FEDERAL RESERVE BANK OF SAN FRANCISCO

WORKING PAPER SERIES

The Crowding-In Effects of Local Government Debt in China

Xiaoming Li
University of International Business and Economics, China

Zheng Liu
Federal Reserve Bank of San Francisco

Yuchao Peng
Central University of Finance and Economics, China

Zhiwei Xu
Fudan University, China

November 2024

Working Paper 2024-35

https://doi.org/10.24148/wp2024-35

Suggested citation:

Li, Xiaoming, Zheng Liu, Yuchao Peng, and Zhiwei Xu. 2024. "The Crowding-In Effects of Local Government Debt in China." Federal Reserve Bank of San Francisco Working Paper 2024-35. https://doi.org/10.24148/wp2024-35

THE CROWDING-IN EFFECTS OF LOCAL GOVERNMENT DEBT IN CHINA

XIAOMING LI, ZHENG LIU, YUCHAO PENG, AND ZHIWEI XU

Abstract. We study how changes in the composition of Chinese local government debt influenced bank risk taking, credit allocation, and local productivity. Using confidential loan-level data and a difference-in-difference identification approach, we show that a debt-to-bond swap program for local governments implemented in 2015 significantly increased bank risk taking through a risk-weighting channel under Basel III capital regulations. The debt swap program converted bank holdings of municipal corporate debt to local government bonds, reducing banks' risk-weighted assets. Banks responded by lowering credit spreads on loans to privately owned firms (POEs) relative to state-owned enterprises (SOEs), with significantly larger reductions in POE credit spreads in provinces with more outstanding government debt. Furthermore, the credit reallocation toward more productive private firms—a crowding-in effect of the debt swap—significantly raised local productivity.

I. Introduction

In response to the 2008-2009 global financial crisis and the more recent COVID-19 pandemic, fiscal policy interventions have mitigated recessions but also led to surges in government debts. In the United States, for example, public debt outstanding surged from about 63 percent of GDP in 2007 to about 123 percent by 2023. During the same periods, the IMF estimates that China's general government debt also swelled from 29

Date: November 8, 2024. First version: May, 2022.

Key words and phrases. Local Government Debt, Credit Allocation, Bank Risk Taking, Misallocation. *JEL classification*: E52, G21, G28.

Li: University of International Business and Economics, China; Email: xmLI.15@saif.sjtu.edu.cn. Liu: Federal Reserve Bank of San Francisco; Email: Zheng.Liu@sf.frb.org. Peng: Central University of Finance and Economics, China; Email: yuchao.peng@cufe.edu.cn. Xu: Fudan University, China; Email: xuzhiwei09@gmail.com. We thank Haoyu Gao, Bo Jiang, Jun Pan, Yong Wang, Yi Wen, and seminar participants at Capital University of Economics and Business, Chinese Academy of Social Sciences, Dongbei University of Finance and Economics, Fudan University, Peking University, Renmin University of China, Shanghai Jiao Tong University, Shanghai University of Finance and Economics, Southwestern University of Finance and Economics, Xi'an Jiao Tong University, Zhejiang University for helpful comments. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of San Francisco or the Federal Reserve System.

percent of GDP in 2007 to 84 percent by 2023.[1] China's augmented government debt, which also includes implicit debt in the form of borrowings through local government financing vehicles (LGFV), jumped from under 50 percent of GDP in 2010 to 117 percent in 2023.[2]

The sharp increases in public debt have generated renewed interest in understanding how public debt interacts with private economic activity. Neoclassical theory suggests that an increase in government debt could crowd out private consumption and investment by pushing up interest rates or exacerbating credit misallocation. The crowding out effect is more pronounced for local government debt where the financial market is segmented. For example, Huang et al. (2020) document evidence that the surge in local government debt in China following the large-scale fiscal stimulus program during the global financial crisis crowded out private firm investment. New Keynesian models, on the other hand, suggest that increases in debt-financed government spending could stimulate private demand, and the stimulus effects are especially large in a deep recession when monetary policy faces the zero-lower-bound constraint on the nominal interest rate (for evidence, see, for example, Miyamoto et al. (2018) and Ramey and Zubairy (2018)).

While most empirical studies focus on changes in the *size* of government debt, our study focuses on changes in the *composition* of government debt. The composition of local government debt varies across countries. According to Pinardon-Touati (2024), bank loans account for 80% of local government debt in most large countries in 2016, with the US as a notable outlier, where bank loans represent only 5% of local government debt.[3] Utilizing a unique context of Chinese local government replacing bank loans with bonds, we provide causal evidence on how changes in the composition of local government debt can crowd in private investments. We argue that such changes in the public debt composition can have important macroeconomic consequences, especially on credit allocations and private investment through banks' risk-taking decisions.

To help understand the channels through which changes in the composition of government debt held by banks may affect bank lending decisions and credit allocation, we build

[1] Source: International Monetary Fund, General government gross debt for China [GGGDTACNA188N], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GGGDTACNA188N, November 5, 2024.

[2] Source: International Monetary Fund. "People's Republic of China: 2024 Article IV Consultation." IMF Staff Country Reports 2024, 258 (2024), accessed November 8, 2024, https://doi.org/10.5089/9798400284281.002.

[3] Ivanov and Zimmermann (2024) document the "privatization" of the US municipal debt due to funding pressures from the municipal bond market. The state and local governments have rapidly increased their reliance on private bank loans from about $30 billion before the Great Recession to over $200 billion in 2023.

a simple theoretical model of bank portfolio choice subject to a capital adequacy requirement (CAR) under Basel III capital regulations. The theory predicts that an increase in the share of bank assets with low risk weights (such as government bonds) would increase bank lending to high-risk projects and reduce credit spreads for those projects.

Empirically, we estimate the quantitative impact of changes in the composition of public debt induced by a local government debt restructuring program—a debt-to-bond swap program implemented in 2015—on bank lending to local firms in China. We identify the causal effects of the debt swap program on bank lending using a difference-in-difference (DID) approach. Before the debt restructuring program, local government debts were financed primarily through LGFVs, which are nominally corporate firms but are implicitly backed by local governments. The LGFVs could raise funds by issuing corporate bonds known as "municipal corporate bonds" (Chen et al., 2020). They could also raise funds through bank loans.[4] The debt-to-bond swap program requires local governments to replace their implicit debt, such as municipal corporate bonds and LGFV corporate loans by local government bonds.[5] Under the Basel III capital regulations, banks assign lower risk weights to their holdings of government bonds than to those of corporate bonds or corporate loans. According to our theory, the increase in the share of local government bonds (in place of LGFV debt) should reduce the banks' risk-weighted assets, enabling them to shift lending to riskier firms with higher returns.

Under China's prevailing policy, state-owned firms (SOEs) receive preferential credit access, with implicit government guarantees (Song et al., 2011; Chang et al., 2019; Liu et al., 2021) . Accordingly, Chinese banks assign higher credit ratings to SOEs than to private firms (Li et al., 2024). Consistent with the predictions of our theory, we document robust empirical evidence that the debt-to-bond swap program has significantly reduced the credit spread for private firms (POEs) relative to SOEs.[6] This finding suggests that the change in the composition of local government debt on banks' balance sheets created a crowding-in effect on private investment. Consistent with the empirical evidence that POEs are on average more productive than SOEs (Hsieh and Klenow, 2009), we find that the crowding in effects of the local government debt swap led to improved local productivity.

[4] Much of the 2008-09 large-scale fiscal stimulus was implemented by China's local governments, which financed infrastructure investment through bank loans to LGFVs (Bai et al., 2016; Zilibotti, 2017; Deng et al., 2015; Chen et al., 2020). See He and Wei (2023) for a review of the related literature.

[5] On November 8, 2024, China announced a new \$1.4 trillion package over five years to help local governments swap some of their off-balance-sheet debt.

[6] In a complementary study, Geng and Pan (2024) examine the credit allocation between SOEs and non-SOEs using pricing information from China's credit market (outside of the banking sector).

For our estimation, we use confidential loan-level data from one of the Big Five banks in China, combined with province-level government debt data and firm-level balance sheet data for China's manufacturing industry. We find that the implementation of the debt swap program in 2015 led to a significant decline in the gap between the loan rate for POEs and that for SOEs (i.e., the POE credit spread), and the decline in the POE credit spread is more pronounced in provinces with higher initial levels of outstanding government debt. In particular, in a province with the average level of initial government debt, the debt-to-bond swap reduced the POE credit spread by about 3.18 percent. In a province with an initial government debt that is one standard deviation above the mean, the debt-to-bond swap reduced the POE credit spread further by about 1.15 percent. These estimates are both statistically significant and economically important. Pre-trend tests suggest that significant reductions in the POE credit spread can be observed only after the implementation of the debt swap program in 2015, but not before.

The local government debt swap not only reduced the relative loan rate on POE loans (an intensive margin), but also increased the probability of lending to POE firms (an extensive margin). We estimate that, in a province with initial government debt that is one standard deviation above the mean, the debt swap program raised the probability of bank lending to POE firms relative to SOEs by about 1.2 percent.

We further show that the debt swap program is a key channel through which changes in the composition of local government debt led to changes in bank lending. Following Bertrand and Mullainathan (2001), we estimate a two-stage least square (2SLS) specification, using the amount of local government debt to be swapped as the channeling variable. We instrument the channeling variable by the interactions between the initial outstanding local government debt and a post-2015 dummy that indicates the years after the debt swap program was implemented. The second-stage regression indicates that in regions with more local government debt (before 2015) to be swapped to government bonds, the loan interest rates for POE firms declined significantly more relative to those for SOEs, and POE firms are also more likely to obtain bank loans relative to SOEs after the implementation of the debt swap program.

The magnitude of the effects of the debt swap program on bank lending to POE firms depends on several characteristics of POE firms. The reduction in credit spreads for a POE firm following the debt swap program is greater if the firm is smaller (in terms of assets), has a lower credit rating, or is located further away from the lender. These findings provide further evidence that the debt-to-bond swap encouraged bank risk-taking. Since local government bonds held by commercial banks are assigned with lower risk weights under Basel III regulations, the debt swap program reduced the risk-weighted bank assets, allowing banks to increase risk-taking in their lending.

Our empirical results are robust. We obtain similar findings when we restrict our sample to exclude LGFV firms, large firms, or local SOEs. The results are also robust when we include additional controls, such as local governments' debt capacity, local GDP growth, and population age. The debt swap program's effects on bank lending differ from those of other policy reforms, such as the deleveraging policy implemented in 2016.

The increased bank lending to POE firms following the debt swap program has important implications for capital allocations and aggregate productivity. We find that those provinces with higher outstanding government debt before implementing the debt swap program have experienced significantly larger increases in total factor productivity (TFP) after the program was put in place in early 2015. This finding adds to the literature on the reallocation effects of policy changes in a distorted economy, both for China (Bleck and Liu, 2018; Cong et al., 2019; Gao et al., 2021; Liu et al., 2021; Li et al., 2024) and for other economies (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009; Gopinath et al., 2017).

Our work contributes to the literature on the linkages between local government debt and private investment. In a closely related study, Huang et al. (2020) document evidence that the surge in local government debt in the form of LGFV debt following the 2008-2009 large-scale fiscal stimulus tightened private firms' funding constraints and crowded out private investment, while leaving SOE investment relatively unaffected. They find that private firms invest less in cities with more public debt, with the reduction in investment larger for firms located farther from banks in other cities or more dependent on external funding. Similar "local crowding out" effects are also observed in Germany (Hoffmann et al., 2021) and France (Pinardon-Touati, 2024). This literature typically focuses on the impact of changes in the size of local government debt on private investment.[7]

Complementary to this literature, we focus on changes in the composition (instead of the size) of local government debt held by commercial banks. Our paper highlights a new risk-weighting channel that connects local government debt with private investment. We show that changing the forms of financing for local government debt (in particular, the

[7]Other related studies have documented the effects of government debt on corporate financing and investments for the US federal government debt (Graham et al., 2014), the US municipal bond (Graham et al., 2014; Adelino et al., 2017), Colombia (Williams, 2018; Önder et al., 2024), and in an international setting (Demirci et al., 2019). Moreover, previous literature also provides evidence on how shifts in sovereign risk affected private credits (Altavilla et al., 2017; Acharya et al., 2018; Bofondi et al., 2018; Becker and Ivashina, 2018; Ongena et al., 2019; De Marco, 2019; Bottero et al., 2020; Baskaya et al., 2024).

debt-to-bond swap) can have significant impacts on bank lending because it changes the composition and the effective riskiness of bank asset holdings. We find that converting local government debts previously financed through LGFV debts into local government bonds led to a significant decline in banks' risk-weighted assets, because government bonds are assigned lower risk weights than LGFV debts under Basel III regulations. Banks respond to a decline in risk-weighted assets by increasing lending to private firms that are more productive and also perceived as riskier borrowers. In line with the findings of Huang et al. (2020), we find that the bank lending responses to the debt-to-bond swap program are highly heterogeneous across regions, and in regions with higher initial levels of local government debt, bank lending responded more to the debt swap program.

More broadly, our paper contributes to the emerging literature on Chinese local government debts and their real consequences following the 2009 four-trillion stimulus in response to the global financial crisis. Most of this massive stimulus package was implemented through local governments, who finance the infrastructure investment by bank loans through the off-balance-sheet local government financing vehicles (LGFVs) (Deng et al., 2015; Bai et al., 2016; Zilibotti, 2017; Cong et al., 2019; Gao et al., 2021; Chen et al., 2023). The 2009 stimulus package was behind the rapid growth of shadow banking after 2012, expediting the development of Chinese corporate bond markets in the post-stimulus period.(Ang et al., 2016; Liu et al., 2017; Chen et al., 2020; Wang et al., 2022) In contrast, our paper explores a more recent aftermath of the stimulus plan—the emergence of Chinese local government bonds, which are *explicitly* guaranteed by Chinese local governments unlike the *implicitly* guaranteed Chinese municipal corporate bonds. We document the unintended yet positive consequences of the 2015 debt-to-bond swap program that reshaped the debt composition of Chinese local governments.

To our knowledge, our paper is the first to examine how changes in the composition of local government debt influence private financing and investment using detailed loan- and firm-level data.

In what follows, Section II provides some institutional backgrounds of China's local government debt reform, Section III presents a simple model featuring bank portfolio choice decisions subject to capital adequacy requirements (CAR), Section IV describes the data sample, the empirical methods, and our main empirical findings, and Section V provides some concluding remarks.

II. China's local government debt-to-bond swap: Some backgrounds

Following China's large-scale fiscal stimulus implemented during the 2008-09 global financial crisis, local government debt surged. Between 2006 and 2013, local government debt outstanding jumped from 5.8% of GDP to 22% (Huang et al., 2020). By the end of 2014, the stock of local government debt rose further to RMB 15.4 trillion, equivalent to 24% of GDP. The Chinese central government tightened regulations by amending the budget law adopted in 1994 to rein in further expansions of local government borrowing. Under the amended budget law, which became effective in early 2015, local governments are required to convert all outstanding debt to local government bonds, and new debt can only be raised through issuing government bonds.

Accompanying the budget law reform, in September 2014, the State Council of the Chinese government published "*Opinions on Strengthening the Administration of Local Government Debts*" (hereafter *Opinion*), establishing a local government direct financing mechanism and the corresponding monitoring system. The *Opinion* sets up a screening process to assess the outstanding debt for which the local governments have repayment obligations. At the end of 2014, the central government concluded the screening process, identifying RMB 15.4 trillion outstanding debt as local governments' repayment obligations. The central government further established a three-year debt-to-bond swap program, starting in early 2015, requiring all local governments to replace their outstanding debt with local government bonds. Before implementing the debt swap program, there were six types of local government debt, including government bonds, bank loans, corporate bonds issued by LGFVs, build-and-transfer loans, trusts, and medium-term notes and short-term financing bills. Out of these six types of debt, government bonds accounted for only 8% of the total outstanding debt. The remaining 92% of the debt, worth about RMB 14.17 trillion, would need to be converted to local government bonds through the debt swap program within three years. Bank loans that were counted as local government debt (in the form of LGFV lending) was the largest component (about 55.4%) of the outstanding debt to be swapped to local government bonds.[8]

Starting in 2015, the newly increased government debt and the swapped outstanding debt must be issued by the provincial governments in the government bonds market. Table 1 displays the aggregate level of local government bonds and their components from 2015 to 2018. The newly issued government bonds are used to swap the outstanding debt assessed at the end of 2014 and to finance the newly increased government debt. The table shows that in the first three years after the implementation of regulation, the government bonds for debt swap account for a major part of the newly issued government bonds. In the year 2015, 83.5% of the newly issued government bonds are used to swap the outstanding debt. The ratio declines over time, but the swapped debt still accounts for 47.9% total newly issued government bonds in 2018. The table also implies that by

[8]Source: the Budget Working Committee of the Standing Committee of the National People's Congress. Website: http://www.npc.gov.cn/zgrdw/npc/zgrdzz/2016-03/29/content_1986294.htm.

Table 1. Local government bonds and debt

	Local Government Bond				Local Government Debt
	(1)	(2)	(3)	(4)	(5)
year	outstanding	newly-issued	swapped	increased	outstanding
2014	1162.3	–	–	–	15407.4
2015	4825.4	3835.1	3202.4 (83.5%)	632.7 (16.5%)	14756.8
2016	10624.0	6045.8	4876.0 (80.7%)	1169.8 (19.3%)	15355.8
2017	14741.5	4358.1	2768.3 (63.5%)	1589.8 (36.5%)	16510.0
2018	18067.0	4165.2	1994.7 (47.9%)	2170.5 (52.1%)	18461.9
Sum	–	18404.2	12841.4 (69.8%)	5562.8 (30.2%)	–

Notes: This table reports the local government bonds and the components. Column (1) is the outstanding of local government bonds. Column (2) is the newly issued local government bonds. Columns (3) and (4) are newly issued bonds for debt swap and increased debt, respectively. Column (5) is the local government's outstanding debt, including government-bond and non-government-bond debt. The difference between Columns (5) and (1) is the local government debt has not been swapped or matured at the end of 2018. All the variables are end-of-year. The unit is billions of RMB. The numbers in parentheses indicate the percentage of newly issued bonds that the corresponding component accounts for. Data source: Ministry of Finance of the People's Republic of China.

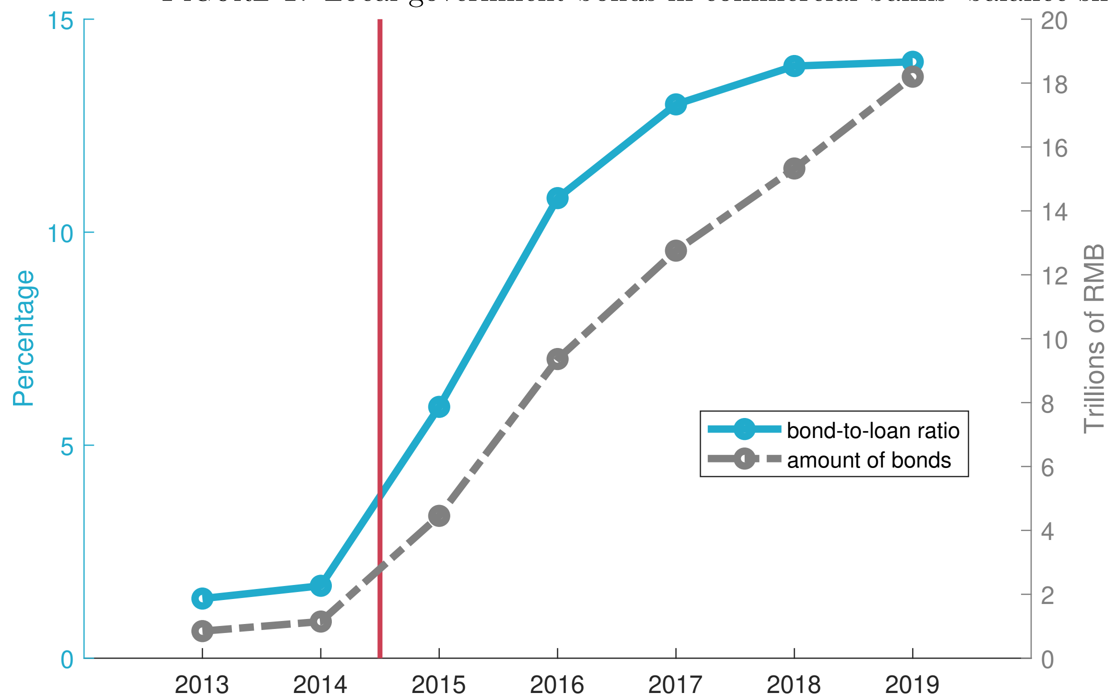
the end of 2018, more than 90% non-government-bond debt had been swapped at the end of 2014.[9]

Commercial banks are the largest and main holders of newly issued government bonds. From 2014 to 2018, on average 88% of the local government bonds are held by commercial banks. The share of government bonds in the commercial banks' assets increases sharply after implementing regulation on the local government debt. Figure 1 shows that in the balance sheet of commercial banks, the government bonds only account for 1.4% of total assets in 2013 and 1.7% in 2014. The ratio surges after 2015 when the regulation becomes effective, increasing to 5.9% in 2015 and achieving 14% in 2019.[10] The large fraction of debt to be swapped in the outstanding debt associated with the fact that commercial banks are the major holders of government bonds indicate that the debt swap program provides a crucial channel through which the regulation may affect the bank's loan allocation decisions.

[9]The total amount of swapped debt by the end of 2018 is 12.8 trillion RMB; while the outstanding debt to be swapped at the end of 2014 is 14.17 trillion RMB.

[10]By the end of 2014, the bank-loan form of local government debt accounts for 12% of the total loans in the commercial banks' balance sheet. The ratio is close to the bond-to-loan ratio at the end of 2018 (13.9%).

FIGURE 1. Local government bonds in commercial banks' balance sheet



Notes: This figure shows the time series of the local government bonds held by commercial banks. The blue line (left axis) indicates the ratio between local government bonds and loans in the commercial banks' balance sheet. The grey line (right axis) indicates the total amount of local government bonds measured by billions of RMB held by commercial banks. The data covers the years of 2013 to 2019. Data source: China Central Depository & Clearing (CCDC) corporation; website: www.chinabond.com.cn

In our empirical analysis, we focus on one commercial bank, one of the Big Five in China. Since 2012, the China Banking Regulatory Commission (CBRC)-China's banking regulator-has implemented a new regulation on commercial banks' capital adequacy ratio (CAR). In particular, systemically important banks such as the Big Five must adopt the new approach to calculate the risk-weighted assets for CAR. According to the bank's CAR annual report, it employs the internal-rating-based (IRB) approach to evaluate the risk-weighted assets for the corporate loans and the regulatory approach for the local government bonds. The internal rating-based approach imposes weight on risky loans according to a risk-weighting function that increases credit risks. While for the regulatory approach, the bank imposes a fixed weight of 20% on the local government bonds. The average value of weights for corporate loans is above 80% for the Big Five banks from 2013 to 2018. Even for the high-quality loans belong to top credit rating categories, the average weight is larger than 50%. In addition, the implementation of the debt swap program not only reduces the risk-weighting of the asset in the commercial bank's balance sheet, it also reduces the risks of the local government debt. Two reasons may reduce the risks of the outstanding debt. First, the provincial government issued the newly issued bonds to swap the outstanding debt, though the prefecture-level government raises most of these debts. Thus, the provincial government would play the role of last resort for the government debt. Second, swapping the outstanding debt for bond largely alleviates the interest payment burden for the local government, as the bond rate is much lower than the loan rate.[11]

As the weights for corporate loans are much higher than the weight for government bonds, we expect that the regulation of local government debt, especially the debt swap program launched in 2015, may significantly change the volume of risk-weighted assets. The more local government debt in the form of corporate loans the bank holds, the larger the reduction in the risk-weighted assets after 2015. Figure 2 provides some cross-bank evidence about the positive relationship between the credit to public sectors in banks' balance sheets, which corresponds to the local government bond, and the total risks of banks' corporate loans measured by the average risk-adjusted weight on corporate loans. The figure shows that a bank holding larger local government bonds tends to take more risks. The result remains valid if we replace the bank credit to the public sector with the amount of local government bonds sold by the underwriter banks.[12]

III. A Simple Model of Banking with Local Government Debt

III.1. **A Baseline Model.** This section presents a static, partial equilibrium model to illustrate how the reform on local government debt affects the bank's capital allocation decisions. To begin with, we consider a simpler model without local government debt.

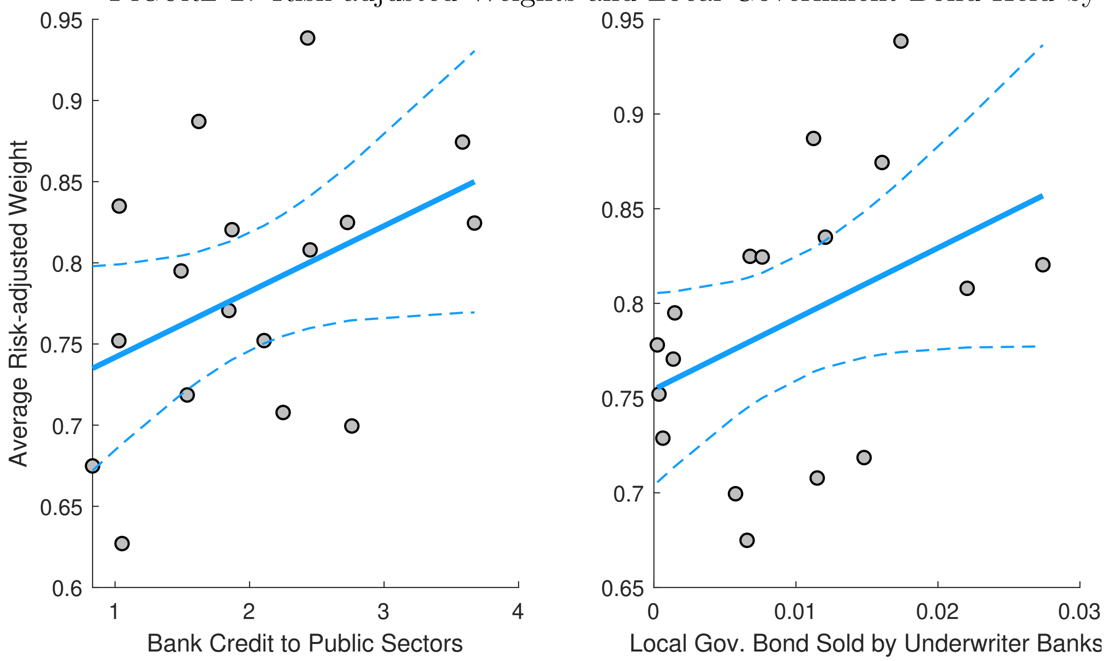
The economy has a competitive banking sector with a continuum, risk-neutral banks. Each bank has an endowment of the net worth of consumption goods e. A representative bank takes deposits d from the households at the risk-free interest rate R_D. The bank can lend up to $k = e + d$ units of goods in an investment project.

We follow John and John (1993) to model the bank's risk-shifting incentives when making investment decisions. The bank meets one specific risky project indexed by $\omega \in [0, 1]$ and one riskless project. The bank can only invest in one of these two projects. The risky and riskless projects are corresponding to POEs and SOEs, respectively. The SOE projects are riskless because of the government's implicit guarantee. The risky (or POE) project ω yields a high return R_H in the good state with probability ω and a low return R_L in the bad state with probability $1 - \omega$. The probability ω is a random variable drawn

[11]The average rate for the local government bond is around 3.5%, while the average loan rate is 9%.

[12]The volume of local government bonds sold by an underwriter bank may not necessarily equal the amount of bonds held by this bank. Some anecdotal evidence suggests that a bank underwrites a local government bond , which also tends to be a large holder of this bond.

FIGURE 2. Risk-adjusted Weights and Local Government Bond Held by Banks



Notes: The left panel plots the average risk-adjusted weight against the bank credit to public sectors (billions of RMB). The left panel plots the average risk-adjusted weight against the volume of local government bonds sold by the underwriter bank (billions of RMB). Each point corresponds to an observation for a particular bank in one year. The average risk-adjusted weight is the average value of risk-adjusted weight for corporate loans in all risk categories. The risk-adjusted weights are computed using the internal rating-based approach. The bank credit to public sectors is mainly in the form of local government bonds, corresponding to the assets with the risk-adjusted weight of 20% according to the regulatory weighting approach. For the local government bond sold by the underwriter bank, we only count those banks who are among the top 2 biggest underwriters. Our sample covers the "Big Five" banks from 2015 to 2018. Data source: CAR Annual Reports for "Big Five" banks and WIND database.

from a uniform distribution with cumulative density function (CDF) $\mathbf{F}(\omega)$. The return on the riskless project is a constant, R_S.

We assume that the bank has a limited liability. If the bank decides to invest in a risky project $\omega \in [0,1]$, with probability ω it will obtain a high outcome with profit $\pi_H = \max\{R_H k - R_D d, 0\}$, and with probability $1-\omega$ it will obtain a low outcome with profit $\pi_L = \max\{R_L k - R_D d, 0\}$. If the bank decides to invest in a riskless project, the profit is $\pi_S = \max\{R_S k - R_D d, 0\}$.

We assume that the rates of return in different states satisfy $R_H > R_S > R_L$, and the return of low outcome R_L is sufficiently low such that the bank always defaults in the low state. Under the limited liability, we have $\pi_L = 0$. Under the above assumption, we further have $\pi_H > \pi_S > \pi_L = 0$.

Now we discuss the bank's optimal decision. Following the setup in John and John (1993), we assume that the bank has private information on the probability ω. The depositors cannot observe ω. Therefore, there exists information asymmetry between the bank and the depositors. The bank receives the external finance (deposit) before making its investment decisions. Before the realization of ω, the bank specifies an investment policy that maximizes the expected profit. The bank informs the depositors about the investment policy. After the realization of ω, the bank chooses one type of project following this investment policy. We assume that any deviation from the investment policy would cause a huge punishment. Thus, the bank always follows the investment policy it specifies. We follow John and John (1993) to consider a trigger strategy of investment policy. In particular, the bank sets a cutoff $\hat{\omega}$ such that it invests the risk project if she observes $\omega > \hat{\omega}$; and the safe project otherwise.

Under the above investment policy, the bank's profit takes a discrete distribution with three states $\{H, S, L\}$

$$\Pi(\hat{\omega}) = \begin{cases} \pi_H, & \text{with prob. } p_H \\ \pi_S, & \text{with prob. } p_S \\ 0, & \text{with prob. } p_L \end{cases}, \tag{1}$$

where $p_H = \int_{\hat{\omega}}^{1} \omega d\mathbf{F}(\omega)$, $p_S = \mathbf{F}(\hat{\omega})$ and $p_L = \int_{\hat{\omega}}^{1} (1-\omega)\, d\mathbf{F}(\omega)$. Under the assumption of uniform distribution, $p_H = \frac{1}{2}(1-\hat{\omega}^2)$, $p_S = \hat{\omega}$ and $p_L = \frac{1}{2}(1-\hat{\omega})^2$. The probabilities for the high (H) and low (L) states decrease with the cutoff $\hat{\omega}$, while the probability of the medium state S increases with $\hat{\omega}$. Therefore, a lower value of cutoff $\hat{\omega}$ indicates a riskier investment policy.

Note that given that the bank invests the risky projects, the lending rate can be defined as the expected rate of return

$$\begin{aligned} R_{lend} &= \frac{1}{1-\hat{\omega}} \int_{\hat{\omega}}^{1} \left[\omega R_H + (1-\omega) R_L\right] d\mathbf{F}(\omega) \\ &= \frac{1}{2}(R_H + R_L) + \frac{1}{2}(R_H - R_L)\hat{\omega}, \end{aligned} \tag{2}$$

which increases with the investment policy $\hat{\omega}$. Regarding the SOE projects, the lending rate is characterized by the return on R_S. Therefore, the relative lending rate between POEs and SOEs $\Delta R_{lend} = R_{lend} - R_S$ also increases with $\hat{\omega}$. The intuition is quite straightforward. A riskier investment policy ($\hat{\omega}$ is lower) indicates that the bank tends to finance more POE projects, resulting a lower average lending rate to POEs compared to SOEs.

The bank chooses the investment policy $\hat{\omega}$ and the deposit d to solve the profit maximization problem

$$V = \max_{\{\hat{\omega},d\}} \left[\max\{R_H k - R_D d, 0\} \int_{\hat{\omega}}^{1} \omega d\mathbf{F}(\omega) + \max\{R_S k - R_D d, 0\} \mathbf{F}(\hat{\omega}) \right], \tag{3}$$

subject to the flow-of-funds constraint

$$k = e + d, \tag{4}$$

and the capital adequacy ratio (CAR) constraint

$$\frac{e}{\xi(\hat{\omega}) k} \geq \psi, \tag{5}$$

where $\xi(\omega)$ is the risk weighting function that indicates how the bank calculates its risk-weighted assets. The commercial bank implements the IRB approach when evaluating the risk-weighted assets. Thus, we further assume that $\xi(\omega)$ satisfy following properties: $\xi'(\omega) < 0$ and $\xi''(\omega) \leq 0$. The property $\xi'(\omega) < 0$ reflects the fact that IRB approach gives a higher weight on the riskier projects. The property $\xi''(\omega) < 0$ indicates that the marginal effect of ω on the weight increases with the level of risk.

Define the leverage ratio as $\lambda = \frac{k}{e}$, then $k = e\lambda$ and $d = e(\lambda - 1)$. Then, the CAR constraint can be rewritten as a leverage constraint

$$\lambda \leq \frac{1}{\xi(\hat{\omega}) \psi}. \tag{6}$$

A binding CAR constraint determines the value of leverage as $\lambda = \frac{1}{\xi(\hat{\omega})\psi}$. The assumption of $\xi'(\omega) < 0$ implies that the leverage increases with the cutoff $\hat{\omega}$, i.e., $\frac{\partial \lambda}{\partial \hat{\omega}} > 0$. A lower $\hat{\omega}$ indicates a riskier project, thus reducing the leverage due to the IRB risk-weighting approach.

Assuming the CAR constraint is binding, we can rewrite the bank's optimization problem as

$$V = \max_{\{\hat{\omega}\}} e \left\{ [(R_H - R_D)\lambda + R_D] \frac{1}{2}\left(1 - \hat{\omega}^2\right) + [(R_S - R_D)\lambda + R_D] \hat{\omega} \right\}, \tag{7}$$

where we have used the flow-of-funds constraint (4) and the binding CAR constraint to substitute out k and d, and we also have employed the properties of the uniform distribution.

The first-order condition for the optimal $\hat{\omega}$ implies that

$$\left[(R_H - R_D) \frac{1 - \hat{\omega}^2}{2} + (R_S - R_D)\hat{\omega} \right] \frac{\partial \lambda}{\partial \hat{\omega}} = [(R_H - R_D)\lambda + R_D]\hat{\omega} - [(R_S - R_D)\lambda + R_D]. \tag{8}$$

where $\frac{\partial \lambda}{\partial \hat{\omega}} = -\frac{1}{\psi}\frac{\xi'(\hat{\omega})}{\xi(\hat{\omega})^2} = -\lambda \frac{\xi'(\hat{\omega})}{\xi(\hat{\omega})}$. The L.H.S. of Eq. (8) indicates the marginal cost of choosing a riskier project. A lower $\hat{\omega}$, or a riskier project, reduces the leverage because of the IRB risk-weighting approach. The R.H.S of Eq. (8) indicates the marginal return of choosing a riskier project. Given a leverage ratio λ, a lower $\hat{\omega}$ raises the upper-tail risk of the return, implying a higher probability of the realization of the good state. In Appendix A, we show that under the assumption $-\xi(\omega)^2 \leq \xi(\omega)\xi''(\omega) - \left[\xi'(\omega)\right]^2 < 0$, there exists a unique $\hat{\omega}$ that solves Eq. (8).

We first show that raising the required level of capitalization (ψ) would reduce bank risk-taking and the bank's leverage ratio. These results are formally stated in Proposition 1 below.

Proposition 1. The bank's optimal investment policy ($\hat{\omega}$) and the leverage ratio (λ) satisfy

$$\frac{\partial \hat{\omega}}{\partial \psi} > 0, \ \frac{\partial \lambda}{\partial \psi} < 0. \tag{9}$$

Thus, both the optimal project risk and the leverage ratio decrease with the level of required capitalization (ψ).

Proof. See Supplemental Appendix A. □

Since the lending rate R_{lend} defined in (2) increases with the investment policy $\hat{\omega}$, the above proposition implies that a larger level of required capitalization raises the lending rate to POE projects.

III.2. **A Model with Local Government Debt.** We incorporate the local government debt into the previous model. We aim to analyze the impact of the regulation of the local government debt on the bank's portfolio decisions. The crucial feature of the regulation is that the local government is required to finance the expenditures by issuing government bonds in the market. For the existing non-government-bond outstanding debt, the local government is required to replace it with government bonds through a three-year debt swap program starting in 2015. Section II provides more details on the institutional background of the related regulations.

Since the government bond and the non-government-bond debt belong to different categories of risky assets, they have different levels of risk weight. According to the regulatory approach the bank evaluates the local government bonds according to the regulatory approach, which considers the local government bonds as a safe asset and assigns a low weight. While for non-government-bond debt, especially corporate loans, the bank employs the IRB approach to compute the risk weights, which are much larger than the weight of government bonds. For instance, the weight for the local government bonds is 20%, while for the corporate loans, the average weight on the commercial bank's balance sheet in China is above 80%. Therefore, the regulation change of local government debt that swaps the government debt with government bonds would effectively reduce the total amount of risk-weighted assets, though the composition does not change, resulting in a more relaxed CAR constraint. This will, in turn, affect the bank's portfolio decisions.

We theoretically study how the regulation changes we discussed before can affect the bank's risk-taking and loan allocation decisions. In the model, The bank holds a fixed amount of outstanding debt of g. The flow-of-funds constraint in the extended model becomes

$$k + g = d + e. \tag{10}$$

We assume that the local government debt g does not bear risk, with a risk-free rate of return R_G. Therefore, analogous to (1), the bank's profit under the different states now becomes

$$\Pi(\hat{\omega}, g) = \begin{cases} \pi_H, & \text{with prob. } p_H \\ \pi_S, & \text{with prob. } p_S \\ 0, & \text{with prob. } p_L \end{cases}, \tag{11}$$

where $\pi_j = R_j k + R_G g - R_D d$ for $j = \{H, S\}$.[13] The CAR constraint (5) now becomes

$$\frac{e}{\xi(\hat{\omega}) k + \xi_g g} \geq \psi. \tag{12}$$

The term $\xi_g g$ in the denominator indicates the risk-weighted local government debt in the bank's asset side. According to the regulation on local government debt implemented in 2015, the local government debt would be swapped by the government bond. As a result, the risk weight ξ_g would decrease after the regulation since the government bond is considered to be a safe asset when computing the risk-weighted capitals. In the model, we employ the change of ξ_g to characterize the regulation and investigate how does the decline in ξ_g affects the bank's portfolio decisions.

Define the ratio between local government debt to the equity as $\mu = \frac{g}{e}$. Then, the CAR constraint (6) now becomes

$$\lambda \leq \frac{1}{\xi(\hat{\omega}) \tilde{\psi}} \tag{13}$$

where $\tilde{\psi} = \frac{\psi}{1 - \xi_g \mu \psi}$ increases with ξ_g. Given the government debt-to-equity ratio μ, the debt swap reduces ξ_g, implying a looser CAR constraint.

[13] Alternatively, we can assume that the local government debt g bears some extent of risk as it is mainly issued by the local government financing vehicles (LGFV). In particular, with probability $1 - p_G$, the bank can get the interest rate R_G^H; and with probability p_G, the government debt g would default and the bank obtains a low payoff R_G^L. We assume that the low payoff R_G^L is not low enough such that the default of local government debt may not directly cause the bank insolvency. The expected rate of return on g satisfies $R_G = p_G R_G^L + (1 - p_G) R_G^H$. In this case, all the results remain the same as those in the case of risk-free g.

Assuming the CAR constraint is binding, we can rewrite the bank's optimization problem in the model with local government debt as

$$V = \max_{\{\hat{\omega}\}} e \left\{ \begin{array}{c} \left[(R_H - R_D)\,\lambda + (R_G - R_D)\,\mu + R_D \right] \frac{1}{2} \left(1 - \hat{\omega}^2\right) \\ + \left[(R_S - R_D)\,\lambda + (R_G - R_D)\,\mu + R_D \right] \hat{\omega} \end{array} \right\}, \tag{14}$$

where we have used the flow-of-funds constraint (10) and the binding CAR constraint (13) to substitute out k and d, and we also have employed the properties of the uniform distribution.

Note that the bank's optimization problem (14) is essentially isomorphic to the problem in the model without local government debt. The main difference is that the parameter ψ in the CAR constraint is replaced with $\tilde{\psi}$, which is decreasing in the risk-weighting coefficient ξ_g. Therefore, the results in Proposition 1 can be directly applied to analyze the impact of debt swap on the bank's optimal decisions. Then, we have the following proposition.

Proposition 2. The bank's investment policy $\hat{\omega}$ and the loan rate spread between POEs and SOEs, ΔR_{loan}, increase with ξ_g, i.e., $\frac{\partial \hat{\omega}}{\partial \xi_g} > 0$ and $\frac{\partial \Delta R_{loan}}{\partial \xi_g} > 0$. Furthermore, the sensitivity of loan rate spread to the debt swap policy measured by $\frac{\partial \Delta R_{loan}}{\partial \xi_g}$ increases with the government outstanding debt g, i.e., $\frac{\partial^2 \Delta R_{loan}}{\partial \xi_g \partial g} > 0$. Therefore, the debt swap policy that converts the government debt to the government bond (ξ_g declines) raises the optimal project risk ($\hat{\omega}$ decreases), reduces the loan rate to POEs, and the reduction is larger for those regions with higher government debt outstanding.

Proof. See Supplemental Appendix A. □

IV. Empirical analysis

The theoretical model predicts that the regulation requiring the local government to swap the government debt with the government bond raises the bank's risk-taking and eases the financing condition for POE projects. The model also predicts that the relative lending rate between POEs and SOEs declines after the regulation of the local government debt. We use these theoretical insights for our empirical identification and have obtained evidence supporting these predictions.

IV.1. **Data and some stylized facts.**

To document the impact of the local government debt reform on the bank's loan allocation, our empirical analysis relies on the local government debt data and the firm-level loan data. We start with the local government debt data.

IV.1.1. *Local government debt data.* The key variable in our empirical analysis is the local government debt. According to the new regulation, only the provincial governments can issue government bonds that include those in the debt swap program. Thus, we employ the local government debt at the provincial level. We particularly focus on the outstanding debt at the end of 2014 because the new regulation becomes effective in 2015. Note that we do not directly use the amount of swapped debt as the key dependent variable because the swapped debt was only realized after 2015, which does not fit the specification of a different-in-different estimation.[14]

Our province-level local government debt data is based on the prefectural-level data manually collected by Qu et al. (2023). According to the official regulation by the central government, local governments in China have an obligation to report information about their debt to the public. Qu et al. (2023) collect the outstanding debt data by sending the application letters to the local governments at the prefectural-city level.[15] They further verify the quality of the collected data by summing up the prefectural-level debt to the province level and comparing it with the provincial debt stock reported by the provincial governments. The two data sets from different sources are very close to each other, indicating the manually collected debt data is reliable. The debt data we use covers all the prefectural cities, excluding those in Xinjiang and Tibet, due to a lack of data. Four directly administered municipalities (e.g., Beijing, Shanghai, Tianjin, and Chongqing) are also excluded. We sum up the prefectural data to the province level. Eventually, we have the local government debt stock at the end of 2014 for 25 provinces.

IV.1.2. *Firm-level loan data.* The second data set we employ is the firm-level loan data. We construct a unique micro data set using confidential loan-level data from one of the "Big Five" commercial banks in China merged with firm-level data in China's Annual Survey of Industrial Firms (ASIF). The loan-level data contain detailed information on each individual loan, including the quantity, the price, and the credit rating, among other indicators. To control for borrower characteristics in our empirical estimation, we merge the loan data with firm-level data taken from the ASIF, which covers all above-scale industrial firms from 1998 to 2013, with 3,964,478 firm-year observations.[16] The ASIF data

[14]In the robustness analysis, we further study the channel effects of debt swap program by using the amount of swapped debt.

[15]The figure of the flow chart in Qu et al. (2023) provides a concrete illustration of their data-collecting process.

[16]Through 2007, the ASIF covered all SOEs regardless of their sizes, as well as large and medium-sized non-SOEs with annual sales above five million RMB. After 2007, the Survey excluded small SOEs with annual sales below five million RMB. After 2011, the ASIF included only manufacturing firms with annual sales above 20 million RMB.

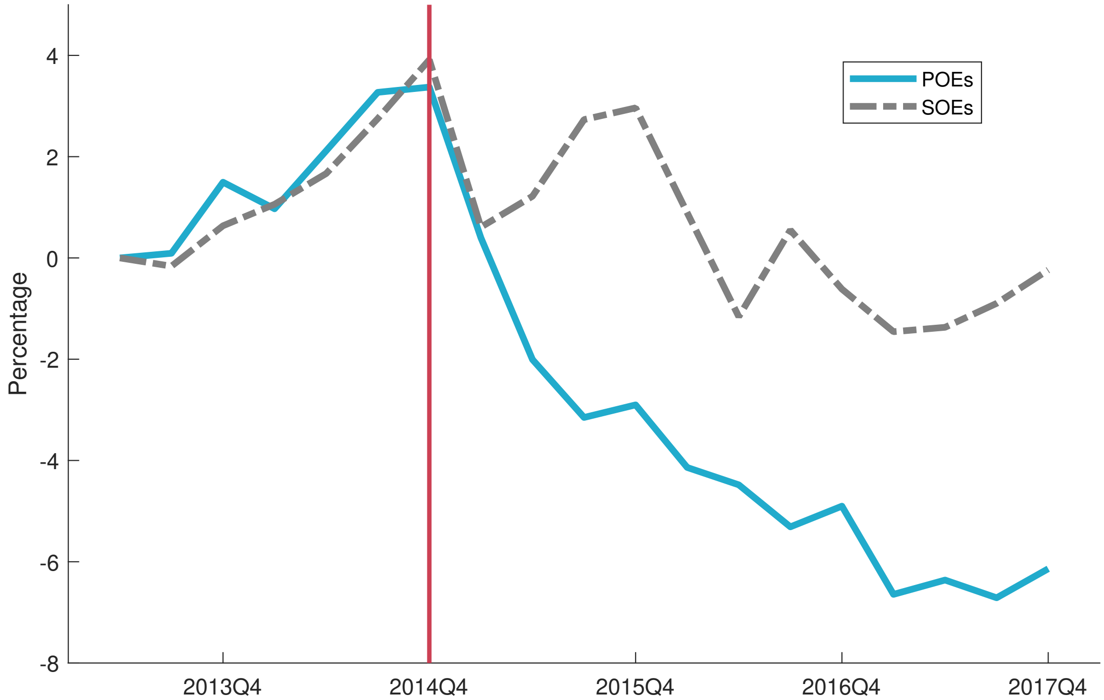
contain detailed information on each individual firm, including the ownership structure, employment, capital stocks, gross output, value-added, firm identification (e.g., company name), and complete information on the three major accounting statements (i.e., balance sheets, profit and loss accounts, and cash flow statements). Without a consistent firm identification code, we merge the loan data with the firm data using firm names. The merged dataset contains information on about 400,000 unique firm-loan pairs from 2008:Q1 to 2017:Q4, accounting for approximately half of the total amount of loans issued to manufacturing firms by the bank. In the regression analysis, we use the sub-sample with the periods from 2013Q1 to 2017Q4 since the bank adopts the internal ratings-based approach for computing the risk-weighted assets starting from the year 2013.

IV.1.3. *POE credit as risky loans.* China's government has provided preferential credit access for SOEs (Song et al., 2011; Chang et al., 2016). Under such preferential policy, SOEs are considered safe borrowers. Based on the same firm-level loan data as used in this paper, Li et al. (2024) empirically show that all else being equal, SOE loans are more likely to receive high credit ratings. An SOE's probability of obtaining a high credit rating is significantly larger than POEs. This empirical finding implies that POE loans, all else being equal, are riskier than SOE loans. According to our theoretical analysis, the debt swap program launched in 2015 would increase the bank's incentives to allocate more POE loans under the capital adequacy ratio constraint, resulting in a decline in the credit spread faced by POEs.

IV.1.4. *Local government debt reform and POE borrowing.* China's regulation on local government debt implemented in 2015 requires the local governments to swap their outstanding debt with local government bonds. As a result, the bank's holdings of government debt are converted to government bonds. The former is considered to be a risky asset, while the latter is a safe asset. When computing the risk-weighted assets, the government debt has a relatively large risk weight, while the government bond takes a low weight. Our theory in Section III.2 predicts that the debt swap program on the local government's outstanding debt lowers the bank's risk-weighted assets and thus relaxes its capital adequacy ratio constraint. As a result, the bank optimally takes more risks by increasing POE loans. This further eases the external financing condition for POEs.

Figure 3 presents some suggestive evidence that the restriction on POEs' credit access has been relatively relaxed than that of SOEs since 2015. The figure shows that the gap between loan rate and benchmark rate, measured by the percentage deviation of loan rate from the benchmark rate, for POEs declined steadily since 2015, suggesting that the regulation of local government debt implemented in the end of 2014 have contributed to changes in the bank's loan allocation to POEs. Furthermore, since POE loans are

Figure 3. The gap between loan rates and benchmark rate for POEs and SOEs

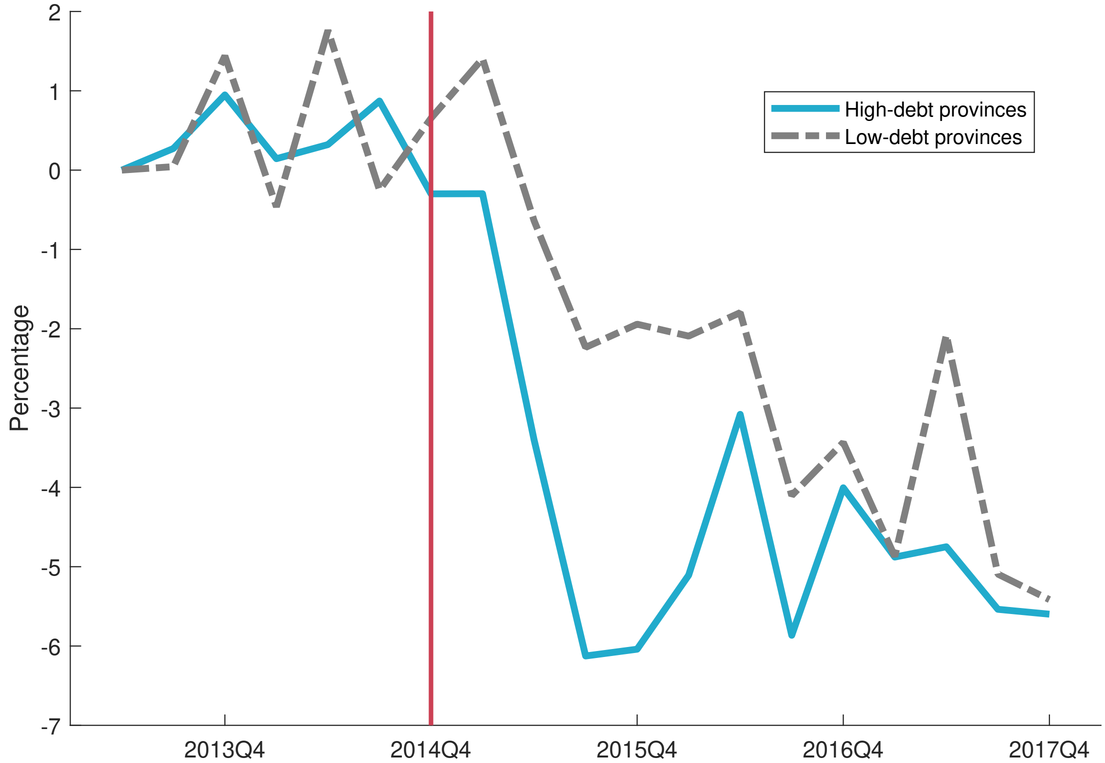


Notes: This figure shows the time series of the average value of gap between loan rate and benchmark rate for POEs (solid line) and SOEs (dashed line), respectively. The data series are in quarterly frequency, from 2013Q1 to 2017Q4. The gap of loan rate is defined as the percentage deviation of the individual loan rate from the benchmark rate. The average value of the gap of loan rate is taken across firms with the same ownership. To make the two time series comparable, we normalize the series by their values in the initial period.

considered as riskier loans comparing to SOEs, we should expect that banks supply more credit to POEs, resulting in a relatively larger reduction of the loan rate after 2015. Figure 3 shows that the reduction of loan rate for POEs is much larger than that for SOEs, reflecting that the regulation eases the external credit condition for POEs to a larger extent.

In 2015, the regulation on local government debt launched a debt swap a program that converts the outstanding debt to a government bond. Provinces with a higher level of outstanding debt would issue more government bonds for debt swapping through the program. Therefore, we should expect that the regulation of the local government debt leads to a larger impact on the POEs' external finance condition for those provinces with higher outstanding debt. Figure 4 presents the suggestive evidence that the regulation eases the POEs' credit access to a greater extent in the provinces with larger outstanding debt. The reduction of loan rates in these high-debt provinces in the post-2015 periods is larger than that in low-debt provinces.

FIGURE 4. The spread of loan rates between POEs and SOEs for different provinces



Notes: This figure shows the spread of the loan rate gaps between POEs and SOEs for different groups of provinces. The data series are in quarterly frequency, from 2013Q1 to 2017Q4. Due to the data availability, we only have the loan rate data for 26 provinces. We classify the provinces with local government outstanding debt of more than 400 billion RMB at the end of 2014 as a high-debt group (including 14 provinces). The remaining provinces are classified as low-debt group (including 12 provinces). The solid and dashed lines are, respectively, the average values of the spread of the loan rate gaps between POEs and SOEs for the high-debt group and the low-debt group. To make the two time series comparable, we normalize the series by their values in the initial period.

IV.2. **The empirical model.** We now formally investigate how the regulation of local government debt implemented in 2015 affects the bank's loan allocation to POEs. Our baseline empirical estimation takes the following triple-difference specification

$$LoanRate_{ifjt} = \alpha \times POE_i \times Post_y + \beta \times POE_i \times Post_y \times GovDebt_j + \gamma \times GovDebt_j \times POE_i + \delta \times GovDebt_j \times Post_y + \theta \times X_f \times \mu_y + u_f + \eta_j + \mu_t + \epsilon_{ifjt}. \quad (15)$$

In this specification, the dependent variable $LoanRate_{ifjt}$ is the percentage deviation of the lending rate of bank loan i borrowed by the firm f from the benchmark loan rate in the province j at period t. Table 2 reports the summary statistics for the key variables in the above regression.[17]

We interpret the regulations of the local government debt as an exogenous event for commercial banks. We use the dummy variable $Post_y$ to indicate the post-2015 periods under the new regulations: it equals one if the year is 2015 or after and zero otherwise. The independent variable POE_i is a dummy variable that takes a value of one if the individual bank loan (indexed by i) is extended to a POE firm and zero otherwise.

Our theoretical model suggests that the regulation on local government debt, especially the debt swap policy, reduces the loan rate for POEs, since the policy eases the bank's capital adequacy ratio constraint by converting the bank's risky loans to relatively safe assets. We include the term $POE_i \times Post_y$ to captures this effect. Our theory predicts that the coefficient α on this interaction term should be negative.

The impact of the regulation on the loan rate for POEs can vary across regions, depending on the regional level of outstanding debt (see Proposition 2). In particular, the province with a high outstanding debt would swap a large volume of government debt. As a result, more risky assets on the bank's balance sheet are converted to safer assets. Under the internal-rating-based approach, the bank's risk-weighted assets decline, and the capital adequacy ratio constraint is loosened. The bank then optimally takes more risks by allocating more POE loans, resulting in a lower loan rate for POE firms. Therefore, the response of loan rate for POEs in the high-debt province should be more sensitive to the regulation than in low-debt provinces. We include the triple term $POE_i \times Post_y \times GovDebt_j$ to capture the above effect. The variable $GovDebt_j$ is the *demeaned* natural logarithm of the government outstanding debt in province j at the end of the year 2014. Note that since $GovDebt_j$ is demeaned from its average value, the coefficient α captures the average impact of regulation on the loan rate of POEs. Our theory predicts that this interaction term's coefficient β should be negative. Besides, we also control for other interaction terms $GovDebt_j \times POE_i$ and $GovDebt_j \times Post_y$, but our theory does not have a clear prediction on the sign of γ and δ.

The variable X_f in Eq. (15) is a vector of control variables for the initial conditions facing firm f (i.e., the borrower of loan i). It includes firm characteristics such as leverage, the returns on equity (ROA), and the tangible asset to total asset ratio. We do not have data on these firm characteristics after 2013 since the ASIF sample only covers the period from 1998 to 2013. For the above initial conditions, we take the average value of each firm

[17] The average value of POE_i indicates the number of POE loans accounts for 95% of the total number of loans in our sample. However, in terms of the volume of loans, the POE loans only account for approximately 60% of total loans, implying that the size of SOE loans is on average, much larger than that of POE loans.

TABLE 2. Summary statistics of key variables in the estimation

	mean	std	min	p25	p50	p75	max
$LoanRate_{ifjt}(\%)$	9.023	11.429	-94.30	0.50	5.00	15.00	221.43
POE_i	0.953	0.212	0	1	1	1	1
$GovDebt_j$	0	0.402	-5.678	-0.025	0.203	0.203	0.315

characteristic over the period from 2011 to 2013. To capture potential time variations of firm characteristics, we follow Barrot (2016) and include interactions between the initial conditions X_f with the year fixed effect μ_y. The set of independent variables also includes provincial fixed effect η_j[18], firm fixed effect u_f and time (quarters) fixed effect μ_t. Finally, the term ϵ_{ifjt} denotes the regression residual.

IV.3. **Empirical results.** We now discuss the empirical estimation results.

IV.3.1. *Baseline estimation results.* We use the loan-level data merged with the local government debt data to estimate the baseline empirical model in Eq. (15). Table 3 reports the estimation results. Column (1) shows the result in a model with difference-in-difference specification, which only contains the interaction term $POE_i \times Post_y$. The estimated coefficient of this term is negative and significant, consistent with our theory's prediction. The negative sign suggests that, after the implementation of the regulation on the local government debt that swaps the outstanding debt with the government bond, the commercial bank takes more risks by providing more credit to POEs, resulting in a lower loan rate for POE firms relative to SOEs. Column (2) shows the result in our baseline estimation, including the DID and triple-difference terms. The latter captures the regional heterogeneity that helps to identify the risk-taking channel through which the regulation affects the bank's credit allocation. The result shows that the coefficients α and β are both negative and significant, suggesting that the regulation of local government debt with a debt swap program reduces the loan rates for POEs ($\alpha < 0$), and the credit easing effect is larger for the provinces with higher local government debt outstanding ($\beta < 0$).

The point estimate of $\beta = -2.849$ implies that for POE firms in the provinces with local government outstanding debt one-standard-deviation (approximately 0.402) higher than the average, the regulation that implements the debt swap program leads to a decline of 1.15% ($= 0.402 \times 2.849\%$) in percentage deviation from the benchmark rate of POEs relative to SOEs, which accounts for 10.1% of the standard deviation of $LoanRate_{ifjt}$. Thus, the impact is not only statistically significant but also economically significant. The

[18]This province indicates the loan provider's location, while the firm fixed effect already includes the loan demander's location fixed effect.

negative value of β implies that the debt swap program affects the bank's credit allocation after the implementation in 2015, not before. Note that compared to the DID result in Column (1), the estimate of α increases from -3.839 to -3.182 in the baseline estimation in Column (2), implying that the debt swap channel captured by the triple-difference term does contribute to the impact of regulation on the loan rates for POEs. The economic significance of the above estimation results can be understood as follows. For firms in a province with local government outstanding debt one-standard-deviation higher than the average (approximately 0.402), the implementation of a debt swap program narrows the spread of loan rate between SOEs and POEs by 6 base-points ($5.18\% \times 1.15\%$), which accounts for 1/7 of the average spread of loan rate in the sample.[19]

IV.3.2. *Parallel trends.* Our difference-in-difference identification assumes that the local government outstanding debt has little impact on POEs lending in the pre-2015 periods, but causes a significant effect on the loan rate for POEs after the new regulations were put in place.

To examine the validity of our parallel trends identification assumption, we estimate the empirical model

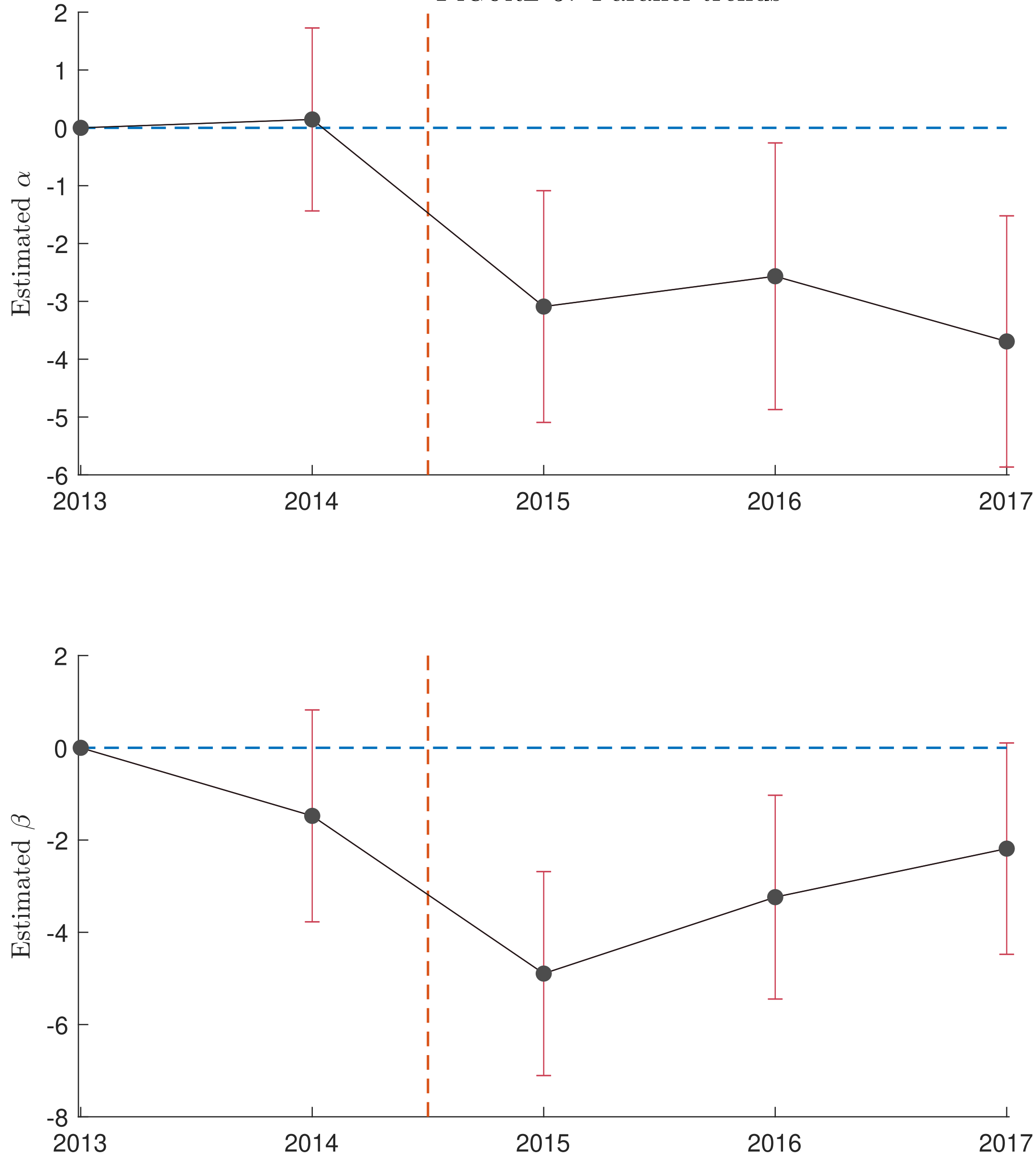
$$\begin{aligned} LoanRate_{ifjt} = & \sum_{\tau} \alpha_{\tau} \times POE_i \times \mathbf{1}_{\tau} + \sum_{\tau} \beta_{\tau} \times POE_i \times \mathbf{1}_{\tau} \times GovDebt_j \\ & + \gamma \times GovDebt_j \times POE_i + \sum_{\tau} \delta_{\tau} \times GovDebt_j \times \mathbf{1}_{\tau} \\ & + \theta \times X_f \times \mu_y + u_f + \eta_j + \mu_t + \epsilon_{ifjt}, \end{aligned} \tag{16}$$

where $\tau \in \{2014, ..., 2017\}$ denotes the year, $\mathbf{1}_{\tau}$ is a dummy variable, which is equal to one in the year of τ and zero otherwise. We specify the year 2013 as the reference year.[20] The other variables have the same definitions as in the baseline model specified in Eq. (15). The parameter α_{τ} measures the average spread of loan rates between POEs and SOEs in year τ, and the parameter β_{τ} measures the marginal effect of the outstanding debt on the loan rate spread between POEs and SOEs in year τ. The reference year is the initial period, 2013. We consider the periods before the new regulation (2013 and 2014), the year when the regulation was implemented (2015), and the years after the regulation shock (2016 and 2017).

[19]The average gap of loan rate between SOEs and POEs in the sample is 42 base-points, i.e., $6.01\% - 5.59\%$.

[20]If we add all the year dummy variables, one of them will be automatically omitted due to collinearity. Now we drop the first year, then the coefficients of other year dummies mean the relative impact to the first year.

FIGURE 5. Parallel trends



Notes: The figure shows the estimated coefficients α_τ and β_τ for the years 2014 to 2017 from the empirical model in Eq. (16). We use 2013 as a reference year. The dots indicate the point estimates and the error bars indicate the 95% confidence bands. The robust standard errors are double clustered at the firm and year-quarter level. The local government debt is measured by the demeaned logarithm of the outstanding debt at the province level. The coefficient α_τ measures the average spread of loan rates between POEs and SOEs in a particular province. The coefficient β_τ measures the marginal effects of government debt on the spread of loan rates between POEs and SOEs.

Table 3. Effects of regulation on the lending to POEs

	(1)	(2)
	$LoanRate_{ifjt}$	$LoanRate_{ifjt}$
$POE_i \times Post_y$	-3.839***	-3.182***
	(0.646)	(0.674)
$GovDebt_j \times POE_i \times Post_y$		-2.849***
		(0.985)
$GovDebt_j \times Post_y$		-1.098
		(0.877)
$GovDebt_j \times POE_i$		0.801
		(2.050)
Constant	10.92***	10.86***
	(0.332)	(0.353)
Initial controls × year FE	yes	yes
Firm FE	yes	yes
Province FE	yes	yes
Year-quarter FE	yes	yes
R^2	0.630	0.630
Observations	147,700	135,133

Notes: Columns (1) reports the estimation result in a difference-in-difference model with interaction term $POE_i \times Post_y$. Column (2) reports the estimation results in the baseline model. Both models include controls for the province fixed effects, the firm fixed effects, the year-quarter fixed effects, and the average firm characteristics (including tangible to total assets ratio, leverage, and ROA) in the years before 2013 interacted with the year fixed effects. The numbers in the parentheses indicate robust standard errors double clustered at the firm and year-quarter level. The levels of statistical significance are denoted by the asterisks: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$. The data sample ranges from 2013:Q1 to 2017:Q4.

Figure 5 shows the point estimates of α_τ and β_τ along with the 95% confidence bands. The figure shows that, in the pre-2015 periods, the estimated values of α_τ and β_τ are insignificantly different from zero, implying that the impact of government outstanding debt in the located provinces on the average value of loan rates for POEs relative to SOEs in 2014, is statistically indifferent to that in 2013, which means the marginal impact is parallel before the shock. The figure also shows that since the regulation of the debt swap program was implemented in 2015 and after, the estimated values of α_τ and β_τ have both turned significantly negative at 95% confidence level, implying significant reductions in the spread of loan rates between POEs and SOEs in the high-debt provinces (relative to the low-debt provinces) relative to the year 2013. The above results suggest that the policy shock, i.e., the implementation of the debt swap program triggered the change of the external financing condition for POE firms, validating our identification assumption.

IV.3.3. *Effects of regulation on the probability of lending to POEs.* Our baseline regression uses the loan rates as the main indicator to characterize the effects of the regulation on the bank's lending to POEs. Alternatively, we investigate how the regulation affects the POEs' access to bank loans. In this exercise, we replace the dependent variable $LoanRate_{ifjt}$ in the baseline regression with the ownership dummy, POE_i. We also drop the interaction terms with POE_i in Eq. (15). We document how the regulation affects the probability of a POE obtaining a bank loan by estimating both the OLS and Probit models. Column (1) displays the results of the parallel trend analysis estimated in the OLS model. Columns (2) and (3) report the results in OLS and Probit models, respectively. The result in Column (1) shows that the regulation implemented in 2015 significantly increases the marginal effect of government outstanding debt on the probability that POEs can obtain bank loans, while this effect is insignificant before 2015. The results in Column (2) and (3) show that the coefficients of the interaction term $GovDebt_j \times Post_\tau$ in the OLS and Probit models are positive and significant, implying that POEs in the province with higher government outstanding debt is easier to obtain bank loans than those POEs in the provinces with lower outstanding debt. In Column (2), the estimated coefficient of 0.0292 implies that one std increase in GovDebt leads to a 1.2% increase in the probability of POE lending (0.4×0.0292). These results are consistent with the main findings in the baseline analysis.

Furthermore, we control for the loan rate to exclude the potential channel of search-for-yield. The local government debt swap program causes the bank to lose profit since the yield of government bonds is lower than that of LGFV loans. Therefore, the bank may lend more money to POEs for higher yields. In Columns (4) and (5), we still find a significantly positive coefficient.

IV.4. **debt swap as the transmission channel.** Our theoretical analysis suggests that the regulation affects the bank's risk-taking behaviors mainly through the debt swap program. This program, starting in 2015, converts the outstanding debt (risky asset) to a government bond (safe asset). Therefore, the province with higher outstanding debt at the end of 2014 would swap a larger volume of the debt to the government bond, resulting in a larger impact of regulation on the bank lending to POE firms. Figure 6 scatterplots the swapped debt from 2015 to 2017 against the government's outstanding debt at the end

Table 4. Effects of regulation on the probability of lending to POEs

POE_i	(1) Parallel trend (OLS)	(2) OLS	(3) Probit	(4) OLS	(5) Probit
$GovDebt_j \times Post_\tau$		0.0292***	0.0118***	0.0370***	0.0137***
		(0.0083)	(0.0041)	(0.00819)	(0.0043)
$LoanRate_{ifjt}$				0.00263***	0.00276***
				(0.00026)	(0.00031)
$GovDebt_j \times year = 2014$	-0.0001				
	(0.00413)				
$GovDebt_j \times year = 2015$	0.0220**				
	(0.00947)				
$GovDebt_j \times year = 2016$	0.0341***				
	(0.0101)				
$GovDebt_j \times year = 2017$	0.0331***				
	(0.0111)				
Initial controls × year FE	yes	yes	yes	yes	yes
Province FE	yes	yes	yes	yes	yes
year-quarter FE	yes	yes	yes	yes	yes
R^2	0.095	0.095	–	0.117	-
Observations	137,790	137,790	137,783	137,790	137,783

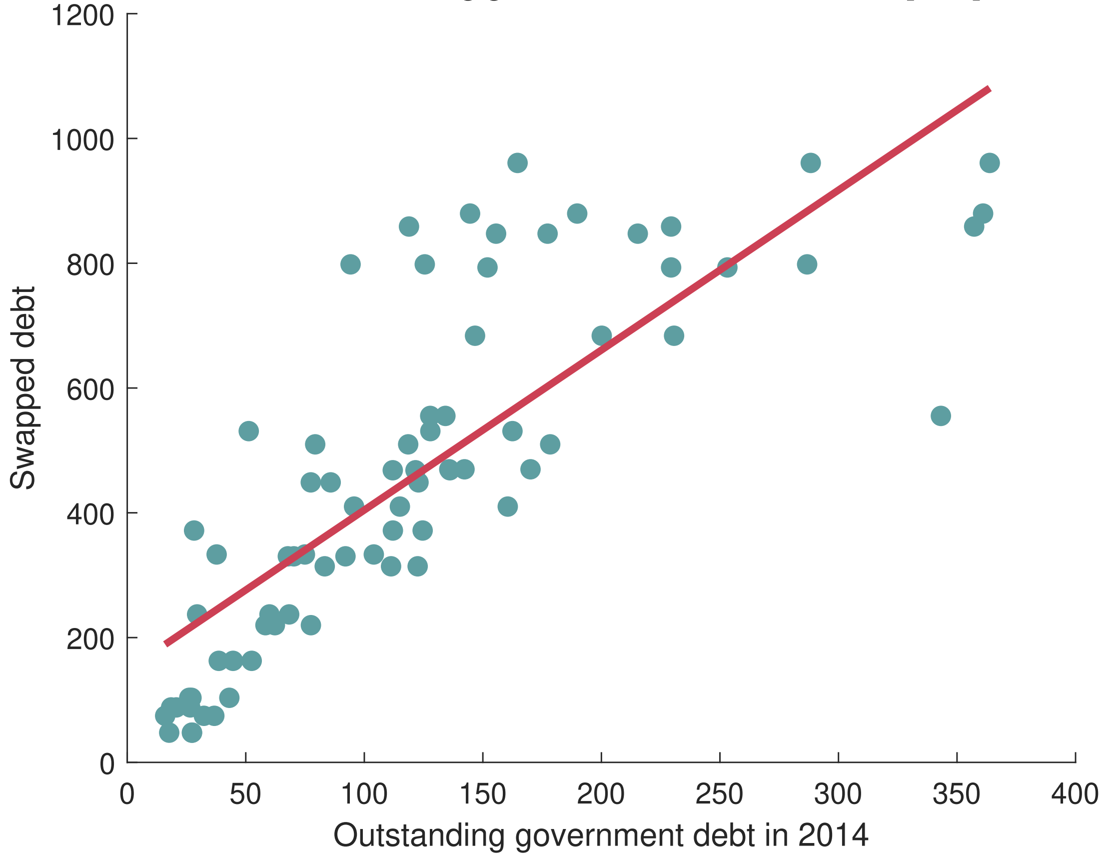
Notes: The dependent variable is a dummy for the ownership of POE firms, i.e., POE_i. Column (1) reports the result of parallel trend analysis in the OLS model. Column (2) and (3) report the results of the OLS model and Probit model, respectively. For the OLS models, the robust standard errors are double clustered at the firm and year-quarter level. For the Probit model, we report margin effects instead of estimated coefficients. The robust standard errors are clustered at the firm level since the Probit model does not support double cluster. The levels of statistical significance are denoted by the asterisks: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$.

of 2014. The figure shows that the correlation between these two variables is significant and positive. The correlation coefficient is 0.85, with a p-value less than 0.0001.

To further identify the channel effects of the debt swap program, we follow Bertrand and Mullainathan (2001) to adopt a 2 stage-least-square (2SLS) estimation approach. The channel variable of interest is $\ln(1 + Swap_{j,y})$, where $Swap_{j,y}$ is the total amount of local government debt being swapped to government bonds in province j and year y.[21]

[21]Since the value of $Swap_{j,y}$ is zero prior to 2015, we employ $\ln(1+Swap_{j,y})$ as the dependent variable.

Figure 6. Outstanding government debt and debt swap at province level



Notes: This figure shows the relationship between the province-level outstanding government debt prior to the regulation and the amount of swapped debt. The vertical axis is the total amount of swapped debt each year from 2015 to 2017. The horizontal axis is the local government's outstanding debt at the end of 2014. Each dot represents a pair of government debts and swapped debts for one particular province. The unit is billions of RMB. The correlation coefficient between these two variables is 0.8 with p-value less than 0.0001.

In Column (1) of Table 5, the dependent variable is $LoanRate_{ifjt}$ and independent variables include the terms regarding the amount of debt swap $\ln(1 + Swap_{j,y}) \times POE_i$ and $\ln(1 + Swap_{j,y})$. In the 2SLS regression, we instrument the term $\ln(1 + Swap_{j,y})$ by $GovDebt_j \times Post_y$, and the interaction term $\ln(1 + Swap_{j,y}) \times POE_i$ by $GovDebt_j \times Post_y \times POE_i$. The bottom panel in Table 5 reports the first-stage regression result. It shows that both the coefficients of the interaction terms $GovDebt_j \times Post_y \times POE_i$ and $GovDebt_j \times Post_y$ for $\ln(1+Swap_{j,y}) \times POE_i$ and $\ln(1+Swap_{j,y})$, respectively, are positive and significant. This result indicates that a province with higher government outstanding debt at the end of 2014 tends to swap a larger amount of the government bond after 2015.

The upper panel of Table 5 displays the estimation results in the second stage. Column (1) shows that in the regression with loan rates as a dependent variable, the estimated coefficient of the term $\ln(1 + Swap_{jy}) \times POE_i$ is negative and significant, implying that POE firms in a province with a larger debt swap have easier access to bank loans after implementing the new regulation. The coefficient means one standard deviation increase in the amount of swapped debt leads to a decline of 11.21% in percentage deviation from the benchmark rate of POEs ($= 3.723 \times 3.013\%$) relative to SOEs, which accounts for 0.98 standard deviation of $LoanRate_{ifjt}$.

These results indicate that the debt swap program provides a crucial channel through which the regulation on the local government debt affects bank lending to POEs.

Column (2) displays the 2SLS estimation results for the regression with POE_i as a dependent variable. As in Table 4, this regression captures the effect of regulation on the extensive margin of lending to POE firms. The result in the first stage shows that the instrument we use for the term $\ln(1 + Swap_{j,y})$ is valid, and the coefficient is positive and significant. The result in the second stage shows that POE firms in a province with a larger volume of swapped debt are more likely to obtain bank loans after the regulation is effective. These results are consistent with those in Table 4 and confirm that the debt swap program provides a crucial channel.

IV.5. **Controlling for loan demand factors.** Our baseline regression uses variations across time and across provinces with different levels of local government debt outstanding to identify the effects of regulation on the bank's lending to POEs. A potential concern is that the easing of POE lending in the post-2015 period might be driven by changes in the loan demand of POEs (relative to non-POEs) instead of changes in lender decisions under the new regulations.

To address this concern, we introduce fixed effects in different levels to mute the effects from the demand or supply sides. In particular, we add the firm × year-quarter fixed effects to exclude all the firm-level time-varying effects on loan rate. Therefore, the demand effects are completely absorbed. The other variables are the same as defined in the baseline regression (15).[22] Column (1) in Table 6 reports the corresponding results. It shows that in the absence of demand effects, the coefficient of triple-difference term $GovDebt_j \times POE_i \times Post_y$ becomes much more negative (-23.66) than that in the baseline analysis (-2.849), implying that muting the demand effect would strengthen the marginal effect of the government outstanding debt on the lending to POEs after the regulation is implemented.

To exclude the demand effect from the firms, we control firm-year-quarter fixed effects. In this estimation, the variations originate from those firms that borrow at least from two different bank branches. Although the estimated coefficients have large magnitudes due

[22]Since we control the firm and year-quarter fixed effects, the interaction term $POE_i \times Post_y$ is automatically suppressed in the regression.

TABLE 5. Channel effects of the debt swap program

	(1)		(2)
Second stage:	$LoanRate_{ifjt}$		POE_i
$\ln(1 + Swap_{j,y}) \times POE_i$	-3.013***		
	(1.027)		
$\ln(1 + Swap_{j,y})$	-1.125		0.0313***
	(0.939)		(0.0092)
Initial controls × FE	yes		yes
Firm FE	yes		no
Year-quarter FE	yes		yes
Province FE	yes		yes
Province controls	-		-
Year FE	-		-
Kleibergen-Paap rk LM statistic	13.172		14.873
Observations	135,133		137,790
First stage:	$\ln(1 + Swap_{j,y}) \times POE_i$	$\ln(1 + Swap_{j,y})$	$\ln(1 + Swap_{j,y})$
$GovDebt_j \times Post_y$	0.0190	0.9249***	0.9332***
	(0.0124)	(0.0403)	(0.0629)
$GovDebt_j \times Post_y \times POE_i$	0.9348***	0.0289	
	(0.0528)	(0.0432)	
F test of excluded instruments	158.28	267.62	219.81

Notes: This table reports the results of the channel effects of debt swap. Columns (1) and (2) correspond regressions based on the loan-level sample. We adopt a 2SLS approach to estimate the channel effect. $\ln(1+Swap_{j,y})$ is the channel variable. In Column (1), we instrument $\ln(1+Swap_{j,y})$ by $GovDebt_j \times Post_y$, and instrument $ln(1 + Swap_{j,y}) \times POE_i$ by $GovDebt_j \times Post_y \times POE_i$. In Column (2), we instrument $\ln(1+Swap_{j,y})$ by $GovDebt_j \times Post_y$. Column (1) has controlled for $GovDebt_j \times POE_i$ and $POE_i \times Post_t$ for consistence with baseline model. Robust standard errors double-clustered at the firm and year-quarter level are reported in parentheses. The levels of statistical significance are denoted by the asterisks: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$.

to the few observations in our sample, it supports that the major impact of regulation on the POEs' borrowing is not a result of the demand side.

Alternatively, we introduce the bank-branch × year-quarter fixed effects to mute the effects from the supply side. Column (2) in Table 6 shows that the triple-difference term $GovDebt_j \times POE_i \times Post_y$ becomes insignificant and the magnitude of the coefficient of

$POE_i \times Post_y$ declines largely from -3.182 in the baseline estimation to -2.196, implying that the key results in the baseline analysis are mainly driven by the loan supply side.

Table 6. Controlling for effects from demand or supply sides

$LoanRate_{ifjt}$	(1) no demand effects	(2) no supply effects
$POE_i \times Post_y$		-2.196**
		(0.785)
$GovDebt_j \times POE_i \times Post_y$	-23.66**	-0.472
	(8.569)	(1.066)
$GovDebt_j \times POE_i$	32.68***	9.405***
	(10.28)	(0.888)
$GovDebt_j \times Post_y$	-10.18**	
	(4.269)	
Initial controls × year FE	–	yes
Firm FE	–	yes
Province FE	yes	–
Year-quarter FE	–	–
Firm × year-quarter FE	yes	no
Branch × year-quarter FE	no	yes
R^2	0.937	0.723
Observations	112,596	134,617

Notes: The dependent variable is the loan rate for POEs, $LoanRate_{ifjt}$. Column (1) reports the result in the estimation where the firm and year-quarter fixed effects are considered to shut down the effects from the demand side. Column (2) reports the result in the estimation where the branch and year-quarter fixed effects are considered to shut down the effects from the supply side. Other control variables are the same as those in the baseline model. The robust standard errors are double clustered at the firm and year-quarter level. The levels of statistical significance are denoted by the asterisks: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$.

IV.6. **Heterogeneous effects on different types of firms.**

IV.6.1. *Size.* We further document the heterogeneous impacts of the debt swap program on different types of POEs. First, we consider heterogeneous effects on the POEs with different sizes. First, we divide POEs into small and large groups using the median of total assets as a threshold. We take SOEs as a control group and re-estimate the baseline model using large POEs and small POEs as the treatment group, respectively. Columns (1) and (2) in Table 7 show that the coefficient of the triple term $GovDebt_j \times POE_i \times Post_y$ is significantly negative and the magnitude is larger for the small POEs than that of the large POEs. Second, we group POEs according to the loan size using the median of loan size as a threshold. Columns (3) and (4) report the corresponding estimation results, which are similar to those in the first two columns. The above findings indicate that the expansionary effect of the debt swap program on external borrowing is more pronounced for POEs (POE loans) with small sizes than those with large sizes.

IV.6.2. *Credit rating.* We document the heterogeneous effects on POEs with different credit ratings. In particular, we label the POEs with a credit rating of AA- and above as high-rating POEs and the remaining POEs as low-rating POEs. Columns (5) and (6) in Table 7 show that the low-rating POEs' term $GovDebt_j \times POE_i \times Post_y$ is significantly negative and has a larger magnitude compared to the high-rating POEs, implying that the bank in the province with larger debt outstanding tends to take more risks in response to the debt swap program.

IV.6.3. *Firm-bank distance.* A bank's risk-taking behavior may lead to more lending to those firms that the bank has relatively less information. We use the distance between the firm and the bank branch to measure the extent of information asymmetry between the bank and the borrowing firms. A larger distance indicates more severe information friction as it is more costly for the bank to acquire the borrower's information. We then divide the firms into long-distance and short-distance groups. Columns (7) and (8) in Table 7 present the estimation results for these two groups, respectively. The results show that the expansionary effect of the debt swap program on the POEs with a long distance from the bank is more pronounced than those POEs close to the banks. A larger reduction in the spread of loan rates for POEs with more severe information asymmetry confirms the risk-taking consequence induced by the debt swap program we document in the baseline analysis. In summary, the heterogeneous-effect analysis in this section confirms our baseline results and aligns with the theoretical predictions.

IV.7. **Robustness.** Our baseline estimation results are robust to sub-sample, excluding large firms or local government financing vehicles (LGFVs), additional controls and alternative definition of government-debt variable $GovDebt_j$.

IV.7.1. *Different subsamples.* One of the most important incentives for the local government to issue debt is to provide financial support for SOE firms or public investment projects through LGFVs. The new regulation largely limits these SOE firms' access to external finance. Therefore, it is possible that the regulation dampens the bank's direct

Table 7. Heterogeneous effects on different types of POEs

$LoanRate_{ifjt}$	(1) Small POEs	(2) Large POEs	(3) Small loan	(4) Large loan	(5) Low-rating	(6) High-rating	(7) Long Dis.	(8) Short Dis.
$GovDebt_j \times POE_i \times Post_y$	-3.295**	-2.453**	-5.626***	0.626	-4.096***	-0.942	-4.362***	-1.851
	(1.347)	(0.929)	(1.536)	(0.812)	(1.147)	(1.066)	(1.078)	(1.444)
$POE_i \times Post_y$	-4.125***	-2.258***	-0.325	-1.763***	-3.383***	-2.869***	-2.474**	-3.770***
	(0.752)	(0.708)	(1.684)	(0.459)	(0.684)	(0.694)	(1.055)	(0.831)
$GovDebt_j \times Post_y$	-1.088	-1.081	0.919	-1.597**	-1.099	-1.107	0.740	-2.559***
	(0.871)	(0.886)	(1.284)	(0.729)	(0.881)	(0.867)	(1.245)	(0.883)
$GovDebt_j \times POE_i$	-	1.038	-	-2.707*	-4.348	0.337	0.334	-
	-	(1.873)	-	(1.470)	(2.685)	(2.284)	(1.854)	-
Initial controls × year FE	yes	yes	yes	yes	yes	yes	yes	yes
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes
Province FE	yes	yes	yes	yes	yes	yes	yes	yes
year-quarter FE	yes	yes	yes	yes	yes	yes	yes	yes
R^2	0.621	0.617	0.621	0.624	0.601	0.676	0.616	0.639
Observations	69,885	70,270	105,868	27,981	81,557	58,597	66,981	67,990

Notes: Columns in the table report the estimation results based on the subsamples, including all SOEs and different types of POEs. We consider four definitions of types of POEs: firm size, loan size, credit rating, and firm-bank distance. All models include controls for the province fixed effects, the firm fixed effects, the year-quarter fixed effects, and the average firm characteristics (including tangible to total assets ratio, leverage, and ROA) in the years before 2013 interacted with the year fixed effects. The numbers in the parentheses indicate robust standard errors double clustered at the firm and year-quarter level. The levels of statistical significance are denoted by the asterisks: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$. The data sample ranges from 2013:Q1 to 2017:Q4.

lending to SOEs and stimulates lending to POEs instead. This transmission channel is distinct from the bank risk-taking channel emphasized in the baseline analysis.

To address this concern, we estimate the baseline model based on a sub-sample that excludes the LGFV firms, the firms with large sizes, or local SOEs. Column (1), (2), and (3) in Table 8 report, respectively, the results based on the sub-samples excluding LGFV firms, dropping top 10% percentile of firms according to their size, and dropping the local SOEs.[23] Notice that the SOE firms in the subsample, excluding the local SOEs, are related to the central government, which is affected little by the regulation of local government debt. The table shows that the estimates of α and β are significant and negative in both sub-sample regressions. These results suggest that the LGFV, large firms, or local SOEs do not affect the bank risk-taking channel identified in our baseline regression.

[23]We also re-estimate the baseline model by dropping the top 5%, 15%, 20%, and 30% of firms according to their size, the results are in line.

Table 8. Regressions based on different sub-samples

$LoanRate_{ifjt}$	(1) drop LGFVs	(2) drop top 10%	(3) drop local SOEs
$POE_i \times Post_y$	-3.218***	-1.945*	-2.981**
	(0.671)	(1.000)	(1.150)
$GovDebt_j \times POE_i \times Post_y$	-2.875***	-3.679***	-3.215*
	(0.987)	(1.194)	(1.647)
$GovDebt_j \times POE_i$	0.806	6.090***	-0.214
	(2.050)	(1.416)	(3.168)
$GovDebt_j \times Post_y$	-1.072	-0.584	-1.295
	(0.870)	(0.999)	(2.020)
Initial controls × year FE	yes	yes	yes
Firm FE	yes	yes	yes
Province FE	yes	yes	yes
year-quarter FE	yes	yes	yes
Observations	135,108	121,450	114,148
R^2	0.625	0.614	0.626

Notes: Column (1) uses the sub-sample that drops LGFV firms. Column (2) uses the sub-sample that drops firms whose total assets in the initial year 2013 are at the top 10% quantile. Column (3) uses the sub-sample that drops local SOEs and only contains SOEs related to the central government. The estimation specification is the same as that in the baseline analysis. The numbers in the parentheses indicate robust standard errors double clustered at the firm and year-quarter level. The levels of statistical significance are denoted by the asterisks: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$. The data sample ranges from 2013:Q1 to 2017:Q4.

IV.7.2. *Debt capacity.* The local government debt reform also regulates the debt capacity for each local government. Thus, it is possible that a tightened financing condition faced by the local SOEs is a result of the limited local government debt capacity. To distinguish this channel from the baseline risk-taking channel, we control the variations of debt capacity and re-estimate the baseline regression. We use the average value of the ratio between local government debt and the debt limit over the years of 2016 and 2017, $DebtCap_j$, to measure the level of debt capacity. A larger value of $DebtCap_j$ indicates a loosened debt constraint in province j. Table 9 shows that the baseline results remain valid after controlling for the potential impact of local government debt constraint on the bank lending decisions.

Table 9. Controlling for local government debt capacity

	(1)	(2)
	$LoanRate_{ifjt}$	POE_i
$GovDebt_j \times POE_i \times Post_y$	-2.210**	
	(1.017)	
$GovDebt_j \times Post_y$	-1.128	0.0277***
	(0.890)	(0.00786)
$POE_i \times Post_y$	22.43*	
	(11.79)	
$GovDebt_j \times POE_i$	0.233	
	(2.105)	
$DebtCap_j \times POE_i \times Post_y$	-0.281**	
	(0.129)	
$DebtCap_j \times Post_y$	0.0129	0.000718
	(0.0983)	(0.000767)
$DebtCap_j \times POE_i$	0.338	
	(0.348)	
Initial controls × year FE	yes	yes
Firm FE	yes	-
Province FE	yes	yes
year-quarter FE	yes	yes
R^2	0.625	0.095
Observations	135,133	137,790

Notes: Columns (1) - (2) report the estimation results controlling for the impact of local government debt constraint. $DebtCap_j$ indicates the local government debt constraint of province j, measured by the average ratio between the local government debt limit in 2016 and 2017. Columns (1) and (2) are the estimations for loan rate and probability of POE loans, respectively. The former regression includes controls for the province fixed effects, the year-quarter fixed effects, and the average firm characteristics (including tangible to total assets ratio, leverage, and ROA) in the years before 2013 interacted with the year fixed effects. The latter regression includes the same set of fixed effects as the former, except for the firm fixed effects. The numbers in the parentheses indicate robust standard errors double clustered at the firm and year-quarter level. The levels of statistical significance are denoted by the asterisks: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$. The data sample ranges from 2013:Q1 to 2017:Q4.

IV.7.3. *Adding more controls.* Our baseline regression includes controls for firm fixed effects, province fixed effects, year-quarter fixed effects, and interactions between firms' initial characteristics and the year fixed effects. To examine the robustness of our results, we now consider several additional controls at the provincial level, including FDI to GDP ratio, Aged population, the logarithm of total loans, and GDP growth rate. FDI to GDP ratio and GDP growth rate can be affected by the expansionary local fiscal policy and impact loan demand. The aged population can affect loan supply (via saving) and loan demand (via economic growth). And the bank risk-taking channel also has an impact on total loan supply. Therefore, we add these potentially omitted variables to see whether our main results are robust. Furthermore, we control for bank branch fixed effect to exclude potential branch-level omitted factors.

Table 10 shows the regression results with these additional controls (one at a time). Our main findings in the baseline estimation remains robust: the regulation eases the lending to POEs by reducing their loan rates through the bank risk-taking channel; the negative impact of regulation is even larger for the provinces with relatively high government outstanding debt.

IV.7.4. *Effects of deleveraging policy: A placebo test.* In December 2015, the Chinese government implemented a deleveraging policy, aiming to reduce the leverage in overcapacity industries. It is possible that the deleveraging policy might have played a role in driving the observed relation between the regulation of government debt and bank risk-taking behaviors.

We conduct a placebo test using China's deleveraging policy to examine this possibility. We define a dummy variable, $DeLev_y$, which equals one if the year is 2016 or after and zero otherwise. In the placebo test, we estimate the baseline empirical model, replacing the variable $Post_y$ in the baseline model with $DeLev_y$. Table 11 shows the estimation results. Unlike the new regulation policy on government debt, the deleveraging policy had no significant impact on bank risk-taking.[24]

IV.7.5. *Alternative definition of $GovDebt_j$.* In the baseline regression, we use the level of outstanding debt $GovDebt_j$ as an indicator of the size of the debt swap program for a particular province. Alternatively, we construct a dummy variable, $HGovDebt_j$ that equals 1 if the level of outstanding debt is above the median (or mean) and zero otherwise to replace $GovDebt_j$ in the baseline estimation. Table 12 shows that for those POE firms in the high-debt provinces, implementing regulation significantly reduces their loan rates. Therefore, the baseline results are robust to the definition of high-debt region.

[24]The debt swap program was implemented from 2015 to 2018, which partially explains why we do not detect breaks in years besides 2015.

TABLE 10. Additional controls

$LoanRate_{ifjt}$	(1)	(2)	(3)	(4)	(5)
$POE_i \times Post_y$	-3.169***	-2.833***	-2.802***	-2.755***	-2.749***
	(0.676)	(0.639)	(0.769)	(0.776)	(0.792)
$GovDebt_j \times POE_i \times Post_y$	-2.839***	-2.614**	-2.443**	-2.420**	-2.435**
	(0.990)	(0.984)	(0.998)	(0.989)	(1.069)
$GovDebt_j \times POE_i$	0.827	0.946	-0.851	-0.820	1.284
	(2.042)	(2.069)	(1.799)	(1.812)	(0.829)
$GovDebt_j \times Post_y$	-1.098	-1.027	0.0815	0.130	0.124
	(0.876)	(0.858)	(0.897)	(0.884)	(0.901)
FDI/GDP_{jt}	-0.499	-2.311**	-3.313***	-3.248***	-3.258***
	(0.749)	(1.066)	(1.135)	(1.112)	(1.119)
$Aged\ Pop_{jt}$		-94.36**	-62.81	-65.08	-65.25
		(38.04)	(37.37)	(37.87)	(38.12)
$\ln(Loan_{jt})$			14.81***	13.77***	13.76***
			(4.356)	(4.515)	(4.538)
$GDP\ Growth_{jt}$				-20.54	-20.76
				(16.17)	(16.33)
Bank Branch FE	no	no	no	no	yes
Initial controls × year FE	yes	yes	yes	yes	yes
Firm FE	yes	yes	yes	yes	yes
Province FE	yes	yes	yes	yes	yes
Year-quarter FE	yes	yes	yes	yes	yes
Observations	135,127	135,127	122,305	122,305	122,305
R^2	0.625	0.626	0.629	0.630	0.630

Notes: The FDI/GDP_{jt} is the FDI to GDP ratio for province j in period t. The $Aged\ Pop_{jt}$ is the aged population share. The $\ln(Loan_{jt})$ is measured by natural logarithms of the total amount of bank loans for province j in period t. All other variables have the same definitions as those in the baseline estimations. All models include controls for the province fixed effects, the firm fixed effects, the year-quarter fixed effects, and the average firm characteristics (including tangible to total assets ratio, leverage, and ROA) in the years before 2013 interacted with the year fixed effects. The numbers in the parentheses indicate robust standard errors double clustered at the firm and year-quarter level. The levels of statistical significance are denoted by the asterisks: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$. The data sample ranges from 2013:Q1 to 2017:Q4.

Table 11. Effects of deleveraging policy: A placebo test

	(1)	(2)
	$LoanRate_{ifjt}$	$LoanRate_{ifjt}$
$GovDebt_j \times POE_i$		-1.014
		(2.180)
$GovDebt_j \times Delev_y$		-0.0828
		(0.925)
$POE_i \times Delev_y$	-2.378	-2.074
	(1.506)	(1.470)
$GovDebt_j \times POE_i \times Post_y$		-0.558
		(1.231)
Initial controls × year FE	yes	yes
Firm FE	yes	yes
Province FE	yes	yes
year-quarter FE	yes	yes
Observations	147,700	135,133
R^2	0.629	0.622

Notes: $Delev_y$ is a dummy, equal to 1 if the year $>=$2016. The estimation specification is the same as that in the baseline analysis. The numbers in the parentheses indicate robust standard errors double clustered at the firm and year-quarter level. The levels of statistical significance are denoted by the asterisks: *** for p $<$ 0.01, ** for p $<$ 0.05, and * for p $<$ 0.1. The data sample ranges from 2013:Q1 to 2017:Q4.

IV.8. **Implication on Total Factor Productivity (TFP).** POEs in China have higher average productivity than SOEs (Hsieh and Klenow, 2009). Thus, the regulation of the local government debt, especially the debt swap program, inducing bank lending to POE firms may raise aggregate productivity. To examine this potential consequence, we document the policy implication on productivity. We compute a measure of TFP for province j in year y as the dependent variable, $\log(TFP_{j,y})$, using the province-level data based on the approach in (Brandt et al., 2013). The independent variable of interest is the interaction term $GovDebt_j \times Post_y$. According to our analysis, the coefficient should be positive, i.e., after the implementation of regulation, the provinces with higher outstanding debt at the end of 2014 experience a larger increase in the average productivity.

Table 12. Alternative definition of local government debt variable

$LoanRate_{ifjt}$	(1) by Median	(2) by Mean
$POE_i \times Post_y$	0.456	-0.797
	(1.762)	(0.854)
$HGovDebt_j \times POE_i \times Post_y$	-4.815**	-2.892**
	(1.787)	(1.041)
$HGovDebt_j \times POE_i$	2.237	2.825
	(2.237)	(2.783)
$HGovDebt_j \times Post_i$	0.621	-1.571
	(2.236)	(1.295)
Initial controls × year FE	yes	yes
Firm FE	yes	yes
Province FE	yes	yes
year-quarter FE	yes	yes
Observations	135,133	135,133
R^2	0.625	0.627

Notes: $HGovDebt_j$ is a dummy equal to 1 if the outstanding debt in province j is above the median/mean, and zero otherwise. Columns (1) and (2) report the results for the cases of median or mean, respectively. The estimation specification is the same as that in the baseline analysis. The numbers in the parentheses indicate robust standard errors double clustered at the firm and year-quarter level. The levels of statistical significance are denoted by the asterisks: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$. The data sample ranges from 2013:Q1 to 2017:Q4.

Table 13 displays estimation results. Column (1) shows the results for parallel trend analysis, implying that the government debt has a positive impact on the average productivity after the regulation is effective in 2015. Column (2) shows the estimation of the relationship between government debt and productivity. The estimation result implies that for POE firms in the provinces with local government outstanding debt 1% higher than the average, the regulation that implements the debt swap program significantly increases productivity by 2.2%.

We also investigate the channel effects of the debt swap program on the provincial TFP. Column (3) displays the 2SLS estimation results for the regression regarding the provincial TFP. We conduct a similar estimation as that in Table 5. The results in Column (3) show that $GovDebt_j \times Post_y$ is a valid instrument for $\ln(1+Swap_{j,y})$, and the correlation between these two variables is significantly positive. Moreover, the swapped debt increases the provincial TFP, and the coefficient is positive and significant. The above results indicate that the debt swap program provides a crucial channel through which the regulation improves productivity. Our analysis suggests that the regulation of the local government debt induces a positive impact on China's aggregate economy by mitigating the credit misallocation between SOEs and POEs.

TABLE 13. Effects of regulation on the provincial TFP

	(1)	(2)		(3)
	$\ln TFP_{jy}$	$\ln TFP_{jy}$		Channel effects
			Second stage:	$\ln(TFP_{j,y})$
$GovDebt_j \times Post_y$		0.0220***	$\ln(1 + Swap_{j,y})$	0.0253***
		(0.00702)		(0.0062)
$GovDebt_j \times year = 2014$	0.00346		Initial controls × FE	-
	(0.00506)		Firm FE	-
$GovDebt_j \times year = 2015$	0.0179**		Year-quarter FE	-
	(0.00754)		Province FE	yes
$GovDebt_j \times year = 2016$	0.0270**		Province controls	yes
	(0.00995)		Year FE	yes
$GovDebt_j \times year = 2017$	0.0271**		Kleibergen-Paap rk LM statistic	41.669
	(0.00994)		Observations	125
Controls	yes	yes	*First stage:*	$\ln(1 + Swap_{j,y})$
Province FE	yes	yes	$GovDebt_j \times Post_y$	0.9385***
Year FE	yes	yes		(0.0496)
R^2	0.684	0.678		
Observations	125	125	F test of excluded instruments	306.51

Notes: The dependent variable is average $\ln TFP_{jy}$ at the province level. Column (1) is the parallel trend analysis. Column (2) estimates the effects of regulation on the province-level TFP. In Columns (1) and (2), other controls include the ratio of FDI to GDP and aged population share. Column (3) reports the results of the channel effects of debt swap on the TFP at the province-year level. We adopt a 2SLS approach to estimate the channel effect. $\ln(1 + Swap_{j,y})$ is the channel variable. We instrument $\ln(1 + Swap_{j,y})$ by $GovDebt_j \times Post_y$. The robust standard errors are reported in parentheses due to the number of provinces in our sample being only 25, less than the threshold for clustered standard errors. The levels of statistical significance are denoted by the asterisks: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$.

V. CONCLUSION

We have studied the effects of China's debt-to-bond swapping program on bank lending. The debt swap program replaced the local government debt held by commercial banks in the forms of LGFV bonds and corporate loans with local government bonds, which are considered low-risk assets under Basel III regulations. We obtain robust empirical evidence suggesting that the debt swap program significantly increased bank lending to private firms, reallocating credit from inefficient SOEs to productive private firms and thus improving aggregate productivity.

References

Acharya, Viral V, Tim Eisert, Christian Eufinger, and Christian Hirsch, "Real effects of the sovereign debt crisis in Europe: Evidence from syndicated loans," *The Review of Financial Studies*, 2018, *31* (8), 2855–2896.

Adelino, Manuel, Igor Cunha, and Miguel A Ferreira, "The economic effects of public financing: Evidence from municipal bond ratings recalibration," *The Review of Financial Studies*, 2017, *30* (9), 3223–3268.

Altavilla, Carlo, Marco Pagano, and Saverio Simonelli, "Bank exposures and sovereign stress transmission," *Review of Finance*, 2017, *21* (6), 2103–2139.

Ang, Andrew, Jennie Bai, and Hao Zhou, "The great wall of debt: Real estate, political risk, and Chinese local government credit spreads," *Columbia Business School Research Paper*, 2016, (15-57).

Bai, Chong-En, Chang-Tai Hsieh, and Zheng Michael Song, "The long shadow of a fiscal expansion," Technical Report, National Bureau of Economic Research 2016.

Barrot, Jean-Noel, "Trade credit and industry dynamics: Evidence from trucking firms," *Journal of Finance*, 2016, *71* (5), 1975–2016.

Baskaya, Yusuf Soner, Bryan Hardy, Sebnem Kalemli-Özcan, and Vivian Yue, "Sovereign risk and bank lending: evidence from 1999 turkish earthquake," *Journal of International Economics*, 2024, *150*, 103918.

Becker, Bo and Victoria Ivashina, "Financial repression in the European sovereign debt crisis," *Review of Finance*, 2018, *22* (1), 83–115.

Bertrand, Marianne and Sendhil Mullainathan, "Are CEOs rewarded for luck? The ones without principals are," *The Quarterly Journal of Economics*, 2001, *116* (3), 901–932.

Bleck, Alexander and Xuewen Liu, "Credit Expansion and Credit Misallocation," *Journal of Monetary economics*, 2018, *94*, 27–40.

Bofondi, Marcello, Luisa Carpinelli, and Enrico Sette, "Credit supply during a sovereign debt crisis," *Journal of the European Economic Association*, 2018, *16* (3), 696–729.

Bottero, Margherita, Simone Lenzu, and Filippo Mezzanotti, "Sovereign debt exposure and the bank lending channel: impact on credit supply and the real economy," *Journal of International Economics*, 2020, *126*, 103328.

Brandt, Loren, Trevor Tombe, and Xiaodong Zhu, "Factor market distortions across time, space and sectors in China," *Review of Economic Dynamics*, 2013, *16* (1), 39–58.

Chang, Chun, Kaiji Chen, Daniel F. Waggoner, and Tao Zha, "Trends and Cycles in China's Macroeconomy," in Martin Eichenbaum and Jonathan A. Parker, eds., *NBER Macroeconomics Annual 2015*, Vol. 30, Chicago: University of Chicago Press, 2016, pp. 1–84.

———, **Zheng Liu, Mark M. Spiegel, and Jingyi Zhang**, "Reserve Requirements and Optimal Chinese Stabilization Policy," *Journal of Monetary Economics*, May 2019, *103*, 33–51.

Chen, Kaiji, Haoyu Gao, Patrick Higgins, Daniel F Waggoner, and Tao Zha, "Monetary Stimulus amidst the Infrastructure Investment Spree: Evidence from China's Loan-Level Data," *The Journal of Finance*, 2023, *78* (2), 1147–1204.

Chen, Zhuo, Zhiguo He, and Chun Liu, "The Financing of Local Government in China: Stimulus Loan Wanes and Shadow Banking Waxes," *Journal of Financial Economics*, 2020, *137*, 42–71.

Cong, Lin William, Haoyu Gao, Jacopo Ponticelli, and Xiaoguang Yang, "Credit Allocation Under Economic Stimulus: Evidence from China," *Review of Financial Studies*, 2019, *32* (9), 3412–3460.

Demirci, Irem, Jennifer Huang, and Clemens Sialm, "Government debt and corporate leverage: international evidence," *Journal of financial economics*, 2019, *133* (2), 337–356.

Deng, Yongheng, Randall Morck, Jing Wu, and Bernard Yeung, "China's pseudo-monetary policy," *Review of Finance*, 2015, *19* (1), 55–93.

Gao, Haoyu, Hong Ru, and Dragon Yongjun Tang, "Subnational debt of China: The politics-finance nexus," *Journal of Financial Economics*, 2021, *141* (3), 881–895.

Geng, Zhe and Jun Pan, "The SOE Premium and Government Support in China's Credit Market," *The Journal of Finance*, October 2024, *79* (5), 3041–3103.

Gopinath, Gita, Sebnem Kalemli-Ozcan, Loukas Karabarbounis, and Carolina Villegas-Sanchez, "Capital Allocation and Productivity in South Europe," *Quarterly Journal of Economics*, 2017 2017, *132* (4), 1915–1967.

Graham, John, Mark T Leary, and Michael R Roberts, "How does government borrowing affect corporate financing and investment?," Technical Report, National Bureau of Economic Research 2014.

He, Zhiguo and Wei Wei, "China's financial system and economy: a review," *Annual Review of Economics*, 2023, *15* (1), 451–483.

Hoffmann, Mathias, Iryna Stewen, and Michael Stiefel, "Growing like Germany: local public debt, local banks, low private investment," 2021.

Hsieh, Chang-Tai and Peter J. Klenow, "Misallocation and Manufacturing TFP in China and India," *The Quarterly Journal of Economics*, November 2009, *124* (4), 1403–1448.

Huang, Yi, Marco Pagano, and Ugo Panizza, "Local crowding-out in China," *The Journal of Finance*, 2020, *75* (6), 2855–2898.

Ivanov, Ivan T and Tom Zimmermann, "The "privatization" of municipal debt," *Journal of Public Economics*, 2024, *237*, 105156.

John, Teresa A and Kose John, "Top-management compensation and capital structure," *The Journal of Finance*, 1993, *48* (3), 949–974.

Li, Xiaoming, Zheng Liu, Yuchao Peng, and Zhiwei Xu, "Bank Risk-Taking, Credit Allocation, and Monetary Policy Transmission: Evidence from China," 2024. Federal Reserve Bank of San Francisco Working Paper 2020-27.

Liu, Laura Xiaolei, Yuanzhen Lyu, and Fan Yu, "Implicit government guarantee and the pricing of Chinese LGFV debt," *Claremont McKenna College Robert Day School of Economics and Finance Research Paper*, 2017, (2922946).

Liu, Zheng, Pengfei Wang, and Zhiwei Xu, "Interest Rate Liberalization and Capital Misallocations," *American Economic Journal: Macroeconomics*, April 2021, *13* (2), 373–419.

Marco, Filippo De, "Bank lending and the European sovereign debt crisis," *Journal of Financial and Quantitative Analysis*, 2019, *54* (1), 155–182.

Miyamoto, Wataru, Thuy Lan Nguyen, and Dmitriy Sergeyev, "Government Spending Multipliers under the Zero Lower Bound: Evidence from Japan," *American Economic Journal: Macroeconomics*, July 2018, *10* (3), 247–77.

Önder, Yasin Kürşsat, Sara Restrepo-Tamayo, Maria Alejandra Ruiz-Sanchez, and Mauricio Villamizar-Villegas, "Government Borrowing and Crowding Out," *American Economic Journal: Macroeconomics*, 2024, *16* (1), 286–321.

Ongena, Steven, Alexander Popov, and Neeltje Van Horen, "The invisible hand of the government: Moral suasion during the European sovereign debt crisis," *American Economic Journal: Macroeconomics*, 2019, *11* (4), 346–79.

Pinardon-Touati, Noémie, "The Crowding Out Effect of Local Government Debt: Micro-and Macro-Estimates," 2024. Unpublished manuscript, Columbia University.

Qu, Xi, Zhiwei Xu, Jinxiang Yu, and Jun Zhu, "Understanding local government debt in China: A regional competition perspective," *Regional Science and Urban Economics*, 2023, *98*, 103859.

Ramey, Valerie A. and Sarah Zubairy, "Government Spending Multipliers in Good Times and in Bad: Evidence from US Historical Data," *Journal of Political Economy*, 2018, *126* (2), 850–901.

Restuccia, Diego and Richard Rogerson, "Policy Distortions and Aggregate Productivity with Heterogeneous Plants," *Review of Economic Dynamics*, October 2008, *11* (4), 707–720.

Song, Zheng, Kjetil Storesletten, and Fabrizio Zilibotti, "Growing Like China," *The American Economic Review*, 2011, *101* (1), 196–233.

Wang, He, Yang Yao, and Yue Zhou, "Markets Price Politicians: Evidence from China's Municipal Bond Markets," *China Center for Economic Research Working Paper Series*, 2022.

Williams, Tomas, "Capital inflows, sovereign debt and bank lending: Micro-evidence from an emerging market," *The Review of Financial Studies*, 2018, *31* (12), 4958–4994.

Zilibotti, Fabrizio, "Growing and slowing down like China," *Journal of the European Economic Association*, 2017, *15* (5), 943–988.

Supplemental Appendices: For Online Publication

Appendix A. Proofs

This section provides the proofs of the propositions in Section III.

Proof of Proposition 1.

Proof. We first show the existence and uniqueness of $\hat{\omega}$. With binding CAR constraint, substitute $\lambda = \frac{1}{\xi(\hat{\omega})\psi}$ into the objective function, and the first-order derivative is

$$\frac{dV/e}{d\hat{\omega}} = \lambda R_S - R_D(\lambda - 1) - \hat{\omega}\left(\lambda R_H - R_D(\lambda-1)\right) + \left[\hat{\omega}\left(R_S - R_D\right) + \frac{1-\hat{\omega}^2}{2}\left(R_H - R_D\right)\right]\frac{d\lambda}{d\hat{\omega}}$$

$$= \lambda\left\{\underbrace{R_S - R_D - \hat{\omega}\left(R_H - R_D\right) + (1-\hat{\omega})R_D\psi\xi(\hat{\omega}) - \frac{\xi'(\hat{\omega})}{\xi(\hat{\omega})}\left[\hat{\omega}\left(R_S - R_D\right) + \frac{1-\hat{\omega}^2}{2}\left(R_H - R_D\right)\right]}_{\equiv g(\hat{\omega})}\right\}$$

The sign depends on the term in the bracket, which we define as $g(\hat{\omega})$. $g(\hat{\omega})$ is decreasing with $\hat{\omega}$ as

$$\begin{aligned}
g'(\hat{\omega}) &= -\left(1 - \hat{\omega}\frac{\xi'}{\xi} + \frac{1-\hat{\omega}^2}{2}\frac{\xi''\xi - \xi'^2}{\xi^2}\right)\left(R_H - R_D\right) \\
&\quad - \left(\hat{\omega}\frac{\xi''\xi - \xi'^2}{\xi^2} + \frac{\xi'}{\xi}\right)\left(R_S - R_D\right) - R_D\psi\xi\left[1 - (1-\hat{\omega})\frac{\xi'}{\xi}\right] \\
&< -\left(1 - \hat{\omega}\frac{\xi'}{\xi} + \frac{1-\hat{\omega}^2}{2}\frac{\xi''\xi - \xi'^2}{\xi^2}\right)\left(R_H - R_D\right) - \left(\hat{\omega}\frac{\xi''\xi - \xi'^2}{\xi^2} + \frac{\xi'}{\xi}\right)\left(R_S - R_D\right) \\
&< -\left(1 + \frac{1-2\hat{\omega}}{2}\frac{\xi'}{\xi} + \frac{1+\hat{\omega}-\hat{\omega}^2}{2}\frac{\xi''\xi - \xi'^2}{\xi^2}\right)\left(R_H - R_D\right) \\
&< -\frac{\hat{\omega}(1+\hat{\omega})}{2}\left(R_H - R_D\right) < 0
\end{aligned}$$

The first inequality holds with the assumption that $\xi'(\hat{\omega}) < 0$. The second inequality holds with the assumption that $0 \leq R_S - R_D \leq R_H - R_S$. The third inequality holds with the assumption that $-\xi^2 \leq \xi\xi'' - \xi'^2 < 0$. For the boundary value, we have

$$g(\hat{\omega})\Big|_{\hat{\omega} = \frac{R_S - R_d}{R_H - R_d}} = (1-\hat{\omega})R_D\psi\xi(\hat{\omega}) - \frac{\xi'(\hat{\omega})}{\xi(\hat{\omega})}\left[\hat{\omega}\left(R_S - R_D\right) + \frac{1-\hat{\omega}^2}{2}\left(R_H - R_D\right)\right] > 0$$

$$g(1) = -\left(R_H - R_S\right) - \frac{\xi'(1)}{\xi(1)}\left(R_S - R_D\right) < R_S - R_D - \left(R_H - R_S\right) < 0$$

Therefore, there exists one unique $\hat{\omega} \in (0,1)$ such that $g(\hat{\omega}) = 0$. The objective value V/e is increasing for $\omega \in (0, \hat{\omega})$, and decreasing for $\omega \in (\hat{\omega}, 1)$.

For comparative analysis w.r.t. ψ. Take full derivation w.r.t. $g(\hat{\omega};\psi)=0$, we have

$$\frac{d\hat{\omega}}{d\psi}=-\frac{\partial g(\hat{\omega};\psi)/\partial\psi}{g'(\hat{\omega})}=-\frac{(1-\hat{\omega})R_D\xi(\hat{\omega})}{g'(\hat{\omega})}>0$$

$$\frac{d\lambda}{d\psi}=\frac{d}{d\psi}\frac{1}{\psi\xi(\hat{\omega})}=-\lambda\left[\frac{1}{\psi}-\xi'(\hat{\omega})\frac{(1-\hat{\omega})R_D}{g'(\hat{\omega})}\right]$$
$$=-\frac{\lambda/\psi}{g'(\hat{\omega})}\left[g'(\hat{\omega})-\xi'(\hat{\omega})(1-\hat{\omega})\psi R_D\right]<0$$

Therefore, a tighter CAR constraint leads to a safer investment policy $\hat{\omega}$, and a lower leverage ratio λ. □

Proof of Proposition 2.

Proof. Note that the bank's optimization problem (14) is essentially isomorphic to the problem in the model without local government debt. The main difference is that the parameter ψ in the CAR constraint is replaced with $\tilde{\psi}$, which is decreasing in the risk-weighting coefficient ξ_g. Therefore, we can show the existence and uniqueness of of $\hat{\omega}$ in the same way with the baseline model. For comparative analysis w.r.t ξ_g, we have

$$\frac{d\hat{\omega}}{d\xi_g}=\frac{d\hat{\omega}}{d\tilde{\psi}}\frac{d\tilde{\psi}}{d\xi_g}=-\frac{(1-\hat{\omega})(g(R_G-R_D)+R_D)\xi}{g'(\hat{\omega})}\tilde{\psi}^2g>0$$

where

$$g'(\hat{\omega})=-(R_H-R_D)-(g(R_G-R_D)+R_D)\tilde{\psi}\xi+(1-\hat{\omega})(g(R_G-R_D)+R_D)\tilde{\psi}\xi'$$
$$-\left[R_S-R_D-\hat{\omega}(R_H-R_D)\right]\frac{\xi'}{\xi}-\left[\hat{\omega}(R_S-R_D)+\frac{1-\hat{\omega}^2}{2}(R_H-R_D)\right]\frac{\xi''\xi-\xi'^2}{\xi^2}$$

A lower risk-weighting coefficient of government bonds leads to a riskier investment policy $\hat{\omega}$, and reduces the loan rate spread ΔR_{loan}.

We next show the sign of the second-order derivation, which is

$$\frac{d^2\hat{\omega}}{d\xi_g dg}=\frac{d}{dg}\left[\frac{d\hat{\omega}}{d\tilde{\psi}}\frac{d\tilde{\psi}}{d\xi_g}\right]=\left[\frac{d}{dg}\frac{d\hat{\omega}}{d\tilde{\psi}}\right]\frac{d\tilde{\psi}}{d\xi_g}+\frac{d\hat{\omega}}{d\tilde{\psi}}\frac{d^2\tilde{\psi}}{d\xi_g dg}$$
$$=\left[\frac{d}{dg}\frac{d\hat{\omega}}{d\tilde{\psi}}\right]\tilde{\psi}^2g-\frac{(1-\hat{\omega})(g(R_G-R_D)+R_D)\xi}{g'(\hat{\omega})}\tilde{\psi}^2\left(1+2\tilde{\psi}\xi_g g\right)>0$$

It is obvious that the second term is positive, while the sign of the first term is ambiguous. We then prove that when $\tilde{\psi}g$ is relatively small, the second term dominates. Since g enters into the objective function directly, and also indirectly through $\tilde{\psi}$, i.e.

$$\frac{d\hat{\omega}}{dg}=\frac{\partial\hat{\omega}}{\partial g}+\frac{\partial\hat{\omega}}{\partial\tilde{\psi}}\frac{\partial\tilde{\psi}}{\partial g}=-\frac{(1-\hat{\omega})\xi\tilde{\psi}}{g'(\hat{\omega})}\left[R_G-R_D+(g(R_G-R_D)+R_D)\tilde{\psi}\xi_g\right]>0$$

Therefore,

$$
\begin{aligned}
\frac{d}{dg}\frac{d\hat{\omega}}{d\tilde{\psi}} &= -\frac{(g(R_G-R_D)+R_D)}{g'(\hat{\omega})}\left[(1-\hat{\omega})\xi' - \xi - \frac{g''(\hat{\omega})}{g'(\hat{\omega})}(1-\hat{\omega})\xi\right]\frac{d\hat{\omega}}{dg} \\
&\quad + \frac{(1-\hat{\omega})(g(R_G-R_D)+R_D)\xi}{g'(\hat{\omega})^2}\left[\frac{\partial g'(\hat{\omega})}{\partial g} + \frac{\partial g'(\hat{\omega})}{\partial \tilde{\psi}}\frac{\partial \tilde{\psi}}{\partial g}\right] - \frac{(1-\hat{\omega})(R_G-R_D)\xi}{g'(\hat{\omega})} \\
&> \frac{(1-\hat{\omega})(g(R_G-R_D)+R_D)\xi\tilde{\psi}}{g'(\hat{\omega})^2}\times \\
&\quad \left[R_G - R_D + (g(R_G-R_D)+R_D)\tilde{\psi}\xi_g\right]\left[2(1-\hat{\omega})\xi' - 2\xi - \frac{g''(\hat{\omega})}{g'(\hat{\omega})}(1-\hat{\omega})\xi\right]
\end{aligned}
$$

The inequality relies on the condition that $g'(\hat{\omega}) < 0$. Substitute into the second order derivation, we have

$$
\begin{aligned}
\frac{d^2\hat{\omega}}{d\xi_g dg} &= \left[\frac{d}{dg}\frac{d\hat{\omega}}{d\tilde{\psi}}\right]\tilde{\psi}^2 g - \frac{(1-\hat{\omega})(g(R_G-R_D)+R_D)\xi}{g'(\hat{\omega})}\tilde{\psi}^2\left(1+2\tilde{\psi}\xi_g g\right) \\
&> \frac{(1-\hat{\omega})(g(R_G-R_D)+R_D)\xi\tilde{\psi}^2}{g'(\hat{\omega})^2}\times \\
&\left\{\tilde{\psi}g\left[R_G - R_D + (g(R_G-R_D)+R_D)\tilde{\psi}\xi_g\right]\left[2(1-\hat{\omega})\xi' - 2\xi - \frac{g''(\hat{\omega})}{g'(\hat{\omega})}(1-\hat{\omega})\xi\right] - g'(\hat{\omega})\left(1+2\tilde{\psi}\xi_g g\right)\right\} \\
&> \frac{(1-\hat{\omega})(g(R_G-R_D)+R_D)\xi\tilde{\psi}^2}{g'(\hat{\omega})^2}\times \\
&\left\{\tilde{\psi}g\left[R_G - R_D + \frac{1}{2}(g(R_G-R_D)+R_D)\tilde{\psi}\xi_g\right]\left[2(1-\hat{\omega})\xi' - 2\xi - \frac{g''(\hat{\omega})}{g'(\hat{\omega})}(1-\hat{\omega})\xi\right] - g'(\hat{\omega})\right\} \\
&> \frac{(1-\hat{\omega})(g(R_G-R_D)+R_D)\xi\tilde{\psi}^2}{g'(\hat{\omega})^2}\times \\
&\left\{\frac{\tilde{\psi}}{4}(g(R_G-R_D)+R_D)\left[2(1-\hat{\omega})\xi' - 2\xi - \frac{g''(\hat{\omega})}{g'(\hat{\omega})}(1-\hat{\omega})\xi\right] - g'(\hat{\omega})\right\} \\
&> \frac{(1-\hat{\omega})(g(R_G-R_D)+R_D)^2\xi\tilde{\psi}^3}{4g'(\hat{\omega})^2}\xi\left[2 - \frac{g''(\hat{\omega})}{g'(\hat{\omega})}(1-\hat{\omega})\right]
\end{aligned}
$$

The second and last inequality relies on the condition that $g'(\hat{\omega}) < -(g(R_G-R_D)+R_D)\tilde{\psi}(\xi-(1-\hat{\omega})\xi')$. The third inequality holds when $\tilde{\psi}g$ is relatively small, i.e. $g(R_G-R_D)\left(\frac{3}{4}+\frac{1}{2}\tilde{\psi}\xi_g g\right) < \left(\frac{1}{4}-\frac{1}{2}\tilde{\psi}\xi_g g\right)R_D$. Lastly, we show that $2-\frac{g''(\hat{\omega})}{g'(\hat{\omega})}(1-\hat{\omega}) > 0$, which is

$$
\begin{aligned}
2g'(\hat{\omega}) - (1-\hat{\omega})g''(\hat{\omega}) &= -2(R_H-R_D) - 2\tilde{\psi}(g(R_G-R_D)+R_D)\left[\xi - 2(1-\hat{\omega})\xi' + \frac{(1-\hat{\omega})^2}{2}\xi''\right] \\
&\quad - \left[\left(1+2\hat{\omega}-3\hat{\omega}^2\right)(R_H-R_D) - 2(1-2\hat{\omega})(R_S-R_D)\right]\frac{\xi''\xi-\xi'^2}{\xi^2} \\
&\quad - \left[2(R_S-R_D) + (1-3\hat{\omega})(R_H-R_D)\right]\frac{\xi'}{\xi} \\
&< 4\hat{\omega}(R_S-R_D) - \hat{\omega}(1+3\hat{\omega})(R_H-R_D)
\end{aligned}
$$

$$< -\left(1-\hat{\omega}\right)\left(R_S-R_D\right) < 0$$

The above inequality holds based on the conditions that $-\xi^2 \leq \xi\xi'' - \xi'^2 < 0$, $g'\left(\hat{\omega}\right) < 0$, and $R_S - R_D < \hat{\omega}\left(R_H - R_D\right)$. □