Earnings Inequality and China's Preferential Lending Policy*

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Abstract

Wages have been distributed increasingly unequally over the past decades for most countries. While policymakers have tried different methods to stop the earnings inequality from widening, the effects have been minimal. In this paper, we propose a novel mechanism through which a preferential lending policy reduces the earnings inequality, inspired by the case of China. As most countries have, China has experienced increasing earnings inequality over the past decades; however, the inequality started to decline substantially after 2009. We argue that this change reflects the following important institutional change in China: since 2009, the local governments have been granted the ability to offer their preferred firms cheap credit. Since many of these preferred firms are unskilled-labor intensive, with a lower financing cost, they increase their investment and hire more unskilled workers, thereby reducing the earnings inequality. We incorporate this mechanism into a two-sector model and show quantitatively that our model can account for most of the decline of the earnings inequality observed 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: Earnings Inequality; Preferential Lending Policy; Misallocation; Economic Growth; Chinese Economy.

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1 Introduction

The skill premium, which is defined as the wage of skilled labor relative to that of unskilled labor, has increased across a broad set of developed and developing countries during the last two decades (see e.g. Goldberg and Pavcnik, 2007; Parro, 2013). Policymakers in developed countries are increasingly concerned and attempted to alleviate earnings inequality by limiting the immigration of unskilled workers or putting up trade barriers against less developed countries. However, most of the evidence from the literature suggests that the effect of immigration and trade has not been substantial enough to stop the overall widening of earnings inequality.[1] This, in turn, raised the question about what else the government can do about earnings inequality. China's recent experience shed light on this question, i.e., the country's earnings inequality was rising over the last decades until 2008 but started to decline substantially after 2009.

In this paper, we propose a novel mechanism through which a preferential lending policy that offers cheap credit to the unskilled-labor intensive sector helps to reduce the earnings inequality. This type of policy was first introduced in China in 2009 in the form of a four-trillion-yuan stimulus package. 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 approximately four-trillion yuan in the next two years, which is 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, which are firms that borrow and spend on behalf of the local government. Since these firms have explicit or implicit guarantees on their debts from the government, they can borrow at a lower

[1] A large stream of literature has studied to what extent the rising earnings inequality might be attributed to changes in immigration or trade. Most empirical studies find a negligible or small effect of immigration on earnings inequality (Borjas, Freeman, and Katz 1997; Card 2009). In addition, the literature also finds a small effect of trade on earnings inequality (Borjas, Freeman, and Katz 1997; Katz and Murphy 1992; Berman, Bound, and Griliches 1994).

cost. Given that the 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. We incorporate this mechanism into a two-sector neoclassical growth model and quantify how the preferential lending policy affected the skill premium in China between 2008 and 2015.

We start by documenting the pattern of earnings inequality in China and the institutional background of the preferential lending policy. We first show the evolution of China's skill premium using the national sample of Urban Household Surveys from 2000 to 2012. Our estimates indicate that the skill premium of workers with a high school education or above relative to those with a middle school education or below rose from 0.33 in 2000 to 0.47 in 2008;[2] however, this trend reversed itself and started to decline after 2009. We then document three features of the preferential lending policy. First, we show that the four-trillion-yuan stimulus package initiated by China's State Council in 2008 was concentrated on a couple of preferred industries that are unskilled-labor intensive. Second, we document that the Ministry of Finance modified the Budge Law during the stimulus, which allowed local governments to borrow through Local Government Financing Vehicles even after the stimulus. This gave rise to a high level of local government debt and aggregate investment. Third, we document that Local Government Financing Vehicles can raise fund with a much lower cost than other firms during our sample period. The first and last observation completes the definition of the preferential lending policy, as follows: the government preferred sector is unskilled-labor intensive and has better access to the financial market. The first two observations imply that such a preferential lending policy is permanent: although the stimulus was finished in 2010, local governments continued to use Local Government Financing Vehicles to borrow

[2] The rising skill premium before 2008 is consistent with previous studies (Ge and Yang 2014; Sheng and Yang 2017). We are the first in the literature to document the declining skill premium after 2009.

and spend afterwards, leading to a long-run impact on earnings inequality in China.

To evaluate the quantitative importance of the preferential lending policy, we build a model in which firms are heterogeneous in terms of skill intensity and access to the financial market. The firms in the government preferred sector 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, the firms in the non-preferred sector are skilled-labor intensive and borrow at the market interest rate. With a lower financing cost, the preferred sector increases its investment and hires more workers, thereby crowding out the resources in the non-preferred sector and driving up the relative demand for unskilled labor. The model is calibrated to the Chinese data, and the simulation results are consistent with several 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.

We conduct a counterfactual exercise to evaluate the quantitative importance of the mechanism described above. Specifically, we introduce the foreign demand using China's net exports data from 2008 to 2015, and show that with the preferential lending policy, the aggregate output increases in the short run. However, the preferential lending policy brings distortions to the economy and may cause welfare loss. We find that for the benchmark model, the preferential lending policy leads to a welfare loss that is equivalent to a 1.9% permanent reduction in consumption. While in the model with foreign demand, the welfare loss is even larger, with a value of 2.1%.

Our paper is related to two strands of the literature. The first is a large literature investigating changes in earnings inequality in both developed and developing countries, e.g.

Katz and Murphy (1992), Autor, Katz, and Krueger (1998), Krusell, Ohanian, Rios-Rull, and Violante (2000), Acemoglu (2003), He and Liu (2008), Ge and Yang (2014), and Sheng and Yang (2017). Our contribution to this literature is to propose a novel mechanism through which a preferential lending policy can affect earnings inequality by inducing higher demand for unskilled workers. To provide a transparent quantification of this new channel, we abstract from the other forces already discussed in this literature.

Our work is also related to the literature examining government's preferential treatment in China and the related factor misallocations. However, the preferential lending policy we study differs from the previous preferential treatments in the literature. First, while Bai, Hsieh, and Song (2016a) argue that local governments help their preferred firms by removing institutional obstacles, such as exempting them from official rules, we emphasize that local governments help their preferred firms by offering cheap capital, which is the first time in history that the local government could distort the capital market towards their preferred firms. Second, Song, Storesletten, and Zilibotti (2011) and Brandt, Tombe, and Zhu (2013) study the government preferential treatment towards state-owned enterprises and its implication on the aggregate economy. However, the existence of state-owned enterprises cannot account for the declining skill premium, because the average education level of employees in state-owned enterprises is significantly higher than that of employees in private enterprises, as shown by the Urban Household Surveys. Therefore, if the government only offers easier access to capital for state-owned enterprises, we should expect an increase in the skill premium. Third, Chang, Chen, Waggoner, and Zha (2016) explore the preferential treatment of strategic industries since 1996 and its implication for the business cycles in China. These strategic industries are capital intensive, which are different from our unskilled-labor intensive industries. Our contribution to this literature is to quantify how a preferential lending policy that is biased towards the unskilled-intensive sector affects the skill premium using a parsimonious model.

2 Empirical Background

This section begins by establishing the facts about the decline of earnings inequality in China since 2009. We then document three important factors that are related to the decline of earnings inequality. First, we show China's government initiated a four-trillion-yuan stimulus package in 2008, which concentrated on a couple of priority areas, and these areas are unskilled-labor intensive. Second, institutional change allowed local governments to borrow through Local Government Financing Vehicles even after the stimulus, which leads to a rising debt level and aggregate investment. Third, Local Government Financing Vehicles can rise funds with much lower costs than other firms.

2.1 Skill Premium

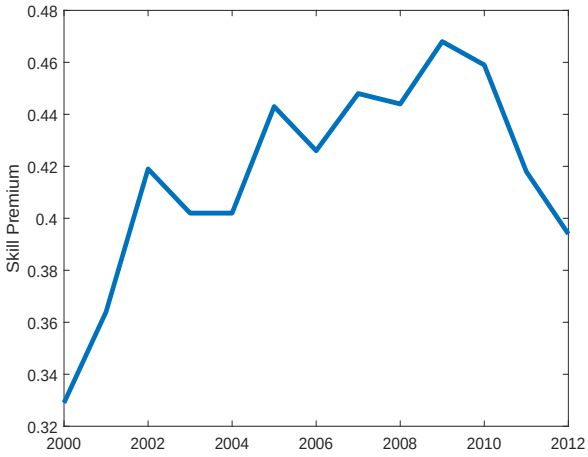
We start by documenting the changes in China's earnings inequality over the last decade, using the national sample of Urban Household Surveys from 2000 to 2012. This survey is conducted by the National Bureau of Statistics in China and is equivalent to the Current Population Surveys conducted in the United States, which have detailed information on household education levels, income, expenditures and other demographic information. The Urban Household Surveys have been frequently used in the empirical literature.

We show the evolution of the skill premium from 2000 to 2012 by computing the conditional skill premium for each year, which is defined as the wage of a worker with a high school education or above relative to that of a worker with a 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

Figure 1: Skill Premium



Source: Urban Household Surveys

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. Appendix A gives a detailed description of the data. In this regression, the coefficient β_1^t reflects the conditional skill premium, which is plotted in Figure 1.

We observe a continuous rise in the skill premium from 2000 to 2009; it peaks in 2009 with a level of 0.47, which indicates that in 2009, when the other conditions are kept the same, workers with a high school education level or above earned 47% more than those with a middle school education or below. The rising skill premium before 2009 is consistent with the empirical findings in other studies, such as Ge and Yang (2014).[3] However, the skill premium exhibits a structural break around 2009, during which the wages of unskilled

[3]Similar to 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 will become clear in Section 2.2, our choice is motivated by the fact that the preferential lending policy has important effects on wages for the workers with a middle school or lower (9-year or less) education level. In Figure 12 in Appendix A, we also report the evolution of the college premium in China. The estimates are very similar to the college premium reported by Sheng and Yang (2017).

workers started to rise faster, resulting in a declining skill premium.[4] Within three years, the skill premium fell sharply from 0.47 in 2009 to 0.39 in 2012, which indicates a major change in China's labor market conditions. In the meanwhile, we should keep in mind that the Urban Household Surveys have two limitations. First, the Urban Household Surveys became discontinued after 2012.[5] Therefore, in what follows, we draw on another piece of evidence with a longer time span to extend our observation on the skill premium. Second, the Urban Household Surveys could under sample the rural-to-urban migrants, because many of them live on the periphery of cities. In next section, we use wage data that is based on firm level Labor Force Surveys (similar to the Establishment Surveys in the United States) to alleviate this problem.

We now use the Gini coefficient, which measures income inequality, to extend our observation on the skill premium to 2015. Given that wage income constitutes 67% of household income, a decline in the skill premium could lead to a decline in income inequality.[6] Figure 2 shows China's Gini coefficient from 2003 to 2015. We can see that the Gini coefficient rises from 2003 to 2008 and starts to decline afterwards. More importantly, the Gini coefficient continues to fall from 2012 to 2015. The persistent and significant decline of income inequality after 2012 indicates that the decline of the skill premium is not a temporary phenomenon. We summarize this finding in the following observation.

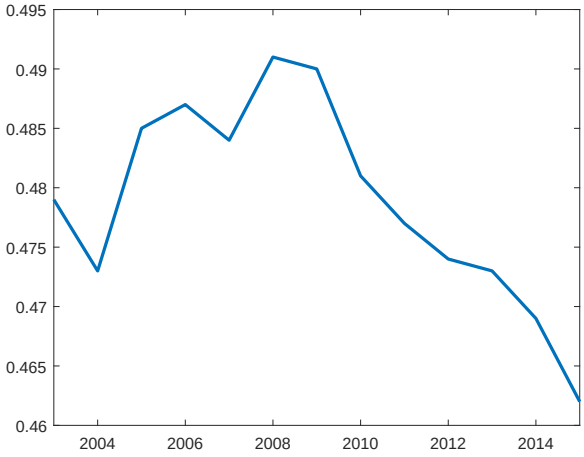
OBSERVATION 1: *The skill premium in China was rising before 2008 and then declined from 2009 till 2015.*

[4] Figure 13 in Appendix A shows the wages of skilled and unskilled workers over this period.

[5] Before 2012, the National Bureau of Statistics collected the Urban Household Survey and Rural Household Survey separately. Since 2013, the National Bureau of Statistics 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.

[6] 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 shares in total household income between 2000 and 2015 are 67%, 7%, 3%, and 22%, respectively.

Figure 2: Gini Coefficient



Source: National Bureau of Statistics

2.2 Preferential Lending Policy: Average Schooling Year

We now describe the preferential lending policy that was first introduced in the form of a stimulus in 2008. We then show how the average schooling years of workers differ between the government's preferred sector and the non-preferred sector.

In November 2008, as China's output growth decelerated during the global financial crisis, the State Council announced a four-trillion-yuan stimulus package to boost its domestic demand. This package planned to spend approximately four-trillion yuan on several priority areas in the next two years, which is roughly 12 percent of China's annual GDP. Table 1 lists the planned amounts of spending in these priority areas.

We group the one-digit industries that are most closely connected to the priority areas of spending as the preferred sector, which includes 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

Table 1: Four-Trillion-Yuan Stimulus

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

Entertainment (R).[7] Using the data on employment and educational attainment by industry from the 2005 Population Census, we show that the average schooling year of the preferred sector is 8.83, which is lower than the average schooling year of 10.35 for the non-preferred sector, indicating that the preferred sector is unskilled-labor intensive. A decomposition of each sector reveals that the major industries in the preferred sector, such as Agriculture, Construction, Transportation, and Water Conservancy are all unskilled-labor intensive, with average schooling years lower than the average of the non-preferred sector. Meanwhile, except for the Households Services, all industries within the non-preferred sector are skilled-labor intensive, with average schooling years higher than the average of the preferred sector.[8] Appendix A shows a complete list of the average schooling years across one-digit industries.

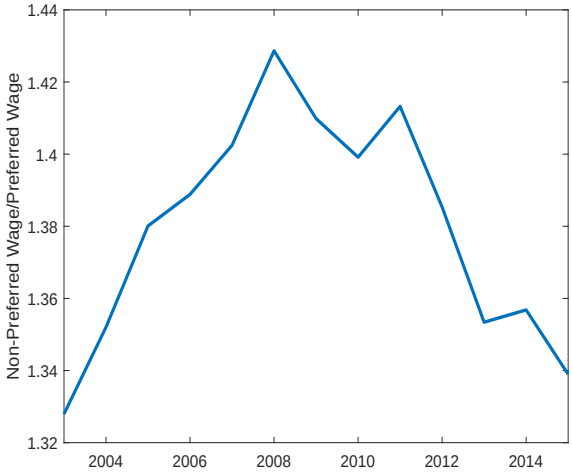
We summarize this finding in the following observation.

OBSERVATION 2: *The stimulus was concentrated on a couple of priority areas, which are unskilled-labor intensive industries.*

[7] According to China's industrial classification 2002 standard, all national economic activities can be divided into one-digit industries, which are labelled from (A) to (T). We exclude International Organizations (T) for the purpose of our study.

[8] Agriculture, Construction, Transportation, and Water Conservancy constitute 86% of the preferred sector employment. Households Services constitutes 7% of the non-preferred sector employment. Note that the preferred sector remains unskilled-labor intensive for the entire sample period.

Figure 3: Non-Preferred Sector Wage/Preferred Sector Wage



Source: China Statistical Yearbook

As the government expanded spending on the preferred sector, the demand for workers in the preferred sector increases, leading to an accelerated increase in the wages of the preferred sector. The wage of non-preferred sector relative to that of the preferred sector falls. As the preferred sector is unskilled-labor intensive, we should expect a similar pattern between the skill premium and the relative wage of the non-preferred sector. Our conjecture is confirmed in Figure 3, where the preferred and non-preferred sector wages are computed using the one-digit industry level wage from China Statistical Yearbook. We observe that the relative wage of the non-preferred sector increases initially from 2003 to 2008 and then started to decline from 2009 to 2015, following a similar pattern as the skill premium. This evidence indicates that the decline of the skill premium is indeed driven by the excessive demand from the preferred sector. Moreover, this evidence also nicely complements the skill premium computed from Urban Household Surveys, as the one-digit industry level wages used here are based on the Labor Force Surveys, which collect information from the enterprises instead of households, alleviating the problem of the Urban Household Surveys where certain types of

workers could be under represented, such as rural-to-urban migrants.[9]

2.3 Preferential Lending Policy: Institutional Change

We now describe an important institutional change that occurred during the stimulus, which makes the preferential lending policy permanent, and its impact on aggregate debt and investment.

When the local governments started to implement the stimulus and began spending in the priority areas, they found themselves prevented from running a budget deficit by the 1994 Budget Law. To circumvent 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, 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 the following:

> *... the 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. (China's Ministry of Finance, 2009)*

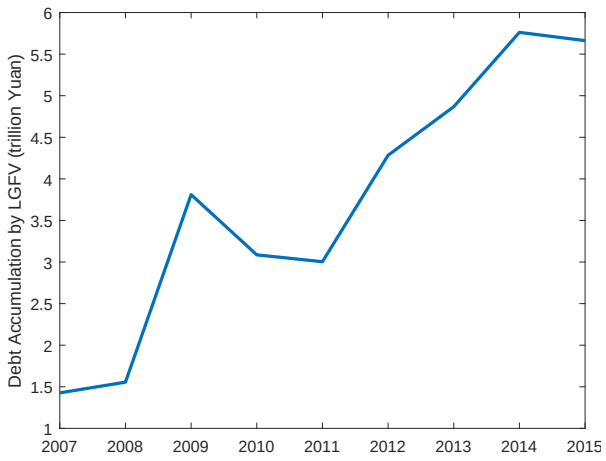
According to calculations by Bai, Hsieh, and Song (2016b), approximately 3/4 of the 4 trillion yuan in the stimulus was financed by Local Government Financing Vehicles. We collect information from the annual financial statements of Local Government Financing Vehicles that issued bonds and compute the total amount of debt they issued.[10] Figure 4

[9]The rural-to-urban migrants could be under represented because many of them live on the periphery of cities. This problem can be mitigated by combining information from the Labor Force Surveys, which is similar to the Establishment Surveys in the United States. The Labor Force Surveys in China collect payroll information from all legal entities in the urban area, which covers approximately 1.6 million enterprises.

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

shows the debt accumulation by Local Government Financing Vehicles, which is defined as the change in the debt stocks of Local Government Financing Vehicles. Before the onset of the financial crisis in 2007, Local Government Financing Vehicles were rarely used as a financing tool, and the debt issued in that year was only 1.5 trillion yuan.[11] However, given the increasing demand for the financing of investment projects in the preferred sector, the debt accumulation by Local Government Financing Vehicles surged to 3.8 trillion yuan in 2009, and further to 5.7 trillion yuan in 2015.

Figure 4: Debt Accumulation by LGFVs



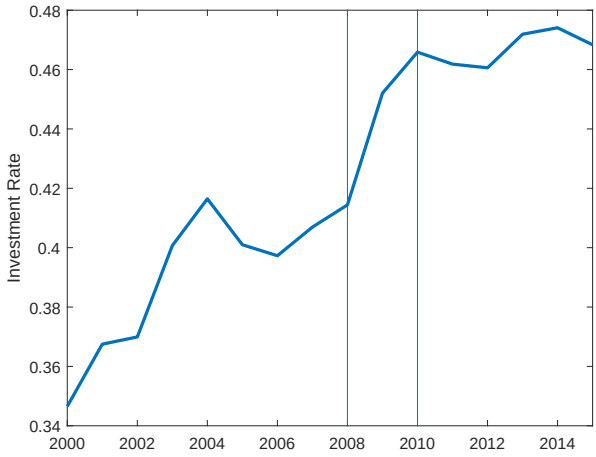
Note: LGFVs stands for Local Government Financing Vehicles. *Source*: WIND

It is important to note that the debt accumulation by the Local Government Financing Vehicles did not stop after the stimulus ended in 2010; the level of debt accumulation continued to rise from 2010 to 2015. This is a result of institutional change; local governments can still use the Local Government Financing Vehicles as a regular tool to circumvent financial constraints on their budgets even after 2010. Moreover, the Local Government Financing Vehicles continue to invest in unskilled-labor intensive industries, such as infrastructure, because of the career incentives created by the economic tournament among local govern-

[11] Local Government Financing Vehicles existed before 2009 but were highly restricted.

ment officials. Previous studies, e.g., Qian and Roland (1998), Maskin, Qian and Xu (2000), Blanchard and Shleifer (2001), and Li and Zhou (2005), show that the central government has established a tournament among local leaders, promoting those achieving fast economic growth and penalizing those with poor performance. As it will become clear in Section 4 and Section 6.1, investing in unskilled-labor intensive industries leads to an increase in output in the short run. Hence, career concerns lead to short-termism behaviors of the local governments, who continue to borrow and spend in the preferred sector. This permanent change in government financing methods is also 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 was fully implemented. Moreover, it remained at a very high level of approximately 0.47 till 2015, which is consistent with the high debt accumulation by Local Government Financing Vehicles after 2010 shown in Figure 4.

Figure 5: Aggregate Investment Rate



Source: China Statistical Yearbook

We summarize these findings in the following observation.

OBSERVATION 3: *The institutional change allowed local governments to borrow through Local Government Financing Vehicles even after the stimulus, leading to a high level of local debt and aggregate investment.*

2.4 Preferential Lending Policy: Financing Cost

Finally, we report the difference in the financing costs between the government preferred and non-preferred sectors using firm level data from WIND.

To facilitate spending on the preferred sector, China's Banking Regulatory Commission 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 lending 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. (China's Banking Regulatory Commission, 2009)*

Banks responded to this guidance by adjusting their credit policies. For example, the Industrial and Commercial Bank of China, the largest among the four major state-owned banks in China, changed its credit policy, as stated in the following quote from 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 credit policy changes towards the government preferred sector indicate that firms in the preferred sector could probably borrow at a lower interest rate than other

firms. Using balance sheet information for all firms that issue bonds from the WIND database during 2009 - 2015, we follow Frank and Shen (2016) to construct the firm-specific average cost of debt, which is defined as the interest and related expense over total debt. We then compare the average costs of debt for two groups of firms, i.e., Local Government Financing Vehicles and others, holding the distribution of firm characteristics fixed. To be specific, we run the following regression,

$$R_{it} = \theta_0 + \theta_{1t} LGFV_{it} + controls + \varepsilon_{it} \tag{2.2}$$

where R_{it} is firm i's average cost of debt, $LFGV_{it}$ is a dummy variable that denotes a firm is a Local Government Financing Vehicle. Column (1) in Table 2 reports the estimate of the relationship between a firm's average cost of debt and whether it is a Local Government Financing Vehicle, controlling for the industry fixed effect, year fixed effect and province fixed effect. As expected, the coefficient on the Local Government Financing Vehicle is negative and statistically significant. In other words, if a firm is a Local Government Financing Vehicle, then its financing cost is much lower than other firms. To test the robustness of our findings, we further control other factors that could affect a firm's financing cost, such as firm size, leverage ratio, and corporate credit rating. Column (2) - (4) indicate that the Local Government Financing Vehicles did enjoy much lower average costs of debt than other firms. The premium paid by other firms over the Local Government Financing Vehicles' rate reflects the preferential lending policy, which is consistent with the credit guidance issued by China's Banking Regulatory Commission.

We summarize this finding in the following observation.

OBSERVATION 4: *The funds raised by local governments through Local Government Financing Vehicles enjoy a much lower cost than those of other firms.*

Table 2: Firm Level Regression

	(1)	(2)	(3)	(4)
LGFV	-0.5975***	-0.5987***	-0.6015***	-0.6142***
	(0.0264)	(0.0273)	(0.0298)	(0.0303)
Firm Size		-0.0302***	-0.0551***	-0.0374***
		(0.0098)	(0.0111)	(0.0140)
Leverage			0.0052***	0.0053***
			(0.0008)	(0.0008)
Corporate Credit Ratings	No	No	No	Yes
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	15560	14468	13168	12917
R^2	0.202	0.211	0.224	0.224

Note: The dependent variable is average cost of debt of each firm. LGFV stands for Local Government Financing Vehicle. We control for firm's size, leverage ratio, corporate credit rating, industry fixed effect, year fixed effect and province fixed effect in each regression. Standard errors are in brackets. *** indicates significance at the one percent level.

2.5 Summary

In this section, we first present the decline of earnings inequality in China since 2009. We then document that the institutional change in 2009 allows local governments to borrow through Local Government Financing Vehicles and invest in areas that are unskilled-labor intensive, leading to a rise in the local government debt level and aggregate investment. In addition, we show that the financing costs of Local Government Financing Vehicles are much lower than the financing costs of other firms. In the following section, we present a quantitative two-sector neoclassical growth model in which the preferential lending policy affects the skill premium.

3 The Model

In this section, we present our benchmark model, which is a two-sector neoclassical growth model with a credit policy that is biased to the preferred sector. We then characterize the

optimality conditions for a competitive equilibrium, based on which we explore the macroeconomic implication of the preferential lending policy.

Household: 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} 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 follows:

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

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

where r_{dt} is the interest rate of deposit and τ_t is a lump-sum tax.[12]

Intermediate Goods Production: There are two sectors, i.e., the preferred and non-preferred sectors, which produce intermediate goods with Cobb-Douglas production technologies, as follows:

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

where $i = 1$ denotes for the preferred sector and $i = 2$ for the non-preferred sector. A_{it} is the sector-level TFP. K_{it}, S_{it}, and L_{it} are the capital, skilled labor, and unskilled labor used in sector i, with α_i, β_i, and γ_i as the factor income share, respectively. Note that $\alpha_i + \beta_i + \gamma_i = 1$.

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

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

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

[12] In China, the government's revenue mainly comes from (a) indirect taxes (Value-added Tax and Business Tax, etc.); (b) seigniorage revenue; (c) the relatively high reserve requirement level; (d) land finance and the resulting high housing prices, etc. The preferential lending policy is essentially financed by such revenues, which are indeed carried 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.

Note that the two 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 lower capital rental rates (i.e., $r_{1t} < r_{2t}$).

Final Good Production: 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:

$$\max_{Y_{it}} Y_t - p_{1t}Y_{1t} - p_2 Y_{2t}$$
$$s.t.\ Y_t = \left(\varphi \left(Y_{1t}\right)^{\frac{\sigma-1}{\sigma}} + (1-\varphi)\left(Y_{2t}\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}, \tag{3.4}$$

where the final good price is normalized to 1.

Banks: 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. Then, the bank rents the capital to firms in both sectors. In equilibrium, the bank's zero-profit condition gives the following:

$$\left(1 + r_{dt}\right) K_t = \left(1 - \delta + r_{1t}\right) K_{1t} + \left(1 - \delta + r_{2t}\right) K_{2t}. \tag{3.5}$$

Preferential Lending Policy: The preferential lending policy takes the following form: the government imposes a lump-sum tax on the household, and uses the tax revenues τ_t to subsidize the bank loans to firms in the preferred sector

$$\tau_t = \Delta r_t K_{1t}, \tag{3.6}$$

where

$$\Delta r_t = r_{2t} - r_{1t.} \tag{3.7}$$

Therefore, the firms in the preferred sector face lower interest rate than the firms in the non-preferred sector, that is $r_{1t} < r_{2t}$.

Competitive Equilibrium: The competitive equilibrium 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 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.*

Therefore, the equilibrium system consists of the optimal choice of a household

$$\frac{U'(c_t)}{U'(c_{t+1})} = \beta\left(1 + r_{dt+1}\right), \tag{3.8}$$

the profit maximization conditions of sector i are as follows:

$$w_{Lt} = \alpha_i p_{it}\frac{Y_{it}}{L_{it}};\ w_{St} = \beta_i p_{it}\frac{Y_{it}}{S_{it}};\ r_{it} = \gamma_i p_{it}\frac{Y_{it}}{K_{it}}, \tag{3.9}$$

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

$$\frac{Y_{1t}}{Y_{2t}} = \left(\frac{\varphi}{1-\varphi}\frac{p_{2t}}{p_{1t}}\right)^{\sigma} \text{ and} \tag{3.10}$$

$$\varphi^{\sigma}\left(p_{1t}\right)^{1-\sigma} + (1-\varphi)^{\sigma}\left(p_{2t}\right)^{1-\sigma} = 1, \tag{3.11}$$

banking's zero-profit condition, (3.5), and the government budget constraint, (3.6).

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

$$\sum_{i=1}^{2} K_{it} = K_t;\ \sum_{i=1}^{2} L_{it} = L;\ \sum_{i=1}^{2} S_{it} = S, \tag{3.12}$$

$$C_t + I_t = Y_t, \text{ and} \tag{3.13}$$

$$K_{t+1} = I_t + (1-\delta) K_t. \tag{3.14}$$

4 Analytic Analysis

In this section, we derive a couple of key equations to illustrate the effects of the preferential lending policy on the skill premium, allocations of capital and labor across sectors, and aggregate output.

A. *Skill Premium*

When the government increases the interest rate subsidy, τ_t, to the preferred sector, the effective interest rate faced by the preferred sector is lower, leading to a greater interest spread between the non-preferred and preferred sector. That is,

$$\frac{\partial \Delta r_t}{\partial \tau_t} > 0. \tag{4.1}$$

To better understand the role of the preferential lending policy in factor allocation and the skill premium. We log-linearize the equilibrium conditions and use $\hat{x} = \Delta x / x$ to denote the relative change of variable x. In Appendix B, we show that the changes in capital and labor allocations are, to a first order approximation, given by

$$\hat{k}_{1t} - \hat{k}_{2t} = (1 + \Xi) \Delta r_t, \tag{4.2}$$

and

$$\hat{l}_{1t} - \hat{l}_{2t} = \Xi \Delta r_t, \tag{4.3}$$

$$\hat{s}_{1t} - \hat{s}_{2t} = \Xi \Delta r_t, \tag{4.4}$$

where

$$\Xi = \frac{(\sigma - 1)\left[\left(1 - \lambda_1^K\right)\gamma_1 + \lambda_1^K \gamma_2\right]}{1 + (\sigma - 1)\left[\left(\lambda_1^L - \lambda_1^S\right)(\beta_2 - \beta_1) + \left(\lambda_1^L - \lambda_1^K\right)(\gamma_2 - \gamma_1)\right]}, \tag{4.5}$$

and

$$\lambda_1^L = L_1/L; \quad \lambda_1^S = S_1/S; \quad \lambda_1^K = K_1/K$$

are the steady state values of preferred unskilled labor share, preferred skilled labor share, and preferred capital share, respectively.

Note that Ξ depends on parameters of the sectoral and aggregate production functions. We show in Appendix B that if $\alpha_1 > \alpha_2$, $\beta_2 > \beta_1$, and $\gamma_2 > \gamma_1$, then $\lambda_1^L > \lambda_1^S$ and $\lambda_1^L > \lambda_1^K$ hold, leading to a positive Ξ, given $\sigma > 1$. Therefore, if the preferred sector is unskilled-labor intensive and the non-preferred sector is both skilled-labor intensive and capital intensive, with appropriate elasticity of substitution, the preferential lending policy will induce more capital and labor to allocate to the preferred sector, crowding out those of the non-preferred sector. We will show in Section 5.1 that these parameter restrictions are satisfied in our calibration.

We now derive the first-order approximation of the skill premium using equations (3.9) and (3.12) as follows:

$$\hat{w}_{St} - \hat{w}_{Lt} = \left(\hat{l}_t - \hat{s}_t\right) - \left(\lambda_1^L - \lambda_1^S\right)\left(\hat{l}_{1t} - \hat{l}_{2t}\right). \tag{4.6}$$

Equation (4.6) decomposes the change in skill premium into two components. The first component is the *relative quantity effect*, which depends on the growth of unskilled labor relative to skilled labor. All else equal, an increase in the relative supply of the skilled labor reduces the skill premium. The second component is the *reallocation effect*, which depends on relative change in the sectoral labor allocation. All else equal, the preferential lending policy induces unskilled labor to allocate to the preferred sector as shown in equation (4.3). Given that the preferred sector uses more unskilled labor to produce, that is $\lambda_1^L > \lambda_1^S$, the labor reallocation results in a negative effect on the skill premium. Let us denote the skill premium by $\pi_{st} = \frac{w_{St}}{w_{Lt}}$, our analysis indicates that the skill premium declines when the government

implements the preferential lending policy:

$$\frac{\partial \pi_{st}}{\partial \tau_t} < 0. \tag{4.7}$$

We summarize the above findings as follows:

Proposition 1 *The preferential lending policy subsidizes interest rate faced by the preferred sector, crowds out capital and labor from the non-preferred sector, and reduces the skill premium.*

B. *Sectoral and Aggregate Output*

Here, we show our model's prediction on changes in aggregate output to rationalize the incentive of the governments to implement the preferential lending policy even after the stimulus. In Appendix B, we derive that the change in sectoral output is, to a first-order approximation, given by

$$\hat{\theta}_{1t} - \hat{\theta}_{2t} = \Xi \Delta r_t, \tag{4.8}$$

where $\theta_{it} \equiv p_{it} Y_{it}$ denotes the output of sector i. All else equal, when $\Xi > 0$, an increase in Δr_t leads to a relative expansion of the preferred sector output. We will use equation (4.8) to capture the magnitude of the preferential lending policy in the quantitative analysis in Section 5.

For the aggregate output, we log-linearize equation (3.4) which gives:

$$\hat{y}_t = \lambda_1^{\theta} \hat{\theta}_{1t} + \left(1 - \lambda_1^{\theta}\right) \hat{\theta}_{2t}, \tag{4.9}$$

where λ_1^{θ} is the steady state value of the preferred output share, $p_1 Y_1 / Y$. Equation (4.9) indicates that the change in aggregate output is a weighted average of the changes of output of both the preferred and non-preferred sectors. We show in Appendix B, when the steady state

preferred output share is above certain threshold, that is $\lambda_1^\theta > \underline{\lambda}$, aggregate output increases as a result. This predication helps to rationalize the incentive of the central government to initiate the stimulus in 2008, when the GDP growth slowed down during the global financial crisis. It also implies that the career incentive of the local governors explains the preferential lending policy after 2010, as they continue to borrow and invest in the preferred sector to promote local GDP.

We now establish the following proposition about the effect of the preferential policy on the sectoral and aggregate output.

Proposition 2 *The preferential lending policy increases the output share of the preferred sector. Moreover, the aggregate output may rise as a result.*

5 Quantitative Analysis

In this section, we bring our model to the data and evaluate the quantitative effects of the preferential lending policy. We show that a calibrated version of the model can account for China's experience from 2008 to 2015.[13] Specifically, our model captures the decline in the skill premium, the rise in the aggregate investment rate, and the reallocation of resources between the preferred and non-preferred sectors. The algorithm for computing the transitional dynamics is provided in the Appendix C.

5.1 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

[13] Our quantitative analysis focuses on the post-2008 period when the preferential lending policy is in practice. One way to interpret the model is that, except for the preferential lending policy, all the other factors that affect the skill premium work in the same way for both the pre and post crisis period. Hence the rising trend of skill premium before 2008 can be interpreted as a result of all other driving forces. All else equal, the skill premium will keep its trend after 2008.

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 the labor supply, we first normalize the supply of unskilled labor L to 1. We then set the steady state skilled labor $\overline{S}$ to 1.09 to match the trend level of skill premium in 2008, which is 0.46. In addition, we compute the path of labor supply S_t between 2009 and 2015 using the employment data by education attaintment in urban area from the Population Census. To be specific, we compute the number of skilled workers relative to the number of unskilled workers from 2005 to 2015, and find that the relative supply of skilled workers started to deviate from its previous trend in 2010. Therefore, we take the percentage deviations from the data and use them to model the exogenous changes in the relative labor supply.

We calibrate the capital and labor income share of the preferred sector and non-preferred sector using information from the 2005 National Input-Output Table.[14] The Input-Output Table decomposes the value added of a sector into the following 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 Input-Output Table into preferred and non-preferred sectors and define the labor income share as the compensation of employees over the total value added. This gives us a labor income share of 0.59 and a capital income share of 0.41 for the preferred sector, while for the non-preferred sector, the labor income share is 0.34 and the 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

[14] We need information from both the National Input-Output Table and the National Census to derive the 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.

preferred and non-preferred sectors, α_i and β_i, we draw information from the 2005 Population Census, along with the 2005 National Input-Output Table. We first divide the 42 disaggregated sectors from the Input-Output Table into preferred and non-preferred sectors. We then assume that the skilled to unskilled labor income ratio is the same for all the 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 back out 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 $\alpha_2 = 0.06$, $\beta_2 = 0.28$.

Following Acemoglu and Guerrieri (2008) and Chang, Chen, Waggoner, and Zha (2016), 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 sectors, which is derived from equation (3.10), as follows:

$$\log \frac{p_{1t}Y_{1t}}{p_{2t}Y_{2t}} = \log\left(\frac{\varphi}{1-\varphi}\right) + \left(1 - \frac{1}{\sigma}\right) \log \frac{Y_{1t}}{Y_{2t}}. \tag{5.1}$$

The variables used in the regression are first HP-filtered with the smoothing parameter setting 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. It is worth noting that, although widely used in academia, HP-filter could introduce spurious relations that have no basis in the underlying data-generating process. Therefore, in the robustness analysis we follow Hamilton (2018) to fit an auto-regressive process to get the cyclical components of the data and use them to re-estimate σ. In Section 5.3, we show that our results are robust to this alternative calibration.

5.2 Main Results

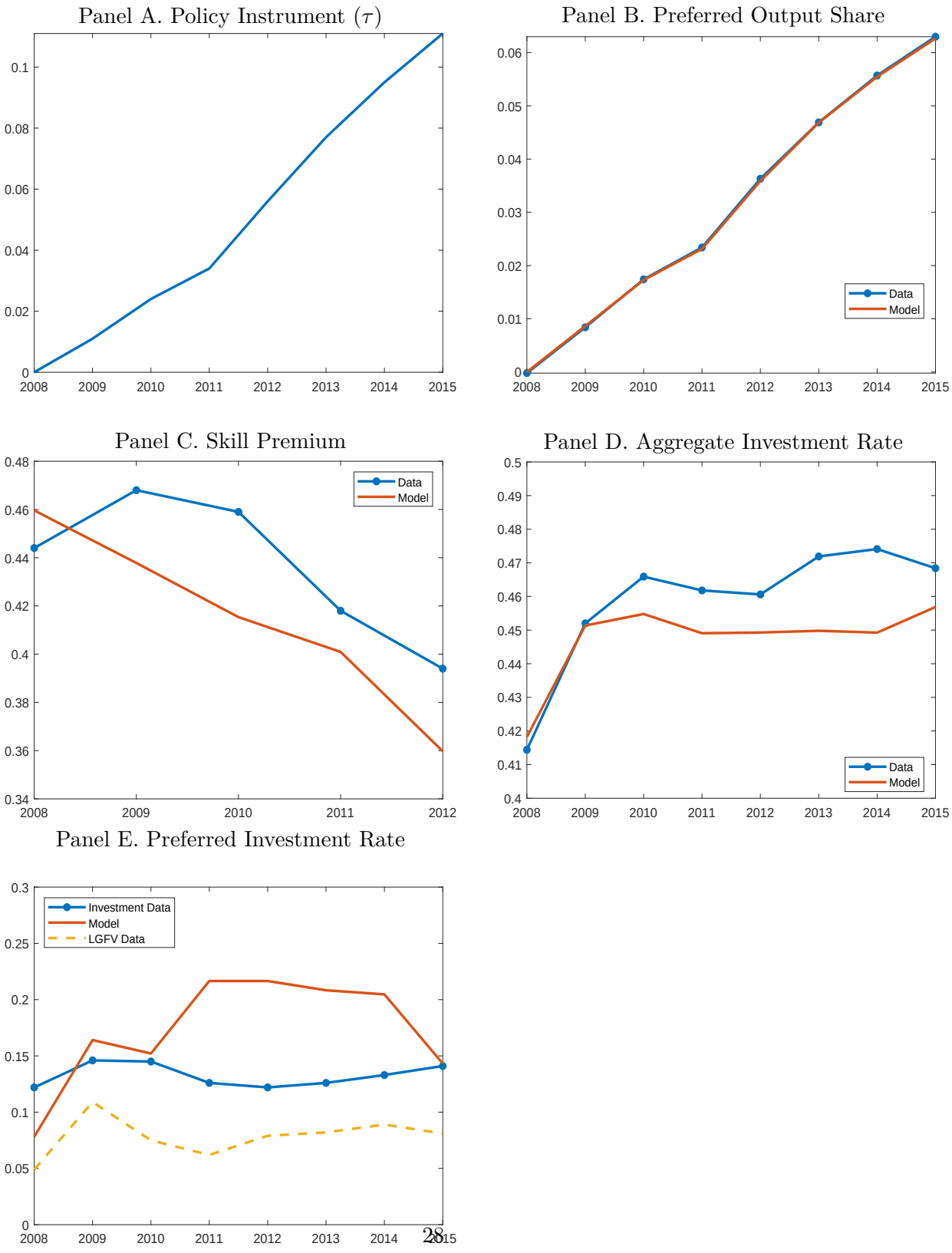
We analyze the quantitative implications of the preferential lending policy in this section. Specifically, the government has implemented the preferential lending policy by subsidizing the interest rate faced by the preferred sector since 2009. Although the subsidy, τ_t, is not directly observed in the data, we show in equation (4.8) in Section 4 that its crowding-out effects are tightly linked to the changes in the relative sectoral output shares. If we examine the preferred output share from 2004 to 2015, defined as the output of the preferred sector over the total output, this ratio began to deviate from its trend in 2009.[15] 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 1.7% in 2010, we set τ_{2010} to 0.024 so that the preferred sector output share rises above the trend by 1.7% in the model. Panel A in Figure 6 shows the calibrated path of τ_t, which changes from 0 in 2008 to 0.111 in 2015 and remains unchanged afterward.[16] 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 lending policy.

Panel C reports the changes in the skill premium, which is the focus of the paper. The simulation shows that the crowding-out effects of the preferential lending policy lead to a declining skill premium. Specifically, the skill premium falls from 0.46 in 2008 to 0.36 in 2012 in the model, where in the data of 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.

[15] 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.

[16] As discussed in Section 2.3, the institutional change is permanent; therefore we assume that the preferential lending policy remains the same after 2015. However, the quantitative results will not show much difference if this policy is sustained for several years after 2015 and then stops.

Figure 6: Benchmark Model: Transition of the Model and 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 0.418 in 2008 (0.415 in the data), rises to 0.46 in 2010 (0.47 in the data), and remains at approximately 0.45 until 2015 (approximately 0.46 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 the decreasing marginal product of capital. Panel E compares the preferred investment rate to the data by presenting two measures of preferred investment rate, as follows: the starred line labeled "Investment Data" is defined as the fixed asset investment in the preferred sector over the aggregate output; the dashed line labeled "LGFV Data" is the debt accumulation by Local Government Financing Vehicles over the aggregate output. Our model captured the pattern of the preferred investment rate reasonably well, i.e. an increase upon policy implementation and relatively stable afterwards. Although the model overshoots the preferred investment rate after 2011, given that our model is highly stylized, we believe the model's prediction is still within a reasonable range.

In summary, our quantitative exercise demonstrates that the preferential lending policy has crowding-out effects on both 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 framework is important for understanding the underlying forces behind the declining skill premium in China.

5.3 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 $\sigma = 3.37$. However, as Hamilton (2018) argued, regressing on the HP-filtered

data is problematic since it may introduce spurious dynamic relations that have no basis in the underlying data-generating process. He instead suggested a better alternative to extract residuals from regressions for each variables with lags so that the drawbacks of the HP-filter can be avoided. In this section, we follow Hamilton (2018) to de-trend and estimate σ, which gives a value of 2.94. We then recalibrate the other parameters to match the same steady state as in the benchmark model. Figure 7 compares the benchmark results with the alternative calibration, where σ is lower.

As shown in Panel A, the model generates similar decline in the skill premium during the 2008 - 2012 period under different values of σ. Moreover, as shown in Panel B, both parameterizations lead to similar patterns of the aggregate investment rate, i.e., a surge in the investment rate from 2008 to 2010 that then remains at a high level after 2010. However, when we set σ to a lower value of 2.94, the aggregate investment rises more upon a shock, leading to a higher investment rate after 2010, which is closer to the data. Therefore, our quantitative results are robust to alternative σ.

6 Discussion

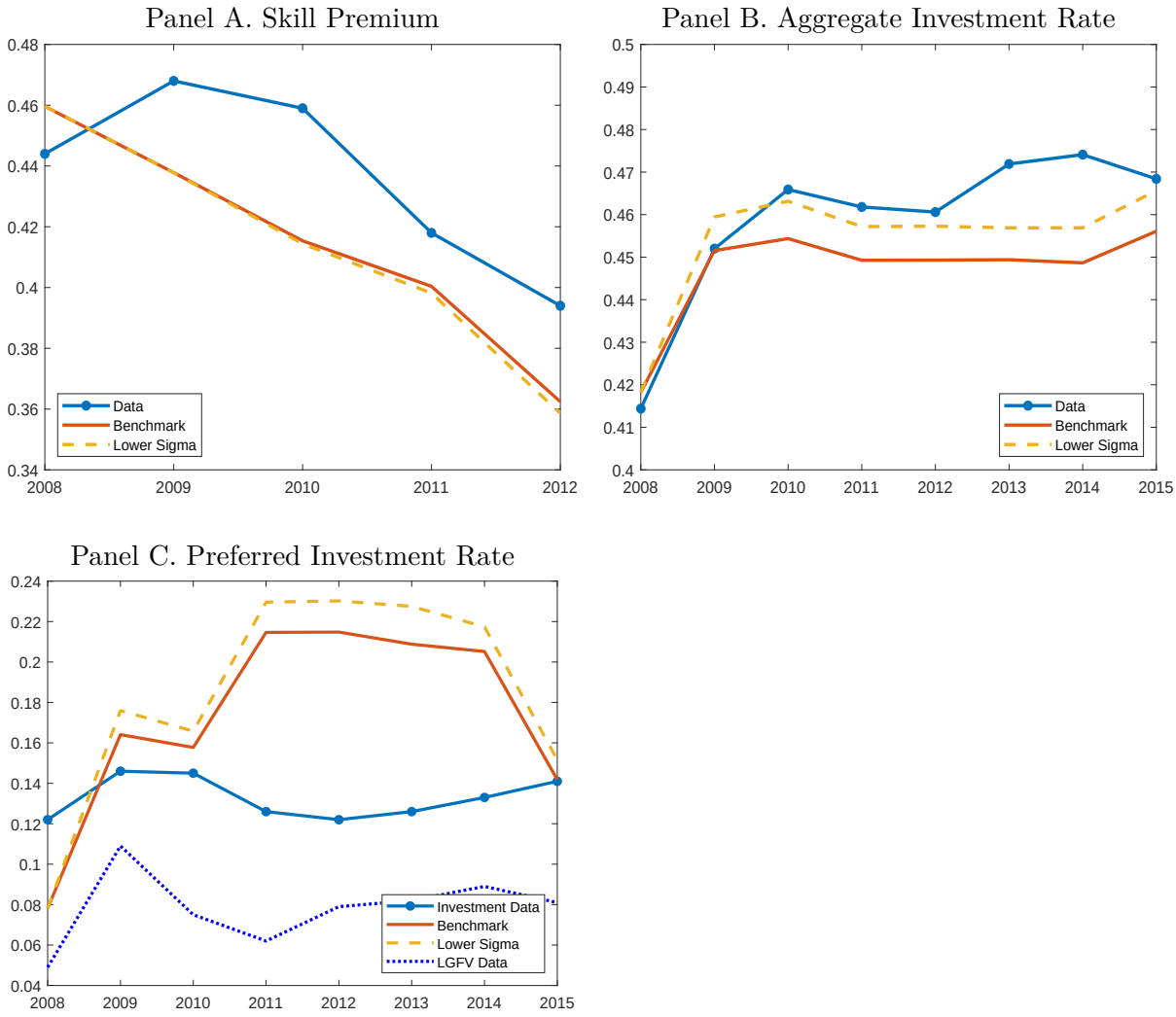
6.1 Foreign Demand Shocks

Due to the 2007 global crisis, China's net export to GDP ratio slumped from 4.3% in 2009 to 2.4% in 2011. However, China's output growth did not fall with such weak foreign demand. In this section, we show the effect of the preferential lending policy on aggregate output and the skill premium using a model with foreign demand shocks.

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

$$c_t + a_{t+1} + \tau_t + \triangle B_t = w_{Lt} l_t + w_{St} s_t + (1 + r_{dt})\, a_t, \tag{6.1}$$

Figure 7: Robustness Analysis



where $\triangle B_t$ denotes the net holdings of foreign assets. To provide a transparent quantification of the preferential lending policy, we abstract from the trade channel discussed in the literature. To be specific, we assume the net exports, NX_t, to be exogenous and sector neutral.[17] Then, the goods market clearing condition becomes as following:

$$C_t + I_t + NX_t = Y_t, \tag{6.2}$$

and in equilibrium, we have

$$NX_t = \triangle B_t. \tag{6.3}$$

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 8. With the exogenous foreign demand shock, we now compare the model prediction for the following two scenarios: (1) an economy without the preferential lending policy ($\tau_t = 0$); (2) an economy with the preferential lending policy, where τ_t is calibrated the same way as in the benchmark. As shown in Figures 8 and 9, the simulation results are dramatically different under these two scenarios. When there is no preferential lending policy, as shown by the dashed line, the crowding-out effect is absent (Panel C), the skill premium keeps its rising trend after 2008 (Panel D), and both the aggregate investment rate and the preferred investment rate remain close to their initial levels (Panels E and F).

In addition, we investigate the model's implications for aggregate output. As shown in Panel G of Figure 9, when there is no preferential lending policy, output will drop from 2009 to 2011 due to weak foreign demand. However, if we implement the preferential lending policy, output will rise after 2009. This suggests that the preferential lending policy is

[17] In the data, China's exporting sector is unskilled-labor intesive. Therefore, a decline in foreign demand should lower the wages of unskilled workers, driving up the skill premium. However, as mentioned in the introduction, many studies find a small effect of trade on the skill premium. To simplify the model, as well as to highlight the main mechanism of preferential lending policy on skill premium, we abstract from the trade and keep the foreign demand shocks as sector neutral in the paper.

Figure 8: Economy with Foreign Demand Shocks

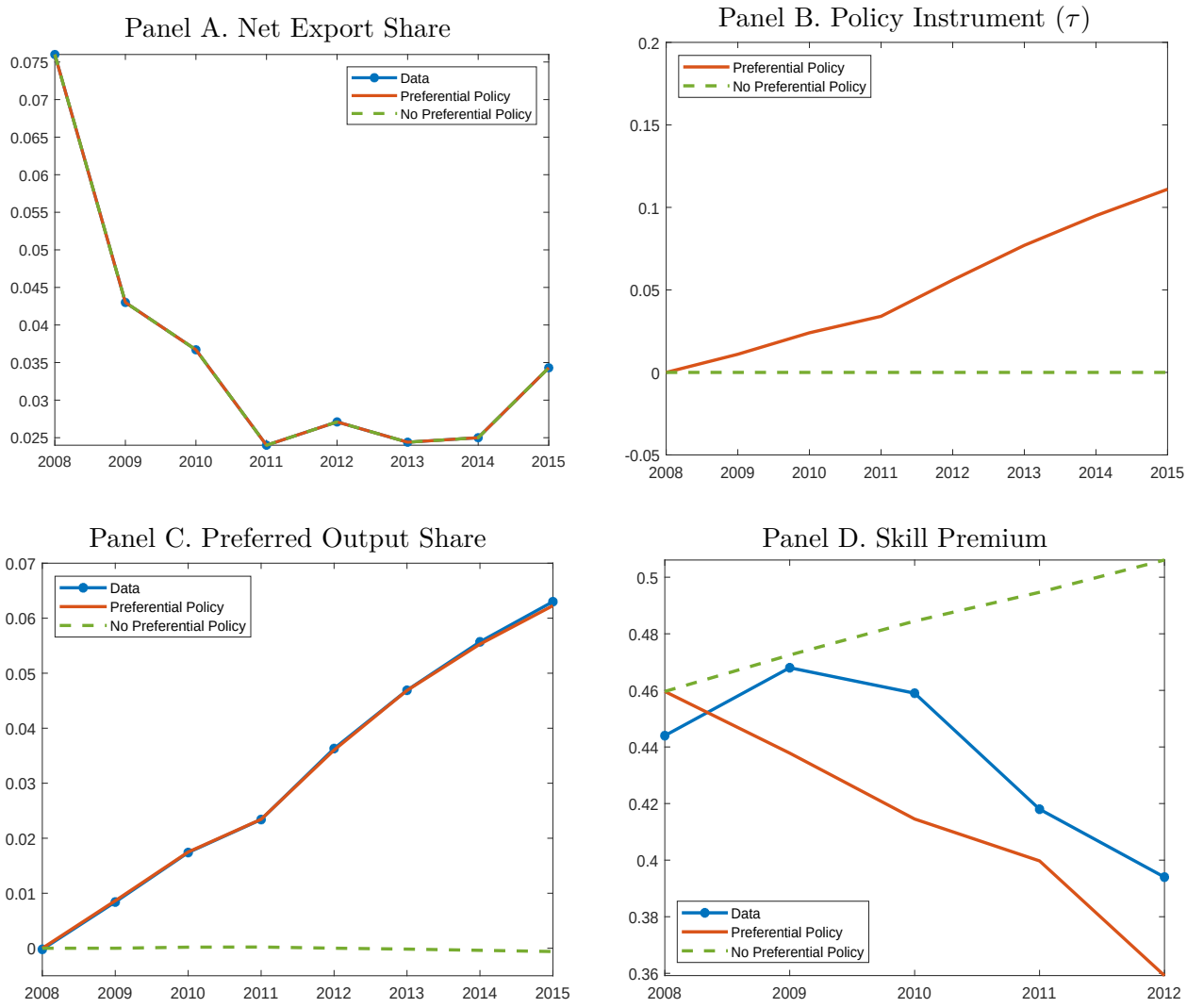
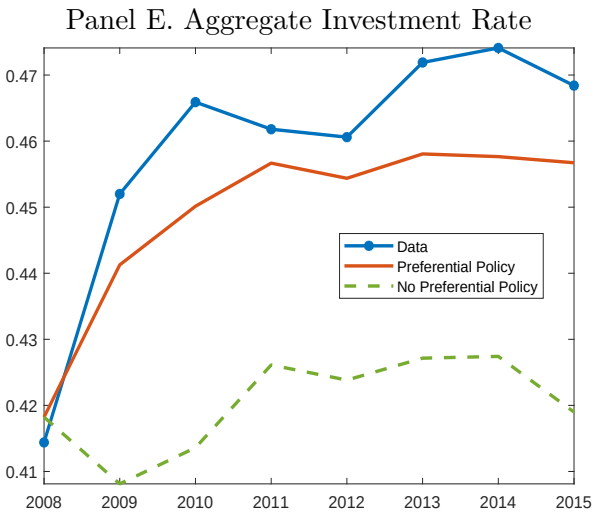
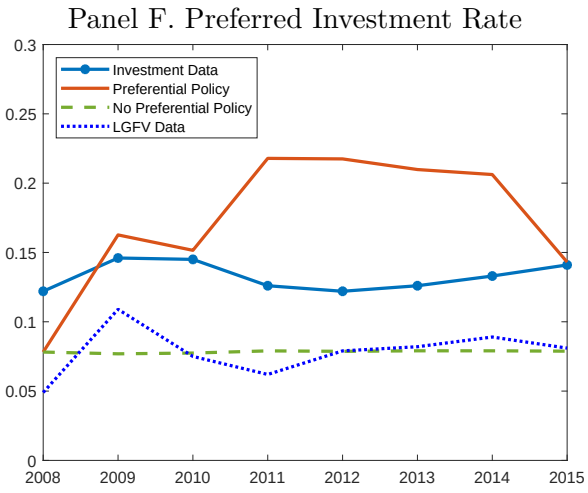
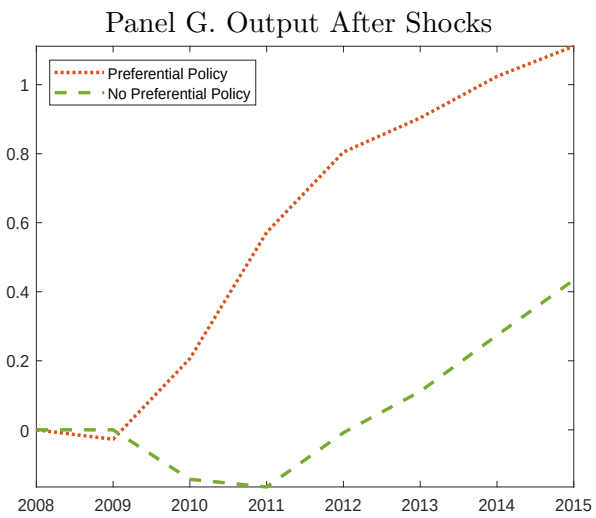


Figure 9: Economy with Foreign Demand Shocks







capable of promoting output in the short run. Moreover, when the likelihood of promotion of local governors increases with their local GDP performance, they have a strong incentive to subsidize the preferred sector to boost local output. This helps us to understand why the debt accumulation by Local Government Financing Vehicles and aggregate investment rate remain high even after the stimulus ended. In a related paper, Xiong (2019) explicitly models the agency problem between the central and local government to explain the over accumulation of debt by Local Government Financing Vehicles after the stimulus.

6.2 Welfare

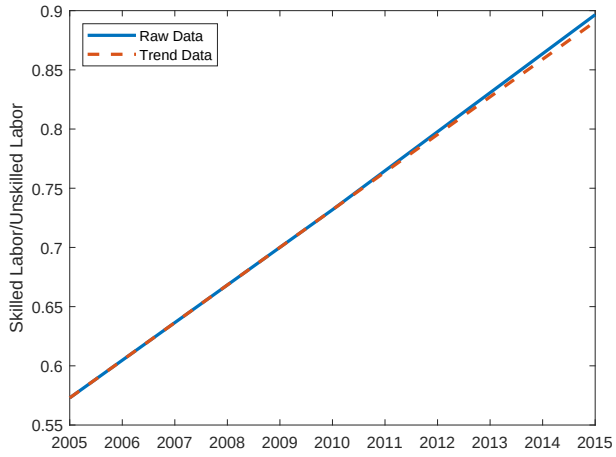
As illustrated above, the preferential lending policy has profound effects on the skill premium in China. It also stimulates the aggregate investment rate and leads to a higher aggregate output. However, such a high investment rate is certainly unsustainable in the long run, and the rise in output comes at the cost of sacrificing consumption. Therefore, implementing the preferential lending policy generates non-trivial distortions and results in welfare loss. In this section, we measure welfare loss by a consumption equivalence in the spirit of Lucas (1987). In particular, we define the welfare loss of the preferential lending policy as the permanent percentage decrease in consumption that is required for the representative household to remain indifferent between living in two economies, i.e., the economy with preferential lending policy ($\tau_t > 0$), and an alternative economy with no preferential lending policy ($\tau_t = 0$). Our calculation suggests that in the benchmark model the preferential lending policy generates a welfare loss that is equivalent to a 1.9% permanent reduction in consumption.

We also compute the welfare loss of the preferential lending policy for model with foreign demand shock. The result suggests that the preferential lending policy induces a welfare loss that is equivalent to a 2.1% permanent reduction in consumption, which is greater than that of the benchmark. This is because the government responds to weak foreign demand by providing more subsidies to the preferred sector, thereby generating larger distortions.

6.3 Changes in Skilled Labor

As shown in equation (4.6), relative quantity effect, that is changes of skilled labor relative to unskilled labor, can also affect the skill premium. After 2009, if the skilled relative to unskilled labor increases at the same speed as pre-2009, all else equal, the skill premium will keep its previous rising trend. Only if the relative skilled labor supply expands much faster than its pre-2009 trend, the skill premium could stop widening. Figure 10 plots the number of skilled workers relative to the number of unskilled workers, using data from the Population Census between 2005 and 2015.[18] The solid line is the ratio of skilled to unskilled labor, which increased steadily from 0.57 in 2005 to 0.9 in 2015. The dashed line is the trend of labor supply computed by extrapolating the data between 2005 and 2010. Note that there is only a modest accelerated growth of the relative supply of skilled labor after 2010, indicating a minor effect on the skill premium. With a counterfactual experiment in Appendix D, we confirm that the relative supply of skilled labor does not contribute much to the declining skill premium .

Figure 10: Skilled to Unskilled Labor Supply



[18]The National Population Census in 2005, 2010, and 2015 reported the employment by education level. This information is not available from the National Population Census before 2005.

6.4 Skill-biased Technological Change

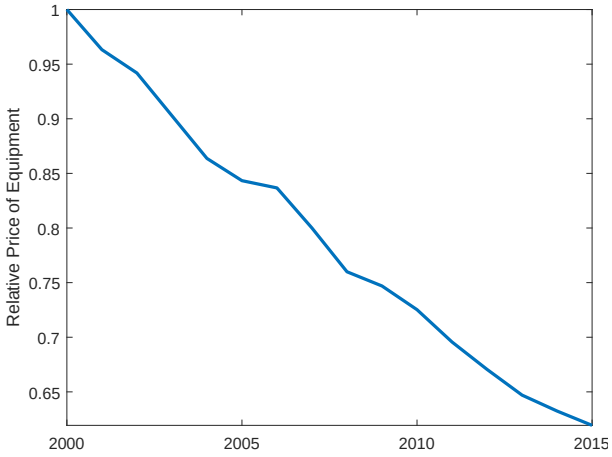
The skill-biased technological change has been considered as the most prominent channel that drives the skill premium in both developed and developing countries during the last two decades. Many studies support the idea that technology is embodied in capital goods, and therefore, the technical change of the last decades is reflected in a decline in the relative price of capital goods. If capital substitutes more for unskilled than for skilled labor (Griliches 1969), then this decrease in the price of capital goods pushes up the relative demand for skilled labor and drives up the skill premium, see e.g. Greenwood, Hercowitz, and Krusell (1997) and Krusell, Ohanian, Rios-Rull, and Violante (2000). This finding is also confirmed by Ge and Yang (2014), who find that skill-biased technological change is one of the major factors behind the rising skill premium in China.

We now examine if the skill-biased technological change contributes to the structural break of the skill premium in 2009. Figure 11 plots prices of equipment in China from 2000 to 2015. The persistent drop from 2000 to 2015 indicates that there has been significant technological improvement in equipment in China. However, there is no slowdown of the decline in equipment prices around 2009. Therefore, the skill-biased technological change can not explain the fall in the skill premium after 2009.

7 Conclusion

In this paper, we study how a preferential lending policy reduces the skill premium by increasing the relative demand for unskilled workers, motivated by the recent experience of China. Since 2009, as the local governments in China obtained a new financing method to borrow and spend in their preferred sector, which is unskilled-labor intensive, the wages of the unskilled workers started to grow faster, leading to a decline of the skill premium. We incorporate this novel mechanism into a two-sector growth model and evaluate the effect of

Figure 11: Relative Price of Equipment



the preferential lending policy quantitatively. The simulation results indicate that the model can account for most of the skill premium decline in China after 2009. We emphasize that although the preferential lending policy promotes local output in the short run, it sacrifices consumption and induces welfare loss in the long run.

Our present study focuses on the preferential lending policy to provide a transparent quantification of the new channel, which is successful in explaining the declining skill premium after 2009. However, building a fully-fledged model with skill-biased technological progress to explain quantitatively the rising skill premium in China before 2009 remains an important topic. We leave this for future research.

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Appendix

A Data

A.1 Urban Household Surveys

We describe the data we use in the regression:

- 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.[19]
- 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.

Note that in the Urban Household Survey, a worker is considered having high school education if the highest education he attends is high school, no matter he obtained a degree or not. Therefore, attending high school right now, dropped out of high school, attended high school but didn't get the degree, and obtained high school degree are all considered as high school education level. Similar definition applies to other education level. Hence, as long as the worker attended high school, he is considered skilled in this paper.

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

A.2 Additional Figures on Skill Premium

Figure 12 shows the college premium, which is defined as wage of workers with a college education or above relative to those with a high school education or below, holding the distribution of worker attributes fixed, such as sex, experience, and province.

Figure 12: College Skill Premium

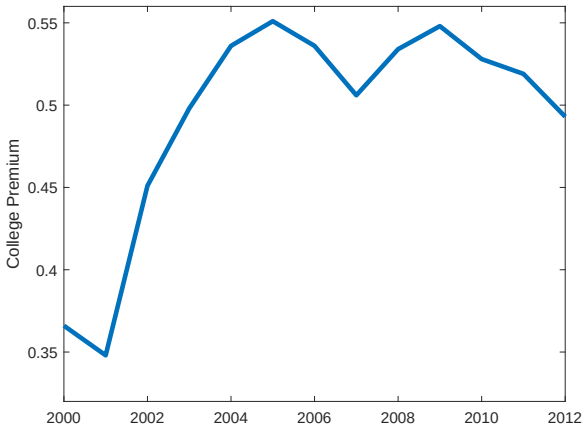
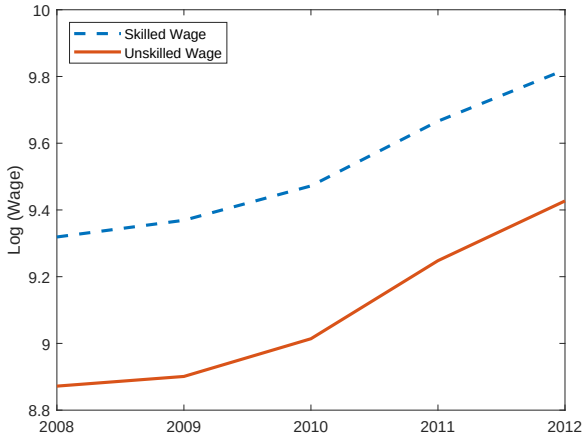


Figure 13 shows the wage level for the skilled worker (high school and above education) and the unskilled worker (middle school and below education) between 2008 and 2012. The wage of unskilled worker started to grow faster after 2009.

Figure 13: Skilled and Unskilled Wage



A.3 Average Schooling Year

In Table 3 below, we list the average schooling year for each one-digit industry within the preferred and non-preferred sector.[20]

Table 3: Average Schooling Year of One-Digit Industries

	Preferred Sector	ASY
A	Agriculture, Forestry, Animal Husbandry, and Fishery	7.31
E	Construction	8.75
F	Transport, Storage, and Post	9.75
N	Management of Water Conservancy, Environment, and Public Facilities	9.99
D	Production and Supply of Electricity, Gas, and Water	11.64
R	Culture, Sports, and Entertainment	11.80
Q	Health, Social Security, and Social Welfare	12.79
	Average of Preferred Sector	8.83

	Non-Preferred Sector	ASY
O	Services to Households and Other Services	8.76
I	Hotels and Catering Services	9.19
C	Manufacturing	9.47
B	Mining	9.68
H	Wholesales and Retail Trades	9.80
K	Real Estate	11.35
L	Leasing and Business Services	11.80
G	Information Transmission, Computer Services and Software	12.86
S	Public Management and Social Organization	13.17
J	Financial Intermediation	13.46
M	Scientific Research, Technical Services, and Geological Prospecting	13.52
P	Education	14.04
	Average of Non-Preferred Sector	10.35

[20] It is discussed in the literature by Chen (1988), Rawski and Mead (1998), and Brandt and Zhu (2010) that the National Bureau of Statistics overestimates the agriculture employment in China. Following Brandt and Zhu (2010), we construct an alternative estimate of the agriculture employment by using detailed labor supply data from the Rural Household Surveys and the Rural Migrant Monitor Surveys and use it to compute the industry level average schooling year. If we use the official data, the average schooling year of the preferred sector is even lower, with a value of 8.61.

B Analytical Derivation

In this section, we prove Propositions 1 and 2.

Derivation of Equation (4.2): By CES price aggregator, equation (3.11), we have

$$\hat{p}_{2t} = -\frac{\lambda_1^p}{1-\lambda_1^p}\hat{p}_{1t}. \tag{B.1}$$

where $\lambda_1^p \equiv \varphi^\sigma \left(\bar{p}_1\right)^{1-\sigma}$, and $\bar{p}_1$ is the steady state value of price of goods 1.

Firm's optimal decision on production of intermediate goods, equation (3.10), can be rewritten as

$$\hat{y}_{1t} - \hat{y}_{2t} = \sigma\left(\hat{p}_{2t} - \hat{p}_{1t}\right). \tag{B.2}$$

Then, using intermediate goods producer's optimal decision on capital allocation, equation (3.9), we have

$$\Delta r_t = \left(\hat{p}_{2t} - \hat{p}_{1t}\right) + \left(\hat{y}_{2t} - \hat{y}_{1t}\right) - \left(\hat{k}_{2t} - \hat{k}_{1t}\right). \tag{B.3}$$

Put equations (B.1), (B.2), and (B.3) together, we can solve for $\hat{p}_{1t}$ as follows,

$$\hat{p}_{1t} = \frac{1-\lambda_1^p}{\sigma - 1}\left[\Delta r_t - \left(\hat{k}_{1t} - \hat{k}_{2t}\right)\right]. \tag{B.4}$$

By firm's production function, equation (3.2), we have

$$\hat{y}_{1t} - \hat{y}_{2t} = \left(\alpha_1 \hat{l}_{1t} - \alpha_2 \hat{l}_{2t}\right) + \left(\beta_1 \hat{s}_{1t} - \beta_2 \hat{s}_{2t}\right) + \left(\gamma_1 \hat{k}_{1t} - \gamma_2 \hat{k}_{2t}\right). \tag{B.5}$$

In addition, firm's optimal decisions on capital and labor allocation, equations (3.9), imply

$$\hat{l}_{1t} - \hat{l}_{2t} = \left(\hat{k}_{1t} - \hat{k}_{2t}\right) - \Delta r_t. \tag{B.6}$$

$$\hat{s}_{1t} - \hat{s}_{2t} = \left(\hat{k}_{1t} - \hat{k}_{2t}\right) - \Delta r_t. \tag{B.7}$$

Substitute equations (B.6) and (B.7) into equation (B.5), we obtain

$$\hat{y}_{1t} - \hat{y}_{2t} = \left(\alpha_1 - \alpha_2\right)\hat{l}_{1t} + \left(\beta_1 - \beta_2\right)\hat{s}_{1t} + \left(\gamma_1 - \gamma_2\right)\hat{k}_{1t} + \left(\hat{k}_{1t} - \hat{k}_{2t}\right) - \left(\alpha_2 + \beta_2\right)\Delta r_t. \tag{B.8}$$

Then, we log-linearize the factor market clear conditions, equations (3.12), to a first oder approximation, and we have

$$\hat{l}_{1t} = \hat{l}_t + \left(1 - \lambda_1^L\right)\left(\hat{l}_{1t} - \hat{l}_{2t}\right), \tag{B.9}$$

$$\hat{s}_{1t} = \hat{s}_t + \left(1 - \lambda_1^S\right)\left(\hat{s}_{1t} - \hat{s}_{2t}\right), \tag{B.10}$$

and

$$\hat{k}_{1t} = \hat{k}_t + \left(1 - \lambda_1^K\right)\left(\hat{k}_{1t} - \hat{k}_{2t}\right), \tag{B.11}$$

where λ_1^L, λ_1^S, and λ_1^K are the steady state value of unskilled, skilled labor share, and capital share in sector 1, respectively.

We further substitute equations (B.9), (B.10) and (B.11) into (B.7), and obtain the following:

$$\begin{aligned}\hat{y}_{1t} - \hat{y}_{2t} =& \phi_0 + \left[1 - (\alpha_1 - \alpha_2)\,\lambda_1^L - (\beta_1 - \beta_2)\,\lambda_1^S - (\gamma_1 - \gamma_2)\,\lambda_1^K\right]\left(\hat{k}_{1t} - \hat{k}_{2t}\right) \\ & - \left[\alpha_1 + \beta_1 - (\alpha_1 - \alpha_2)\,\lambda_1^L - (\beta_1 - \beta_2)\,\lambda_1^S\right]\Delta r_t\end{aligned}, \tag{B.12}$$

where $\phi_0 \equiv \left[(\alpha_1 - \alpha_2)\,\hat{l}_t + (\beta_1 - \beta_2)\,\hat{s}_t + (\gamma_1 - \gamma_2)\,\hat{k}_t\right]$ is a parameter that captures the changes in factor endowment. Note that ϕ_0 does not change with the policy shocks, τ_t. To save the notations as well as keep a neat expression, without loss of generality, we let ϕ_0 equal to 0 in the follow derivation.

In a final step, putting equations (B.1), (B.2), and (B.4) into (B.12), we obtain equation (4.2).

Derivation of Equations (4.3) and (4.4): Once we get the expression for $(\hat{k}_{1t} - \hat{k}_{2t})$ as in equation (4.2), we substitute it into equations (B.6) and (B.7) and (4.4). We then obtain equations (4.3) and (4.4), respectively.

Derivation of Conditions that $\lambda_1^L > \lambda_1^S$ and $\lambda_1^L > \lambda_1^K$: By optimal conditions of labor allocations across sectors, $w_{Lt} = \alpha_i p_{it} \frac{Y_{it}}{L_{it}}$ and $w_{St} = \beta_i p_{it} \frac{Y_{it}}{S_{it}}$, we have

$$\frac{\alpha_1}{\beta_1}\frac{S_1}{L_1} = \frac{\alpha_2}{\beta_2}\frac{S_2}{L_2}. \tag{B.13}$$

Note that $\lambda_1^L = L_1/L$ and $\lambda_1^S = S_1/S$. We can rewrite equation (B.13) as the following:

$$\frac{\alpha_1}{\beta_1}\frac{\lambda_1^S}{\lambda_1^L} = \frac{\alpha_2}{\beta_2}\frac{1 - \lambda_1^S}{1 - \lambda_1^L}, \tag{B.14}$$

which can be further written as

$$\frac{1}{\lambda_1^L} = \frac{\alpha_2}{\alpha_1}\frac{\beta_1}{\beta_2}\frac{1}{\lambda_1^S} + \left(1 - \frac{\alpha_2}{\alpha_1}\frac{\beta_1}{\beta_2}\right). \tag{B.15}$$

Since $\alpha_1 > \alpha_2$ and $\beta_2 > \beta_1$, obviously we have $\frac{\alpha_2}{\alpha_1}\frac{\beta_1}{\beta_2} < 1$. Therefore, equation (B.15) implies

$$\frac{1}{\lambda_1^L} < \frac{\alpha_2}{\alpha_1}\frac{\beta_1}{\beta_2}\frac{1}{\lambda_1^S}, \tag{B.16}$$

which gives us the following conditions, given that $\frac{\alpha_1}{\alpha_2}\frac{\beta_2}{\beta_1} > 1$:

$$\lambda_1^L > \frac{\alpha_1}{\alpha_2}\frac{\beta_2}{\beta_1}\lambda_1^S > \lambda_1^S. \tag{B.17}$$

Similarly, we can derive the condition that $\lambda_1^L > \lambda_1^K$, as long as $\alpha_1 > \alpha_2$ and $\gamma_2 > \gamma_1$ are satisfied. In particular, combine $w_{Lt} = \alpha_i p_{it}\frac{Y_{it}}{L_{it}}$ and $r_t = \gamma_i p_{it}\frac{Y_{it}}{K_{it}}$, we have

$$\frac{\alpha_1}{\gamma_1}\frac{K_1}{L_1} = \frac{\alpha_2}{\gamma_2}\frac{K_2}{L_2}. \tag{B.18}$$

Given the definition of λ_1^L and λ_1^K that $\lambda_1^L = L_1/L$ and $\lambda_1^K = K_1/K$, the equation (B.18) can be further written as the following:

$$\frac{1}{\lambda_1^L} = \frac{\alpha_2}{\alpha_1}\frac{\gamma_1}{\gamma_2}\frac{1}{\lambda_1^K} + \left(1 - \frac{\alpha_2}{\alpha_1}\frac{\gamma_1}{\gamma_2}\right). \tag{B.19}$$

Given $\alpha_1 > \alpha_2$ and $\gamma_2 > \gamma_1$, and thereby $\frac{\alpha_2}{\alpha_1}\frac{\gamma_1}{\gamma_2} < 1$, the equation (B.19) implies

$$\lambda_1^L > \lambda_1^K. \tag{B.20}$$

Derivation of Equation (4.6): By firm's optimal decisions on skilled and unskilled labor allocation, equation (3.9), we have

$$\hat{w}_{St} - \hat{w}_{Lt} = \hat{l}_{it} - \hat{s}_{it}. \tag{B.21}$$

We substitute equations (B.9) and (B.10) into equation (B.21), we obtain equation (4.6).

Derivation of Equation (4.8): By definition of θ_{it}, we have

$$\hat{\theta}_{1t} - \hat{\theta}_{2t} = (\hat{p}_{1t} - \hat{p}_{2t}) + (\hat{y}_{1t} - \hat{y}_{2t}), \tag{B.22}$$

By putting equations (B.3), (B.22) and (4.2) together, we obtain equation (4.8).

Derivation of Equation (4.9): Note that the aggregate output can be written as

$$Y_t = p_{1t}Y_{1t} + p_{2t}Y_{2t} = \theta_{1t} + \theta_{2t}, \tag{B.23}$$

Then, log-linearize equation (B.13), we have

$$\hat{y}_t = \lambda_1^\theta \hat{\theta}_{1t} + \left(1 - \lambda_1^\theta\right)\hat{\theta}_{2t}, \tag{B.24}$$

where λ_θ^1 is the steady state value of sectoral output share in sector 1.

Rewrite equation (B.24) as the following

$$\hat{y}_t = \hat{\theta}_{2t} + \lambda_1^{\theta} \left(\hat{\theta}_{1t} - \hat{\theta}_{2t} \right). \tag{B.25}$$

The preferential lending policy depresses the effective interest rate in preferred sector, i.e., condition (4.1) hold. Therefore, we have

$$\frac{\partial \left(\hat{\theta}_{1t} - \hat{\theta}_{2t} \right)}{\partial \tau_t} > 0. \tag{B.26}$$

Define $\underline{\lambda} \equiv \max \{ \frac{-\hat{\theta}_{2t}}{\hat{\theta}_{1t} - \hat{\theta}_{2t}} \}$. The following condition holds as long as $\lambda_1^{\theta} > \underline{\lambda}$:

$$\frac{\hat{y}_t}{\partial \tau_t} > 0. \tag{B.27}$$

Therefore, the preferential lending policy is capable of promoting the aggregate output as long as the steady state preferred output share is above certain threshold, that is $\lambda_1^{\theta} > \underline{\lambda}$.

C Shooting Algorithm for Solving the Model

C.1 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:
$$r_d = \frac{1}{\beta} - 1; \tag{C.1}$$

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

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

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

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

6. using the optimal conditions for sector 2,
$$\left(\frac{K_2}{L_2}\right)^{\alpha_2 - \frac{(1-\alpha_2)(1-\beta_2)}{\beta_2}} = \beta_2 (\alpha_2)^{\frac{1-\beta_2}{\beta_2}} (p_2 A_2)^{\frac{1}{\beta_2}} (w_L)^{-\frac{1-\beta_2}{\beta_2}} (w_S)^{-1} \text{ and} \tag{C.6}$$
$$\left(\frac{K_2}{S_2}\right) = (\alpha_2 p_2 A_2)^{\frac{1}{\beta_2}}\left(\frac{K_2}{L_2}\right)^{\frac{1-\alpha_2}{\beta_2}} (w_L)^{-\frac{1}{\beta_2}}; \tag{C.7}$$
$$r_{2t} = (1-\alpha_2-\beta_2)\, p_{2t} A_{2t}\left(\frac{K_{2t}}{L_{2t}}\right)^{-\alpha_2}\left(\frac{K_{2t}}{S_{2t}}\right)^{-\beta_2}; \tag{C.8}$$

7. using the product function,
$$\frac{Y_1}{L_1} = A_1\left(\frac{K_1}{L_1}\right)^{1-\alpha_1}\left(\frac{K_1}{S_1}\right)^{-\beta_1} \text{ and} \tag{C.9}$$

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

8. optimal allocation across sectors,

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

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

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

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

10. capital allocation and output in each sector:

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

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

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

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

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

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

11. total capital stock,

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

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

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

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

13. aggregate output,

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

14. solve the consumption by:

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

The household budget constraint is satisfied automatically.

C.2 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.[21]

   (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,

$$\frac{U'(c_t)}{U'(c_{t+1})} = \beta\left(1 + r_{dt+1}\right). \tag{C.25}$$

   (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 some point in the future. Similarly, if the guessed value of K_2 is too low, then the

[21] See Appendix C.3 for details.

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.

C.3 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 $\{p_{it}, w_{Lt}, w_{St}, r_{2t}\}$, 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
$$p_{2t} = \left[\frac{1 - \varphi^{\sigma} (p_{1t})^{1-\sigma}}{(1-\varphi)^{\sigma}}\right]^{\frac{1}{1-\sigma}}; \tag{C.26}$$

2. choose w_{St} and solve for K/S
$$\left(\frac{K_{1t}}{S_{1t}}\right) = \frac{w_{St}}{r_{1t}} \frac{(1 - \alpha_{1t} - \beta_{1t})}{\beta_{1t}}; \tag{C.27}$$

3. obtain K/L and w_L as
$$\left(\frac{K_{1t}}{L_{1t}}\right)^{\alpha_1} = \gamma_1 \frac{p_{1t} A_1}{r_{1t}} \left(\frac{K_{1t}}{S_{1t}}\right)^{-\beta_1} \text{ and} \tag{C.28}$$
$$w_{Lt} = \alpha_1 p_{1t} A_1 \left(\frac{K_{1t}}{L_{1t}}\right)^{1-\alpha_1} \left(\frac{K_{1t}}{S_{1t}}\right)^{-\beta_1}; \tag{C.29}$$

4. using the optimal conditions for sector 2,
$$\left(\frac{K_{2t}}{L_{2t}}\right)^{\alpha_2 - \frac{(1-\alpha_2)(1-\beta_2)}{\beta_2}} = \beta_2 (\alpha_2)^{\frac{1-\beta_2}{\beta_2}} (p_{2t} A_2)^{\frac{1}{\beta_2}} (w_{Lt})^{-\frac{1-\beta_2}{\beta_2}} (w_{St})^{-1}; \tag{C.30}$$

$$\left(\frac{K_{2t}}{S_{2t}}\right) = (\alpha_2 p_{2t} A_2)^{\frac{1}{\beta_2}} \left(\frac{K_{2t}}{L_{2t}}\right)^{\frac{1-\alpha_2}{\beta_2}} (w_{Lt})^{-\frac{1}{\beta_2}} \text{ and} \tag{C.31}$$

$$r_{2t} = \gamma_2 p_{2t} A_2 \left(\frac{K_{2t}}{L_{2t}}\right)^{-\alpha_2} \left(\frac{K_{2t}}{S_{2t}}\right)^{-\beta_2}; \tag{C.32}$$

5. using the product function in each sector,

$$\frac{Y_{1t}}{L_{1t}} = A_1 \left(\frac{K_{1t}}{L_{1t}}\right)^{1-\alpha_1} \left(\frac{K_{1t}}{S_{1t}}\right)^{-\beta_1}; \tag{C.33}$$

$$\frac{Y_{2t}}{L_{2t}} = A_2 \left(\frac{K_{2t}}{L_{2t}}\right)^{1-\alpha_2} \left(\frac{K_{2t}}{S_{2t}}\right)^{-\beta_2}; \tag{C.34}$$

6. using the optimal allocation across sectors, we have

$$\frac{L_{1t}}{L_{2t}} = \frac{\frac{Y_{2t}}{L_{2t}}}{\frac{Y_{1t}}{L_{1t}}} \frac{Y_1}{Y_2} = \frac{\frac{Y_2}{L_2}}{\frac{Y_1}{L_1}} \left(\frac{\varphi}{1-\varphi} \frac{p_{2t}}{p_{1t}}\right)^{\sigma}; \tag{C.35}$$

7. from labor market clearing conditions,

$$L_{2t} = \frac{L}{1 + \frac{L_{1t}}{L_{2t}}} \text{ and} \tag{C.36}$$

$$L_{1t} = L - L_{2t}; \tag{C.37}$$

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

$$K_{1t} = L_{1t} \left(\frac{K_{1t}}{L_{1t}}\right); \tag{C.38}$$

$$S_{1t} = K_{1t} \left(\frac{K_{1t}}{S_{1t}}\right)^{-1}; \tag{C.39}$$

$$K_{2t} = \frac{K_{2t}}{L_{2t}} L_{2t} \text{ and} \tag{C.40}$$

$$S_{2t} = K_{2t} \left(\frac{K_{2t}}{S_{2t}}\right)^{-1}; \tag{C.41}$$

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

$$K_{1t} + K_{2t} = K_t \text{ and} \tag{C.42}$$

$$S_{1t} + S_{2t} = S; \tag{C.43}$$

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

$$r_{dt} = r_{2t} - \delta. \tag{C.44}$$

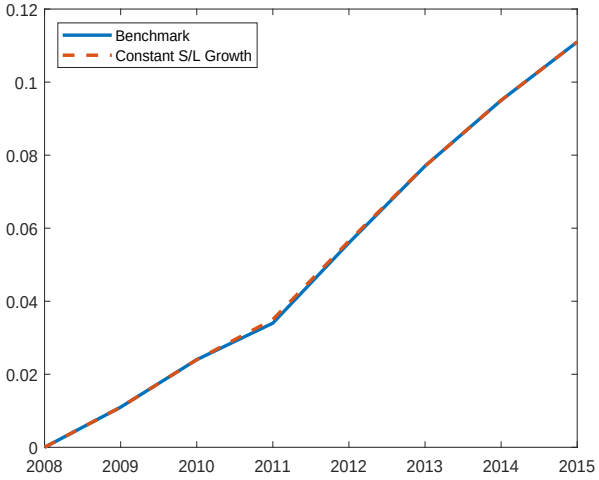
The other static variables $\{Y_{1t}, Y_{2t}, Y_t\}$ are given by the corresponding production functions (3.2) and (3.4).

D Counterfactual Experiment on Labor Supply

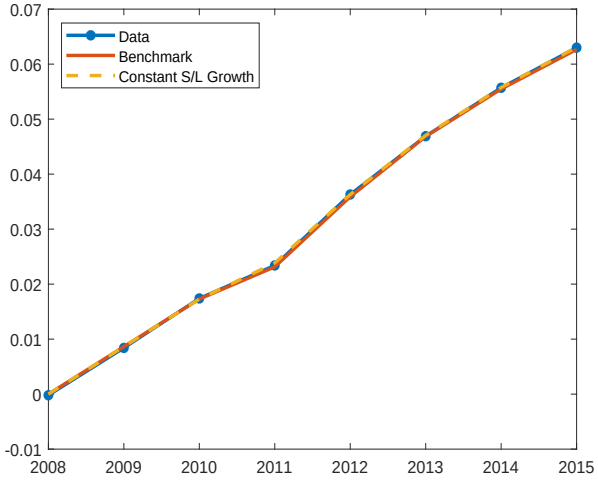
To quantify the changes of relative labor supply on the skill premium, we perform a counterfactual experiment where we keep the growth of relative skilled to unskilled labor supply the same as its pre-2009 level. That is, the relative quantity effect is removed. The dashed line in Figure 14 shows the counterfactual results, and the solid line shows our benchmark results with both relative quantity effect and reallocation effect. As shown in Panel C, the difference between the solid and the dashed line is minimal, which indicates that the changes in the relative skilled to unskilled labor supply after 2009 does not contribute much to the declining skill premium.

Figure 14: Counterfactual Experiment: Constant Growth of Labor Supply

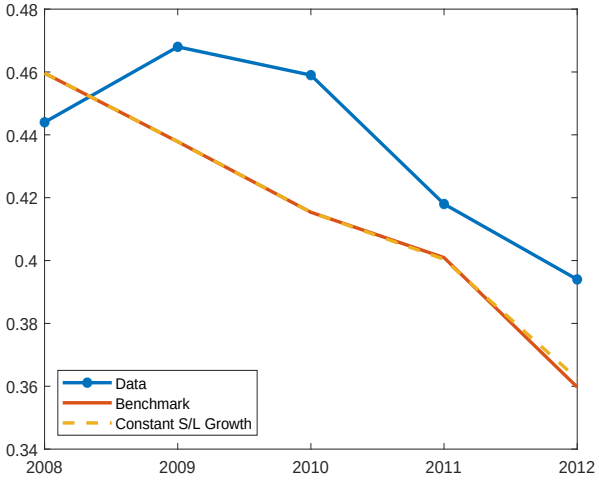
Panel A. Policy Instrument (τ)



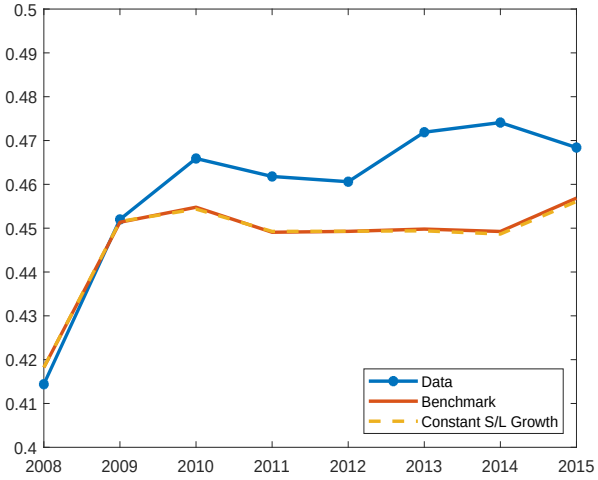
Panel B. Preferred Output Share



Panel C. Skill Premium



Panel D. Aggregate Investment Rate



Panel E. Preferred Investment Rate