-lasting. For simplicity, we assume that the policy remains the same after 2015. However, the quantitative results will not show much difference if such a policy is sustained for several years after 2015 and then stops.

Figure 7: Benchmark Model: Transition in the Model and Data

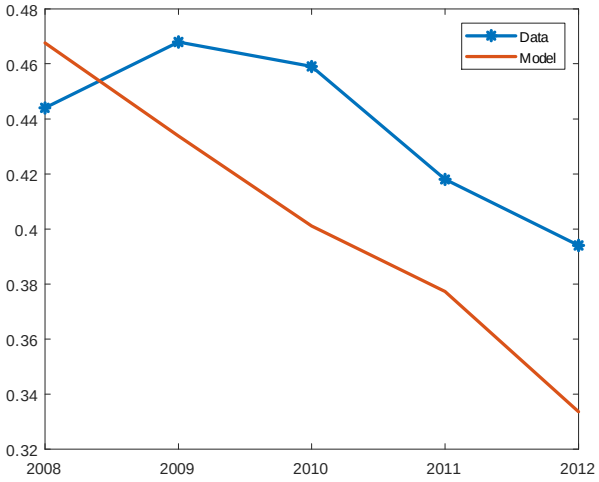
Panel A. Policy Instrument (τ)



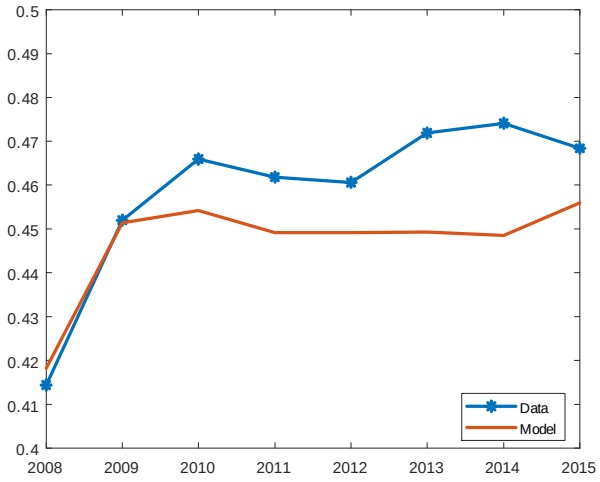
Panel B. Preferred Output Share



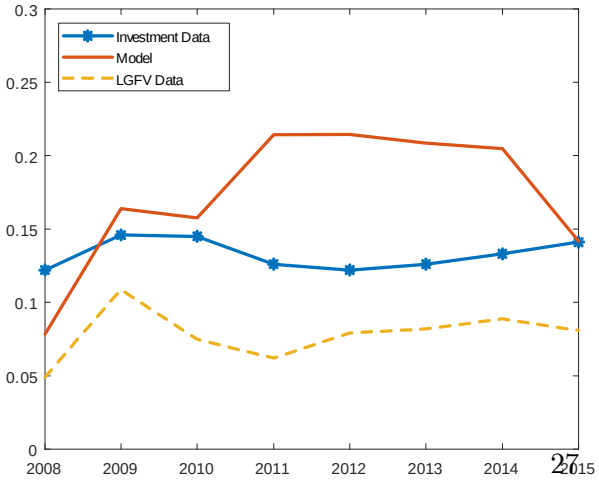
Panel C. Skill Premium



Panel D. Aggregate Investment Rate



Panel E. Preferred Investment Rate



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 by construction, reflecting the crowding-out effect of the preferential policy.

Panel C reports the changes in the skill premium, which is one of the key facts that we are studying. Simulation shows that the crowding-out effects of the preferential policy lead to a falling trend in the skill premium. Specifically, the skill premium declines from 0.47 in 2008 to 0.38 in 2011 in the model, where in the data the skill premium falls from 0.47 in 2009 to 0.40 in 2012. Therefore, our model is capable of accounting for both the trend and the magnitude of the falling skill premium observed in the data.

Panel D shows that the aggregate investment rate in the model tracks both the level and trend in the data reasonably well. In the model, the aggregate investment rate initially stays at 41.8% in 2008 (41.5% in the data), rises to 45% in 2010 (46.5% in the data), and remains around 45% - 46% to 2015 (around 46% - 47% in the data). Given that our model is not calibrated to the aggregate investment rate, this result implies that our mechanism helps in understanding the rising investment rate in China, unlike the standard neoclassical growth model with decreasing marginal product of capital.

The preferential policy that stimulates investment in the preferred sector is the driving force for the decline in skill premium and the crowding-out effects on resource reallocation. Panel E compares the preferred investment rate to the data, by presenting two measures of preferred investment rate based on the data: the starred line labeled "Investment Data" is defined as the fixed asset investment in the preferred sector over aggregate output; the dashed line labeled "LGFV Data" is the debt accumulation by LGFVs over aggregate output. Our model did reasonably well at capturing the pattern of the preferred investment rate, i.e. an increase upon policy implementation and relative stability afterwards. Although the model

overshoots the preferred investment rate after 2011 by about 5%, given that our model is highly stylized, we believe the model's prediction is still within a reasonable range.

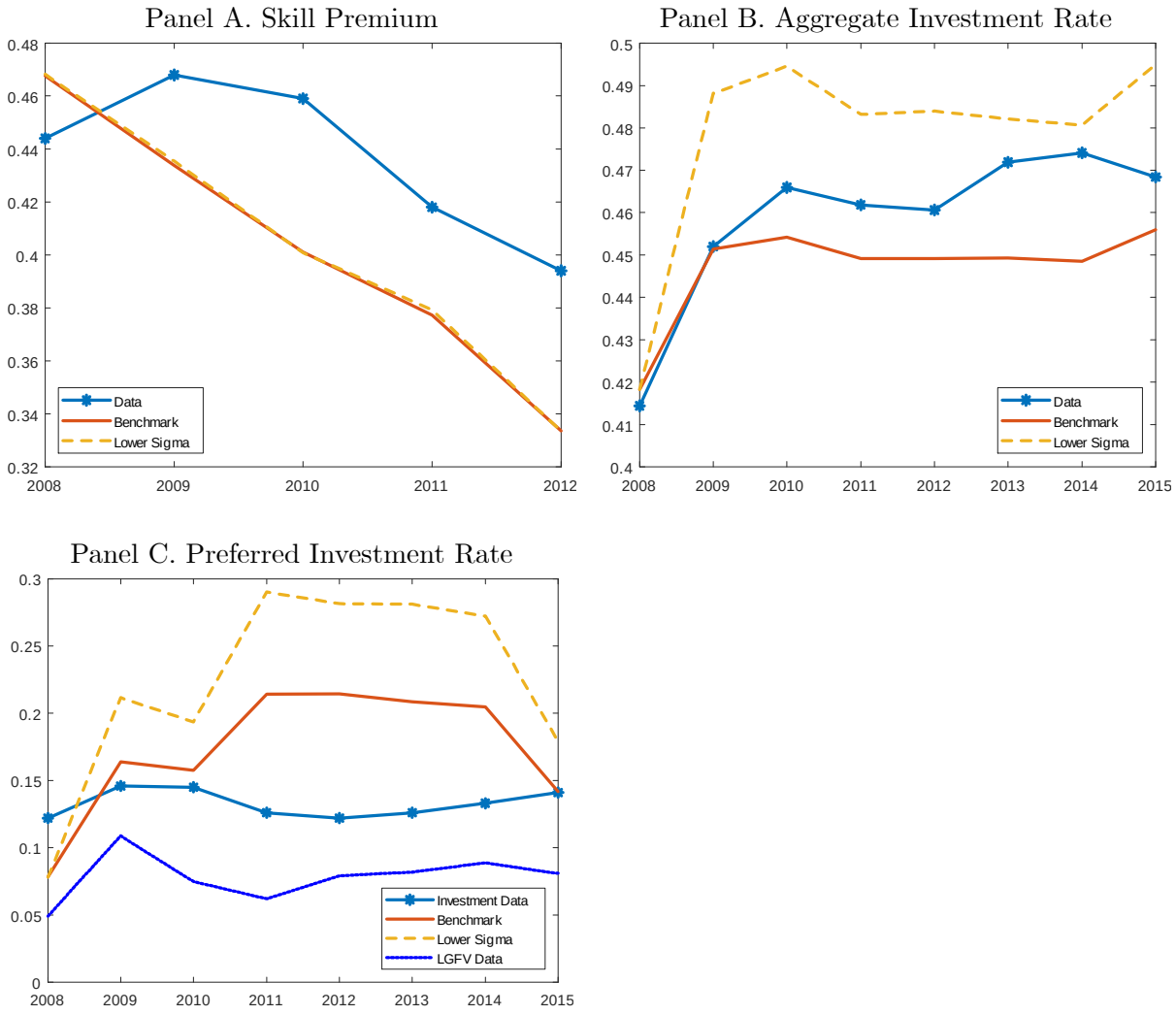
In sum, our quantitative exercise demonstrates that the preferential policy has crowding-out effects on both the capital and labor markets, which in turn generates quantitative outcomes that are broadly in line with the empirical facts in China. These results indicate that our theory is very important for understanding the Chinese economy over the last decade.

4.3 Robustness Analysis

Since the elasticity of substitution in the aggregate production function, σ, plays a crucial role in the resource reallocation, we now experiment with other values for σ. In the benchmark calibration, we estimate σ with HP-filtered data by setting the smoothing parameter to 100, which gives us $\sigma = 3.37$. In this section, following Rvan and Uhlig (2002), we set the smoothing parameter of the HP-filter to 6.25, which gives us $(\sigma - 1)/\sigma = 0.551$ with the t-statistic 2.96, implying $\sigma = 2.23$. We then recalibrate the other parameters to match the same steady state as in the benchmark model. Figure 8 compares the benchmark model results with the robustness analysis results, where σ is lower.

As shown in Panel A, the model generates same decline in skill premium during 2008 - 2012 under different values of σ, which means that change in the elasticity of substitution hardly affects skill premium. Moreover, as shown in Panel B, both parameterizations lead to a rising investment rate from 2008 to 2010, which remains at a high level after 2010. However, when we set σ to a lower value of 2.23, the aggregate investment increases more upon shock, leading to an investment rate around 48% after 2010. As shown in Panel C, the difference in the aggregate investment rate mainly comes from the difference in the preferred investment rate. The dashed line indicates that the preferred investment rate jumps by about 5% in each year, which is higher than in the benchmark.

Figure 8: Robustness Analysis



4.4 Foreign Demand Shocks

In the benchmark model, to highlight the effects of the preferential policy, we abstract from the change in foreign demand. However, during 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 2011. In this section, we introduce foreign demand shock to show that the previous results from the benchmark model still hold.

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

$$c_t + a_{t+1} + \tau_{t+1} + \triangle B_t^* = w_{Lt} l_t + w_{St} s_t + (1 + r_{dt})\, a_t, \tag{4.2}$$

where $\triangle B_t^*$ denotes the net holdings of foreign assets. We use NX_t to denote the net export and the goods market clearing condition becomes[24]

$$C_t + I_t + NX_t = Y_t. \tag{4.3}$$

Note that in the equilibrium, we have

$$NX_t = \triangle B_t^*. \tag{4.4}$$

For simplicity, we assume $\triangle B_t^*$ to be exogenous and therefore NX_t can be interpreted as foreign demand shock.[25] In the following exercise, we calibrate NX_t/Y_t to match the net export share in the data from 2008 to 2015, as shown in Panel A in Figure 9.[26]

With the exogenous foreign demand shock, we now compare the model prediction for two

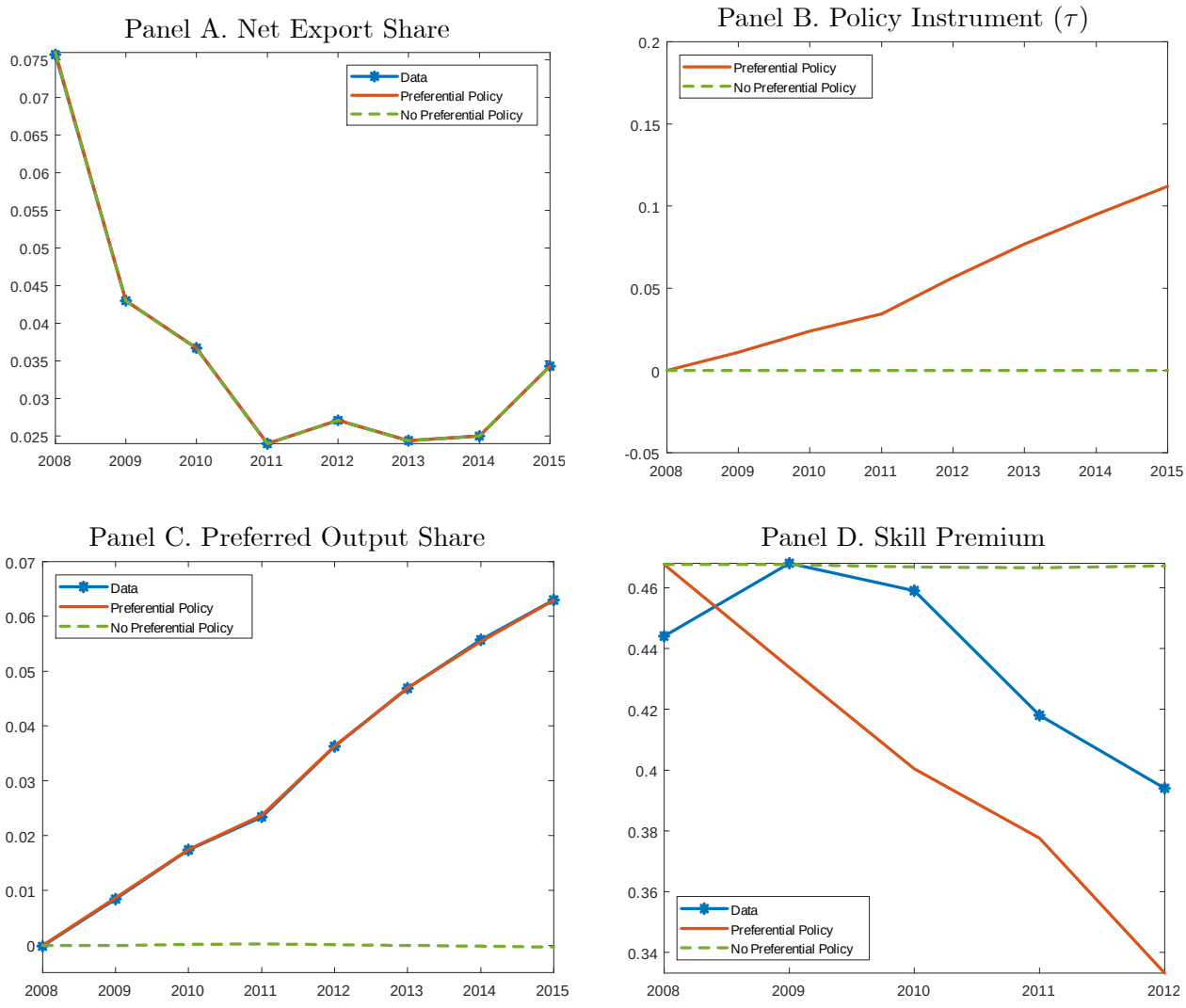
[24] In the current version, we do not endogenously model the importing and exporting decisions.

[25] 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 in this dimension. However, the key insights into skill premium and crowding-out effects still hold for more general models.

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

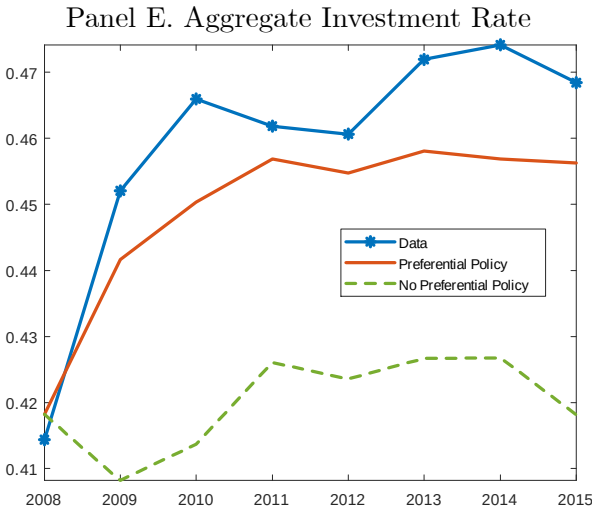
scenarios: (1) an economy without the preferential policy ($\tau_t = 0$); (2) an economy with the preferential policy, where τ_t is calibrated the same way as in the benchmark.

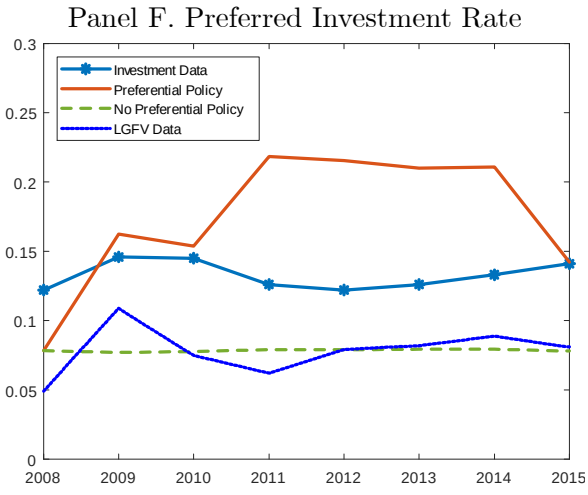
Figure 9: Economy with Foreign Demand Shocks

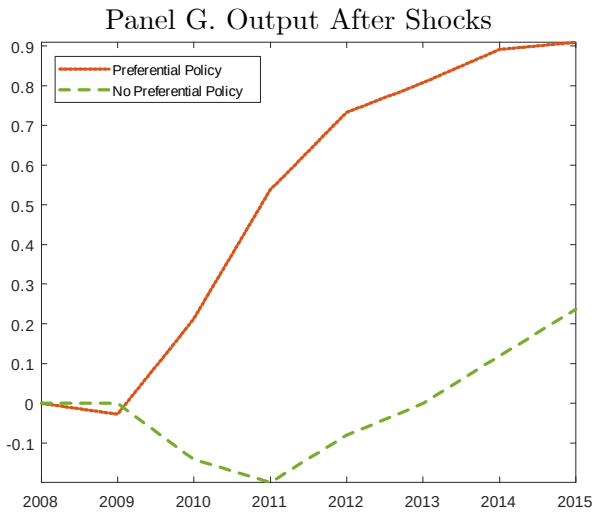


As shown in Figures 9 and 10, the simulation results are dramatically different under these two scenarios. When there is no preferential policy, as shown by the dashed line, the crowding-out effect is absent (Panel C), the skill premium does not change (Panel D), and both the aggregate investment rate and the preferred investment rate remain around their

Figure 10: Economy with Foreign Demand Shocks







initial levels (Panels E and F).

In addition, we investigate the model's implications for aggregate output. As shown in Panel G of Figure 10, when there is no preferential policy, output will drop from 2009 to 2011 due to weak foreign demand. However, if we implement the preferential policy, output will rise after 2009. Hence, our model suggests that, the preferential policy is capable of promoting output in the short run. This finding is related to Li and Zhou (2005), who document the empirical fact that the likelihood of promotion of local governors in China increases with their local GDP performance. Therefore, if local governors only concern themselves about GDP performance during their tenure, then they have a strong incentive to subsidize the preferred sector to promote short run output growth. This helps us to understand why the debt accumulation by LGFVs and aggregate investment rate remain high even after the stimulus plan was finished. Since many of the investment projects concentrate on the unskilled labor intensive sector, such as infrastructure, the skill premium continue to decline after 2010.

5 Alternative Explanations

Aside from the preferential policy, there are other important factors that could impact the skill premium, such as changes in the skilled labor supply and advances in investment-specific technology. In this section, we show that these alternatives are not supported by the data.

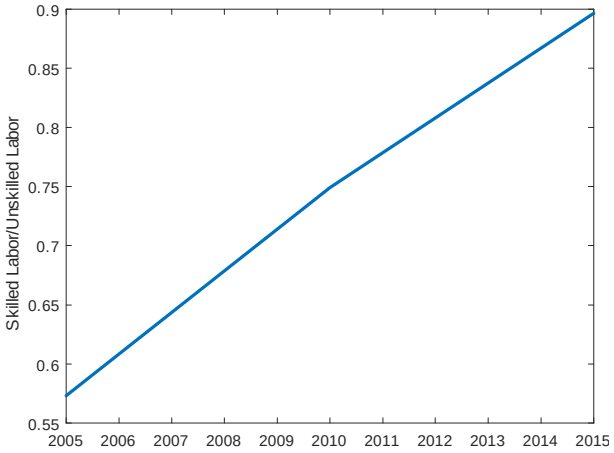
5.1 Expansion of the Skilled Labor Supply

One alternative explanation for the falling skill premium is an increase in the skilled labor supply. Figure 11 shows the ratio of skilled labor to unskilled labor, which increased from 0.55 in 2005 to 0.9 in 2015, indicating a rapid increase in the relative supply of skilled labor.[27]

It is true that an expansion in the skilled labor supply can lower the skill premium.

[27] The National Population Census in 2005, 2010, and 2015 reported the employment by education level. We interpolate between the three points. This information is not available from the National Population Census before 2005.

Figure 11: Skilled to Unskilled Labor Supply



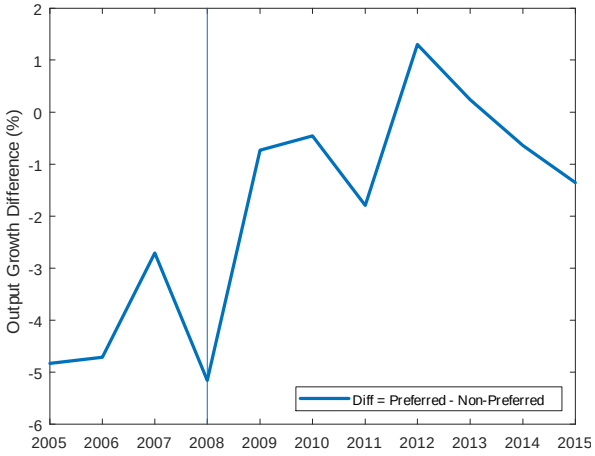
However, if this supply-driven channel dominates, we should observe an expansion of the skilled-labor-intensive sector, which is the non-preferred sector in our paper. However, this prediction is contrary to the data, where we actually observe an expansion of the preferred sector. In Figure 12, we plot the output growth rate difference between the preferred sector and the non-preferred sector. Between 2005 and 2008, the average output growth difference was -4.4% while this gap shrank to around -0.5% between 2009 and 2015, indicating that the preferred sector grew faster than the non-preferred sector after 2008. Hence, the increase of the skilled labor supply cannot be the key factor driving the declining skill premium since 2009.

5.2 Capital-Skill Complementarity

Previous studies has shown that technological advances in new equipment trigger a decline in equipment price, which leads to increased accumulation of equipment. Given that capital substitutes more for unskilled than for skilled labor, the decrease of equipment price would increase demand for skilled labor which increases the skill premium.[28]

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

Figure 12: Sector Output Growth Difference



We now examine if this capital-skill complementarity channel contributes to the structural break of the skill premium in 2009. Figure 13 plots equipment price in China. The persistent price drop from 2000 to 2015 indicates that there has been significant technological improvement in equipment in China. As there is no slowdown of the decline in equipment prices, the capital-skill complementarity channel cannot contribute to the fall in the skill premium after 2009.[29]

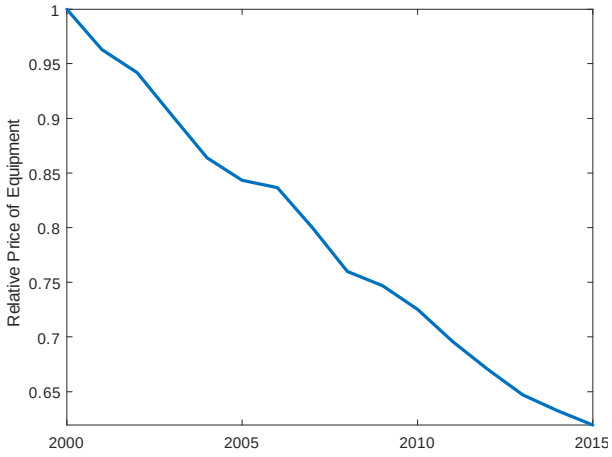
6 Conclusion

In this paper, we document the following new stylized facts about the Chinese economy: i) the structural break of the rising trend in the skill premium in China around 2009; ii) the rising aggregate investment rate from 2008 to 2015; iii) at the firm level, firm with less educated workers have lower return to capital after 2008. We believe that the preferential policy biased towards unskilled labor intensive sectors is the main driving force behind these facts. We then build a two-sector model and evaluate the effects of this preferential policy

Violante (2000).

[29] In fact, the declining capital price indicates that the skill premium should increase after 2009, as it does for the pre-2009 period. This result highlights the importance of the preferential policy, which leads to a decline in the skill premium.

Figure 13: Relative Price of Equipment



quantitatively. The simulation results are consistent with China's transitional experience during the last decade.

We believe that our model has many important policy implications that can be explored in future research. First, our model shows that preferential policy is capable of promoting the output level in the short run. Hence, the local governments have strong incentive to subsidize the preferred sector. However, this could sacrifice consumption or welfare in the long run. Second, this model implies that we cannot ascribe the falling skill premium since 2009 to college enrollment expansion. Third, our results imply that the high investment rate in China is unsustainable, as it generates large distortions in both the capital and labor markets and may result in nontrivial welfare loss.

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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 cannot use weekly or hourly wage to be consistent with the previous literature, because 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.[30]

- 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. The National Census in 2005 reported the number of employees at each education level for two-digit industries. We weigh the schooling year of each

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

education 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. 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 assets 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 sector:

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

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

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

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

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

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

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.[31]

[31] 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 follows:

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.[32]

   (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 in step 2 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

[32] 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 detail 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 $\{K_{it}, L_{it}, S_{it}, Y_{it}, Y_t\}$ are all 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 sector,

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

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

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 sector:

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

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

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

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

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).