The Mandarin Model of Growth*

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Abstract

In China's hybrid economy, the central government employs economic performance evaluations to guide career advancements of local officials. When local governments face stringent debt constraints, these career incentives can spur growth. However, when debt constraints are relaxed, such incentives may lead to short-termism, over-leveraging, and crowding out of private investment. We examine the impact of these career incentives and, through counterfactual analysis, find that they contributed to half of China's extraordinary pre-2008 growth. Post-2008, however, tighter control of local government debt would have been more critical to sustaining growth. The overall welfare implications of the Mandarin system remain ambiguous.

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Over the past four decades, China has undergone transformative economic reforms, rising to become the world's second-largest economy. Despite this growth, its recent slowdowns have sparked concerns about economic and financial stability that impact both China and the global economy (Song and Xiong (2018)). This paper proposes a macroeconomic framework tailored to China's unique landscape, characterized by significant state intervention, particularly through massive infrastructure investments and industrial policies. This hybrid system, distinct from other major economies, faces unique challenges like high investment rates and escalating debt levels, which this framework aims to elucidate.

To understand the state's influence on the Chinese economy, it is essential to grasp its hierarchical structure, with the central government at the top and authority cascading down through provinces, cities, counties, and townships. While the central government sets overarching goals, local governments are pivotal in implementing these plans. They play a crucial role in infrastructure development—building roads, highways, and airports—and in driving local economic growth by fostering business-friendly environments, developing new markets, and formulating local industrial policies. The efficiency of this Mandarin system ultimately shapes the state's capacity to govern effectively.

Two international comparisons highlight the critical role of local governments in the Chinese economy. Firstly, from 2013 to 2017, local governments financed a major portion of China's infrastructure sector, which constituted 23.1% of its total capital—higher than the United States' 18.2% and more than double the European Union's 9.9%. Secondly, during the same period, local government revenue in China, including land sales, accounted for up to 25.2% of GDP, significantly exceeding the 13.9% in the U.S. and 10.0% in European OECD countries.[1]

China's central authority manages local governments through the cadre system, appointing officials who, despite their autonomy in economic and fiscal matters, are evaluated based on central government criteria vital for career progression. This system, mirroring the traditional Mandarin bureaucracy, ensures adherence to central policies and has been a cornerstone of Chinese governance for over two millennia. Yet, the incentives and disciplinary measures for local leaders evolve, reflecting shifts in the central authority's priorities and capabilities, thus shaping China's economic trajectory.[2]

[1] The data sources for compiling China's local government revenue are detailed in Section A.5.1. For OECD countries, we consider state and local government revenue, excluding social security funds. The data was sourced from the OECD's "Government At a Glance".

[2] Originating from the Soviet nomenklatura, the current Chinese cadre system was established in the

In this paper, we introduce a dynamic general equilibrium model with multiple regions that captures career incentives within the Mandarin system. Local governments enhance firm productivity by investing in regional infrastructure. These firms source capital from a national market that pools household savings and capital demand to set the interest rate. Local governments allocate fiscal resources between infrastructure development and government consumption. The central government evaluates local governors based on economic performance, incentivizing them to invest in infrastructure. This approach aligns with the signal-jamming mechanism described by Holmström (1982), where performance assessments motivate local governors to prioritize infrastructure to advance their careers.

We characterize a decentralized equilibrium where local leaders, driven by personal consumption and career progression, invest in infrastructure with little concern for household welfare in their or other regions. Their career-driven incentives introduce a divergence in fiscal choices between consumption and investment, similar to the investment wedge in business cycle accounting. In settings with closed-form solutions, the propensity of local governments to invest increases with stronger career incentives. Generally, strong career incentives consistently enhance steady-state aggregate output.

However, career incentives designed to enhance local economic performance may lead local leaders to prioritize short-term gains, potentially undermining long-term fiscal stability and affecting the broader economy. Studies by Bai, Hsieh and Song (2016) and Chen, He and Liu (2020) attribute China's recent surge in leverage primarily to local governments, rather than the central government, private enterprises, or households. Our estimates show that the local government debt-to-GDP ratio rose from 10.5% in 2007 to 47.0% in 2017, significantly surpassing the central government's 16.2%. This accumulation of local government debt, by increasing overall capital demand, may raise interest rates and create pecuniary externalities that impact other regions.

To examine these issues, we extend the model to include local government debt, allowing leaders to balance the immediate gains from output growth against the costs of future debt repayments and potential liquidity risks. Liquidity shortages, possibly requiring central government intervention, could influence performance evaluations, thus enforcing financial discipline on local leaders. This discipline creates a wedge, decoupling local government

1950s, dismantled during the Cultural Revolution, and reinstated in the 1980s (Burns (1987); Burns (1994); Manion (1985)). Political science literature details its adaptation to the market economy, noting its role in conveying policy priorities to lower-level officials, collecting performance data, and managing evaluations and rewards (Shirk (1993); Huang (1996); Whiting (2001); Edin (2003)).

consumption growth from the interest rate. In the model's steady-state decentralized equilibrium, stronger career incentives heighten local government investment and leverage, which may crowd out private sector investment in a capital-constrained market. Conversely, stricter financial discipline reduces leverage, facilitating private capital but potentially discouraging infrastructure investment. Thus, the long-term effect of career incentives on economic outcomes is ambiguous due to these offsetting effects.

In our "institutional accounting" analysis, we quantify local leaders' career incentives and financial discipline from the wedges. Career incentives peaked during the Jiang-Zhu administration (1998-2002) but declined to 33% of their peak by Xi's first term (2013-17), alongside significantly more lenient financial discipline. These shifts align with observations in the political science literature that central authority priorities have varied over time, transitioning from political campaigns to economic development as the main career advancement criterion under Jiang's leadership (Shirk (1993); Edin (2003)). The focus later shifted to social welfare during the Hu-Wen era and to anti-corruption campaigns under Xi (Zuo (2015); Li and Manion (2023)).

To validate externally, we correlate inferred career incentives with the ages of local leaders, a key promotion factor in the cadre system (Yao and Zhang (2015)). Using "institutional accounting" on provincial data, we extract career incentives for each province and regress these incentives against the average ages of provincial and city leaders, controlling for year and province fixed effects. Results indicate a significant, negative correlation, particularly at the city level, consistent with economic performance being more vital for lower-tier officials' career progression (Landry, Lü and Duan (2018)). This correlation weakens post-2008, reflecting the diminished incentive structure under the Hu-Wen and Xi administrations. Variations in the magnitude of career incentives and their relationship with leaders' ages help explain the inconsistent findings across different study periods (Sheng (2022); Manion (2023)).

Our analysis reveals a positive correlation between inferred career incentives and Total Factor Productivity (TFP) growth across provinces, indicating that these incentives motivate local governments to boost economic performance beyond infrastructure development. The surge in TFP during the late 1990s and 2000s was notably driven by the entry of new firms (Brandt, Van Biesebroeck and Zhang (2012)). Moreover, local officials in China have facilitated the entry of private enterprises into previously restricted sectors (Bai, Hsieh and

Song (2020); Bai et al. (2020)), enhancing the positive effects of infrastructure investments on firm productivity, especially when combined with improvements in the institutional environment (Qian, Ru and Xiong (2024)).[3] The decline in career incentives may have notably contributed to the slowdown in TFP growth in China post-2008, at both aggregate and firm levels (Brandt et al. (2023)). This trend highlights the need for further research into how the Mandarin system impacts TFP growth, opening an interesting direction for future studies.

We conduct two counterfactual analyses. The first examines the impact of career incentives on China's rapid economic growth during the 1990s and 2000s, indicating that these incentives were critical. Without them, the annual output growth rate of 9.5% from 1993 to 2007 would have halved to 4.9%, due to reduced infrastructure development and hindered private sector capital accumulation. The growth effect of career incentives wanes as infrastructure saturates. Restoring career incentives to their peak levels from the Jiang-Zhu era would not significantly impact growth in the post-2008 period.

The second counterfactual tightens financial discipline post-2008, finding that prohibiting local government borrowing could increase annual growth by one percentage point by reducing the crowding-out effect on private sector capital. While career incentives have minimal growth impact in the same period under lax financial conditions, combining the restoration of peak-level career incentives with restricted borrowing could boost growth by 1.8 percentage points—0.8 points higher than tightening financial discipline alone. This additional gain underscores the importance of integrating career incentives with financial discipline in the Mandarin system.

Finally, we explore the welfare implications of the Mandarin model. Interestingly, the first-best allocation results in lower steady-state aggregate output compared to the decentralized equilibrium. While overinvestment in infrastructure boosts output, it reduces consumption levels in the decentralized equilibrium. Consequently, the Mandarin model may decrease welfare despite increasing output.

Our study builds on extensive research into China's transition from a centrally-planned to a market-oriented economy. Seminal works by Qian and Roland (1998), Maskin, Qian and Xu (2000), Blanchard and Shleifer (2001), and Li and Zhou (2005), reviewed by Xu (2011) and Qian (2017), emphasize how China's 1978 reforms shifted focus from ideological loyalty

[3] Other avenues for improving economic performance include restructuring inefficient state-owned enterprises (Hsieh and Song (2015); Chen et al. (2021)), increasing and better allocating R&D investments (König et al. (2022)), and maintaining local judicial independence (Liu et al. (2022)).

to economic performance, transforming regional governments into "helping hands" for development. However, the literature has yet to fully examine the negative effects of strong career incentives, particularly their role in fostering short-termism. This gap is crucial for understanding China's rising debt and real estate challenges. Our paper fills this gap by exploring incentive issues within the Mandarin system, complementing the work of Brunnermeier, Sockin and Xiong (2022) and Sockin and Xiong (2023) on information deficits, which emphasize the market's role in information discovery for officials.

Our analysis highlights the externalities of local government debt, contributing to the empirical literature on the crowding-out effect of borrowing by state-owned enterprises and local governments during China's post-2008 stimulus (Bai, Hsieh and Song (2016); Cong et al. (2019); Chen, He and Liu (2020); Huang, Pagano and Panizza (2020)). Specifically, our model offers quantitative assessments of the impact of local governments' relaxed financial discipline. The crowding-out effect on private sector capital is large and consistent with the compelling empirical evidence presented in Chen et al. (2023).

Our paper addresses a critical gap in the literature by quantitatively analyzing how institutional changes affect China's economic growth. We develop a framework to examine local governments' intertemporal decisions and their macroeconomic impacts. Our approach to China's capital market and external imbalances aligns with Song, Storesletten and Zilibotti (2011). We extend this pioneering macroeconomic framework by offering a deeper understanding of China's unique institutional structure, thus contributing to the literature on China's macroeconomic development, as recently reviewed by Chen and Zha (2023).

Our institutional accounting approach builds on business cycle accounting principles (Cole and Ohanian (2004); Chari, Kehoe and McGrattan (2007)) and aligns with recent quantitative studies on the Soviet Union (Cheremukhin et al. (2017)) and pre-reform China (Cheremukhin et al. (2024)). A key distinction of our model is that the wedges are microfounded by underlying institutions, enabling us to derive institutional parameters from them. Furthermore, unlike typical models in this area, our framework incorporates government debt rather than assuming a balanced budget. The significant effects of institutional parameters on growth and welfare in the Chinese economy also contribute to the broader literature on the role of institutions in growth and development (e.g., Glaeser et al. (2004); Acemoglu and Robinson (2013)).

Institutional accounting offers a novel way for analyzing China's political selection mechanism. Unlike existing studies that focus on the relationship between economic performance and promotions, our estimates are based on local leaders' economic decisions, reflecting their perceived career incentives, which may not always align with actual promotions. Although age has minimal impact on observed promotions (Yao and Zhang (2015)), our analysis shows that age accounts for over half of the variance in inferred career incentives across regions. These inferred career incentives not only align with political science narratives on shifts in central policy priorities but also quantify their impact on growth and welfare.

The rest of the paper is organized as follows: Section 1 documents key stylized facts for our analysis. Section 2 presents the baseline model. Section 3 investigates the extended model with local government debt. Section 4 conducts institutional accounting, while Section 5 presents counterfactual exercises. Section 6 concludes.

1 Stylized Facts

This section highlights key features of the Chinese economy that motivate our model: significant infrastructure capital, shifting local government revenue allocation, rising local government debt, and the widening gap between regulated and market-based interest rates.

1.1 Infrastructure

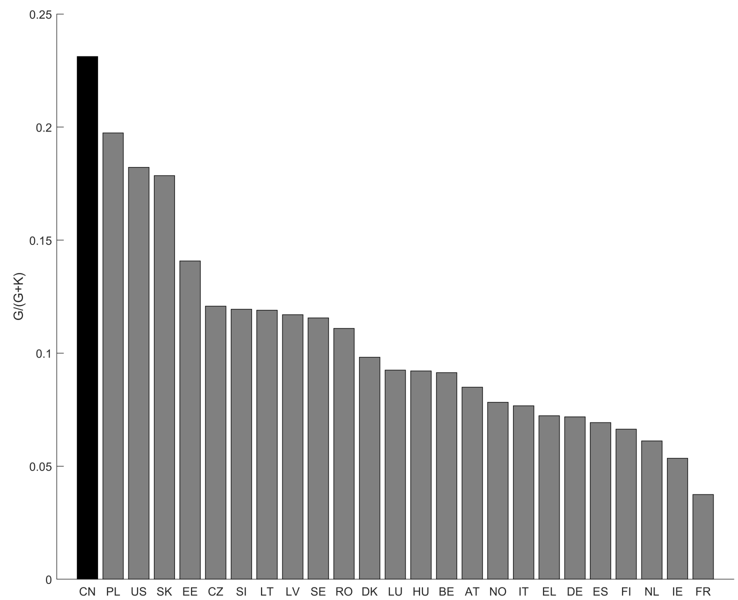
Classical growth literature (e.g., Young (1928) and Hirschman and Sirkin (1958)) characterizes infrastructure as a sector with significant positive externalities. Modern studies often include industries like Energy, Transportation, Water and Sanitation, and Telecommunications in the infrastructure sector (Mirabile, Marchal and Baron (2017)). Another perspective links infrastructure to the public sector, viewing it as a public good (Fay et al. (2019)).

We adopt a synthetic definition of infrastructure, identifying essential industries requiring government investment to internalize externalities. We categorize capital into infrastructure and non-infrastructure based on sector, using real industry-level investment figures to estimate capital across the U.S., China, and the European Union countries.[4] However, China's

[4]The detailed procedures for the U.S. and EU countries are outlined in Appendix A.1. To ensure consistency, we developed a concordance table aligning infrastructure sector codes for China and the EU with those for the U.S. Bennett et al. (2020) provides an estimation of U.S. infrastructure capital by distinguishing "basic," "digital," and "social" categories. Our methodology aligns closely with their assessment of basic infrastructure capital, with our estimates exceeding theirs by an average of 2.5% for 2013-17. We have chosen to exclude "digital" category from our definition of infrastructure due to the predominance of private ownership in the telecommunication industries (Bennett et al. (2020)).

fixed asset investments, the sole source for industry-level investment data in the country, were significantly overstated in the late 2000s and 2010s (Chen et al. (2019)). To address this issue, we apply corrections based on the revisions made by China's National Bureau of Statistics (NBS) to the aggregate investment figures since 2003 (see Appendix A.2).

Figure 1: Capital Share of the Infrastructure Sector across Countries



Note: This figure plots $\frac{G}{G+K}$ for the U.S., China, and the European Union countries, where G and K are capital stock in the infrastructure and non-infrastructure sectors, respectively. See Appendix A.3 and A.2 for the estimation of G and K.

Figure 1 shows the average share of infrastructure capital relative to total capital in China, the U.S., and the EU from 2013 to 2017. China leads with 23.1% of its total capital in infrastructure, surpassing the U.S. at 18.2% and being about 1.5 times greater than the EU average of 9.9%. Appendix A.3 reviews various methodologies for estimating infrastructure capital. Despite differing methods, the consistent finding is that China's infrastructure capital share is significantly higher than the world average, highlighting its substantial investment in this sector.

The government's dominant role in infrastructure is evident.[5] In China, state-owned enterprises drive infrastructure projects (Bai and Qian (2010)). After the 2008 global financial crisis, China's "four-trillion" fiscal stimulus empowered local governments to raise

[5]In the U.S., the public sector accounted for 63.4% of all infrastructure investment from 2013 to 2017, compared to just 16.7% in non-infrastructure sectors (Bennett et al. (2020)). This pattern is corroborated by World Bank data for most low- and middle-income nations (Fay et al. (2019)).

funds through Local Government Financing Vehicles (LGFVs), which have since become a key funding source for infrastructure investment (Bai, Hsieh and Song (2016); Chen, He and Liu (2020); Zhang and Xiong (2020)). Private-sector infrastructure investment, typically occurring within Public-Private Partnerships (PPPs), is negligible.[6]

1.2 Allocation of Local Government Revenue

In China, local governments have four main revenue sources: tax revenue with transfers from the central government, land sale proceeds, infrastructure-related revenue, and social security fund contributions. Contributions to social security funds, designated for pensions and medical insurance, are excluded from our analysis, as we focus on how local government revenue is allocated to infrastructure and other expenditures.

Table 1 summarizes the two primary sources of local government revenue: tax revenue combined with central transfers, and land sales. Over the sample period, the ratio of combined tax revenue and transfers to GDP increased by nearly 50%. Since the early 2000s, land sales have become a significant revenue source for local governments (Liu and Xiong (2020)), with the ratio of land sales to GDP rising to 6.5% during the 2018-22 period.

Table 1: Local Government Revenue (in Percent of GDP)

	1993-97	1998-02	2003-07	2008-12	2013-17	2018-22
Tax Revenue plus Transfer	11.9	14.4	16.6	19.0	19.6	17.5
Land Sales	0	1.0	3.9	5.4	5.6	6.5

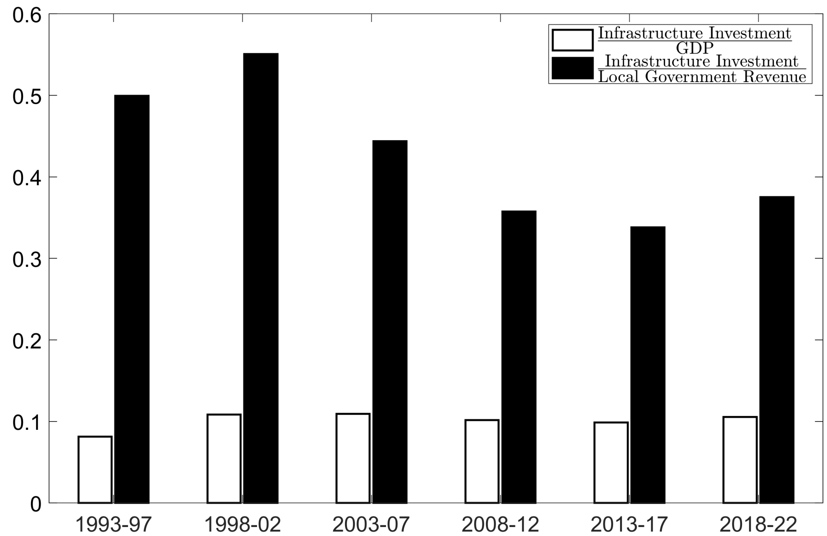
Note: See Appendix A.5.1 for details on the construction of local government revenue and data sources.

NBS classifies 94.2% of infrastructure investments from 2003 to 2017 as "regional". For simplicity, we assume all such investments are financed by local governments.[7] Similarly, we assume all infrastructure-related revenue goes to local governments. As data on infrastructure revenue is unavailable, we infer it using a model-based approach (Section 4).

[6] A common practice is "real debt disguised as fake equity" (minggushizhai), where local governments agree to repurchase private equity in a PPP project at a future date, keeping the debt off their balance sheets temporarily. Wang et al. (2020) suggests that such "fake equity" can be identified when a PPP project receives government funds or subsidies. Applying this criterion to CEIC data reveals that from 2017 to 2021, 93.7% of PPP project investment was government-funded.

[7] Although the central government may directly fund some regional projects, these cases are rare. Funds from the central government for local infrastructure typically fall under transfers to local governments. For robustness, we perform an analysis in the Appendix A.2.4 assuming all "non-regional projects" investments were entirely financed by the central government. This hypothetical scenario does not significantly affect our main results.

Figure 2: Average Propensity to Invest



Note: The white and black bars plot the ratio of infrastructure investment to GDP and to local government revenue, respectively.

Figure 2 presents two measures of infrastructure investment: as a percentage of GDP (white bars) and relative to local government revenue (black bars). The infrastructure-to-GDP ratio rose from 8.2% in 1993-97 to 10.9% in 1998-02 and has remained stable since. However, the infrastructure-to-revenue ratio, reflecting local governments' propensity to invest, fell sharply, from a peak of 55.1% in 1998-02 to 33.8% in 2013-17. This decline is due to the rapid increase in local government revenue as a share of GDP, as shown in Table 1.

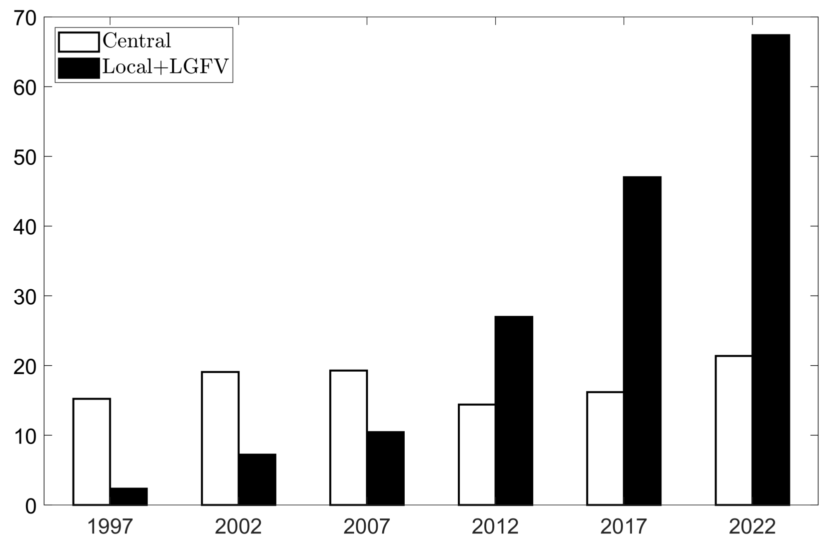
This important trend, often overlooked in the literature, is key to our quantitative analysis. Our model interprets the shift away from infrastructure investment as a sign of declining career incentives for local officials.

1.3 Rising Debt and Interest Rate

Before 2008, China's budget law prohibited local governments from running budget deficits. During this time, local government debt was explicitly controlled by the central government, totaling just 2.8 trillion yuan in 2007, or about 10% of GDP. To fund the massive 2008 stimulus program, which required substantial local financing, the central government allowed local governments to borrow through LGFVs, leading to a rise in implicit debt that did not appear on official balance sheets. This financial deregulation made LGFVs a key tool for local governments to bypass the budget law (Bai, Hsieh and Song (2016)).

Figure 3 shows the sharp rise in local government debt since 2008. While central government debt as a percentage of GDP grew modestly from 19.3% in 2007 to 21.4% in 2022, local government debt, including formal and LGFV debt, surged from 10.5% to 67.4%—a key focus of our analysis. Moreover, local government debt outpaced revenue, with the debt-to-revenue ratio climbing from 40.1% in 2007 to 258.0% in 2022.

Figure 3: Government Debt / GDP (%)



Note: The white and black bars plot the central and local government debt-to-GDP ratio, respectively. See Appendix A.4 for the estimation of local government debt. Data source for central government debt is in Appendix A.5.

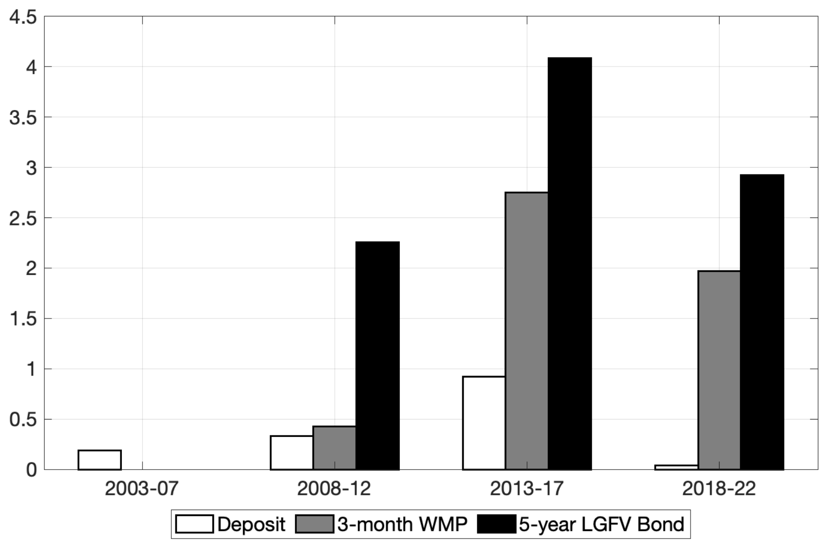
The rise in local government debt has coincided with an increase in market-based interest rates, raising capital costs for businesses, especially private firms, as shown in Figure 4. The government heavily regulates key bank rates, with the white bars in Figure 4 depicting regulated three-month deposit rates minus inflation.

In the late 2000s, banks started offering shadow banking products, such as Wealth Management Products (WMPs), to stay competitive in attracting deposits, especially amid the sharp rise in local government debt after 2008 (Hachem (2018); Hachem and Song (2021)). The gray bars in Figure 4 show the real return on WMPs, r_t^P, calculated as the average return on WMPs (with maturities between 60-120 days) minus inflation.[8] This market-based rate was around 0.4% in 2008-12, close to the regulated rate of 0.3%. However, WMP returns rose significantly in 2013-17, with r_t^P reaching 2.8%, 1.8 percentage points above the regulated rate. Though r_t^P fell slightly to 2% in 2018-22, the gap between market-based and

[8]Notably, 35% of WMPs fall within this maturity bracket, with similar results for extended maturities.

regulated rates persisted.

Figure 4: Real Interest Rates



Note: The white bars plot the three-month deposit rates minus inflation. The grey and black bars plot the average return on WMPs (with maturities between 60-120 days) and coupon rate for 5-year LGFV bonds, both minus inflation. Data source: WIND.

Another market-based interest rate is the coupon rate of LGFV bonds.[9] Unlike direct local government debt, LGFV obligations aren't officially recognized, so LGFVs must secure financing at market-driven rates rather than benefiting from lower, regulated rates. LGFV bonds have longer maturities than WMPs, with 29% maturing in 5 years and 22% beyond. The black bars of Figure 4 show the real coupon rate r_t^B, the average for 5-year LGFV bonds minus inflation. The two market-based interest rates r_t^P and r_t^B are highly correlated at annual frequency from 2008 to 2022, with a correlation of 0.95. Both rates rose sharply compared to regulated rates in 2013-17 and maintained a significant spread in 2018-22.

In summary, since 2008, local government debt has surged, along with a widening gap between regulated and market-based interest rates.

2 The Baseline Model

This section presents a baseline model that extends a standard macroeconomic framework by incorporating career incentives for local governors to invest in infrastructure, excluding

[9]In the Chinese bond market, bonds are typically issued at par, making the coupon rate equal to the bond yield (Ding, Xiong and Zhang (2022)).

debt financing to isolate its effects. Debt financing will be introduced in the next section.

2.1 Firms and Infrastructure

We consider an economy with infinitely many regions, indexed by i, and infinitely many periods, indexed by $t = 0, 1, 2, \cdots$ In region i, local output is produced by a representative firm following Cobb-Douglas technology:

$$Y_{it} = A_{it} G_{it}^{\alpha_G + \gamma} K_{it}^{\alpha_K} L_{it}^{1-\alpha_G-\alpha_K},$$

where A_{it} is local productivity, K_{it} is the firm's capital and G_{it} is the infrastructure provided by the local government. The parameters α_G and γ capture the two components of output influenced by the infrastructure, whether internalized by infrastructure providers or not. We assume $\gamma + \alpha_G + \alpha_K < 1$. The government imposes a tax rate τ_{it}^{Y} on the firm's output.[10]

Infrastructure G_{it} is immobile across regions, while capital K_{it} is fully mobile in a national competitive rental market with a rental price r_t^K. Each period, the representative firm in region i rents capital K_{it} to maximize its profit $(1 - \tau_{it}^{Y}) Y_{it} - r_t^K K_{it} - w_{it} L_{it} - T_{it}^{G}$, where w_{it} is the wage and T_{it}^{G} represents a lump-sum payment to the infrastructure provider. The first-order condition gives

$$K_{it} = \left(\frac{\alpha_K \left(1 - \tau_{it}^{Y}\right)}{r_t^K} \right)^{\frac{1}{1-\alpha_K}} A_{it}^{\frac{1}{1-\alpha_K}} G_{it}^{\frac{\gamma+\alpha_G}{1-\alpha_K}} L_{it}^{\frac{1-\alpha_G-\alpha_K}{1-\alpha_K}}. \tag{1}$$

Substituting this expression into the output equation:

$$Y_{it} = \left(\frac{\alpha_K \left(1 - \tau_{it}^{Y}\right)}{r_t^K} \right)^{\frac{\alpha_K}{1-\alpha_K}} A_{it}^{\frac{1}{1-\alpha_K}} G_{it}^{\frac{\gamma+\alpha_G}{1-\alpha_K}} L_{it}^{\frac{1-\alpha_G-\alpha_K}{1-\alpha_K}}. \tag{2}$$

The firm's optimal capital choice and output are proportional to local infrastructure $G_{it}^{\frac{\gamma+\alpha_G}{1-\alpha_K}}$, meaning that developing G_{it} attracts more capital K_{it} at the local level. However, we will later explore how local government borrowing to fund these investments may raise capital costs for firms, potentially crowding out investments at the national level.

In our model, G_{it} is the primary driver of economic growth, representing not just physical infrastructure but also broader policies aimed at enhancing firm productivity. These include formal reforms and informal arrangements that reduce entry barriers for private firms, often

[10]For robustness, we have also explored a more general production technology that displays constant elasticity of substitution between G_{it} and K_{it} in Appendix A.8.1.

at the expense of state-owned enterprises, as well as industrial policies for technological development. While career incentives tied to economic performance motivate local officials to adopt these measures, our analysis primarily focuses on the physical aspects of infrastructure.

2.2 Households and Banks

The economy features overlapping generations of households, following Diamond (1965). Each generation, born at t, lives for two periods with preferences:

$$U_t^H = \log C_{t,t}^H + \beta \log C_{t,t+1}^H + b_t \log B_{t+1},$$

where $C_{t,t}^H$ and $C_{t,t+1}^H$ are non-housing consumption in periods at t and $t+1$, β is the discount rate, and B_{t+1} represents bequests. The parameter b_t reflects impure altruism based on the size of the bequest (e.g., Andreoni (1989)). We assume that local governments provide housing and collect rent $\phi_t Y_t$ from young households, without modeling housing demand and supply.

The household budget constraints are $C_{t,t}^H = Y_t^H + B_t - \phi_t Y_t - W_{t+1}^H$ and $C_{t,t+1}^H = (1 + r_{t+1}) W_{t+1}^H - B_{t+1}$, where W_t^H denotes the household saving, and Y_t^H represents the young household's total income (to be specified later). With log utility, the household consumes a fixed fraction of current income and saves the rest for the next period:

$$W_{t+1}^H = \frac{\beta + b_t}{1 + \beta + b_t} \left(Y_t^H + B_t - \phi_t Y_t \right), \tag{3}$$

$$B_{t+1} = \frac{b_t \left(1 + r_{t+1}\right)}{1 + \beta + b_t} \left(Y_t^H + B_t - \phi_t Y_t \right). \tag{4}$$

Two remarks are in order. First, while bequests and rent are quantitatively significant, they are not central to our key insight. Therefore, we set $b_t = \phi_t = 0$ in the theoretical analysis. Second, the use of logarithmic utility simplifies household decision-making. In the quantitative analysis, we will employ more general CRRA preferences to check for robustness.

There are competitive national banks that absorb all household savings and provide capital to firms at the rental price r_t^K. To capture the mechanism behind China's persistent current account imbalances, we assume that banks can hold foreign assets at the world interest rate r_t^w, which serves as a floor for r_t, but they cannot borrow from international markets (Song, Storesletten and Zilibotti (2011)).[11]

[11] We can generalize the borrowing constraint by assuming $F_t \geq F_t^*$, where F_t^* is the minimum foreign reserve requirement. For simplicity, we set $F_t^* = 0$ in Section 2 and 3, and introduce a positive F_t^* in the quantitative analysis.

At the end of each period, banks decide between allocating funds to capital or foreign assets for the next period. The banks' balance sheet at the end of period $t-1$ is

$$q_{t-1}^K K_t + F_t = W_t^H, \tag{5}$$

where q_{t-1}^K is the technology state for building capital in period $t-1$, $K_t \equiv \int K_{it} di$ and $F_t \geq 0$ represent total capital and foreign assets at the beginning of period t. The left-hand side represents the banks' assets. The banks' profit at period t is $\left(r_t^K + (1-\delta_K)\, q_t^K\right) K_t + (1+r_t)\left(F_t - W_t^H\right)$, where $\delta_K \in [0,1]$ is the capital depreciation rate.

We introduce an exogenous unit intermediation cost of ξ_t in the rental price, reflecting higher capital costs for private firms (Song, Storesletten and Zilibotti (2011); Hsieh and Song (2015)). The zero-profit condition determines the equilibrium rental rate:

$$r_t^K = (1+r_t) q_{t-1}^K - (1-\delta_K) q_t^K + \xi_t. \tag{6}$$

We will set ξ_t to 0 and q_t^K to 1 in the theoretical analysis, but calibrate their values in the quantitative analysis.

The young household supplies labor L_{it} inelastically to region i, earning a competitive local wage of $(1-\tau_{it}^Y)(1-\alpha_G-\alpha_K)Y_{it}/L_{it}$. The household also receives firm profits, $(1-\tau_{it}^Y)\alpha_G Y_{it} - T_{it}^G$, and revenue from financial intermediation, $\xi_t K_t$. Therefore, total household income is $Y_t^H = \int ((1-\tau_{it}^Y)(1-\alpha_K)Y_{it} - T_{it}^G) di + \xi_t K_t$.

If $q_{t-1}^K K_t < W_t^H$, household savings exceed capital demand, causing the interest rate r_t to equal r_t^w. When this constraint does not hold, r_t is determined by the capital market clearing condition: $q_{t-1}^K K_t = W_t^H$.

2.3 Local Government

We assume the country follows a system of fiscal federalism, where each local government receives revenue R_{it}^G and allocates it to local infrastructure and its own spending. In this section, we assume local government cannot save or borrow, so its budget constraint is

$$C_{it}^G + q_t^G I_{it}^G = R_{it}^G, \tag{7}$$

and infrastructure evolves as

$$G_{it+1} = I_{it}^G + (1-\delta_G)\, G_{it}, \tag{8}$$

where q_t^G reflects the technology for building infrastructure and $\delta_G \in [0,1]$ is the depreciation rate. The local government budget funds two items: C_{it}^G, which benefits government employees, and I_{it}^G, which boosts local firm productivity but does not directly benefit government employees, creating a key agency problem in our model.

In the model, local government revenue R_{it}^G has two components. The first is tax revenue, assumed to be proportional to output, $\tau_{it}^Y Y_{it}$, where the tax rate τ_{it}^Y is set by the central government and exogenous to local governments. This paper focuses on the role of the central government in evaluating local governors rather than on its tax rate decisions or policy interventions.[12]

The second component comes from providing infrastructure services to local firms. In China, most infrastructure is developed and operated by local state-owned enterprises (SOEs). Since SOEs are essentially extensions of the government, their revenue is treated as part of government revenue. Assume a competitive market, where a continuum of local SOEs, indexed by j, provide $G_{it}(j)$ to firms, with $G_{it}(j)$ perfectly substitutable across providers, and $G_{it} = \int G_{it}(j)\, dj$. This leads to the conditions $\left(1-\tau_{it}^Y\right)\alpha_G Y_{it} = T_{it}^G$ and $Y_t^H = \int((1-\tau_{it}^Y)(1-\alpha_G-\alpha_K)Y_{it})di + \xi_t K_t$. Thus, local government revenue is

$$R_{it}^G = \tau_{it} Y_{it}, \text{ where } \tau_{it} \equiv \tau_{it}^Y + \left(1-\tau_{it}^Y\right)\alpha_G. \tag{9}$$

Career Incentives

In contrast to typical federal systems where regional governors are elected, China's local officials are appointed by the central government. As noted by Xu (2011) and Qian (2017), this system grants local governments significant fiscal autonomy and evaluates them based on standardized economic performance criteria. This motivates local officials to support local economic development rather than exploit it, a factor widely recognized as critical to China's rapid growth. In Western countries, political career incentives tied to local elections influence development priorities, with some regions focusing on growth and others on environmental concerns. In China, the central government applies uniform performance measures to all local officials, allowing it to effectively direct subnational policies. According to Maskin, Qian and Xu (2000), similar economic conditions across China's regions enhance the effectiveness of this governance model.

[12] Chinese local governments play a crucial role in allocating government expenditure, accounting for the majority of the country's total government general budgetary expenditure (85% in 2013-17). This share would be even higher if expenditures financed by land sales and local state-owned enterprises were included.

To incorporate the career incentives, we specify the productivity of region i as

$$A_{it} = e^{a_{it}+\varepsilon_{it}}, \tag{10}$$

where $a_{it} \sim N(\bar{a}_i, \sigma_a^2)$ represents the governor's ability to develop the economy, with a normal distribution of mean $\bar{a}_i$ and variance σ_a^2. The term $\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$ is a region-specific component independent of the governor, also normally distributed with mean 0 and variance σ_ε^2. These components are unobservable, and their distributions are common knowledge.[13]

We assume that a new governor, randomly drawn from $N(\bar{a}_i, \sigma_a^2)$, is assigned to a region each period. The governor serves for one period and is concerned with how the central government perceives their ability based on observed performance. Specifically, the governor takes control of region i at the end of period $t-1$ after Y_{it-1} is realized and then chooses C_{it-1}^G and G_{it}. Since the governor's ability influences local productivity at t, local output Y_{it} provides useful information about his ability, which the central government evaluates as

$$\widehat{a}_{it} = E\left[a_{it}|Y_{it}\right].$$

Substituting Y_{it} from equation (2), we obtain a linear expression for log output:

$$y_{it} \equiv \log(Y_{it}) = a_{it} + \varepsilon_{it} + \tfrac{\gamma+\alpha_G}{1-\alpha_K}\log(G_{it}), \tag{11}$$

omitting constant terms. This shows that local output $\log(Y_{it})$ serves as a signal of the governor's ability a_{it}. Sine the governor can boost output by investing more on infrastructure, career incentives drive greater infrastructure investment, overcoming the preference for more government consumption. This aligns with the implicit incentives outlined by Holmström (1982) and Gibbons and Murphy (1992).

We assume the central government evaluates governors based solely on regional output (Y_{it}), not infrastructure stock (G_{it}) or other local inputs, due to concerns over data manipulation. Local governments, which can influence local statistics bureaus, may distort reports. However, regional output remains the most reliable measure, as it is routinely audited by the National Bureau of Statistics due to its importance for policy decisions and tax calculations. Inflating output is costly for local governments as it increases their tax obligations to

[13] An earlier version of our paper included a nationwide unobservable common shock affecting all regions, allowing the central government to compare outputs across regions to evaluate governors. However, incorporating this shock complicated our analysis of aggregate economic dynamics.

the central government. Additionally, since output is largely produced by private firms, it's harder to manipulate compared to government-controlled infrastructure data.[14]

We assume the central government has rational expectations and anticipates the local governor's choice $G_{it} = G^*_{it}$, even if it does not observe G_{it}. Thus, when evaluating output, the central government adjusts y_{it} by deducting its expected level, using the statistic:

$$z_{it} \equiv y_{it} - \frac{\gamma + \alpha_G}{1 - \alpha_K} \log\left(G^*_{it}\right) = a_{it} + \varepsilon_{it} + \frac{\gamma + \alpha_G}{1 - \alpha_K} \left[\log\left(G_{it}\right) - \log\left(G^*_{it}\right)\right]. \tag{12}$$

From the central government's perspective, since $G_{it} = G^*_{it}$, it simplifies to

$$z_{it} = a_{it} + \varepsilon_{it}. \tag{13}$$

Applying Bayes' Theorem, the central government evaluates the governor using the rule:

$$\hat{a}_{it} = E\left[a_{it} \middle| \left\{z_{it}\right\}_{i=1,\ldots,M}\right] = \bar{a}_i + \frac{\sigma_a^2/\sigma_\varepsilon^2}{\sigma_a^2/\sigma_\varepsilon^2 + 1}\left(z_{it} - \bar{z}_{it}\right).$$

From the local governor's perspective, z_{it} depends on his own choice G_{it} in equation (12), making the central government's perception $\hat{a}_{it}$ increase with G_{it}:

$$\hat{a}_{it} - \bar{a}_i = \frac{\sigma_a^2/\sigma_\varepsilon^2}{\sigma_a^2/\sigma_\varepsilon^2 + 1}\left[\left(a_{it} - \bar{a}_i\right) + \varepsilon_{it} + \frac{\gamma + \alpha_G}{1 - \alpha_K}\left(\log G_{it} - \log G^*_{it}\right)\right]. \tag{14}$$

Thus, the local governor is incentivized to increase G_{it} to enhance the central government's perception of his ability, as the central government cannot distinguish between the local governor's inherent ability and the infrastructure investment. This dynamic exemplifies the signal-jamming mechanism coined by Holmström (1982).

We specify that the central government rewards local governors based on their ability inferred from equation (14): $\hat{\kappa}_t\left(\hat{a}_{it} - \bar{a}_i\right)$, where $\hat{\kappa}_t > 0$ measures the intensity of the career incentives, which may vary over time. In practice, city mayors or party secretaries in China typically serve about four years, with career outcomes (promotions, lateral moves, or demotions) strongly influenced by performance. This term simulates the incentives tied to these career dynamics. Substituting from equation (14), the career incentives become

$$\hat{\kappa}_t\left(\hat{a}_{it} - \bar{a}_i\right) = \hat{\kappa}_t \frac{\sigma_a^2/\sigma_\varepsilon^2}{\sigma_a^2/\sigma_\varepsilon^2 + 1}\left[\left(a_{it} - \bar{a}_i\right) + \varepsilon_{it} + \frac{\gamma + \alpha_G}{1 - \alpha_K}\left(\log G_{it} - \log G^*_{it}\right)\right],$$

which provides a direct incentive to boost $\ln G_{it}$.

[14]While infrastructure may seem easier to observe than GDP, Pritchett (2000) notes that investment totals often fail to reflect actual capital due to corruption, making infrastructure an unreliable measure of regional performance.

Thus, the governor's utility in each period is

$$U_{it}^{G} = \log C_{it}^{G} + \kappa_t \log G_{it+1}, \tag{15}$$

where $\kappa_t \equiv \hat{\kappa}_{t+1} \frac{\sigma_a^2/\sigma_\varepsilon^2}{\sigma_a^2/\sigma_\varepsilon^2+1} \frac{\gamma+\alpha_G}{1-\alpha_K}$ captures the governor's current-period incentive to invest in infrastructure. The governor is motivated by both the welfare of government employees and her own career advancement.

2.4 The Equilibrium

We now characterize the equilibrium, making several simplifications. First, we consider a limiting scenario where $\sigma_a^2 \to 0$, $\sigma_\varepsilon^2 \to 0$, but $\sigma_a^2/\sigma_\varepsilon^2$ remains constant. In this scenario, each governor still faces the same career incentives to build infrastructure. Second, households have no bequest motives and do not pay housing rents (i.e., $b_t = \phi_t = 0$). Third, we eliminate regional heterogeneity by assuming local productivity, tax rate and labor supply are constant and identical across regions (i.e., $A_{it} = A$, $\tau_{it}^Y = \tau^Y$, $r_t^w = r^w$, and $L_{it} = L$). We normalize L to unity, allowing us to drop it from the analysis. We also assume constant technologies for producing infrastructure and capital, normalizing them to unity (i.e., $q_t^G = q_t^K = 1$), and eliminate financial frictions by setting $\xi_t = 0$. Under these assumptions, equation (6) simplifies to $r_t^K = r_t + \delta_K$. Finally, we assume constant career incentives (i.e., $\kappa_t = \kappa$), allowing the local government's problem to be written in a recursive form.

Due to regional symmetry, we drop the subscript i. Let the local government budget be W_t^G, which is allocated to C_t^G and G_{t+1}. The budget constraint (7) simplifies to

$$C_t^G + G_{t+1} = W_t^G, \tag{16}$$

with the next-period budget W_{t+1}^G given by

$$W_{t+1}^G = \tau Y_{t+1} + (1-\delta_G) G_{t+1}.$$

The aggregate state in each period is fully characterized by $\left(G_t, W_t^H\right)$. Let the local governor's discount factor be β_G. We assume $\beta_G(1+r^w) < 1$. A low β_G reflects the positive probability that the governor might leave office in the subsequent period, which will be specified in Section 4. Given the law of motion for the aggregate state, $\left(G_{t+1}, W_{t+1}^H\right) = \mathcal{H}\left(G_t, W_t^H\right)$, the local government problem in each period is

$$V^G\left(W_t^G | G_t, W_t^H\right) = \max_{C_t^G, G_{t+1}} \log C_t^G + \kappa \log G_{t+1} + \beta_G V^G\left(W_{t+1}^G | G_{t+1}, W_{t+1}^H\right), \tag{17}$$

subject to the budget constraint (16). The policy function solved from equation (17) is denoted by $G_{t+1} = \mathcal{H}^G\left(W_t^G | G_t, W_t^H\right)$.

Each region is influenced by the aggregate state, as the interest rate is determined by capital market clearing. Depending on whether the capital market constraint is binding, the interest rate r_t is given by

$$r_t = \max\left\{r^w, \mathcal{R}\left(G_t, W_t^H\right)\right\}, \text{ where } \mathcal{R}\left(G_t, W_t^H\right) \equiv \frac{\alpha_K\left(1-\tau^Y\right)AG_t^{\gamma+\alpha_G}}{\left(W_t^H\right)^{1-\alpha_K}} - \delta_K. \tag{18}$$

If households' savings W_t^H exceed firms' capital demand K_t, the interest rate r_t is set by the world interest rate r^w. If the capital market constraint binds, r_t is determined by the condition: $W_t^H = K_t$.

The output is given by

$$Y_t = \mathcal{Y}\left(G_t, W_t^H\right) = \left(\frac{\alpha_K\left(1-\tau^Y\right)}{\max\left\{r^w, \mathcal{R}\left(G_t, W_t^H\right)\right\} + \delta_K}\right)^{\frac{\alpha_K}{1-\alpha_K}} A^{\frac{1}{1-\alpha_K}} G_t^{\frac{\gamma+\alpha_G}{1-\alpha_K}}. \tag{19}$$

By symmetry across regions, aggregate savings are proportional to aggregate output:

$$W_{t+1}^H = sY_t, \text{ where } s \equiv \frac{\beta}{1+\beta}\left(1-\tau^Y\right)\left(1-\alpha_G-\alpha_K\right). \tag{20}$$

The parameter s is the aggregate saving rate. The perceived law of motion $\left(G_{t+1}, W_{t+1}^H\right) = \mathcal{H}\left(G_t, W_t^H\right)$ satisfies

$$G_{t+1} = \mathcal{H}^G\left(W_t^G | G_t, W_t^H\right), \; W_{t+1}^H = s\mathcal{Y}\left(G_t, W_t^H\right).$$

In summary, the equilibrium consists of the governor's infrastructure choice $\mathcal{H}^G\left(W_t^G | G_t, W_t^H\right)$, the interest rate $r_t = \max\left\{r^w, \mathcal{R}\left(G_t, W_t^H\right)\right\}$, the output $Y_t = \mathcal{Y}\left(G_t, W_t^H\right)$, and the law of motion of the aggregate state $\mathcal{H}\left(G_t, W_t^H\right)$, which is consistent with the local governor's choices. Since each local government makes its decisions independently and takes the interest rate as given, we refer to this equilibrium as the decentralized equilibrium, contrasting with the first-best economy we will analyze later.

The first order condition from equation (17) establishes

$$\left(1 - \underbrace{\kappa\frac{C_t^G}{G_{t+1}}}_{\text{investment wedge}}\right)\frac{C_{t+1}^G}{C_t^G} = \beta_G\left(1 + MRG_{t+1}\right), \tag{21}$$

where $MRG_{t+1} \equiv \tau \frac{\gamma+\alpha_G}{1-\alpha_K} \frac{Y_{t+1}}{G_{t+1}} - \delta_G$ represents the local government's marginal product of infrastructure. This equation shows that career incentives introduce an investment wedge, affecting the governor's intertemporal trade-off. Stronger career incentives (higher κ) lead to higher growth in government consumption by increasing G_{t+1} at the expense of C_t^G.

Under log preferences, where the income and substitution effects of the interest rate cancel each other out, the equilibrium can be fully characterized by the following proposition.

Proposition 1 ***(Decentralized Equilibrium)***

1. *If $\delta_G = 1$, the local governor's optimal infrastructure choice is*
$$G_{t+1} = \frac{\kappa + \beta_G \frac{\gamma+\alpha_G}{1-\alpha_K}}{1+\kappa} \tau Y_t, \tag{22}$$
and private capital evolves as $K_{t+1} = \min \left\{ sY_t, \left(\frac{\alpha_K \left(1-\tau^Y\right) A}{r^w+\delta_K} \right)^{\frac{1}{1-\alpha_K}} G_{t+1}^{\frac{\gamma+\alpha_G}{1-\alpha_K}} \right\}$.

2. *In the steady state, the interest rate r_* is given by* $r_* = \max \left\{ r^w, \frac{\alpha_K \left(1-\tau^Y\right)}{s} - \delta_K \right\}$, *and the output Y_* is* $Y_* = \left(A g_*^{\gamma+\alpha_G} \min \{\bar{s}, s\}^{\alpha_K} \right)^{\frac{1}{1-\gamma-\alpha_G-\alpha_K}}$, *where* $g_* \equiv \frac{G_*}{Y_*} = \frac{\kappa+\beta_G \frac{\gamma+\alpha_G}{1-\alpha_K}}{\delta_G \kappa + 1 - \beta_G (1-\delta_G)} \tau$ *and* $\bar{s} \equiv \frac{\alpha_K \left(1-\tau^Y\right)}{r^w+\delta_K}$.

When $\delta_G = 1$, $g_t \equiv \frac{G_{t+1}}{Y_t}$ is proportional to the local government's propensity to invest. From the budget constraint, $c_t \equiv \frac{C_t^G}{Y_t}$ is proportional to the local government's propensity to consume, where $c_t = \tau - g_t$. Thus, equation (22) shows that stronger career incentives always increase g_t at the cost of c_t. This is intuitive, as κ in the Euler equation (21) operates like a positive investment wedge.

Using equation (2), the steady state output can be expressed as a function of r_* and g_* without restricting $\delta_G = 1$:
$$Y_* = \left(\left(\frac{\alpha_K \left(1-\tau^Y\right)}{r_* + \delta_K} \right)^{\alpha_K} A g_*^{\gamma+\alpha_G} \right)^{\frac{1}{1-\alpha_G-\gamma-\alpha_K}}. \tag{23}$$
When $\delta_G = 1$, the second part of Proposition 1 shows that if the aggregate saving rate s is lower than a threshold $\bar{s}$, the capital market constraint binds, and $r_* = \frac{\alpha_K \left(1-\tau^Y\right)}{s} - \delta_K > r^w$. In this steady state, a higher κ unambiguously increases Y_* but does not affect the interest rate, i.e., $\frac{\partial g_*}{\partial \kappa} > 0$ and $\frac{\partial r_*}{\partial \kappa} = 0$. This occurs for two reasons: first, local governments are excluded from the capital market, making their decisions independent of the interest rate; second, a higher κ increases output by boosting infrastructure, which raises both private capital demand and supply, canceling out any effect on r_*.

2.5 First-Best Allocation

We now analyze the first-best equilibrium, where the social planner allocates resources across government and household consumption, infrastructure, non-infrastructure capital, and foreign assets. This first-best allocation highlights the inefficiencies present in the decentralized equilibrium described in Proposition 1.

We assume the planner's objective is to maximize the discounted sum of a geometric average of government and household consumption:

$$U_0^C = \rho \log C_{-1,0}^H + \sum_{t=0}^{\infty} \beta_C^t \left(\log C_t^G + \rho \left(\log C_{t,t}^H + \beta \log C_{t,t+1}^H\right)\right), \tag{24}$$

where β_C is the social planner's discount factor, which may also represent the central government's. We assume $\beta_G < \beta_C < \frac{1}{1+r^w}$. The parameter $\rho \geq 0$ captures the extent to which the central government internalizes household welfare.

The social planner chooses $\{C_t^G, C_{t,t}^H, C_{t,t+1}^H, G_{t+1}, K_{t+1}, F_{t+1}\}_{t=0}^{\infty}$ and $C_{-1,0}^H$ to maximize U_0^C in equation (24), subject to the following resource constraint:

$$C_t^G + C_{t,t}^H + C_{t-1,t}^H + G_{t+1} + K_{t+1} + F_{t+1} = Y_t + (1-\delta_G) G_t + (1-\delta_K) K_t + (1+r^w) F_t, \tag{25}$$

and the borrowing constraint: $F_{t+1} \geq 0$. Like in the competitive equilibrium, the social planner cannot borrow from abroad.

We first define $SRG_t \equiv (\gamma + \alpha_G) \frac{Y_t}{G_t} - \delta_G$ and $SRK_t \equiv \alpha_K \frac{Y_t}{K_t} - \delta_K$, which represent the social returns to G_t and K_t, respectively. These differ from MRG_t and MRK_t in the decentralized equilibrium for two reasons. First, MRG_t and MRK_t are based on local government revenue τY_t and after-tax firm revenue $\left(1-\tau^Y\right) Y_t$, while social returns are based on aggregate output Y_t. Second, local governors overlook the pecuniary externality of G_t. The elasticity of Y_t with respect to G_t is $\frac{\gamma+\alpha_G}{1-\alpha_K}$ for local governors, but it is $\gamma + \alpha_G$ for the social planner, who internalizes the externality.

We assume $\tau < 1 - \alpha_K$, ensuring that the effect of τ on MRG_t dominates the pecuniary externality, thereby guaranteeing $SRG_t > MRG_t$. Unlike G_t, K_t is mobile across regions, so it does not generate pecuniary externality and SRK_t is always higher than MRK_t.

The first-order conditions for the first-best allocation are

$$SRG_{t+1} = SRK_{t+1} \geq r^w, \tag{26}$$

$$C_t^G = \frac{1}{\rho} C_{t,t}^H = \frac{\beta_C}{\beta\rho} C_{t-1,t}^H, \tag{27}$$

$$\frac{C_{t+1}^G}{C_t^G} = \beta_C \left(1 + SRG_{t+1}^G\right). \tag{28}$$

Equation (26) governs the first-best intratemporal capital allocation, showing that SRG_{t+1} and SRK_{t+1} should be equal in the first-best allocation, whether they are above or equal to r^w. They exceed r^w if the external borrowing constraint $F_{t+1} \geq 0$ is binding. This equation highlights an inefficiency in the decentralized equilibrium – capital misallocation among G_{t+1}, K_{t+1}, and F_{t+1}, if $SRG_{t+1} > SRK_{t+1}$. In such cases, a positive κ could improve allocative efficiency between G_{t+1} and K_{t+1}. Additionally, since $MRK_{t+1} < SRK_{t+1}$ in the decentralized equilibrium, household wealth may be inefficiently allocated to foreign assets.

The first-best intratemporal consumption allocation follows from equation (27), where ρ affects only consumption allocation but does not influence intertemporal decisions. As a result, the first-best aggregate output is independent of ρ.

The first-best intertemporal allocation follows equation (28). Compared to the local government's Euler equation (21) under $\kappa = 0$, equation (28) reveals two inefficiencies in local government decisions without career incentives: First, $\beta_C > \beta_G$ reflects the inefficiency arising from local governors' lower discount rate.[15] This form of short-termism, as we will discuss later, also contributes to over-leveraging driven by their career incentives. Second, the return to G_{t+1} for local governors, MRG_{t+1}, is lower than SRG_{t+1}. These inefficiencies reduce the growth of C_t^G below the first-best level, leading to underinvestment in infrastructure. Introducing career incentives can improve welfare by moving the intertemporal allocation closer to the first-best.[16]

Under $\delta_G = \delta_K = 1$ and $Y_0 < \frac{1}{\beta_C}\left(\frac{A\alpha_K^{\alpha_K}(\gamma+\alpha_G)^{\gamma+\alpha_G}}{1+r^w}\right)^{\frac{1}{1-\gamma-\alpha_G-\alpha_K}}$, the first-best allocation has the following closed-form solutions: $F_{t+1} = 0$, $G_{t+1} = \beta_C(\gamma + \alpha_G) Y_t$, and $K_{t+1} = \beta_C \alpha_K Y_t$. The infrastructure investment rate $\frac{G_{t+1}}{Y_t}$ in the decentralized equilibrium, as given by equation (22), is always insufficient compared to the first-best, particularly without career incentives.[17] The non-infrastructure investment rate $\frac{K_{t+1}}{Y_t}$ in the decentralized equilibrium, under a binding

[15] The political economy literature, such as Acemoglu, Golosov and Tsyvinski (2008), has formally analyzed the inefficiencies caused by politicians' impatience.

[16] Without career incentives, addressing local governments' under-investment by adjusting the tax rate would require setting it higher than the current level—a solution that could be politically challenging to implement.

[17] Our analysis omits corruption as a factor in public infrastructure investment. While local governors may over-invest for personal gain, we focus on career incentives as the primary explanation for the observed over-investment. Despite China's decade-long anti-corruption campaign, the persistence of over-investment and rising local government debt suggests that corruption is not the main driver. This supports our view that career incentives offer a more plausible explanation.

capital market constraint, matches the household saving rate s, which may either exceed or fall short of the first-best rate.

The steady state first-best allocation can be extended to cases where δ_G or δ_K is less than 1. The capital allocation follows: $\frac{G_*}{Y_*} = \frac{\beta_C(\gamma+\alpha_G)}{1-\beta_C(1-\delta_G)}$ and $\frac{K_*}{Y_*} = \frac{\beta_C \alpha_K}{1-\beta_C(1-\delta_K)}$, with social returns $SRG_* = SRK_* = \frac{1}{\beta_C} - 1$. In any decentralized equilibrium where $\frac{G_*}{Y_*}$ and $\frac{K_*}{Y_*}$ fall short of their first-best levels, a higher κ can move the allocation closer to the first-best.

3 Local Government Debt

While strong incentives can help address local governments' underinvestment, they may also encourage short-term behavior among officials. A salient form of this short-termism is local government over-leveraging. In this section, we extend the baseline model to incorporate local government borrowing.[18]

Let D_{it+1} be the debt issued by local government i at the end of period t. The local government repays $(1 + r_{t+1})\, D_{it+1}$ in period $t + 1$, leading to the following budget constraint:[19]

$$C_{it}^G + q_t^G I_{it}^G = \tau_{it} Y_{it} - (1 + r_t)\, D_{it} + D_{it+1}. \tag{29}$$

Increased borrowing leads to higher future debt repayment obligations and elevates the risk of financial distress. While local governments in China benefit from a central government credit guarantee during financial distress, officials face disciplinary penalties through the cadre evaluation system when such distress occurs.[20]

To capture this, we let each period in our model be a long interval (taken as five years in our quantitative analysis) and is divided into two subperiods: beginning and end. The local government receives a fraction $1 - \nu$ of its tax revenue at the start of each period, while the remaining fraction ν at the end. The liquidity shock ν, a random variable drawn from the distribution $f(\nu)$ for $\nu \in (\underline{\nu}, 1)$ with $\underline{\nu} \in (0, 1)$, follows $\int_{\underline{\nu}}^1 f(\nu)\, d\nu = 1$.

[18] In Appendix A.6, career incentives may lead local governments to overreport output, even at the cost of higher tax payments to the central government. This suggests that unreliable economic statistics in China could be a systemic issue linked to the Mandarin system.

[19] We assume, for simplicity, that the interest rate for local governments is identical to that for households. While this assumption is inconsequential for institutional accounting in Section 4, it becomes relevant for the counterfactual exercises in Section 5, where we differentiate between the two interest rates.

[20] Debt has been incorporated into the criteria for evaluating local government officials. As noted by Liu, Oi and Zhang (2022) (p. 66), "Local officials would be evaluated based on how well they solved debt problems, including those left by their predecessors."

At the beginning of each period, the local government must repay $(\theta_t + r_t) D_{it}$, where θ_t represents the scheduled repayment fraction in addition to the interest payment. A liquidity shortage occurs when the received tax revenue $(1-\nu)\tau_{it}Y_{it}$ falls short of the debt payment.

The local government's leverage ratio is defined as

$$e_{it} \equiv \frac{(\theta_t + r_t) D_{it}}{\tau_{it}Y_{it}}, \tag{30}$$

which reflects not only its debt level relative to fiscal revenue but also its short-term repayment pressure. A liquidity shortage occurs when $1-\nu \leq e_{it}$, where $1-\nu$ represents the minimum liquid cash flow needed to avoid financial distress, as discussed in Titman and Tsyplakov (2007). Unlike typical cases where financial distress harms firm cash flows, we emphasize liquidity shortages affect the central government's evaluation of local governors.

When a liquidity shortage occurs, the local government must report the issue to the central government, which provides temporary fiscal support. Although this intervention does not result in any fiscal or financial consequences for the local government or lender, it signals financial risk to the central government, negatively affecting the local governor's performance review. The expected negative impact is $\hat{\omega}_t \Pr(e_{it+1} \geq 1-\nu)$, where $\hat{\omega}_t > 0$ reflects the severity of the punishment.

We adopt the following left-skewed distribution for the liquidity shock ν:

$$f(\nu) = \begin{cases} \frac{1/\log(1/\underline{\nu})}{\nu} & \text{if } v \in [\underline{\nu}, 1], \\ 0 & \text{if } v \in [0, \underline{\nu}), \end{cases}$$

where $\underline{\nu} > 0$ is a fixed parameter that determines both the lower bound and the mean $E[\nu] = \frac{1-\underline{\nu}}{\log(1/\underline{\nu})}$. We assume $\hat{\omega}_t = -\frac{\omega_t}{\mathbb{E}[\nu]}$, meaning the punishment for liquidity shortage is scaled by the expected severity of tax revenue delay. The rationale is that liquidity shortages in scenarios with more available liquidity (lower $\mathbb{E}[\nu]$) should incur harsher penalties. By further assuming $\underline{\nu} \to 0$, the high career cost disciplines the governor from taking leverage levels above 1.[21]

Taken together, the local governor's instantaneous utility can be written as

$$U^G\left(C_{it}^G, G_{it+1}, e_{it+1}\right) = \left\{ \begin{array}{ll} \log C_{it}^G + \kappa_t \log G_{it+1} & \text{if } e_{it+1} < 0, \\ \log C_{it}^G + \kappa_t \log G_{it+1} + \omega_t \log(1 - e_{it+1}) & \text{if } e_{it+1} \in [0, 1). \end{array} \right. \tag{31}$$

[21]If $e_{it+1} \geq 1$, the local government's high leverage will surely induce a liquidity shortage, resulting in a career cost of $\omega_t \log(1/\underline{\nu})$, which approaches infinity as $\underline{\nu} \to 0$. If $e_{it+1} < 1$, the expected career cost is finite, given by $\omega_t \log(1 - e_{it+1})$.

The term $\omega_t \log(1 - e_{it+1}) < 0$ captures the expected career cost from leverage-induced financial distress, with $\omega_t > 0$ representing the central government's financial discipline.

Local governments borrow from banks, whose aggregate balance sheet becomes

$$q_{t-1}^K K_t + D_t + F_t = W_t^H, \tag{32}$$

where $D_t \equiv \int D_{it} di$ is total local government debt. The capital market constraint is generalized to

$$q_{t-1}^K K_t + D_t \leq W_t^H. \tag{33}$$

If this constraint is binding, the interest rate is determined by the domestic capital market clearing. Otherwise, the interest rate is determined by the world rate $r_t = r_t^w$.

As in Section 2.4, our analysis in this section focuses on a stationary representative-region model where the career concern parameters and other exogenous variables remain constant. We first examine the equilibrium under a fixed interest rate in Section 3.1, and then explore the equilibrium with an endogenously determined interest rate in Section 3.2.

3.1 Exogenous Interest Rate

In this subsection, we analyze the equilibrium by fixing the interest rate exogenously at $r_t = \hat{r}$ for all t, with $\beta_G(1 + \hat{r}) < 1$. The local government's problem is

$$V^G\left(W_t^G\right) = \max_{C_t^G, G_{t+1}, e_{t+1}} U^G\left(C_t^G, G_{t+1}, e_{t+1}\right) + \beta_G V^G\left(W_{t+1}^G\right), \tag{34}$$

subject to

$$C_t^G + G_{t+1} = W_t^G + D_{t+1}, \tag{35}$$

where e_{t+1} follows equation (30) and $W_{t+1}^G = \tau Y_{t+1} + (1 - \delta_G) G_{t+1} - (1 + \hat{r}) D_{t+1}$.

We denote the policy functions that solve equation (34) as $D_{t+1} = \mathcal{H}^D\left(W_t^G\right)$ and $G_{t+1} = \mathcal{H}^G\left(W_t^G\right)$. The law of motion for W_t^G is $W_{t+1}^G = \mathcal{H}^W\left(W_t^G\right)$, where

$$\mathcal{H}^W\left(W_t^G\right) = \tau\left(\frac{\alpha_K\left(1 - \tau^Y\right)}{\hat{r} + \delta_K}\right)^{\frac{\alpha_K}{1-\alpha_K}} A^{\frac{1}{1-\alpha_K}} \mathcal{H}^G\left(W_t^G\right)^{\frac{\gamma+\alpha_G}{1-\alpha_K}} + (1 - \delta_G)\mathcal{H}^G\left(W_t^G\right) - (1 + \hat{r})\mathcal{H}^D\left(W_t^G\right). \tag{36}$$

When local governments can use debt, their net worth W_t^G may drop below zero, leading to a potential liquidity shortage. Lemma 1 in Appendix A.9.2 shows that there exists a non-empty region $\mathbb{W} = (\underline{W}, \bar{W}]$ such that for $W_t^G \in \mathbb{W}$, the local government can always avoid a liquidity shortage, and its value function is continuous and concave. The lemma also provides sufficient conditions to rule out local government saving (i.e., $D_{t+1} < 0$).

This lemma allows us to simplify equation (34) as follows:

$$V^G\left(W_t^G\right) = \max_{C_t^G, G_{t+1}, e_{t+1}} \log C_t^G + \kappa \log G_{t+1} + \omega \log\left(1 - e_{t+1}\right) + \beta_G V^G\left(W_{t+1}^G\right), \tag{37}$$

subject to $D_{t+1} \geq 0$ and equation (35). The choice of D_{t+1} follows the Euler equation:

$$\left(1 - \underbrace{\frac{\omega e_{t+1}}{1 - e_{t+1}} \frac{C_t^G}{D_{t+1}}}_{\text{disciplining wedge}}\right) \frac{C_{t+1}^G}{C_t^G} = \beta_G\left(1 + \hat{r}\right) - \lambda_t^D C_{t+1}^G, \tag{38}$$

where λ_t^D is the multiplier associated with the constraint $D_{t+1} \geq 0$.

Suppose $\lambda_t^D = 0$, implying $D_{t+1} > 0$. In the special case where $\omega = 0$, equation (38) simplifies to the standard Euler equation, suggesting a decline in government consumption at the rate of $\beta_G\left(1 + \hat{r}\right) < 1$, leading to long-run immiserization. This highlights the form of short-termism emphasized by our model. The combination of impatience and debt usage drives high current government consumption and, consequently, low growth in government consumption. Introducing a positive ω creates a wedge in the Euler equation. This "disciplining wedge" arises from the constraints imposed by debt-induced liquidity shortages, which serve to reduce current government consumption, thereby promoting higher growth in government consumption.

The optimal allocation between G_{t+1} and C_t^G is determined by

$$\left(1 - \underbrace{\kappa \frac{C_t^G}{G_{t+1}}}_{\text{investment wedge}} - \frac{\gamma + \alpha_G}{1 - \alpha_K} \frac{D_{t+1}}{G_{t+1}} \underbrace{\frac{\omega e_{t+1}}{1 - e_{t+1}} \frac{C_t^G}{D_{t+1}}}_{\text{disciplining wedge}}\right) \frac{C_{t+1}^G}{C_t^G} = \beta_G\left(1 + MRG_{t+1}\right). \tag{39}$$

This equation generalizes equation (21).

Consider a special case with $\omega = 0$. Combining equations (38) and (39) leads to:

$$1 - \underbrace{\kappa \frac{C_t^G}{G_{t+1}}}_{\text{investment wedge}} = \frac{1 + MRG_{t+1}}{1 + \hat{r}}.$$

This equation shows that in the absence of both career incentives and financial discipline ($\omega = \kappa = 0$), $MRG_{t+1} = \hat{r}$. Furthermore, career incentives $\kappa > 0$ lead to lower $MRG_{t+1} < \hat{r}$, and thus higher G_{t+1}. This occurs due to the investment wedge, which mitigates the potential under-investment in G_{t+1}, as MRG_{t+1} is lower than the social return SRG_{t+1} (as discussed in Section 2.5).

Proposition 2 characterizes the steady state of the economy under two scenarios. The local government accumulates positive debt if the central government's discipline on leverage ω is below a threshold level $\bar{\omega}$, and takes no debt if $\omega > \bar{\omega}$.

Proposition 2 ***(Steady State under*** $\hat{r}$***)***

1. *If* $\kappa \in (0, \bar{\kappa})$ *and* $\omega \in (0, \bar{\omega})$ *(i.e., modest career incentives and financial discipline), where* $\bar{\kappa}$ *and* $\bar{\omega}$ *are defined in Appendix A.9.3, the equilibrium in steady state has the following properties:*

    (a) *There exists an interior steady state where the local government takes positive leverage* $e_*(\hat{r}) \in (0,1)$*. The leverage* $e_*(\hat{r})$ *is given in Appendix A.9.3 and has the following properties:* $\frac{\partial e_*(\hat{r})}{\partial \kappa} > 0$, $\frac{\partial e_*(\hat{r})}{\partial \omega} < 0$, *and* $\frac{\partial e_*(\hat{r})}{\partial \hat{r}} < 0$.

    (b) *The steady-state infrastructure investment is* $G_* = g_*(\hat{r}) Y_*$*, where* $g_*(\hat{r})$ *is given in Appendix A.9.3 and satisfies:* $\frac{\partial g_*(\hat{r})}{\partial \kappa} > 0$, $\frac{\partial g_*(\hat{r})}{\partial \omega} < 0$, *and* $\frac{\partial g_*(\hat{r})}{\partial \hat{r}} < 0$.

2. *If* $\omega \geq \bar{\omega}$ *(i.e., strong discipline on leverage) and* $\kappa < \frac{\frac{\gamma+\alpha_G}{1-\alpha_K}(1-\beta_G(1+\hat{r}))}{1+\hat{r}-\frac{\gamma+\alpha_G}{1-\alpha_K}}$*, with* $\delta_G = 1$*, there exists a set* $\mathbb{W}^+ \equiv \left(\underline{W}^+, \bar{W} \right] \subseteq \mathbb{W}$ *such that* $\forall W^G \in \mathbb{W}^+$*,* $\mathcal{H}^D\left(W^G\right) = 0$ *(i.e., zero debt) and* $\mathcal{H}^{W^G}\left(W^G\right) \in \mathbb{W}^+$.

In the first case, it is intuitive that the interior steady state of local government leverage e_* decreases with financial discipline ω and the interest rate $\hat{r}$, but increases with career incentives κ. The increase in leverage with career incentives complicates the long-run effect of κ on the steady-state share of local government infrastructure investment g_*. To explore this, we differentiate the steady-state budget constraint and Euler equation (38):

$$\frac{\partial c_*(\hat{r})}{\partial \kappa} = -\tau \frac{1-\beta_G(1+\hat{r})}{\omega(\theta+\hat{r})} \frac{\partial e_*(\hat{r})}{\partial \kappa} < 0, \tag{40}$$

$$\delta_G \frac{\partial g_*(\hat{r})}{\partial \kappa} = -\frac{\partial c_*(\hat{r})}{\partial \kappa} - \tau \frac{\hat{r}}{\theta+\hat{r}} \frac{\partial e_*(\hat{r})}{\partial \kappa}. \tag{41}$$

Equation (40) shows that higher κ reduces the local government's propensity to consume in the steady state, as in the baseline model without debt. However, equation (41) shows that $\frac{\partial e_*(\hat{r})}{\partial \kappa} > 0$ may offset $\frac{\partial c_*(\hat{r})}{\partial \kappa} < 0$ in determining the sign of $\frac{\partial g_*(\hat{r})}{\partial \kappa}$. Similarly, $\frac{\partial g_*(\hat{r})}{\partial \omega}$ and

$\frac{\partial g_*(\hat{r})}{\partial \hat{r}}$ are also ambiguous due to opposing forces: $\frac{\partial c_*(\hat{r})}{\partial \omega} > 0$, $\frac{\partial c_*(\hat{r})}{\partial \hat{r}} > 0$ while $\frac{\partial e_*(\hat{r})}{\partial \omega} < 0$ and $\frac{\partial e_*(\hat{r})}{\partial \hat{r}} < 0$. However, sufficiently low κ and ω ensure that $\frac{\partial g_*(\hat{r})}{\partial \kappa} > 0$, $\frac{\partial g_*(\hat{r})}{\partial \omega} < 0$, and $\frac{\partial g_*(\hat{r})}{\partial \hat{r}} < 0$.

In the second case, strong discipline ($\omega \geq \bar{\omega}$) combined with other conditions is sufficient to reduce local government debt to zero. This makes the economy identical to the baseline model, where $\frac{\partial g_*(\hat{r})}{\partial \kappa} > 0$ and $\frac{\partial g_*(\hat{r})}{\partial \hat{r}} = 0$.

3.2 Endogenous Interest Rate

We now let interest rate be endogenously determined by the capital market constraint (33):

$$r_t = \max\left\{r^w, \mathcal{R}\left(G_t, D_t, W_t^H\right)\right\}, \tag{42}$$

where

$$\mathcal{R}\left(G_t, D_t, W_t^H\right) = \frac{\alpha_K\left(1-\tau^Y\right) A G_t^{\gamma+\alpha_G}}{\left(W_t^H - D_t\right)^{1-\alpha_K}} - \delta_K. \tag{43}$$

The resulting output is

$$Y_t = \mathcal{Y}\left(G_t, D_t, W_t^H\right) \equiv \left(\frac{\alpha_K\left(1-\tau^Y\right)}{\max\left\{r^w, \mathcal{R}\left(G_t, D_t, W_t^H\right)\right\} + \delta_K}\right)^{\frac{\alpha_K}{1-\alpha_K}} A^{\frac{1}{1-\alpha_K}} G_t^{\frac{\gamma+\alpha_G}{1-\alpha_K}}. \tag{44}$$

We again focus on the steady state of the economy, where the interest rate r_* is constant. Proposition 3 considers two cases: one where the capital market constraint is slack and the other where it is binding, depending on the household saving rate s.

Proposition 3 ***(Endogenous Interest Rate)***

For $\omega > 0$ and a sufficiently low r^w, there exist s^0 and s^1 with $s^0 < s^1$, such that the following two cases arise:

1. *For $s > s^1$, the capital market constraint (33) is slack in the steady state, and $r_* = r^w$.*
2. *For $s \in (s^0, s^1)$, the capital market constraint (33) is binding in the steady state and determines r^*. Moreover,*
   - *(a) $r_* \in \left(r^w, \frac{1}{\beta_G} - 1\right)$, $\frac{\partial r_*}{\partial \kappa} > 0$ and $\frac{\partial r_*}{\partial \omega} < 0$;*
   - *(b) $e_* \in (0,1)$, $\frac{\partial e_*}{\partial \kappa} > 0$ and $\frac{\partial e_*}{\partial \omega} < 0$;*

When the household saving rate s is higher than s^1, the capital market constraint is not binding and the interest rate r_* equals the world interest rate r^w. However, when $s \in (s^0, s^1)$, the capital market constraint is binding, determining the interest rate at an interior level r_*, with a positive level of local government borrowing. Our analysis focuses on this latter case.

Part 2(a) of Proposition 3 examines the effects of κ and ω on the equilibrium interest rate r_*. As established by Proposition 2, with a fixed interest rate, a higher κ increases the steady-state local government leverage ratio, $\frac{\partial e_*(\hat{r})}{\partial \kappa} > 0$. This rise in leverage drives up the interest rate in the capital market, $\frac{\partial r_*}{\partial \kappa} > 0$, thereby crowding out capital to firms. Conversely, a higher ω reduces the leverage ratio e_*, lowering the equilibrium interest rate, $\frac{\partial r_*}{\partial \omega} < 0$, and increasing capital to firms.

The effects of κ and ω on g_* are more nuanced. In general equilibrium, we have

$$\frac{\partial g_*}{\partial \kappa} = \underbrace{\frac{\partial g_*(r_*)}{\partial \kappa}}_{>0} + \underbrace{\frac{\partial g_*(r_*)}{\partial r_*}\frac{\partial r_*}{\partial \kappa}}_{\text{GE effect}<0}. \tag{45}$$

The first term represents the partial equilibrium (PE) effect of κ, while the second term captures the general equilibrium (GE) effect. For sufficiently small κ and ω, Part 1(b) of Proposition 2 ensures that $\frac{\partial g_*(r_*)}{\partial \kappa} > 0$ and $\frac{\partial g_*(r_*)}{\partial r_*} < 0$. Given $\frac{\partial r_*}{\partial \kappa} > 0$, the GE effect is negative and offsets the positive PE effect. Similarly, $\frac{\partial g_*}{\partial \omega}$ comprises both PE and GE effects. Since $\frac{\partial g_*(r_*)}{\partial \omega} < 0$ and $\frac{\partial g_*(r_*)}{\partial r_*} < 0$, the PE effect is negative, while the GE effect is positive. In summary, while the effects of κ and ω on g_* are predictable under a fixed interest rate, the offsetting GE effects make the overall net effects ambiguous in general equilibrium.

Moreover, the GE effects also affect the steady-state output Y_* through r_*, as shown by equation (23). For example, a higher κ raises r_*, crowds out K_*, and thereby reducing Y_*. Conversely, a higher ω reduces r_*, crowds in K_*, and increases Y_*. In Section 5, our quantitative analysis will show that the crowding-in effect of ω can be so significant that imposing stricter financial discipline can actually increase Y_*.

The GE effects of local government debt on interest rates align with the issues discussed in Section 1.3. When the capital market is constrained, increased local government borrowing raises interest rates and reduces firm investment. To analyze the welfare implications of local government debt, we revisit the first-best allocation outlined in Section 2.5. The first-best allocation satisfies $\frac{C^G_{t+1}}{C^G_t} = \beta_C (1 + SRG_{t+1}) = \beta_C (1 + SRK_{t+1})$. In contrast, the Euler equation in a decentralized equilibrium without career incentives or financial discipline ($\kappa = \omega = 0$) is $\frac{C^G_{t+1}}{C^G_t} = \beta_G (1 + MRG_{t+1}) = \beta_G (1 + MRK_{t+1})$, if $MRK_{t+1} > r^w$. Since $SRG_{t+1} > MRG_{t+1}$ and $SRK_{t+1} > MRK_{t+1}$, the first-best allocation results in higher government consumption growth. This indicates underinvestment in infrastructure or excessive government borrowing in the decentralized equilibrium. We will use the first-best equilibrium as the benchmark to evaluate more general cases in our quantitative analysis.

4 Institutional Accounting

Although institutional parameters like κ and ω, key to understanding local government behavior and the Mandarin system's efficiency, are not directly observable, our model offers a framework to derive them from observed economic variables.

4.1 National-Level Accounting

In this subsection, we begin with institutional accounting at the national level, assuming all regions are identical. This extends our representative-region model from Sections 2 and 3 to account for changes in κ_t, ω_t, and other external variables over time. In the next subsection, we introduce province-specific variables, such as κ_{it} and ω_{it}, to capture regional variations.

As noted in Section 1.3, local governments were prohibited from using debt before 2008, but deregulation allowed them to issue LGFV debt. To reflect this shift, we apply the benchmark model from Section 2 to the pre-2008 period and the extended model from Section 3 to the post-2008 period.

For the pre-2008 period, to account for the small amount of local government debt set by the central government, we extend the local government budget constraint from equation (7) to (29) with exogenous D_{t+1}. Additionally, our representative-region model accommodates time-varying parameters such as κ_t, ω_t, A_t, τ_t^Y, q_t^G, and q_t^K, along with a trend growth rate g^A for TFP. The local governor's optimization problem is detailed in Appendix A.9.6. The first-order condition for this extended model generalizes the previous equation (21):

$$\left(1 - \underbrace{\frac{\kappa_t C_t^G}{q_t^G G_{t+1}}}_{\text{investment wedge}}\right) \frac{C_{t+1}^G}{C_t^G} = \beta_G \left(MRG_{t+1} + 1\right) \frac{q_{t+1}^G}{q_t^G}, \tag{46}$$

where $MRG_t \equiv \tau_t \frac{\gamma+\alpha_G}{1-\alpha_K} \frac{Y_t}{q_t^G G_t} - \delta_G$ is generalized by the time-varying q_t^G.

For the post-2008 period, we adopt the model from Section 3, which allows local government debt. The first-order conditions under time-varying parameters and a trend growth rate generalize those established in equations (38) and (39):

$$\left(1-\underbrace{\frac{\omega_t e_{t+1}}{1-e_{t+1}}\frac{C_t^G}{D_{t+1}}}_{\text{disciplining wedge}}\right)\frac{C_{t+1}^G}{C_t^G}=\beta_G\left(1+r_{t+1}\right), \tag{47}$$

$$\left(1-\underbrace{\frac{\kappa_t C_t^G}{q_t^G G_{t+1}}}_{\text{investment wedge}}-\frac{\gamma+\alpha_G}{1-\alpha_K}\frac{D_{t+1}}{q_t^G G_{t+1}}\underbrace{\frac{\omega_t e_{t+1}}{1-e_{t+1}}\frac{C_t^G}{D_{t+1}}}_{\text{disciplining wedge}}\right)\frac{C_{t+1}^G}{C_t^G}=\beta_G\left(MRG_{t+1}+1\right)\frac{q_{t+1}^G}{q_t^G}. \tag{48}$$

The derivations are provided in Appendix A.9.6.

Equations (46), (47) and (48) form the foundation for institutional accounting. Given other model parameters, we can deduce the sets $\{\kappa_t,\omega_t\}_{t=0}^{T}$ from the data sets $\left\{C_t^G,q_t^G\right\}_{t=0}^{T+1}$ and $\{G_t,D_t,Y_t,r_t,\tau_t\}_{t=1}^{T+1}$. This institutional accounting relies entirely on the local governor's intertemporal optimality conditions, making it independent of how the interest rate is determined. Therefore, any household-side model will remain consistent as long as it generates the necessary savings to match the observed interest rates.[22]

Data and Parameters

In our analysis, one period represents a five-year span, corresponding to a full governmental term, with $t=1$ covering the years 1993-97 during Jiang Zemin's first term.[23] We begin by calibrating the output elasticities using China's Input-Output Tables, which detail capital income across industries, to determine the values of α_G and α_K. These values represent the proportion of capital income, net of production taxes, relative to GDP in each sector. Our calibrations are based on the Input-Output Tables for 2002, 2007, 2012, and 2017. After calculating sectoral capital shares for each year and averaging the results, we set α_G at 0.05 and α_K at 0.40.

We use the official depreciation rates for "Construction and Installation," "Purchase of Equipment and Instruments," and "Others" to calculate the depreciation rate for each

[22]Our approach mirrors the model-based accounting methods developed by Cheremukhin et al. (2017) and Cheremukhin et al. (2024), which quantify the impact of time-varying wedges on long-term economic performance. While straightforward and transparent, these techniques assume perfect foresight, which may be unrealistic in our context. Changes in institutional parameters like κ_t and ω_t could lead to unexpected changes. To address this, we explore an alternative approach in Appendix A.8.2, where changes in κ_t and ω_t are unanticipated and perceived as permanent, meaning agents assume $\kappa_{t+\iota}$ and $\omega_{t+\iota}$ remain at their current values for any $\iota>0$. This affects household savings behavior and interest rates, yet interestingly, the results align closely with our original findings.

[23]Appendix A.7 explains how we convert annual variables into five-year equivalents.

industry, based on the average fixed asset composition across these categories. This yields δ_G at 0.130 and δ_K at 0.147.[24] See detailed methodology and calculations in Appendix A.3.

Table 2: Calibrated Parameters

	Value	Target
α_G	0.050	Infrastructure capital share
α_K	0.400	Non-infrastructure capital share
γ	0.025	Estimates in the literature
annual δ_G	0.130	Infrastructure capital depreciation rate
annual δ_K	0.147	Non-infrastructure capital depreciation rate
annual π	0.780	Estimated probability of staying in office
θ	0.79	the share of due debt

Early research (e.g., Aschauer (1989)) assumed a high infrastructure capital output elasticity $\alpha_G + \gamma$, but recent literature adopts much smaller values. We choose $\gamma = 0.025$ as our benchmark and consider two extreme cases, $\gamma = 0$ and $\gamma = 0.05$, in Appendix A.8.1. The results are robust across these values of γ.[25]

We assume $\beta_G = \beta\pi$, where π is estimated to match the probability of a governor remaining in the same region in the next period. Let Tn be the tenure of a city-level governor (either the party secretary or mayor). The probability of t-period tenure, $\Pr(Tn = t)$, follows $\pi^{t-1}(1-\pi)$. Using data compiled by Jiang (2018) for the period 1993-15, the average duration is 48.6 months. We use maximum likelihood to estimate the monthly π, which

[24]Our depreciation rates, similar to those by Bai, Hsieh and Qian (2006), are higher than their U.S. counterparts. While high depreciation rates might bias returns to capital net of depreciation downward, we use the perpetual inventory method to calculate sectoral capital stock. This method lowers G_t and K_t in line with the high depreciation rates, ensuring the robustness of our quantitative results, including returns to capital.

[25]Leeper, Walker and Yang (2010) and Boehm (2020) set $\alpha_G + \gamma = 0.05$ for the U.S. If we set $\alpha_G = 0.047$ for the U.S., based on the capital income share in infrastructure industries, the implied γ would be 0.003. For China, Henderson et al. (2022) set $\alpha_G + \gamma = 0.06$, based on a meta-analysis by Melo, Graham and Brage-Ardao (2013) and estimates by Wang, Wu and Feng (2020), implying $\gamma = 0.01$ under $\alpha_G = 0.05$. Alder, Song and Zhu (2023) use a gravity model of trade with network externalities and agglomeration effects to estimate returns on city-to-city road investments in China, finding aggregate returns of 3.1% in 2017. In our model, the aggregate returns to infrastructure are $(\gamma + \alpha_G)\frac{Y_t}{q_{t-1}^G G_t} + \frac{q_t^G}{q_{t-1}^G}(1-\delta_G) - 1$. Calibrating γ using the annual Y_t and G_t for 2017 to match the 3.1% returns yields $\gamma = 0.011$. There is also evidence for higher values of $\alpha_G + \gamma$. Calderón, Moral-Benito and Servén (2015) estimate a long-run production function using cross-country panel data and find $\alpha_G + \gamma$ ranges from 0.07 to 0.10, though this includes telecommunications infrastructure.

converts to an annual π of 0.78 and a five-year π of 0.29. The annualized, time-invariant household discount factor β is set at 0.98.

We calibrate θ to match the share of local government bonds maturing in 2018-22 relative to the total outstanding local government bonds at the beginning of 2018, resulting in $\theta = 0.79$. Table 2 summarizes the calibration of the constant parameters.

Table 3: Time-Varying Parameters

	Value						Target
t	1 (93-97)	2 (98-02)	3 (03-07)	4 (08-12)	5 (13-17)	6 (18-22)	
a_t	1	1.12	1.35	1.53	1.56	1.63	Solow Residuals
τ_t	0.16	0.20	0.25	0.28	0.29	0.28	Equation (49)
r_t^w	-3.49%	3.47%	0.18%	0.31%	0.92%	0.03%	Real Deposit Rate
r_t		$= r_t^w$		2.24%	4.08%	2.92%	Real LGFV Coupon Rate (post-2008)

We next calibrate the time-varying parameters. We construct G_t and K_t using perpetual inventory method (see Appendix A.2).[26] The log of TFP, a_t, is estimated as Solow residuals: $a_t = \log Y_t - (\alpha_G + \gamma)\log G_t - \alpha_K \log K_t - (1 - \alpha_G - \alpha_K) L_t$, where L_t is the employed population, based on data from the NBS website. The estimated aggregate TFP is reported in the first row of Table 3.

We map various sources of local government revenue R_t^G to corresponding parts in the model. The first part is output tax revenue $\tau_t^Y Y_t$. To utilize data on local tax revenue and fiscal transfers, we separate taxes paid to local governments $\tau_t^{YG} Y_t$ and central government $\tau_t^{YC} Y_t$, where $\tau_t^Y = \tau_t^{YG} + \tau_t^{YC}$, and $\tau_t^{YC} Y_t$ is redistributed to local governments. We assume land revenue is proportional to GDP, $H_t = \phi_t Y_t$, extending equation (9) to

$$\tau_t = \tau_t^Y + \left(1 - \tau_t^Y\right)\alpha_G + \phi_t. \tag{49}$$

The parameters τ_t^{YG}, τ_t^{YC} and ϕ_t are set equal to the ratio of local general budget revenue, net transfers from central government, and land sale revenue to GDP for each period. The second row in Table (3) shows the values of τ_t implied by equation (49), which is nearly doubled during the period.[27] Appendix A.5.1 provides details on τ_t^{YG}, τ_t^{YC} and ϕ_t . The

[26] q_t^G and q_t^K reflect the relative price of infrastructure and non-infrastructure investments in terms of consumption. To construct these price indexes, we use the official price indexes for three types of fixed assets and the average fixed asset composition of infrastructure and non-infrastructure capital. We then use the price index relative to the GDP deflator to approximate q_t^G and q_t^K.

[27] The difference between τ_t and the ratio of R_t^G to GDP in Table 1 is due to the model-based ratio of infrastructure service income to GDP, $\left(1 - \tau_t^Y\right)\alpha_G$.

share of fiscal transfers and land sales in total local government revenue was small in the 1990s and early 2000s but grew dramatically, stabilizing around 50% in 2008-17.

Before 2008, China had a large current account surplus, resulting in a rapid accumulation of foreign reserves and reflecting a loose capital market with $r_t = r_t^w$, as noted by Song, Storesletten and Zilibotti (2011). However, the capital market tightened significantly after 2008.[28] Since 2013, China's foreign reserves have stabilized around USD 3 trillion, indicating the presence of a minimum foreign reserve requirement.[29] To account for this, we introduce the minimum foreign reserve requirement F_t^*. The equilibrium interest rate will be $r_t = r_t^w$ if $F_t > F_t^*$, and $r_t > r_t^w$ if the constraint binds, with r_t determined by the capital market clearing condition.[30] As illustrated in Figure 4, market-based interest rates have been significantly higher than regulated rates since the late 2000s.

Consistent with these facts, we assume the minimum foreign reserve requirement was not binding until 2008. For the post-2008 period, we set the endogenously determined r_t to the real LGFV coupon rate (as shown in the fourth row of Table 3).[31] Following Song, Storesletten and Zilibotti (2011), we set r_t^w equal to the real deposit rate, which is the average of deposit rates minus the inflation rate (see the third row of Table 3).

We set the long-run TFP growth trend g^A to be 1%. The output, capital, consumption, and debt are all detrended by $(1 + g^A)^{\frac{1}{1-\alpha_K-\alpha_G-\gamma}}$, the long-run growth rate.

Quantitative Results

Table 4 reports our estimates of local governors' career incentives and financial discipline for each five-year period from 1993 to 2017. Using equation (46) for 1993-2007 and equations (47) and (48) for 2008-2017, we calculate the investment and disciplining wedges for each

[28] The current account surplus, which was around 10% of GDP in 2007-08, declined to an average of 2% thereafter. Bai, Hsieh and Song (2016) show that LGFVs, established to fund the 2008 stimulus program, increased the aggregate investment rate by 5 percentage points, contributing to about two-thirds of the decline in the current account surplus since 2008.

[29] A Chinese think tank estimated the minimum to be USD 2.6 trillion (https://zhuanlan.zhihu.com/p/573945966). The Chinese government maintains foreign reserves through tight capital account controls. Feng et al. (2024) estimate that bypassing these controls through overseas IPOs incurs a cost equivalent to a 66% valuation discount.

[30] Two points are worth noting: first, the gap between domestic and world interest rates results in a financial loss from holding foreign bonds, which is negligible for the accounting exercises but considered in the counterfactual exercises in Section 5. An alternative approach, following Bai, Hsieh and Song (2016), assumes convex lending costs, allowing the interest rate to adjust based on domestic fund demand under positive foreign reserves.

[31] Another market-based interest rate is the return on WMPs, and our results are robust to using this alternative interest rate (see Appendix A.8.1).

period, which are then used to derive κ_t and ω_t.[32]

Table 4: Institutional Accounting at the National Level

t	1 (1993-97)	2 (1998-02)	3 (2003-07)	4 (2008-12)	5 (2013-17)
	Panel A: Career Incentives				
investment wedge	0.88	0.92	0.91	0.81	0.75
$\frac{q_t^G G_{t+1}}{C_t^G}$	1.27	1.43	0.96	0.62	0.58
κ_t	1.11	1.31	0.88	0.50	0.44
	Panel B: Financial Discipline				
disciplining wedge	-	-	-	0.80	0.76
$\frac{(1-e_{t+1})D_{t+1}}{e_{t+1}C_t^G}$	-	-	-	1.53	1.17
ω_t	-	-	-	1.22	0.90

Note that κ_t is equal to the investment wedge multiplied by $\frac{q_t^G G_{t+1}}{C_t^G}$, reflecting the allocation of local government resources between future infrastructure and current consumption. In Panel A, the first row shows that the investment wedge remains stable across periods. The second row reports $\frac{q_t^G G_{t+1}}{C_t^G}$, which initially rises but then drops significantly, mirroring the trend in local governments' propensity to invest in Figure 2. As a result, κ_t increases during the Jiang-Zhu administration (1998-2002) and declines under Hu-Wen's first term (2003-2007), reaching only 33% of its peak by Xi's first term (2013-2017).

The parameter ω_t is the disciplining wedge multiplied by $\frac{(1-e_{t+1})D_{t+1}}{e_{t+1}C_t^G}$, representing the allocation between future liquidity and current consumption. In Panel B of Table 4, the first row shows the disciplining wedge remained stable from 2008-2012 to 2013-2017. However, the second row shows a substantial drop in $\frac{(1-e_{t+1})D_{t+1}}{e_{t+1}C_t^G}$ from 1.53 to 1.17, leading to a significant decline in ω_t (the third row) from 1.22 in 2008-12 to 0.90 in 2013-17.[33]

This cycle of career incentives aligns with political science literature, reflecting shifts in the central authority's priorities over time. The transition from political loyalty to economic development in the 1980s was well recognized by local officials, as Shirk (1993) noted.

[32] Institutional accounting cannot recover κ_t and ω_t for 2018-22, as this requires data on local government consumption and interest rates from 2023-27, which are not yet available.

[33] Prohibiting local government borrowing before 2008 effectively imposed a strict disciplining mechanism with high ω_t. In alternative analysis, we used equations (47) and (48) to calculate the implied investment and disciplining wedges for pre-2008 periods. The implied ω_t values were 2.83 for 1993-1997, 4.30 for 1998-2002, and 2.82 for 2003-2007, all substantially higher than post-2008 levels.

Economic achievements became the primary evaluation criteria during the Jiang era, as evidenced by Edin (2003)'s surveys of performance contracts for local officials in 12 counties in 1996-1999. This is also consistent with the positive effects of economic performance on career advancement in the 1980s and 1990s (e.g., Li and Zhou (2005); Chen, Li and Zhou (2005); Landry (2008)).

In the mid-2000s, the priority shifted toward "social welfare." Shirk (2022) observed a gradual decline in the emphasis on economic growth starting with the Hu-Wen administration. Zuo (2015) argued that this leadership focused on balancing economic development with social policy. This shift may explain why empirical findings during this period became more mixed (e.g., Shih, Adolph and Liu (2012); Yao and Zhang (2015); Landry, Lü and Duan (2018); Chen and Kung (2019)).[34]

Under Xi's regime, the political system underwent significant transformation, particularly due to the anti-corruption campaign started during his first term, which greatly affected the cadre management system. Li and Manion (2023) found that city-level leaders' promotions from 2013-17 were uncorrelated with economic performance and were instead closely tied to the intensity of the anti-corruption crackdown. Sheng (2022) also found no correlation between promotion and economic performance at the provincial level.

Manion (2023) reviews empirical studies on promotion and economic performance, which vary widely in data, measures, and methodologies. Using provincial data from 1981 to 2018, Sheng (2022) offers the most comparable estimates across regimes, showing a strong positive correlation between career advancement and economic performance only in 1990-2002. Wang, Yao and Zhang (2022) estimated the fixed effects of city leaders on GDP growth, serving as proxies for how the central government assesses local leaders' competence. Their findings indicate a significant influence on promotions during 1994-2002, which weakened in later years. Consistent with these studies, our approach challenges the assumption of a stationary incentive structure in the post-Mao era. Our model's inferred career incentives align with reduced-form estimates, showing a strong link between economic performance and career advancement in 1993-2002, which weakened afterward.

[34] There is also evidence of political selection influenced by patronage or factional ties (Shih, Adolph and Liu (2012); Jia, Kudamatsu and Seim (2015); Jiang (2018); Fisman et al. (2020); Francois, Trebbi and Xiao (2023)).

4.2 Provincial-Level Accounting

We now extend our representative-region model to a heterogeneous-region model, with each region representing a province, where institutional parameters κ_{it} and ω_{it} vary by time and region.[35] We focus on the provincial level due to the lack of city-level data on infrastructure and local government debt.

We construct region-specific data as follows. Census and one-percent population surveys provide provincial employment data for specific years, with interpolation for other years. We measure L_{it} as the average employment for province i at period t (Appendix A.5.4). Annual provincial fixed capital formation is used to calculate G_{it} and K_{it}. Following Chen et al. (2019), we adjust post-2004 provincial investments to account for discrepancies between national fixed capital formation and the sum of provincial data, indicating potential over-reporting by local governments (Appendix A.2.5).[36] Provincial TFP A_{it} is estimated using the same procedure as aggregate TFP: $a_{it} = \log Y_{it} - (\alpha_G + \gamma) \log G_{it} - \alpha_K \log K_{it} - (1 - \alpha_G - \alpha_K) L_{it}$.

We construct provincial local government debt using the same method and data sources as for aggregate local government debt (Appendix A.4.1). The local output tax rate is $\tau_{it}^{Y} = \tau_{it}^{YG} + \tau_{t}^{YC}$, where τ_{it}^{YG} and τ_{t}^{YC} are local and central government tax rates, respectively. We proxy τ_{it}^{YG} using the ratio of general budget revenue to provincial GDP. τ_{t}^{YC} is calibrated to balance the central government budget: $\tau_{t}^{YC} Y_t = \sum_i \tau_{it}^{Tr} Y_{it}$, where τ_{it}^{Tr} is the ratio of fiscal transfers to provincial GDP. Thus, the local government revenue to GDP ratio is

$$\tau_{it} = \tau_{it}^{YG} + \tau_{it}^{Tr} + \left(1 - \tau_{it}^{Y}\right) \alpha_G + \phi_{it}, \tag{50}$$

where ϕ_{it} is the ratio of land sale revenue to provincial GDP. See Appendix A.5.1 for data sources for these variables.

Table 5 presents summary statistics for the inferred values of κ_{it} and ω_{it}. While the average values align with κ_t and ω_t in Table 4, significant variation exists across provinces. This variation, though somewhat surprising in a uniform institutional framework, can be attributed to differences in career incentives and penalties faced by local governors, influenced by career paths, local economic conditions, and provincial practices.

[35] Landry (2008)), where the central authority oversees only provincial officials, who in turn manage city-level leaders. This decentralization leads to regional variations in policy priorities, as documented by Zuo (2015).

[36] In 2021, China's National Bureau of Statistics released adjusted aggregate investment data but did not update the provincial-level data.

Table 5: Provincial-level Institutional Accounting

	t	1 (1993-97)	2 (1998-02)	3 (2003-07)	4 (2008-12)	5 (2013-17)
Mean	κ_{it}	1.27	2.14	0.89	0.47	0.44
	ω_{it}	-	-	-	1.24	0.94
Std. Dev.	κ_{it}	1.09	2.00	0.32	0.22	0.21
	ω_{it}	-	-	-	0.35	0.31

Age and Career Incentives

Exploring the correlation between estimated institutional parameters and local governors' career motivations helps assess the external validity of our findings. In China's political system, age significantly impacts promotion prospects. City-level officials must retire at 60 unless promoted to the provincial level, where they can serve until 65. Studies highlight age as a key predictor of promotion (Yao and Zhang (2015); Sheng (2022)). While factors like connections and capabilities also influence career paths, they are harder to measure and yield mixed results (Shih, Adolph and Liu (2012); Wiebe (2020)). Thus, we use age as a proxy to examine career incentives, focusing on the relationship between local governors' ages and the estimated κ_{it}.

Since our estimated institutional parameters κ_{it} and ω_{it} are at the provincial level, we first calculate the average age of the provincial party secretary and governor for each period.[37] As infrastructure projects are primarily executed by cities, the province-wide κ_{it} may reflect the motivations of city-level officials. Therefore, we also calculate the average age of all city party secretaries and mayors within each province.

Table 6 presents the results of regressing κ_{it} on leader age. Controlling for time fixed effects, we find a significantly negative association between career concerns and the average age of leaders at both provincial and city levels (first column). This relationship remains robust after accounting for both time and province fixed effects (second column). The coefficient for city-level leaders is larger and more significant than for provincial-level leaders, consistent with research showing that economic performance is more important for lower-tier officials' advancement (Landry, Lü and Duan (2018)). The last two columns split the sample into pre- and post-2008 periods, revealing that the city-level correlation exists only pre-2008.

[37] While the party secretary generally holds more power, the governor is often more accountable for economic performance (Chen and Kung (2019)), so we assign equal weight to both roles.

This aligns with findings on the weakening of merit-based promotions under the Hu-Wen and Xi administrations. These results are robust to alternative γ values and different levels of winsorization for κ_{it} (see Appendix A.8.1). Based on the estimate in the second column, a one-standard-deviation increase in the average age of city leaders (around 4.1 years) explains about 54% of the variation in κ_{it}.

Table 6: Age and Career Incentives

Dep. Variable	κ_{it}			
	Whole Sample		1993-2007	2008-2017
Ave. Age of Province Leaders	-0.0602*	-0.0656*	-0.0849	-0.0209*
	(0.0348)	(0.0377)	(0.0556)	(0.0121)
Ave. Age of City Leaders	-0.0883*	-0.1607**	-0.1152*	0.0141
	(0.0468)	(0.0688)	(0.0664)	(0.0226)
Period Fixed Effects	Yes	Yes	Yes	Yes
Province Fixed Effects	No	Yes	No	No
Observations	150	150	90	60
Adj. R^2	0.2750	0.4272	0.1460	0.0139

Note: The dependent variable is κ_{it}, the career incentive parameter for local governors in province i at period t inferred from institutional accounting. Explanatory variables include the average age of province and city leaders (party secretary and governor/mayor) based on the data complied by Jiang (2018) in the same province and period. Standard errors are reported in parentheses. Each observation is a province-period of 5 years. The sample covers the periods from 1993 to 2017. The first two columns use the whole sample. The last two columns divide the sample into pre-2008 and post-2008 periods.

Our analysis provide a new perspective on the economic impact of China's political selection system. Local governors' decisions are shaped by their perceptions of the career evaluation framework. Since the estimate of κ_{it} is derived from their economic decisions, it reflects perceived career incentives, which may differ from actual promotion outcomes. Previous research has focused on the link between economic performance and promotions, showing little impact of age on promotions. For example, Yao and Zhang (2015) found that age's influence on promotion, even after considering the "city leader effect" from GDP growth, is "not economically significant." Our analysis suggests a mismatch between perceived promotion criteria and actual outcomes. While age appears to have a negligible effect on promotions, it nonetheless plays a crucial role in shaping career incentives and influencing local government economic decisions.

Career Incentives and TFP Growth

We further examine the relationship between the estimated institutional parameters and TFP growth, finding a positive correlation at both national and provincial levels. Nationally, there is a strong correlation of 0.87 between κ_t and future GDP growth g^A_{t+1}. This relationship is not a byproduct of our calibration process. Typically, an increase in G_{t+1}, indicating a higher κ_t, would boost GDP growth but not necessarily TFP growth unless infrastructure's contribution to production technology is misrepresented. However, as shown in Appendix A.8.1, this strong correlation between κ_t and g^A_{t+1} persists across different output elasticity values for infrastructure γ.

At the provincial level, Table 7 shows a significant correlation between g^A_{it+1} and κ_{it}, with time fixed effects controlled in Column 1 and both time and province fixed effects in Column 2.[38] From Column 2, a one-standard-deviation increase in κ_{it} accounts for 17% of the standard deviation in g^A_{it+1}. The decline in average κ_{it} from 1998-2002 to 2013-2017 is linked to a 0.6 percentage point drop in annual TFP growth, representing 19% of the total decline in that period. These results hold across different values of γ and levels of winsorization for κ_{it} (see Appendix A.8.1).

Table 7: Career Incentives and TFP Growth

Dep. Variable	g^A_{it+1}			
	Whole Sample		1993-2007	2008-2017
κ_{it}	0.0027*	0.0035**	0.0028	-0.0001
	(0.0015)	(0.0018)	(0.0017)	(0.0094)
Period Fixed Effects	Yes	Yes	Yes	Yes
Province Fixed Effects		Yes		
Observations	150	150	90	60
Adj. R^2	0.3883	0.4632	0.0579	0.0408

Note: The dependent variable is g^A_{it+1}, the TFP growth in province i from period t to $t+1$. See Table 6 for the definition of κ_{it} and the sample period corresponding to each column.

The results from Table 7 highlight that strong incentives (κ_{it}) drive local governors to

[38] If local officials use information unavailable to the central government to predict higher g^A_{it+1}, they might reduce G_{it+1} and increase C^G_{it}, potentially lowering the estimated κ_{it}. This local knowledge would create a negative association between κ_{it} and g^A_{it+1}, making the observed positive correlation particularly significant.

employ strategies beyond infrastructure development to boost GDP. A key factor behind the high TFP growth in the late 1990s and 2000s was the entry of new firms, as noted by Brandt, Van Biesebroeck and Zhang (2012). Officials actively promoted local economic development, a hallmark of China's informal institutions during this period (Bai, Hsieh and Song (2020); Bai et al. (2020)). A crucial element was attracting private investments by easing entry barriers for private enterprises and protecting them from financial penalties. Qian, Ru and Xiong (2024) showed that infrastructure investments' effectiveness in enhancing firm productivity was amplified by the 2005 "36 Clauses" reform, which improved the business environment for private firms. Judicial independence also played a key role in boosting local productivity (Liu et al. (2022)). A supportive environment attracted foreign investment, generating productivity spillovers (Gong (2023)). Additionally, effective industrial policies spurred TFP growth by increasing R&D and improving its allocation (König et al. (2022)), while restructuring inefficient SOEs further enhanced productivity (Hsieh and Song (2015)).

The last two columns in Table 7 split the sample into pre- and post-2008 periods, showing that the cross-province correlation between career incentives and TFP growth is driven entirely by the pre-2008 period. This suggests the channel disappeared after 2008 (Bai, Hsieh and Song (2020)).

5 Impacts on Growth and Welfare

In this section, we perform counterfactual exercises to assess the impact of institutions characterized by κ_t and ω_t on economic growth. Unlike our previous institutional accounting, which ignored the household sector and assumed fixed interest rates, these exercises incorporate the household sector's role in influencing interest rates through savings. A simple two-period OLG model is insufficient, as it only reflects the savings of younger households and doesn't capture the observed rapid rise in the wealth-to-income ratio (Piketty, Yang and Zucman (2019)).

We use a full model with bequest motives, calibrating parameters to match household wealth accumulation. We also incorporate CRRA (Constant Relative Risk Aversion) preferences, allowing us to account for varying household savings responses to interest rate changes, based on the elasticity of intertemporal substitution, ζ. Logarithmic preferences serve as our baseline, with ζ ranging from 0.5 to 1.5 in robustness checks (see Appendix A.8.2). We also account for demographic changes and financial frictions affecting K_t. All counterfactuals are conducted using the representative-region model from Section 4.1.

5.1 Calibration

We derive the financial friction parameter ξ_t by matching the firm's optimality condition: $K_t = \frac{\alpha_K \left(1-\tau_t^Y\right) Y_t}{r_t^K}$, where r_t^K follows equation (6).[39] These results are reported in the first row of Table 8. Song, Storesletten and Zilibotti (2011) find a rapid decline in ξ_t during the 2000s, predicting that it would fall to zero by 2019. Our calibration aligns with this trend but shows ξ_t remains positive in 2018-2022. We assume $\xi_t = 0$ and annualize $\Delta a_t = 1\%$ for $t \geq 10$, with ξ_t and Δa_t for $t \in \{7, 8, 9\}$ linearly extrapolated from earlier data. Labor supply L_t for $t \geq 7$ is projected using working-age population growth data from the United Nations' World Population Prospects 2022.

All the other time-varying parameters for $t > 6$, including τ_t and r_t^w, are set to their calibrated values at $t = 6$. The bequest motive b_t, which the accounting approach does not account for, is now calibrated by matching W_t^H. We obtain $\left\{W_t^H\right\}_{t=1}^7$ from equation (32). Given B_1 and $\{b_t\}_{t=1}^6$, equations (3) and (4) generate $\left\{W_t^H\right\}_{t=2}^7$ based on initial household wealth and the interest rate sequence. We assume the economy was in a steady state before 1993, with $b_t = b_1 \ \forall t \leq 0$, providing the initial household wealth W_1^H.

Table 8: Time-Varying Parameters

$t =$	1 (93-97)	2 (98-02)	3 (03-07)	4 (08-12)	5 (13-17)	6 (18-22)	Assumptions for ≥ 6
annual ξ_t (%)	24.12	15.53	18.58	13.43	6.00	5.14	reaching zero friction at $t = 10$
annual a_t	first row in Table 3						reaching trend growth at $t = 10$
τ_t and r_t^w	second and third rows in Table 3						
b_t	0.04	0.52	1.36	2.71	2.47	3.16	equal to the value at $t = 6$
κ_t	the third row in Panel A of Table 4					0.52	
ω_t	the third row in Panel B of Table 4					0.78	

In addition, we distinguish the deposit rate in equation (4) from the market-based interest rate. On average, only 13.3% of total deposits in 2008-22 were invested in WMPs, which access the market-based rate. Therefore, we set the deposit rate as a weighted average of r_t^w and r_t, with the weight corresponding to the share of WMP balances in total deposits. Matching $\left\{W_t^H\right\}_{t=1}^7$ from the model to the data enables us to determine the seven unknowns: B_1 and $\{b_t\}_{t=1}^6$.

[39] We assume revenue from financial intermediation $\xi_t K_t$ is paid to young households, with total income $Y_t^H = \left(1-\tau_t^Y\right)\left(1-\alpha_G-\alpha_K\right) Y_t + \xi_t K_t$.

Our previous institutional accounting estimated κ_t and ω_t for each 5-year period up to 2013-17 (i.e., $t = 5$), as reported in Table 4. We cannot use the local governor's Euler equations to determine κ_6 and ω_6 for 2018-22 due to missing interest rate and government consumption data for 2023-27. Having incorporated the household sector as the capital supplier, we can now calibrate κ_6 and ω_6 to match G_7 and D_7 (infrastructure capital and local government debt) observed at the start of 2023 by simulating the economy with $\kappa_t = \kappa_6$ and $\omega_t = \omega_6$ for $t \geq 6$. This approach gives $\kappa_6 = 0.52$ and $\omega_6 = 0.78$.[40]

Table 9 summarizes the calibrated model dynamics. The pre-2008 and 2008-2022 variables match the data by calibration, while values for 2023-2037 and the steady state are model predictions. The model projects rapid GDP growth, with g_t rising from 0.46 in 2008-22 to 0.62 in 2023-37. The leverage ratio e_t rises, but the interest rate r_t drops from 3.09% to 1.05%. Holding a constant r_t, the higher g_t boosts output and savings. In general equilibrium, the interest rate decreases, and aggregate output rises, with annual output per worker growth averaging 3.9% over the next 15 years. The model predicts non-monotonic transitional dynamics, with g_t falling to 0.61 in the steady state and the interest rate rising to 1.35%, both negatively impacting aggregate output growth.

Table 9: Aggregates by the Calibrated Model

	1993-2007	2008-2022	2023-2037	steady state
g_t	0.29	0.46	0.62	0.61
c_t	0.11	0.24	0.21	0.21
e_t	0.02	0.17	0.42	0.41
r_t (%)	0.21	3.09	1.05	1.35
$\Delta \log \frac{Y_t}{L_t}$	0.082	0.069	0.039	0.019

Note: $g_t \equiv \frac{G_t}{Y_t}$ and $c_t \equiv \frac{C_t^G}{Y_t}$. All the variables are averaged over t. We further annualize g_t, r_t, and $\Delta \log \frac{Y_t}{L_t}$ (without detrending).

5.2 Counterfactual Analyses

We use the calibrated economy to conduct counterfactual analyses, assessing the quantitative impacts of altering career incentives and financial discipline on past performance and future

[40] Notably, κ_6 is higher than κ_5, mainly due to $\frac{q_t^G G_{t+1}}{C_t^G}$ increasing from 0.58 to 0.70 between 2013-17 and 2018-22. However, caution is needed when interpreting these results, as this calibration method differs. Moreover, the zero-Covid policy likely reduced local governments' consumption propensity in 2018-22, with Covid-related infrastructure spending reflecting different evaluation criteria.

growth. We explore five scenarios:

1. Remove Career Incentives: From the start of market-oriented reforms in the early 1990s, set $\kappa_t = 0$ for $t \geq 1$, while maintaining pre-2008 local government debt levels and post-2008 calibrated financial discipline ω_t in Table 8.

2. Remove Financial Discipline: Starting in 2008, with initial conditions matching actual data, set $\omega_t \approx 0$ for $t \geq 4$, while maintaining the calibrated career incentives κ_t.[41]

3. Increase Career Incentives: Starting in 2008, restore the highest level of career incentives observed in 1998-2002 by setting $\kappa_t = 1.31$ for $t \geq 4$, while maintaining pre-2008 local government debt levels and post-2008 calibrated financial discipline (identical to the first counterfactual).

4. Impose Strict Financial Discipline: Starting in 2008, set $\omega_t \to \infty$ for $t \geq 4$, while maintaining the calibrated career incentives (identical to the second counterfactual).

5. Combined Increase in Incentives and Discipline: Starting in 2008, set $\kappa_t = 1.31$ and $\omega_t \to \infty$ for $t \geq 4$.

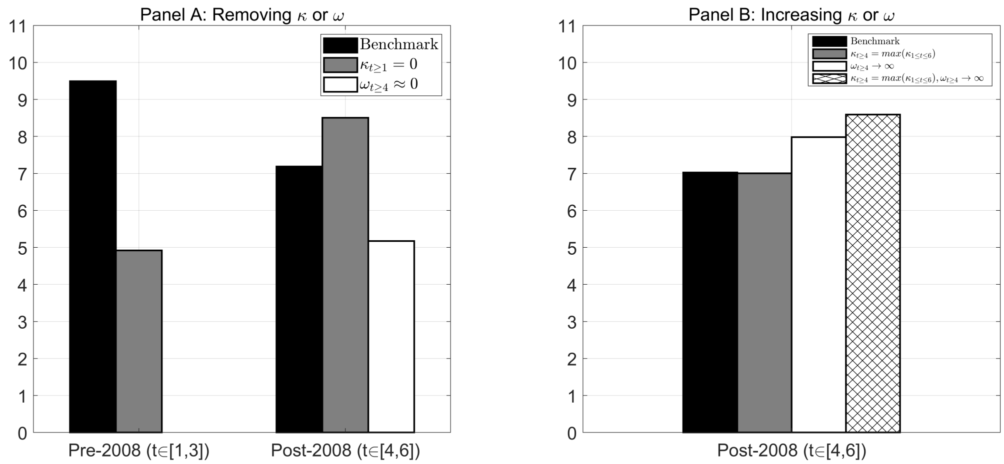
Figure 5 shows the transitional growth for the calibrated and counterfactual economies, while Table 10 reports the steady-state aggregates for each scenario.

In the first counterfactual, with career incentives fully removed, the immediate impact is severe: as shown in Panel A of Figure 5, the counterfactual growth rate drops from 9.5% in the actual data to 4.9% in the pre-2008 period, primarily due to reduced infrastructure investment. While the growth rate improves relative to the benchmark in the 2008-22 period, Table 10 shows that steady-state aggregate output is 0.23 log points lower than in the calibrated economy.

This outcome highlights the crucial role of career incentives in driving infrastructure investment and overall output. In the counterfactual, g_* drops to just 14% of its value in the calibrated economy. Removing career incentives also reduces local government leverage (e_*) and the interest rate (r_*). Following the analysis in Section 3.2, although the lower interest rate attracts more private capital, boosting Y_*, this positive general equilibrium (GE) effect is outweighed by the negative partial equilibrium (PE) effect of significantly reduced g_*.

[41] Since e_* approaches 1 as ω drops to zero, we use a modest value of 0.1 for ω, as smaller values complicate the numerical solution.

Figure 5: Counterfactual Output Growth



Note: The black bars in both panels represent output growth in the benchmark case. The gray and white bars in the left panel represent the first and second counterfactual, respectively. The gray, white and gridded bars in the right panel represent the third, fourth, and fifth counterfactual, respectively. "Pre-2008" and "Post-2008" refer to the period 1993-07 and 2008-22, respectively.

In the second counterfactual, relaxed financial discipline reduces aggregate output growth from 7.2% in the data to 5.2% for 2008-22 (Figure 5), mainly due to the crowding-out effect. Local government leverage (e_t) ascends from 0.17 in the data to 0.58 in the counterfactual, pushing the interest rate up from 3.1% to 6.7%. Table 10 shows that in the steady state, the positive PE effect of relaxed financial discipline is outweighed by the negative GE effect. Specifically, $e_* = 0.92$ nears its upper limit, and r_* rises to 3.93% from 1.35% in the calibrated economy, indicating significant crowding out of private capital. As a result, Y_* falls by 0.16 log points, despite a modest decrease in g_*. Overall, the impact of relaxed financial discipline on output is less severe than removing career incentives in the first scenario.

Table 10: Steady State Aggregates in the Counterfactuals

	Calibrated Economy	Counterfactuals				
		Removing κ or ω		Increasing κ or ω		
		(1)	(2)	(3)	(4)	(5)
g_*	0.61	0.09	0.59	1.02	0.55	0.98
c_*	0.21	0.28	0.17	0.15	0.21	0.15
e_*	0.41	0.25	0.92	0.56	0.00	0.00
$r_*(\%)$	1.35	0.52	3.93	2.11	0.04	0.04
$\log Y_*^{CF} - \log Y_*^{BM}$		-0.225	-0.164	0.025	0.074	0.157

Note: Columns 1-5 correspond to counterfactuals 1-5, respectively. $\log Y_*^{CF}$ and $\log Y_*^{BM}$ denote $\log Y_*$ in the benchmark calibrated economy and corresponding counterfactual, respectively. See Table 9 for the definition of the other variables.

In the third counterfactual, enhancing career incentives has minimal impact on growth in 2008-22 (Figure 5). As shown in Table 10, g_* increases by half compared to the calibrated economy. Its output effect is moderated by increases in e_* and r_*. Consequently, aggregate output Y_* is only 0.03 log points higher than in the calibrated economy.

In the fourth counterfactual, strict financial discipline boosts output growth in 2008-2022 by 1.0 percentage points (Figure 5), due to the minimized crowding-out effect. Strict discipline reduces local government debt to zero, lowering the interest rate and increasing private capital, which raises aggregate output despite reduced infrastructure investment. In the steady state, as shown in Table 10, both g_* and r_* are lower in the calibrated economy. However, the positive effect of the lower r_* on Y_* dominates that the negative effect of the lower g_*, resulting in a 0.07 log point increase in Y_* compared to the calibrated economy.

The fifth counterfactual combines the strongest career incentives with the strictest financial discipline. The strong career incentives drive local governors to expand infrastructure despite tight budget constraints, while prohibiting local government debt prevents infrastructure investment from crowding out private capital. This combination results in a 1.6 percentage point increase in the growth rate for 2008-22 (Figure 5). Table 10 shows a substantial increase in steady-state g_* as in counterfactual 3. The interest rate r_* remains nearly identical to that in counterfactual 4. The combined changes to κ_* and ω_* result in a 0.16 log point increase in Y_*, which is 0.06 log points higher than the sum of the individual effects of enhancing career incentives and tightening financial discipline. This cross-term highlights the complementarity between κ_* and ω_* in their combined impact on Y_*.[42]

5.3 Welfare Implications

This subsection examines the welfare implications of career incentives. First, we solve the first-best allocation. The social planner's problem, defined in Appendix A.9.7, extends the model in Section 2.5 to include q_t^G and q_t^K, necessary for our quantitative analysis. The first-order conditions (28)-(27) still apply, but the social returns are now generalized as: $SRG_t \equiv (\gamma + \alpha_G) \frac{Y_t}{q_{t-1}^G G_t} + \frac{q_t^G}{q_{t-1}^G} (1 - \delta_G) - 1$ and $SRK_t \equiv \alpha_K \frac{Y_t}{q_{t-1}^K K_t} + \frac{q_t^K}{q_{t-1}^K} (1 - \delta_K) - 1$. The assumption $\beta_C (1 + r^w) < 1$ is extended to $\beta_C (1 + r^w) < (1 + g^A)^{\frac{1}{1-\alpha_K-\alpha_G-\gamma}}$.

We compare aggregate output and welfare implications in the first-best allocation and

[42] Zero-Covid policies may have skewed the calibration of κ_t and ω_t for $t \geq 6$. If the actual career incentives and financial discipline were weaker than estimated, future increases in κ_t and ω_t could potentially yield even larger positive effects on aggregate output.

the calibrated economy. Welfare is measured using the equivalent consumption variation (φ) relative to the calibrated economy. Specifically, φ is calculated to make the social planner indifferent between two scenarios: a lifetime consumption stream in the calibrated economy, $\{C_t^{G,EQ}, C_{t-1,t}^{H,EQ}, C_{t,t}^{H,EQ}\}_{t=0}^{\infty}$, each scaled by $(1+\varphi)$, and a lifetime consumption stream in the first-best allocation, $\{C_t^{G,FB}, C_{t-1,t}^{H,FB}, C_{t,t}^{H,FB}\}_{t=0}^{\infty}$. A welfare gain occurs if $\varphi > 0$ and a loss if $\varphi < 0$, comparing the first-best to the calibrated economy (Song et al. (2015)).

We assume the social planner uses the same discount factor as the households ($\beta_C = 0.98$). Recall that the parameter ρ measures the welfare weight the planner assigns to households relative to government employees. While ρ does not affect first-best capital allocation and thus the aggregate output (as shown by Section 2.5), it is crucial for determining first-best consumption allocation and welfare implications. We consider two values for ρ: 1 and 2.5.

Table 11: Comparing the First-Best Allocation and the Calibrated Economy

	First-Best Allocation			Calibrated Economy		
	(1)	(2)	(3)	(4)	(5)	(6)
	1993-07	2008-22	Steady State	1993-07	2008-22	Steady State
g_t	0.22	0.32	0.48	0.29	0.46	0.61
k_t	0.98	1.70	2.63	0.79	1.40	2.69
$\log Y_t^{FB} - \log Y_t^{BM}$	0.14	0.10	-0.05	-	-	-

Note: $g_t \equiv \frac{G_t}{Y_t}$ and $k_t \equiv \frac{K_t}{Y_t}$ are annualized. $\log Y_t^{BM}$ and $\log Y_t^{FB}$ denote $\log Y_t$ in the benchmark and first-best economy, respectively.

Columns 1 and 2 in Panel A of Table 11 summarize the transitional dynamics of the first-best allocation for the pre- and post-2008 periods. Compared to the calibrated decentralized equilibrium (Columns 4 and 5), the social planner chooses a lower infrastructure investment ratio yet a higher private capital output ratio in both periods. In these periods, first-best aggregate output surpasses the decentralized output by about 0.14 and 0.10 log points, respectively, suggesting excessive infrastructure investment and insufficient private capital investment in the decentralized economy. Notably, Column 3 reveals that in the steady state, both the first-best g_* and k_* are lower than their counterparts in the decentralized economy (Column 6). This results in a 0.05 log points reduction in aggregate output, indicating over-investment in both sectors in the calibrated economy.

We have also examined the impact of ρ on the first-best consumption allocation and welfare. At $\rho = 1$, balancing government and household welfare equally, the first-best government-to-household consumption ratio $\frac{C^G}{C^H} = 0.50$, with a welfare gain of 10.8%. Increasing ρ to 2.5 results in a first-best $\frac{C^G}{C^H}$ ratio of 0.20 and a welfare gain of 19.1%.[43]

Table 12: Welfare Implications of the Counterfactuals

	Removing κ or ω		Increasing κ or ω		
	(1)	(2)	(3)	(4)	(5)
$\rho = 1$	-15.51%	-15.18%	-9.42%	1.56%	-3.55%
$\rho = 2.5$	-20.63%	-12.69%	-3.83%	2.06%	2.47%

Note: This table reports the equivalent consumption variation ψ when comparing the counterfactual to the calibrated economy. Columns 1-5 correspond to counterfactuals 1-5, respectively.

Next, we evaluate the welfare impacts of modifying the institutional parameters in five counterfactual scenarios. Although the optimal allocation doesn't directly address government leverage, analyzing welfare across these scenarios allows us to explore the welfare implications of government debt. From the previous subsection, counterfactuals 1 and 2, which remove career incentives and financial discipline, respectively, yield a lower steady-state output than the calibrated economy. Conversely, counterfactuals 3 and 4 enhance career incentives and financial discipline separately, while counterfactual 5 strengthens both, leading to notably higher steady-state output in counterfactual 5.

Table 12 reports the equivalent consumption variation φ when comparing each counterfactual to the calibrated economy. Columns 1 and 2 show that removing career incentives or financial discipline results in reduced welfare, aligning with the lower steady-state output of these scenarios. However, Column 3 reveals that although stronger career incentives boost steady-state output, welfare decreases by -9.4% and -3.8% for the two ρ values. This decline results from the over-investment in infrastructure and excessive government leverage, diminishing government and household consumption.

Column 4 indicates that enhancing financial discipline improves welfare by 1.6% and 2.1% for the two ρ values, contrasting the negative welfare impacts of intensified career incentives and highlighting the detrimental effects of government over-leverage. This improvement also suggests that the calibrated economy suffers from excessive leverage. Column 5 illustrates that simultaneously strengthening career incentives and financial discipline produces mixed

[43] Comparatively, the U.S. averaged a government-to-private consumption ratio of 22.20% from 1993 to 2022, suggesting $\rho = 2.5$ gives a reasonable consumption allocation.

welfare outcomes, dependent on the ρ value, due to the counteracting welfare effects of these adjustments.

6 Conclusion

We have developed a macroeconomic framework to assess the impact of the Mandarin system in China's hybrid economy. Our analysis reveals that agency frictions—specifically career incentives and financial discipline—play a pivotal role in driving China's growth and welfare. Strong career incentives, in particular, account for half of China's pre-2008 growth, and removing them would result in significant losses in both output and welfare.

However, career incentives are not a panacea for promoting growth or improving welfare. Post-2008, their influence wanes due to loose financial discipline and an abundance of infrastructure capital. During this period, financial discipline becomes the dominant factor in a tight capital market, where government borrowing crowds out private investment, slows growth, and diminishes welfare. Moreover, excessive reliance on career incentives within the Mandarin system can backfire. While output may rise, over-investment driven by these incentives can reduce consumption, resulting in substantial welfare losses.

Our study has several limitations that future research should address. First, we treat career incentives and financial discipline as exogenous institutional factors, whereas some institutional changes may be endogenous responses to macroeconomic conditions. For example, loosening financial discipline could be a deliberate response to the global financial crisis. One may argue that weakening career incentives in an economy with lower growth potential is a rational decision for central authorities, given the cost-benefit tradeoff. Future research could explore politico-economic explanations for the shifts in career incentives and financial discipline, building on estimates from our institutional accounting. Second, although statutory tax rates are set by the central government, local authorities may still influence effective tax rates by adjusting their tax collection efforts. Lastly, we assume that infrastructure capital impacts land sales solely through income, without considering the housing market. Future research should delve deeper into how the Mandarin system influences growth and welfare, incorporating endogenous local tax rates and housing market dynamics.

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A Appendix of "The Mandarin Model of Growth" by Michael Song and Wei Xiong

A.1 Estimation of Infrastructure Investment and Capital

In this paper, we estimate infrastructure capital as the total capital stock in the infrastructure industries. Table A1 presents the infrastructure industries by industry code for the U.S., China and the European Union countries. The detailed estimation procedures for the U.S., EU countries, and China are provided in Appendix A.1.1, A.1.2, and A.2, respectively.[44]

Table A1: Infrastructure and Non-Infrastructure Industries

	US (2012 NAICS Code)	China (2017 NEIC Code)	EU (NACE Rev.2)
Infrastructure	Utilities (22)	Production and supply of electricity, gas and water (D)	Electricity, gas, steam and air conditioning supply (35)
			Water supply (36)
		Management of Water Conservancy, Environment and Public Facilities (N)	Sewerage, waste management and remediation activities (37-39)
	Air transportation (481)	Air transport (56)	Air transport (51)
	Water transportation (483)	Water transport (55)	Water transport (50)
	Railroad transportation (482)	Railway transport (53)	
	Truck transportation (484)	Road transport (54)	Land transport and transport via pipelines (49)
	Transit and ground passenger transportation (485)		
	Pipeline transportation (486)	Transport via pipelines (57)	
	Other transportation and support activities (487,488)	Loading, unloading and forwarding agency (58,59)	
Non-Infrastructure	The other industries		

A.1.1 The U.S. Data

All data used for the U.S. are from the Bureau of Economic Analysis (BEA). We calculate the real infrastructure and non-infrastructure capital according to

$$Z_t = \sum_{j \in J(Z)} RFA^P_{jt} + \sum_{h \in H(Z)} RFA^S_{ht}, \tag{A1}$$

where $Z \in \{G, K\}$. $J(Z)$ is the set of infrastructure industries ($Z = G$) or non-infrastructure industries ($Z = K$) listed in Table A1. We omit time subscript t when its absence does not

[44] Bai and Qian (2010) provide a detailed account of China's development of infrastructure in three sectors: electricity, highways, and railways. See also Zhang and Barnett (2014). Jiang, Miao and Zhang (2022) and Chen et al. (2023) include the two-digit industries "storage" and "post" and one-digit industry "information transmission, computer services, and software" in the infrastructure sector.

cause confusion. In equation (A1), RFA_j^P in the first component on the left-hand side represents privately-owned real fixed capital in industry j, which is directly available from the BEA. For non-infrastructure industries ($j \in J(K)$), we use the sum of the fixed-cost net capital stock of private nonresidential and residential capital stock for RFA_j^P. For infrastructure industries ($j \in J(G)$), we use the fixed-cost net capital stock of private nonresidential capital stock for RFA_j^P.

However, data on government capital by industry is not available. Instead, the BEA reports the nominal government capital stock by asset type (Current-Cost Net Stock of Government Fixed Assets). Table A2 classifies these asset types into eight asset groups, five for infrastructure and three for non-infrastructure, for the reason that will be clear below.

Table A2: Infrastructure and Non-Infrastructure Asset Groups

	Asset Group h	Asset Type for Government Capital	Asset Type for Nonresidential Private Capital
Infrastructure	1	Water systems	Water Supply
	2	Sewer systems	Sewage and waste disposal
	3	Conservation and development	Highway and conservation and development
	4	Power	Wind and solar
			Electric
			Petroleum pipelines
			Petroleum and natural gas
	5	Highways and streets	Air transportation
		Transportation	Other transportation
			Other railroad
			Track replacement
			Local transit structures
			Other land transportation
Non-infrastructure	6	Other Structures	Other Structures
	7	Equipment	Equipment
	8	Intellectual Property Products	Intellectual Property Products

Denote by NFA_h^S and RFA_h^S the total government nominal and real fixed capital of asset group h, respectively. $\sum_{h\in H(Z)} RFA_h^S$ in equation (A1) represents the total government infrastructure or non-infrastructure capital for $Z = G$ or K, respectively, where $H(Z)$ is the set of the infrastructure or non-infrastructure asset groups. We assume the price index for government capital to be identical to the price index for nonresidential private capital of the same type. However, the asset types for private capital (the third column of Table A2) are not identical to those for government capital. To achieve concordance, we classify all asset types into eight groups, as shown in the first column of Table A2. We then obtain the total nominal government capital stock by asset group, NFA_h^S, and the total nonresidential nominal and real private capital stock by asset group, NFA_h^P and RFA_h^P, respectively. Finally, we calculate the government real fixed capital of asset group h, RFA_h^S, using the following equation:

$$RFA_{ht}^{S} = \frac{RFA_{ht}^{P}}{NFA_{ht}^{P}} NFA_{ht}^{S}.$$

A.1.2 The EU Data

All data used for the EU countries are from the EuroStat database. EuroStat provides data on real fixed assets by both industry and asset type. However, EuroStat's classification of asset type is considerably less granular than that of the BEA (see Table A3). So, our estimation of infrastructure capital remains based on industry classification (NACE Rev.2).

Table A3: Asset Type Classification in EuroStat

Total Construction	Dwellings Other buildings and structures
Machinery and equipment and weapons systems	Transport equipment Computer hardware Telecommunications equipment Other machinery and equipment and weapons systems
Cultivated biological resources	
Intellectual property products	Research and development Computer software and databases

The data for real capital stock by industry begins in 2000. Our sample covers the period from 2003 to 2017, encompassing 23 countries (Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Romania, Slovakia, Slovenia, Spain, and Sweden). We aim to exclude capital from two-digit industries under the one-digit industry "Transportation and Storage" (H) from our infrastructure calculations: "Warehousing and support activities for transportation" (52) and "Postal and courier activities" (53). However, data for industries 52 and 53 are only available for 8 countries. To address this, we first compute the share of capital in industries 52 and 53 within industry H for these 8 countries, denoted by ϑ_t^{RFA}. We assume that this share is representative across all countries and use ϑ_t^{RFA} to adjust the capital stock in industry H for all countries.

Denote by RFA_{mjt} the real capital stock of fixed assets in industry j, country m, in year t. We calculate the real infrastructure and non-infrastructure capital for each country m as

$$Z_{mt} = \sum_{j \in J(Z)} RFA_{mjt},$$

where $J(Z)$ is the set of infrastructure or non-infrastructure industries defined in Table A1. Z_{mt} is the EU data used for Figure 1.

A.2 China's Sectoral Investment and Capital

Unlike the U.S. and EU countries, capital stock data is not directly available for China. The National Bureau of Statistics of China (NBS) provides two time-series for aggregate investment: nominal fixed capital formation (NFCF) and nominal fixed asset investment (NFAI). A key difference is that NFAI includes expenditures on land purchases and used capital, which are excluded from NFCF in national accounts (see, e.g., Bai and Qian (2010); Brandt and Zhu (2010); Chen et al. (2019)). However, the NBS provides industry-specific NFAI, which is crucial for constructing sector-specific investment. Moreover, NBS categorizes NFAI into three uses: "Construction and Installation", "Purchase of Equipment and Instruments", and "Others". For each of these categories, NBS provides a price index and depreciation rate. We will employ these use-specific price indices and depreciation rates to derive sector-specific real investment and depreciation rates. The following table summarizes the data directly available from NBS and their corresponding notations.

Table A4: National-Level Investment Data

Notation	Definition	Sample Period	Data Source
$NFCF_t$	Nominal Aggregate Fixed Capital Formation	1952-2022	NBS website
$NFAI_t$	Nominal Aggregate Fixed Asset Investment	1952-2022	CYS + NBS website + NBS (2009)
$NFAI_{et}$	Nominal Fixed Asset Investment of Use e	1952-2022	NBS website + NBS (2009)
$NFAI_{jt}$	Nominal Fixed Asset Investment in Industry j	1985-2022	CYS + SYFAI + NBS website
$NFAI_{ejt}$	Nominal Fixed Asset Investment of Use e in Industry j	2004-2022	CYS
$PFCF_t$	Aggregate Price Index for Fixed Capital Formation	1952-1995	NBS (1997)
$PFAI_t$	Aggregate Price Index for Fixed Asset Investment	1990-2019	NBS website
$PFAI_{et}$	Price Index for Fixed Asset Investment of Use e	1990-2019	NBS website

Note: CYS refers to China Statistical Yearbook. SYFAI refers to Statistical Yearbook of the Chinese Investment in Fixed Assets. NBS (1997) refers to Gross Domestic Product of China 1952-1995. NBS (2009) refers to China Compendium of Statistics 1949-2008.

The rest of this section is divided into three subsections. Section A.2.1 details the adjustments for the raw data on industry-specific nominal fixed asset investment $NFAI_{jt}$. Section A.2.2 explains how to construct real aggregate fixed capital formation $RFCF_t$ and categorize it into industry-specific fixed capital formation $RFCF_{jt}$ using the industry composition of $NFAI_{jt}$. Section A.2.3 outlines the estimation of sector-specific initial capital stock and depreciation rates, followed by the application of the perpetual inventory method to impute infrastructure and non-infrastructure capital.

A.2.1 Adjusting the Raw Data

China's official investment data was severely inflated since the mid-2000s (Chen et al. (2019)). Rampant data manipulation prompted the NBS to revise both $NFCF_t$ and $NFAI_t$. The revision adjusts downwards $NFCF_t$ and $NFAI_t$ by an average of 1.3% and 30.7%, respectively, for the period 2004-19.[45] In this paper, we use the latest revised $NFCF_t$ and $NFAI_t$.

However, the NBS has not yet revised the disaggregate investment data. Therefore, we adjust $NFAI_{et}$, $NFAI_{jt}$, and $NFAI_{ejt}$ by the same proportion as the NBS's revision to $NFAI_t$.

While we rely on $NFAI_{jt}$ to back out sectoral investment and capital, it is not entirely comparable over time for two reasons. First, $\sum_j NFAI_{jt}$ is not always equal to $NFAI_t$. In addition, prior to 2004, NBS only reported "Capital Construction" and "Innovation" in $NFAI_{jt}$ by industry, except for 1996-98 and 2002-03 when complete data on each subcomponent in $NFAI_{jt}$ was available.[46]

To address these inconsistencies, we make the following assumptions. (1) The industry-specific share of "Capital Construction" and "Innovation" in $NFAI_{jt}$ for the years prior to 1996 is identical to the share in 1996. (2) We linearly interpolate the industry-specific shares for 1999-2001. (3) For post-2004 $NFAI_{jt}$, which excludes fixed asset investments in rural areas or by rural households, we assume the share of rural investments in $NFAI_{jt}$ is identical to the share in $NFAI_t$. Table A5 summarizes our adjustments and data sources.

Table A5: Constructing Industry-Specific Nominal Fixed Asset Investment ($NFAI_{jt}$)

	Data Available	Adjustment	Data Source
1985-1995	$NFAI_{jt}$ in "Capital Construction" and "Innovation" only	Same share of "Capital Construction" and "Innovation" in $NFAI_{jt}$ as in 1996	CYS + SYFAI
1996-1998	Complete	-	SYFAI
1999-2001	$NFAI_{jt}$ in "Capital Construction" and "Innovation" only	Linear Interpolation	CYS
2002-2003	Complete	-	SYFAI
2004-2010	$NFAI_{jt}$ in Urban Areas	Same share of rural investments in $NFAI_{jt}$ as in $NFAI_t$	CYS
2011-2022	$NFAI_{jt}$ without Rural Households		

Note: See Table A4 for definitions of CYS and SYFAI.

The second reason is the changes in industry classification. The issue is less severe at the sector level, where the infrastructure industries $j \in J(G)$ correspond to two one-digit infrastructure industries: "Production and supply of electricity, gas and water" and "Management of Water Conservancy, Environment and Public Facilities", along with the group of "Transportation industries" that includes all two-digit transportation industries. To make $J(G)$ comparable over time, we make the following adjustments. (1) Remove the industries of storage, post and telecommunication

[45] We infer the revisions by comparing the official data in China's Statistical Yearbooks with the latest data available on the NBS website.

[46] $NFAI_t$ was also classified into "Capital Construction", "Innovation", "Real Estate Development", and "Others" by the "Channel of Management". The NBS discontinued this classification in 2004.

services from the one-digit industry "Transportation, Storage, Post and Telecommunication Services" for 1985-92. (2) Remove the industry of geological prospecting from the one-digit industry "Geological Prospecting and Water Conservancy" for 1985-92 and 2002. (3) Add the industries of environment and public facilities to the one-digit industry of "Management of Water Conservancy, Environment and Public Facilities" for 1985-2002. The adjustments are based on the assumption that the industry composition of $NFAI_{jt}$ prior to 2003, when classified according to the 2003 industry classification system, is identical to the composition in 2003.

We make two more minor adjustments. NBS has stopped releasing the level of fixed asset investment since 2018. We use the growth of the investment to infer the level. NBS has also stopped releasing all the investment price indices since 2019. We extend the time series by assuming investment price indices have same change rate as GDP deflator in the post-2019 period.

A.2.2 Sector-Specific Real Investment

We begin by converting nominal investments into real terms. $RFAI_{et} = NFAI_{et}/PFAI_{et}$ is straightforward. However, since $PFAI_{ejt}$ is not available, we assume $PFAI_{ejt} = PFAI_{et}$. It is important to note that $PFAI_{et}$ is only available after 1990 (see Table A4). We make two assumptions. (1) $PFAI_{et} = PFAI_t$ for years prior to 1990. (2) $PFAI_t = PFCF_t$, the price index for fixed capital formation implied by the nominal and real fixed capital formation in "The Gross Domestic Product of China 1952-1995" published by NBS. We then calculate $RFAI_{ejt} = NFAI_{ejt}/PFAI_{et}$, $RFAI_{jt} = \sum_e RFAI_{ejt}$ and $RFAI_t = \sum_e RFAI_{et}$.[47]

The NBS does not produce a price index for fixed capital formation. Following Bai, Hsieh and Qian (2006), we utilize $PFAI_{et}$ to derive $RFCF_t$. Specifically, we categorize $NFCF_t$ into $NFCF_{et}$ based on the proportion of $NFAI_{et}$ in $NFAI_t$:

$$NFCF_{et} = \frac{NFAI_{et}}{NFAI_t} NFCF_t. \tag{A2}$$

We then deflate $NFCF_{et}$ by $PFAI_{et}$ to obtain $RFCF_{et}$, which leads to $RFCF_t$:

$$RFCF_t = \sum_e RFCF_{et} = \sum_e \frac{NFCF_{et}}{PFAI_{et}}. \tag{A3}$$

Next, we use real fixed asset investment $RFAI_{jt}$ to construct real fixed capital formation $RFCF_{jt}$ for each infrastructure industry $j \in J(G)$:

$$RFCF_{jt} = \frac{RFAI_{jt}}{RFAI_t} RFCF_t. \tag{A4}$$

The assumption is that the industrial composition in $RFCF_t$ is identical to that in $RFAI_t$. This allows us to infer the sector-specific investments:

$$I_{Gt} = \sum_{j \in J(G)} RFCF_{jt},$$

$$I_{Kt} = RFCF_t - I_{Gt}.$$

[47] $NFAI_{ejt}$ is only available after 2004 (Table A4). For years prior to 2004, we assume the share of $NFAI_{ejt}$ in $NFAI_{jt}$ is equal to the share in 2004.

A.2.3 Sector-Specific Capital Stock

We impute infrastructure and non-infrastructure capital using the perpetual inventory method:

$$Z_{t+1} = I_{Zt} + (1 - \delta_Z) Z_t,$$

where $Z \in \{G, K\}$. To implement this method, we need to know δ_G, δ_K, and the initial capital stocks G_{t_0} and K_{t_0}.

Calibrating Capital Depreciation Rate Denoted by δ_e the depreciation rate for capital of use e. NBS set δ_e to 0.08, 0.24 and 0.15 for "Construction and Installation", "Purchase of Equipment and Instruments", and "Others", respectively (Bai, Hsieh and Qian, 2006). We calibrate δ_Z as the weighted average of δ_e: $\delta_Z = \sum_e \omega_{Ze} \delta_e$, where ω_{Ze} is the proportion of real investment of use e in the sector-specific real investment. To obtain ω_{Ze}, we first categorize $RFCF_{jt}$ into $RFCF_{ejt}$ for infrastructure industry $j \in J(G)$ as in equation (A4):

$$RFCF_{ejt} = \frac{RFAI_{ejt}}{\sum_e RFAI_{ejt}} RFCF_{jt}. \tag{A5}$$

We then calculate

$$I_{Get} = \sum_{j \in J(G)} RFCF_{ejt},$$

$$I_{Ket} = RFCF_{et} - I_{Get}.$$

Next, we compute $\omega_{Zet} = \frac{I_{Zet}}{I_{Zt}}$. As ω_{Zet} remains stable over time, we set ω_{Ze} to the average of ω_{Zet} between 1993 and 2022. This gives the calibrated value of δ_Z in Table 2.

Determining Initial Capital Stock We first construct a long time series for the aggregate capital stock, starting from 1952, based on $RFCF_{et}$ obtained from equation (A3). We then use the earliest data on $RFCF_j$ from equation (A4) to decompose the aggregate capital stock in 1985 into sector-specific capital stock, giving us the initial Z_{1985}.

Specifically, the aggregate capital stock, denoted by RFA_t, is imputed by $\sum_e RFA_{et}$, where

$$RFA_{et+1} = RFCF_{et} + (1 - \delta_e) RFA_{et},$$

and

$$RFA_{e1952} = \frac{RFCF_{e1952}}{\log(RFCF_{e1955}/RFCF_{e1952})/3 + \delta_e}.$$

We then obtain Z_{1985} by decomposing RFA_{e1985}:

$$G_{1985} = \frac{Ratio^G_{1985}}{1 + Ratio^G_{1985}} RFA_{1985}, \tag{A6}$$

$$K_{1985} = RFA_{1985} - G_{1985}, \tag{A7}$$

where $Ratio^G_{1985}$ is the ratio of G_{1985} to K_{1985}, approximated by

$$Ratio^G_{1985} = \frac{I_{G1985}(\log(I_{K1988}/I_{K1985})/3 + \delta_K)}{I_{K1985}(\log(I_{G1988}/I_{G1985})/3 + \delta_G)}.$$

A.2.4 Robustness Check: Removing Non-Regional Projects

To conduct the robustness checks for the sensitivity of our main findings to the inclusion of "non-regional projects" in local infrastructure investments (see Appendix A.8), this section outlines the procedures of adjusting sectoral capital stocks by assuming non-regional projects are entirely financed by the central government.

Denote by $\psi_t \equiv \frac{NFAI_t^{\text{non-regional}}}{NFAI_t}$ the share of non-regional FAI and by $\psi_{j\in J(G)t} \equiv \frac{NFAI_{j\in J(G)t}^{\text{non-regional}}}{NFAI_{j\in J(G)t}}$ the share for infrastructure industry j. We need to replace $RFCF_t$ and $RFCF_{j\in J(G)t}$ with $RFCF_t^{\text{regional}} = (1-\psi_t)\,RFCF_t$ and $RFCF_{j\in J(G)t}^{\text{regional}} = \left(1-\psi_{j\in J(G)t}\right)RFCF_{j\in J(G)t}$. Table A6 details the data availability for aggregate-level $NFAI_t^{\text{non-regional}}$ and methodologies to address missing data. The industry-specific $NFAI_{j\in J(G)t}^{\text{non-regional}}$ are adjusted in a similar way.

Table A6: Constructing the Share of Non-Regional Investment Projects (ψ_t)

	Data Availability for $NFAI_t^{\text{non-regional}}$	Adjustment	Data Source
1952	N.A.	Same as in 1953	
1953-1979	Only for "Capital Construction"	Same as the share for "Capital Construction"	SYFAI
1980-1981	Only for "Capital Construction" and "Innovation"	Same as the share for "Capital Construction" and "Innovation"	SYFAI
1982-1992	Complete	-	SIFAC
1993-2003	Complete	-	CYS
2004-2010	$NFAI_t^{\text{non-regional}}$ in Urban Areas	Same as the share for $NFAI_t$ in urban areas	CYS
2011-2017	$NFAI_t^{\text{non-regional}}$ without Rural Household	The same as the share for $NFAI_t$ without rural households	CYS
2018-2022	$NFAI_t^{\text{non-regional}}$ is not available	Same as in 2017	-

Note: SIFAC refers to "Statistical on Investment in Fixed Assets of China (1950-2000)". See Table A4 for definitions of CYS and SYFAI.

A.2.5 Provincial-Level Sectoral Investment and Capital

Table A7 summarizes the provincial-level official statistics, excluding Tibet. The NBS provides provincial nominal fixed capital formation and fixed asset investment, $NFCF_{it}$ and $NFAI_{it}$, where i is the province index. Data for the post-1993 period are obtained from the NBS website, while data for 1952-1992 are obtained from "China Compendium of Statistics 1949-2008" compiled by NBS (2009).[48]The NBS provides the price index for provincial fixed asset investment, $PFAI_{it}$,

[48]We rely on Hsueh and Li (1999) for the following missing $NFCF_{it}$: Hubei and Ningxia 1952-77, Guangdong 1978-92, and Zhejiang 1952-92. We break out Sichuan and Chongqing using the sum from Hsueh and Li (1999) and the Sichuan data from NBS (2009). For Jiangxi and Hainan 1952-77, we estimate $NFCF_{it}$ by assuming that the share of $NFCF_{it}$ in the province's expenditure GDP is equal to that of Hubei and

but does not publish the price index for provincial fixed capital formation. The NBS also reports provincial fixed asset investment by use, $NFAI_{eit}$, and by industry, $NFAI_{jit}$.

Table A7: Provincial-Level Investment Data

Notation	Definition	Sample Period	Source
$NFCF_{it}$	Nominal Provincial Fixed Capital Formation	1952-2022	NBS website + NBS (2009)
$NFAI_{it}$	Nominal Provincial Fixed Asset Investment	1952-2022	NBS website + CYS + NBS (2009)
$NFAI_{eit}$*	Nominal Provincial Fixed Asset Investment of Use e	1996-1998, 2002-2022	NBS website + SYFAI
$NFAI_{jit}$	Nominal Provincial Fixed Asset Investment in Industry j	1993-2022	CSY + SYFAI
$PFAI_{it}$	Provincial Price Index for Fixed Asset Investment	1993-2022	NBS website
$PFAI_{eit}$	Provincial Price Index for Fixed Asset Investment of Use e	1993-2022	NBS website

*$NFAI_{eit}$ is directly accessible for 1996-1998 and 2002-2019 in SYFAI. To extend the data until 2022, we utilize growth rates sourced from the NBS website. The missing values are obtained under the assumption that the change in the proportion of investment by use for each province, $\frac{NFAI_{eit}}{NFAI_{it}}$, aligns with the national-level change. The proportions are normalized so that their sum equals 1 for each province.

Adjusting the Raw Data The NBS has adjusted the aggregate investments $NFCF_t$ and $NFAI_t$ downwards but has not yet revised the regional statistics. Moreover, applying the NBS's aggregate-level adjustment uniformly across provinces would be inappropriate, as the extent of data manipulation varies significantly among provinces (Chen et al. (2019)). Therefore, we adjust $NFCF_{it}$ for the period 2004-17 following the methodology of Chen et al. (2019).

An additional challenge is the potential discrepancy between the sum of provincial statistics and the national aggregate. To address this, we scale each province's fixed capital formation by the same proportion to ensure $\sum_i NFCF_{it} = NFCF_t$. Similar adjustments are made to align provincial and national data for output $\sum_i Y_{it} = Y_t$ and for tax revenue $\sum_i \tau_{it} Y_{it} = \tau_t Y_t$.

In line with the adjustments outlined in Section A.2.1, we make the following modifications to the provincial data. For 2003, remove the industries of storage and post. For 1993-02, (1) remove the industries of storage, post, and telecommunication services; remove the industry of geological prospecting; add the industries of environment and public facilities.

$NFAI_{it}$ for Sichuan prior to 1997 includes investments in both Sichuan and Chongqing. To separate Chongqing's $NFAI_{it}$, we assume that its share in Sichuan's $NFAI_{it}$ before 1997 is equal to its share in 1997.

Real Sectoral Investment and Capital Given the potential manipulation of $NFAI_{it}$, the reliability of provincial price index $PFAI_{iet}$ is also questionable. We opt to set $PFAI_{iet} = PFAI_{et}$ instead of using $PFAI_{iet}$ in the data. This gives

$$RFCF_{it} = \sum_e RFCF_{iet} = \sum_e \frac{NFCF_{iet}}{PFAI_{et}},$$

where

Guangdong, respectively.

$$NFCF_{iet} = \frac{NFAI_{iet}}{NFAI_{it}} NFCF_{it}.$$

The next step is to disaggregate $RFCF_{it}$ into $RFCF_{jit}$. Following the same strategy in equation (A4), we assume

$$RFCF_{jit} = \frac{RFAI_{jit}}{RFAI_{it}} RFCF_{it}, \tag{A8}$$

where

$$RFAI_{it} = \sum_e \frac{NFAI_{eit}}{PFAI_{et}}.$$

The key assumption is to trust the industrial composition of provincial fixed asset investment. To obtain $RFAI_{jit}$ in equation (A8), we employ the following procedures. We first break $NFAI_{jit}$ into $NFAI_{ejit}$ by assuming the industry-specific composition of use e in $NFAI_{jit}$ is identical across provinces. We then set $PFAI_{ejit} = PFAI_{et}$ to obtain

$$RFAI_{jit} = \sum_e RFAI_{ejit} = \sum_e \frac{NFAI_{ejit}}{PFAI_{et}}.$$

It follows immediately

$$I_{Git} = \sum_{j \in J(G)} RFCF_{jit},$$

$$I_{Kit} = RFCF_{it} - I_{Git},$$

$$Z_{it+1} = I_{Zit} + (1 - \delta_Z) Z_{it}.$$

The procedure for determining the initial capital stocks for 1993 follows the same methodology as outlined in Section A.2.

A.3 The Share of Infrastructure: International Comparison

The literature offers three approaches to define infrastructure: by industry, government ownership, or asset type. Regardless of the methodology employed, all these approaches consistently demonstrate that China's share of infrastructure investment or capital is substantially higher than the world average.

The first approach combines government investment with private infrastructure investment. Using disaggregated cross-country budget data, Fay et al. (2019) estimate China's infrastructure investment at 16% of GDP in 2011, significantly higher than the 5.2% world average. However, this approach may incorrectly include non-infrastructure government spending or exclude infrastructure investment by state-owned enterprises. Our data suggests a lower figure of 9.3% for China in 2011.

The second approach aggregates investment in Energy, Transport infrastructure, Water and Sanitation and Telecoms, the four broadly defined infrastructure industries in Mirabile, Marchal and Baron (2017). Using our own data for China, these industries account for an average of 26.2%

of total investment in China between 2004 and 2017, again, significantly exceeds the world average. [49]

Infrastructure investments can also be classified by asset type (Bennett et al. (2020)). A McKinsey's report (Dobbs, Leung and Lund (2013)) defines infrastructure by roads, rail, ports, airports, power, water, and telecom and obtains the data from various sources such as International Transport Forum (ITF) for transport, Global Water Intelligence (GWI) for water, and HIS Global Insight (IHS) for energy and telecom. According to Inderst (2016), which is based on the McKinsey's report, China's infrastructure investment was 8.5% of its GDP in 1992-2011, more than double the world average of 3.8%.

A.4 China's Local Government Debt

Our definition of local government debt encompasses both explicit and implicit debt. Data for explicit local government debt is sourced from official channels, including the National Auditing Office (NAO), the National People's Congress (NPC), and the Mininstry of Finance. Following NAO (2013), explicit debt refers to "the debt that government has the responsibility to repay". Implicit local government debt includes "the debt to which the government would fulfill the responsibility of guarantee" and "the debt to which the government would bailout when the debtor encounters difficulty in repayment" (NAO, 2013). The majority of the implicit debt is in local government financing vehicles (LGFVs). We collect balance sheet data from the WIND database for a total of 2833 LGFVs that have issued bonds since 2003.[50] A caveat is that WIND may miss some LGFVs that are no longer active, potentially leading to an underestimation of LGFV debt in earlier years. Importantly, not all LGFV debt is implicit. We will identify the proportion of LGFV debt that belongs to explicit debt to avoid double-counting. The following equation shows our construction of D_t, the outstanding local government debt at the end of year t:

$$D_t = \underbrace{D_t^{EX}}_{\text{explicit debt}} + \underbrace{LGFV_t - LGFV_t^{EX}}_{\text{implicit debt}}, \tag{A9}$$

where D_t^{EX} denotes the explicit debt, $LGFV_t$ is the total outstanding interest-bearing debt of LGFVs, and $LGFV_t^{EX}$ is the explicit debt component in $LGFV_t$.[51]

Explicit Debt Table A8 summarizes our data sources and methodologies for addressing missing data. D_t^{EX} is directly available for 2010, 2012, June 2013, 2014, and subsequent years. We derive

[49]Using data from World Development Indicator (https://databank.worldbank.org/source/world-development-indicators), we find the infrastructure investment share to be 5.2% for Algeria in 2005, 4.6% for Brazil in 2011, 5.0% for Colombia in 2006, 4.7% for Indonesia in 2017, and 20.6% for Peru in 2015. Only these five countries have complete data for the corresponding years.

[50]Following Bai, Hsieh and Song (2016), we exclude LGFVs that are part of the same holding group and share the consolidated balance sheet.

[51]We define interest-bearing debt as the sum of short- and long-term debt (Huang, Pagano and Panizza (2020)). Short-term debt comprises short-term borrowing, notes payable, non-current liabilities due within one year, other current liabilities, and short-term bonds payable. Long-term debt equals long-term borrowing plus bonds payable.

the missing values for 2011 and 2013 through linear interpolation. NAO (2011) reports annual growth rates of D_t for 1997, 1998, and 2008-10, as well as average growth rates of D_t in 1998-02 and 2002-07. Using these growth rates and assuming that annual growth of D_t within the 1999-02 and 2003-07 periods is identical to the annualized growth rate of D_t in 1998-02 and 2002-07, respectively, we reconstruct D_t^{EX} for 1996-09. For the earliest years in our sample period, we set $D_t^{EX} = 0$ in 1992 and use linear interpolation to estimate D_t^{EX} for 1993-95.

Table A8: Constructing Local Government Debt

Period	Explicit Debt	Period	Implicit Debt
1992	Set to Zero	1992-07	Set to Zero
1993-95	Linear interpolation		
1996-2009	Inferred from NAO (2011) + Linear interpolation		
2010	NAO report (2011)	2008-22	Outstanding interest-bearing LGFV debt from WIND - Explicit LGFV debt***
2011	Linear interpolation		
2012	NAO (2013)		
2013	Linear interpolation		
2014	NPC report in 2016*		
2015-2022	Ministry of Finance**		

* http://www.npc.gov.cn/zgrdw/npc/zgrdzz/2016-03/29/content_1986294.htm.
** Ministry of Finance data available from "China Electronic Local Government Bond Market Access" at http://www.celma.org.cn.
*** See the text for estimation of explicit LGFV debt.

Implicit Debt $LGFV_t$ is directly available from 2003 onwards. NAO (2011, 2013) and the NPC report in 2016 provide $LGFV_t^{EX}$ for the end of 2010 and 2014, and June 2013. We linearly interpolate $LGFV_t^{EX}$ for 2011-13. Since implicit local government debt was strictly regulated before 2008, we assume zero implicit debt, meaning the share of $LGFV_t^{EX}$ in $LGFV_t$ is 100% before 2008. We linearly interpolate this share for 2008 and 2009.

The share of $LGFV_t^{EX}$ further decreases after 2015 due to new State Council's regulations that prohibit local government from raising debt through LGFVs.[52] This is evidenced by decomposing D_t^{EX} into

$$D_t^{EX} = LGB_t + LGFV_t^{EX} + \text{others},$$

where LGB_t stands for outstanding local government bonds at the end of year t. The share of LGB_t in D_t^{EX} increases from 32.7% in 2015 to 99.3% in 2020, according to Ministry of Finance data available at the China Local Government Bond Information Disclosure Platform (www.celma.org.cn). This implies $LGFV_t^{EX} = 0$ in 2020. We linearly interpolate $LGFV_t^{EX}$ for 2015-19 and assume $LGFV_t^{EX} = 0$ continues to hold after 2020. Finally, we use equation (A9) to impute D_t.

A.4.1 Provincial-Level Local Government Debt

Explicit Debt Similar to A8, Table A9 summarizes our data sources and methodologies for addressing missing data. D_t^{EX} is directly available for 2012, 2015, and subsequent years. For

[52] link for the official document.

2007-11, missing values are estimated by assuming that D_{it}^{EX} grows at the same rate of $LGFV_{it}$, adjusted by a constant common to all provinces to ensure $\sum_i D_{it}^{EX} = D_t^{EX}$. Provincial-level data before 2007 is scarce. We construct D_{it}^{EX} for these years by assuming it grows at the same rate of D_t^{EX}.

Implicit Debt

$LGFV_{it}$ is directly available from WIND for 2003-22. For years prior to 2003, we construct $LGFV_{it}$ assuming it grows at the same rate as $LGFV_t$. Data on $LGFV_{it}^{EX}$ is limited. Provincial Auditing Reports on Government Debt in 2013 provide the explicit local government debt for each province in June 2013, from which we infer $LGFV_{it}^{EX}$ for that month. We then estimate $LGFV_{it}^{EX}$ at the end of 2012 by assuming that $\frac{LGFV_{it}^{EX}}{D_{it}^{EX}}$ is identical to the June ratio, adjusted by a constant common to all provinces to ensure $\sum_i \left(LGFV_{it} - LGFV_{it}^{EX}\right) = LGFV_t - LGFV_t^{EX}$.[53] We next construct $LGFV_{it}^{EX}$ for 2008-22 by assuming that the implicit local government debt, $LGFV_{it} - LGFV_{it}^{EX}$, grows at the same rate as $LGFV_{it}$, adjusted, again, by a common factor in each period to ensure $\sum_i \left(LGFV_{it} - LGFV_{it}^{EX}\right) = LGFV_t - LGFV_t^{EX}$.

Table A9: Constructing Provincial-Level Local Government Debt

Period	Explicit Debt D_{it}^{EX}	Period	Implicit Debt
1992	Set to zero	1992-07	Set to zero
1993-06	Growing at the same rate of D_t^{EX}		
2007-11	Growing at the same rate of $LGFV_{it}$ + Adjustment	2008-22	Outstanding interest-bearing LGFV debt from WIND - Explicit LGFV debt**
2012	Provincial Auditing Reports on Government Debt		
2013-14	Same for 2007-11		
2015-22	Ministry of Finance*		

* Ministry of Finance data available from "China Electronic Local Government Bond Market Access" at http://www.celma.org.cn.
*** See the text for estimation of explicit LGFV debt.

A.5 The Other Chinese Data

A.5.1 Composition of China's Local Government Revenue

We set τ_t^{YG}, τ_t^{YC} and ϕ_t equal to the ratio of local general budget revenue, net transfers from central government and land sale revenue to GDP in each period, respectively. For local budget revenue, we use budgetary and extra-budgetary revenue from the NBS website. The latter was phased out by 2010. Net transfers are calculated by subtracting "Transfers to Central Government" from "Transfers to Local Government" as reported in Finance Yearbook of China (for 1993-2021) and National Government Final Account (for 2022). Land revenue data is from China Land & Resources Almanac (for 1998-2004), China Land and Resources Statistical Yearbook (for 2005-17), and Statistical Bulletin of China's Natural Resources 2022 by Ministry of Natural Resources

[53] Data for Guizhou and Tianjin's D_{it}^{EX} in 2012 are missing. We assume that their explicit debt as a share of China's total explicit debt at the end of 2012 is identical to their respective share in June 2013. The estimated $LGFV_{it}^{EX}$ for Hainan and Guizhou exceeds $LGFV_{it}$, suggesting $LGFV_{it}$ might be underestimated. For these two provinces, we set $LGFV_{it}$ equal to the estimated $LGFV_{it}^{EX}$.

(for 2018-22). Land revenue prior to 1998 is unavailable and assumed to be zero. It's important to note that before selling pre-occupied land, local governments must relocate existing occupants, incurring significant expenses for compensation and land preparation. Net proceeds from land sales after deducting these costs can be substantially less than the gross revenue. However, since these expenses contribute to government investment outlays, we incorporate the entire revenue from land sales into the government's fiscal budget.

Table A10: Local Government Revenue (in Percent of GDP)

	1993-97	1998-02	2003-07	2008-12	2013-17	2018-22
τ^{YG}	9.3	10.0	10.7	11.1	11.6	9.9
τ^{YC}	2.6	4.4	6.0	8.0	8.0	7.7
ϕ	0.0	1.0	3.9	5.4	5.6	6.5

Provincial budget revenue data is from the Finance Yearbook of China (for 1993-21) and the NBS website (for 2022). Provincial net transfer data is available from the Finance Yearbook of China (for 1995-21). We set τ_{it}^{Tr} for 1993-97 and 2018-22 equal to the average provincial net transfer GDP ratio in 1995-97 and 2018-21, respectively. Provincial land revenue data comes from the same source as country-level data (for 1998-17) and the China Natural Resources Statistical Yearbook (for 2019-21). We set ϕ_{it} for 2018-22 equal to the average land sale revenue to GDP ratio in 2019-21.

A.5.2 Central Government Debt

Denote by D_t^{CG} the outstanding central government debt at the end of year t. While data for D_t^{CG} is not available before 2005, the NBS publishes two relevant metrics in the China Statistical Yearbook: "Central Government Debt Issuance", denoted by ΔD_t^{CG}, and "Central Government Payment for the Principal and Interest of Debt", denoted by RD_t^{CG}. These metrics allow us to back out D_t^{CG} in 1992-04 by

$$D_t^{CG} = D_{t+1}^{CG} - \Delta D_{t+1}^{CG} + RD_{t+1}^{CG}.$$

A.5.3 National-level Employment Data

Table A11: Employment Data

Notation	Definition	Sample Period	Source
L_t	Employed Population	1952-2023	NBS website
N_t^{age}	Total Population by Age	2022-2100	World Population Prospects 2022

The data on employed population is sourced from the NBS. For post-2023 projections, we assume the employed population grows at the same rate as the working-age population.[54] Total population by age is projected using the United Nations' World Population Prospects 2022. Specifically, in line with existing literature (Attanasio, Kitao and Violante (2007); Papetti (2021)).

A.5.4 Provincial-Level Employment Data

Provincial-level employed population data are available in China Statistical Yearbook for 1993-05, 2007-10, and 2020-22. However, as Brandt, Tombe and Zhu (2013) points out, official province-level data often include migrants in their province of residence (or Hukou) rather than in their workplace province. To address this issue, we use provincial-level employment data from census or one-percent population surveys, adjusted by provincial-level population, to disaggregate national-level employment into provincial-level figures. For years prior to 2020 without census or population surveys, we obtain data through linear interpolation. Post-2020 data are derived by assuming that employment in each province grows at the same rate as the provincial population reported by the NBS.

A.6 Output Overreporting

Powerful incentives may also lead to short-termist behaviors in local officials, contributing to some of China's key economic challenges. In this subsection, we examine output overreporting by local officials before addressing over-leveraging by local governments in the subsequent section.

China features a complex hierarchical structure for reporting economic data. The National Bureau of Statistics (NBS) is responsible for compiling national statistics, while local statistics bureaus, which operate under the significant influence of local governments, manage regional data. Studies by Chen et al. (2019) and Hortacsu, Liang and Zhou (2017) have noted that the aggregate of provincial GDP figures consistently exceeds the national GDP by approximately five percent. This significant discrepancy indicates that local statistics bureaus collectively tend to overreport provincial GDP figures. Additionally, Chen et al. (2019) conducted a forensic analysis further validating the overreporting of provincial GDP and capital investment figures, highlighting systemic issues in China's statistical reporting practices.

To analyze overreporting, we adjust the model for this subsection by assuming that the central government cannot directly observe regional output in the current period and instead depends on each governor's report. To curb overreporting, the central government collects a portion of the reported output as tax revenue, consistent with the tax-sharing arrangement between the central and local governments in China. Consequently, overreporting local output results in larger tax transfers to the central government.

Specifically, we assume that a governor can report Y'_{it} as his region's output, which might differ from the actual output Y_{it}. If the governor overreports the log output y'_{it} by an amount ϕ_{it}, where $y'_{it} = y_{it} + \phi_{it}$ and the actual log output y_{it} is given by equation (11), then the reported log output

[54] We define the working age as 22 to 57 years old, which represents a weighted average of male and female retirement ages (Song et al. (2015)).

is $y'_{it} = a_{it} + \varepsilon_{it} + \frac{\gamma+\alpha_G}{1-\alpha_K} log(G_{it}) + \phi_{it}$. While the local government collects a tax of τY_{it} based on the actual output, it must transfer a fraction of the tax revenue to the central government at a rate of $\tau_c < \tau$ based on the reported output level Y'_{it}. Thus, the residual tax revenue for the local government is

$$T_{it} = \tau Y_{it} - \tau_c Y'_{it} = \tau Y_{it}(1 - (\tau_c/\tau)e^{\phi_{it}}).$$

In assessing the reported output, the central government anticipates that the local governor will invest G^*_{it} in infrastructure and overreport by ϕ^*_{it}. It then constructs a sufficient statistic:

$$z'_{it} \equiv y'_{it} - \frac{\gamma+\alpha_G}{1-\alpha_K} log(G^*_{it}) - \phi^*_{it} = a_{it} + \varepsilon_{it} + \frac{\gamma+\alpha_G}{1-\alpha_K}[log(G_{it}) - log(G^*_{it})] + (\phi_{it} - \phi^*_{it}).$$

From the central government's perspective, $log(G_{it}) = log(G^*_{it})$ and $\phi_{it} = \phi^*_{it}$, meaning that it filters out the impacts of infrastructure investment and overreporting in equilibrium. However, from the governor's perspective, both G_{it} and ϕ_{it} are under his control and directly affect his performance evaluation.

By expanding the governor's optimization in equation (17) and omitting regional subscript i, we have

$$V^G\left(W^G_t | G_t, Y_t\right) = \max_{C^G_t, G_{t+1}, \phi_t} \log C^G_t + \kappa \log G_{t+1} + \kappa_\phi \phi_t + \beta_G V^G\left(W^G_{t+1} | G_{t+1}, Y_{t+1}\right), \tag{A10}$$

where $\kappa_\phi > 0$ represents the incentive to overreport. The output inflation ϕ_t reduces the current period budget: $W^G_t = Y_t(\tau - \tau_c e^{\phi_t})$, which is allocated by the governor: $C^G_t + G_{t+1} = W^G_t$.

Proposition 4 ***(Output Overreporting)***

The governor overreports its output by $\phi_t = log\left(\tau/\tau_c\right) - log\left(1 + 1/\kappa_\phi\right)$.

This mechanism, whereby regional governors overreport output, is conceptually similar to earnings manipulation by publicly listed firms, as discussed in Stein (1989).

Proposition 4 highlights that the lack of reliable economic statistics in China might not merely be random noise but could represent a systematic issue rooted in the Mandarin system. Furthermore, Proposition 4 provides comparative statics indicating that such overreporting increases with the career incentives (κ_ϕ) and decreases with the associated fiscal cost (τ_c).

A.7 Constructing Five-Year Variables

This appendix details the conversion of annual variables to five-year variables. For time-invariant annual parameters $X \in \left\{\beta, \beta_G, 1 - \delta_{Z\in\{G,K\}}\right\}$, the conversion is straightforward: the five-year counterpart is X^5. Time-variant variables require a more involved process. For expositional ease, we denote X_{yt} as the annual variable X in year yt, and X_t as the corresponding five-year variable at period t in the model.

For capital stocks and local government debt, we set them to their corresponding annual variable at the beginning of the first year at period t. For interest rates $X_{yt} \in \left\{1 + r^w_{yt}, 1 + r_{yt}\right\}$, $X_t = \Pi_{yt} X_{yt}$.

The technology q_t^Z is set equal to the five-year relative price $\frac{P_t^{I_Z}}{P_t^Y}$, where $P_t^{I_Z}$ is the five-year price index for investment in sector $Z \in \{G, K\}$, and P_t^Y is the five-year price index for output. These price indices are obtained from $\frac{NX_t}{X_t}$, where NX_t and X_t are the five-year nominal and real variables, $X_t \in \{I_{Gt}, I_{Kt}, Y_t\}$. Five-year nominal variables are obtained by simple summation: $NX_t = \sum_{yt} NX_{yt}$. Five-year real sector-specific investment is inferred from $I_{Zt} = Z_{t+1} - (1 - \delta_Z) Z_t$, $Z \in \{G, K\}$, ensuring consistency with five-year real capital stocks and depreciation rates. Five-year real output simply follows $Y_t = \sum_{yt} Y_{yt}$.

Finally, real local government debt is given by $D_t = \frac{ND_t}{P_{t-1}^Y}$, where ND_t denotes nominal local government debt. This allows us to express the local government budget constraint in real terms as in equation (29).

A.8 Robustness Check

A.8.1 Institutional Accounting

We conduct the following robustness exercises, all of which confirm our main findings from Section 4 on institutional accounting.

1. Winsorize κ_{it} at 2.5% and 5% levels, then rerun the regressions in Table 6 and 7. The results are presented in Table A12 and A13.

2. Redo national- and provincial-level institutional accounting with different values of γ and r_t. We try $\gamma = 0$ and 0.05. The externality parameter γ affects MRG_{it} and is relevant for institutional accounting. For post-2008 interest rates, $r_t = r_t^P$ for $t \in [4, 7]$. The main institutional accounting results and external validity checks in Table 4 and 6 are replicated in Table A14 and A15. Moreover, we re-estimate provincial-level TFP using these alternative values of γ. The regressions in 7 are replicated in Table A16.

3. Redo national- and provincial-level institutional accounting with the production technology generalized to a Constant Elasticity of Substitution (CES) form:

$$Y_{it} = A_{it} \left[\frac{\gamma + \alpha_G}{\gamma + \alpha_G + \alpha_K} G_{it}^{\frac{\sigma-1}{\sigma}} + \left(1 - \frac{\gamma + \alpha_G}{\gamma + \alpha_G + \alpha_K} \right) K_{it}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}(\gamma + \alpha_G + \alpha_K)} L_{it}^{1-\alpha_G-\alpha_K}, \tag{A11}$$

   where σ is the elasticity of substitution between G_{it} and K_{it}. We try $\sigma = 0.5$ and $\sigma = 1.5$. Equation (47) and, therefore, the calibrated values of ω_t remain unchanged. The only difference in equation (48) is the derivative of Y_{it} with respect to G_{it}, which will follow equation (A11). The institutional accounting results are replicated in Table A17 and A18. We re-estimate provincial-level TFP using the CES production technology under alternative values of σ. The regressions in 7 are replicated in Table A19.

4. Redo national-level institutional accounting using infrastructure capital constructed from investments without non-regional projects (see Appendix A.2.4). The main results in Table 4 are replicated in Table A14.

5. Assume that changes to κ_t and ω_t are unanticipated and perceived as permanent. Infer these changes by matching G_{t+1} and D_{t+1} implied by the full-fledged model to the data. The results, presented in Table A21, are very close to those in Table 4 under perfect foresight.

All the results are robust except that the estimated coefficient of κ_{it} in the regression of TFP growth with both province and period fixed effects becomes marginally insignificant when G_{it} and K_{it} become sufficiently complementary (see the second column of Table A19).

Winsorization

Table A12: Age and Career Concerns: Winsorization

Dep. Variable	2.5% Winsorization κ_{it}		5% Winsorization κ_{it}	
Ave. Age of Province Leaders	-0.0469	-0.0520	-0.0215	-0.0107
	(0.0289)	(0.0315)	(0.0140)	(0.0149)
Ave. Age of City Leaders	-0.0627	-0.1229**	-0.0342*	-0.0661**
	(0.0389)	(0.0576)	(0.0189)	(0.0272)
Period Fixed Effects	Yes	Yes	Yes	Yes
Province Fixed Effects				Yes
Observations	150	150	150	150
Adj. R^2	0.3109	0.4484	0.4984	0.6182

Table A13: Career Concerns and TFP Growth

Dep. Variable	g^A_{it+1}			
κ_{it} under 2.5% Winsorization	0.0033*	0.0042*		
	(0.0018)	(0.0021)		
κ_{it} under 5% Winsorization			0.0077**	0.0082*
			(0.0038)	(0.0045)
Period Fixed Effects	Yes	Yes	Yes	Yes
Province Fixed Effects		Yes		Yes
Observations	150	150	150	150
Adj. R^2	0.3887	0.4628	0.3923	0.4602

Alternative γ and r_t

Table A14: Institutional Accounting under Different γ and r_t

t	1 (1993-97)	2 (1998-02)	3 (2003-07)	4 (2008-12)	5 (2013-17)
			Panel A: $\gamma = 0$		
κ_t	1.13	1.33	0.89	0.52	0.46
ω_t	-	-	-	1.22	0.90
			Panel B: $\gamma = 0.5$		
κ_t	1.09	1.30	0.86	0.48	0.41
ω_t	-	-	-	1.22	0.90
			Panel C: $r_t = r_t^P$ for $t \in [4, 7]$		
κ_t	1.11	1.31	0.88	0.50	0.43
ω_t	-	-	-	1.35	0.97

Table A15: Age and Career Concerns under Different γ and r_t

Dep. Variable	κ_{it} under $\gamma = 0$		κ_{it} under $\gamma = 0.05$		κ_{it} under $r_t = r_t^P$ for $t \in [4, 7]$	
Ave. Age of Province Leaders	-0.0605*	-0.0659*	-0.0599*	-0.0654*	-0.0601*	-0.0656*
	(0.0349)	(0.0377)	(0.0347)	(0.0376)	(0.0348)	(0.0377)
Ave. Age of City Leaders	-0.0887*	-0.1612**	-0.0879*	-0.1602**	-0.0883*	-0.1605**
	(0.0469)	(0.0689)	(0.0467)	(0.0687)	(0.0468)	(0.0688)
Period Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects		Yes		Yes		Yes
Observations	150	150	150	150	150	150
Adj. R^2	0.2725	0.4270	0.2774	0.4275	0.2762	0.4284

Table A16: Career Concerns and TFP Growth under Different γ and r_t

Dep. Variable	g^A_{it+1}					
κ_{it} under $\gamma = 0$	0.0029*	0.0037**				
	(0.0015)	(0.0017)				
κ_{it} under $\gamma = 0.05$			0.0026*	0.0033*		
			(0.0015)	(0.0018)		
κ_{it} under $r_t = r^P_t$ for $t \in [4, 7]$					0.0027*	0.0035**
					(0.0015)	(0.0018)
Period Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects		Yes		Yes		Yes
Observations	150	150	150	150	150	150
Adj. R^2	0.4053	0.4918	0.3692	0.4335	0.3882	0.4632

CES Production Function

Table A17: Institutional Accounting under CES Production

t	1 (1993-97)	2 (1998-02)	3 (2003-07)	4 (2008-12)	5 (2013-17)
			Panel A: $\sigma = 0.5$		
κ_t	1.01	1.24	0.82	0.39	0.30
ω_t	-	-	-	1.22	0.90
			Panel B: $\sigma = 1.5$		
κ_t	1.14	1.34	0.90	0.53	0.48
ω_t	-	-	-	1.22	0.90

Table A18: Age and Career Incentives under CES

Dep. Variable	κ_{it} under $\sigma = 0.5$		κ_{it} under $\sigma = 1.5$	
Ave. Age of Province Leaders	-0.0608*	-0.0654*	-0.0603*	-0.0658*
	(0.0347)	(0.0378)	(0.0349)	(0.0377)
Ave. Age of City Leaders	-0.0873*	-0.1613**	-0.0887*	-0.1609**
	(0.0466)	(0.0690)	(0.0469)	(0.0688)
Period Fixed Effects	Yes	Yes	Yes	Yes
Province Fixed Effects		Yes		Yes
Observations	150	150	150	150
Adj. R^2	0.2864	0.4275	0.2717	0.4271

Table A19: Career Incentives and TFP Growth under CES

Dep. Variable	g^A_{it+1}			
κ_{it} under $\sigma = 0.5$	0.0030*	0.0029		
	(0.0016)	(0.0019)		
κ_{it} under $\sigma = 1.5$			0.0027*	0.0037**
			(0.0015)	(0.0018)
Period Fixed Effects	Yes	Yes	Yes	Yes
Province Fixed Effects		Yes		Yes
Observations	150	150	150	150
Adj. R^2	0.2820	0.3339	0.4069	0.4868

Removing Non-Regional Projects

Table A20: Institutional Accounting: Removing Non-Regional Projects

t	1 (1993-97)	2 (1998-02)	3 (2003-07)	4 (2008-12)	5 (2013-17)
	Panel A: Career Incentives				
investment wedge	0.87	0.91	0.91	0.80	0.74
$\frac{q_t^G G_{t+1}}{C_t^G}$	1.01	1.21	0.87	0.55	0.55
κ_t	0.87	1.10	0.79	0.44	0.40
	Panel B: Financial Discipline				
disciplining wedge	-	-	-	0.79	0.76
$\frac{(1-e_{t+1})D_{t+1}}{e_{t+1}C_t^G}$	-	-	-	1.48	1.15
ω_t	-	-	-	1.17	0.88

Unanticipated and Permanent Change in κ_t and ω_t

Table A21: Institutional Accounting under Unanticipated and Permanent Change in κ_t and ω_t

t	1 (1993-97)	2 (1998-02)	3 (2003-07)	4 (2008-12)	5 (2013-17)
κ_t	1.13	1.20	0.76	0.45	0.35
ω_t	2.94	3.95	2.47	1.09	0.70

A.8.2 CRRA Household Preferences

We extend the model by generalizing household preferences to CRRA (Constant Relative Risk Aversion), with the ζ representing the elasticity of intertemporal substitution. We re-calibrate the household bequest parameter b_t under $\zeta = 0.5$ or 1.5. Then, we re-do all the counterfactuals using the re-calibrated model. The results in Table 8 to 10 are replicated in Table A22 to A24. All the counterfactual results are quantitatively robust.

Table A22: Calibrated b_t under Different ζ

	1 (93-97)	2 (98-02)	3 (03-07)	4 (08-12)	5 (13-17)	6 (18-22)	Assumptions for ≥ 6
$\zeta = 0.5$	0.00	0.20	2.10	7.73	6.31	10.40	equal to the value at $t = 6$
$\zeta = 1.5$	0.06	0.70	1.19	1.90	1.81	2.12	

Table A23: Aggregates by the Calibrated Model

	$\zeta = 0.5$				$\zeta = 1.5$			
	1993-07	2008-22	2023-37	steady state	1993-07	2008-22	2023-37	steady state
g_t	0.29	0.46	0.62	0.61	0.29	0.46	0.62	0.61
c_t	0.11	0.24	0.21	0.21	0.11	0.24	0.21	0.21
e_t	0.02	0.17	0.42	0.41	0.02	0.17	0.42	0.41
r_t (%)	0.21	3.09	1.04	1.35	0.21	3.09	1.06	1.36
$\Delta \log \frac{Y_t}{L_t}$	0.082	0.069	0.039	0.019	0.082	0.069	0.038	0.019

Note: All the variables are averaged over t. We further annualize g_t, r_t, and $\Delta \log \frac{Y_t}{L_t}$ (without detrending).

Table A24: Steady State Aggregates in the Counterfactuals

	Weakening Career Concerns				Strengthening Career Concerns					
	$\zeta = 0.5$		$\zeta = 1.5$		$\zeta = 0.5$			$\zeta = 1.5$		
	(1)	(2)	(1)	(2)	(3)	(4)	(5)	(3)	(4)	(5)
g_*	0.09	0.59	0.09	0.59	1.02	0.55	0.98	1.02	0.55	0.98
c_*	0.28	0.17	0.28	0.18	0.15	0.21	0.15	0.15	0.21	0.15
e_*	0.25	0.92	0.25	0.92	0.56	0.00	0.00	0.56	0.00	0.00
r_*(%)	0.50	4.01	0.54	3.89	2.13	0.04	0.04	2.10	0.03	0.04
$\log Y_*^{CF} - \log Y_*^{BM}$	-0.223	-0.169	-0.226	-0.160	0.024	0.074	0.156	0.026	0.075	0.157

Note: g_t,r_t are all annualized. $\log Y_*^{CF}$ and $\log Y_*^{BM}$ denote $\log Y_*$ in the benchmark calibrated economy and corresponding counterfactual, respectively.

A.9 Proofs

A.9.1 Proof of Proposition 1

When $\delta_G = 1$, we combine Euler equation (21) and the budget constraint (16), and obtain closed-form solutions for C_t^G and G_{t+1} as

$$C_t^G = cY_t \equiv \frac{1 - \beta_G \frac{\gamma+\alpha_G}{1-\alpha_K}}{1+\kappa} \tau Y_t,$$

$$G_{t+1} = gY_t \equiv \frac{\kappa + \beta_G \frac{\gamma+\alpha_G}{1-\alpha_K}}{1+\kappa} \tau Y_t.$$

If $s > \bar{s} \equiv \frac{\alpha_K(1-\tau^Y)}{r^w+\delta_K}$, we have $r_* = r^w$, and equation (2) implies

$$Y_* = \left(\frac{\alpha_K\left(1-\tau^Y\right)}{r^w+\delta_K}\right)^{\frac{\alpha_K}{1-\alpha_K-\gamma-\alpha_G}} A^{\frac{1}{1-\alpha_K-\gamma-\alpha_G}} g^{\frac{\gamma+\alpha_G}{1-\alpha_K-\gamma-\alpha_G}} = \left(Ag^{\gamma+\alpha_G}\bar{s}^{\alpha_K}\right)^{\frac{1}{1-\gamma-\alpha_G-\alpha_K}}.$$

If $s < \bar{s}$, we have $r_* = \frac{\alpha_K(1-\tau^Y)}{s} - \delta_K$, and equation (2) implies

$$Y_* = \left(\frac{\alpha_K\left(1-\tau^Y\right)}{r_*+\delta_K}\right)^{\frac{\alpha_K}{1-\alpha_K-\gamma-\alpha_G}} A^{\frac{1}{1-\alpha_K-\gamma-\alpha_G}} g^{\frac{\gamma+\alpha_G}{1-\alpha_K-\gamma-\alpha_G}} = \left(Ag^{\gamma+\alpha_G}s^{\alpha_K}\right)^{\frac{1}{1-\gamma-\alpha_G-\alpha_K}}.$$

A.9.2 Lemma 1 and Proof

Lemma 1 ***(Desire to Borrow)*** *Assume $\theta > \bar{\theta} \equiv \delta_G \frac{\gamma+\alpha_G}{1-\alpha_K}$. For any given $\omega > 0$, the following properties hold for the local government's optimal strategy:*

1. *There exists $\underline{W} < 0$ such that for $W_t^G > \underline{W}$, the optimization problem in equation (34) has a unique value function $V^G(W_t^G)$, which is continuous and concave.*
2. *There exists a non-empty set $\mathbb{W} = (\underline{W}, \bar{W}]$ such that $\forall W_t^G \in \mathbb{W}$, $\mathcal{H}^D(W_t^G) \geq 0$.*
3. *If κ is sufficiently small, $\forall W_t^G \in \mathbb{W}$, $\mathcal{H}^W(W_t^G) \in \mathbb{W}$.*

Proof: To simplify notation, we define $\breve{A} \equiv \left(\frac{\alpha_K(1-\tau^Y)}{\hat{r}+\delta_K}\right)^{\frac{\alpha_K}{1-\alpha_K}} A^{\frac{1}{1-\alpha_K}}$. We first prove that if $\theta > \bar{\theta} \equiv \delta_G \frac{\gamma+\alpha_G}{1-\alpha_K}$, value function (34) has a unique solution $V^G\left(W_t^G\right)$, which is continuous and concave, for $W_t^G > \underline{W}$, where

$$\underline{W} \equiv -\left(1-\gamma-\alpha_G-\alpha_K\right)\left(\left(\gamma+\alpha_G\right)^{\gamma+\alpha_G}\left(\frac{\tau\breve{A}}{(\theta+\hat{r})\left(1-\alpha_K\right)}\right)^{1-\alpha_K}\right)^{\frac{1}{1-\gamma-\alpha_G-\alpha_K}} < 0.$$

Note that the local government cannot avoid a certain liquidity shortage for $W_t^G \leq \underline{W}$. This can be seen from the fact that for $W_t^G \leq \underline{W}$, the local government is unable to lower the leverage ratio e_{t+1} below 1 conditional on $C_t^G > 0$ and $G_{t+1} > 0$.

We next show that $\theta > \bar{\theta}$ ensures that for $\forall W_t^G > \underline{W}$, local government can choose $e_{t+1} < 1$ and $W_{t+1}^G > \underline{W}$. Note that if the current-period government with $W_t^G > \underline{W}$ can avoid absolute liquidity shortage and, at the same time, keep the next-period government wealth $W_{t+1}^G > \underline{W}$, then there must exist a sequence of policy choices that can certain absolute liquidity shortage for all future periods. The feasibility is established by constructing the current-period policy choices that deliver $e_{t+1} < 1$ and $W_{t+1}^G > \underline{W}$. Specifically, we find that $C_t^G \downarrow 0$, $G_{t+1} \uparrow (W_t^G - \frac{1-\alpha_K}{1-\alpha_K-\gamma-\alpha_G}\underline{W}) > 0$ and $D_{t+1} = -\frac{1-\alpha_K}{1-\alpha_K-\gamma-\alpha_G}\underline{W} > 0$ can satisfy the government budget constraint and guarantee:

$$e_{t+1} = \frac{(\theta+\hat{r})\,D_{t+1}}{\tau\breve{A}\,(G_{t+1})^{\frac{\gamma+\alpha_G}{1-\alpha_K}}} = \frac{(\theta+\hat{r})\left(-\frac{1-\alpha_K}{1-\alpha_K-\gamma-\alpha_G}\underline{W}\right)}{\tau\breve{A}\left(W_t^G - \frac{1-\alpha_K}{1-\alpha_K-\gamma-\alpha_G}\underline{W}\right)^{\frac{\gamma+\alpha_G}{1-\alpha_K}}} < \frac{(\theta+\hat{r})\left(-\frac{1-\alpha_K}{1-\alpha_K-\gamma-\alpha_G}\underline{W}\right)}{\tau\breve{A}\left(-\frac{\gamma+\alpha_G}{1-\alpha_K-\gamma-\alpha_G}\underline{W}\right)^{\frac{\gamma+\alpha_G}{1-\alpha_K}}} = 1,$$

$$\begin{aligned} W_{t+1}^G &= \frac{(\theta+\hat{r})\,D_{t+1}}{e_{t+1}} + (1-\delta_G)\,G_{t+1} - (1+\hat{r})\,D_{t+1} \\ &> \left[-(1-\theta)\,\frac{1-\alpha_K}{1-\alpha_K-\gamma-\alpha_G} + (1-\delta_G)\,\frac{\gamma+\alpha_G}{1-\alpha_K-\gamma-\alpha_G}\right](-\underline{W}) > \underline{W}. \end{aligned}$$

Then, we apply Theorem 4.6 in Stokey and Lucas (1989) to prove that equation (34) has a unique solution $V^G\left(W_t^G\right)$ for $W_t^G > \underline{W}$. We can also establish the continuity and concavity of $V^G\left(W_t^G\right)$ by applying Theorem 4.6 and 4.8 in Stokey and Lucas (1989), respectively.

We prove the second part of the lemma by contradiction. To ease notation, we define $\bar{G} \equiv \left(\frac{(\gamma+\alpha_G)\tau\breve{A}}{(1-\alpha_K)(\hat{r}+\delta_G)}\right)^{\frac{1-\alpha_K}{1-\alpha_K-\gamma-\alpha_G}}$ and $\bar{W} \equiv \tau\breve{A}\bar{G}^{\frac{\gamma+\alpha_G}{1-\alpha_K}} + (1-\delta_G)\,\bar{G}$ such that MRG equals $\hat{r}$ - i.e., $\hat{r}+\delta_G = \tau\frac{\gamma+\alpha_G}{1-\alpha_K}\breve{A}\bar{G}^{-\frac{1-\alpha_K-\gamma-\alpha_G}{1-\alpha_K}}$. The set $\mathbb{W} \equiv \left(\underline{W}, \bar{W}\right]$.

Suppose there exists $W_t^G \in \mathbb{W}$ such that $\mathcal{H}^D\left(W_t^G\right) < 0$. Then, the envelop condition, the first-order condition w.r.t. D_{t+1}, and $\beta_G(1+\hat{r}) < 1$ guarantee $\frac{\partial V\left(W_t^G\right)}{\partial W_t^G} < \frac{\partial V\left(W_{t+1}^G\right)}{\partial W_{t+1}^G}$, which implies $W_{t+1}^G < W_t^G$ by the strict concavity of the value function. $W_{t+1}^G < W_t^G < \bar{W}$ and $D_{t+1} < 0$ are sufficient for $W_{t+1}^G + (1+\hat{r})\,D_{t+1} < \bar{W}$ or, equivalently, $\tau\breve{A}G_{t+1}^{\frac{\gamma+\alpha_G}{1-\alpha_K}} + (1-\delta_G)\,G_{t+1} < \bar{W}$. Since $\tau\breve{A}G_{t+1}^{\frac{\gamma+\alpha_G}{1-\alpha_K}} + (1-\delta_G)\,G_{t+1}$ is monotonically increasing in G_{t+1}, we have $G_{t+1} < \bar{G}$, which implies $MRG_{t+1} > \hat{r}$.

However, $\mathcal{H}^D\left(W_t^G\right) < 0$ also implies the following first-order conditions:

$$\frac{1}{C_t^G} = \frac{\kappa}{G_{t+1}} + \beta_G\,(1+MRG_{t+1})\,\frac{\partial V\left(W_{t+1}^G\right)}{\partial W_{t+1}^G},$$

$$\frac{1}{C_t^G} = \beta_G\,(1+\hat{r})\,\frac{\partial V\left(W_{t+1}^G\right)}{\partial W_{t+1}^G},$$

which give

$$\frac{1}{C_t^G}\,(\hat{r} - MRG_{t+1}) = \frac{\kappa}{G_{t+1}}\,(1+\hat{r})\,.$$

Since $\kappa \geq 0$, $\hat{r} \geq MRG_{t+1}$. Contradiction. This proves the second part of this lemma.

For the third part of this lemma, we only need to prove that when κ is sufficiently small, $\forall W_t^G \in \mathbb{W}$, $\mathcal{H}^W\left(W_t^G\right) \leq \bar{W}$. This proof is accomplished by contradiction. Suppose there exists $W_t^G \in \mathbb{W}$ such that $\mathcal{H}^W\left(W_t^G\right) > \bar{W}$. This, together with $D_{t+1} \geq 0$ by the second part of the lemma, implies $\tau Y_{t+1} + (1-\delta_G) G_{t+1} = W_{t+1}^G + (1+\hat{r}) D_{t+1} > \bar{W}$, which further implies $G_{t+1} > \bar{G}$ and $\hat{r} > MRG_{t+1}$.

We next show that $\hat{r} \leq MRG_{t+1}$ must be true for any government optimal choice $D_{t+1} \geq 0$. First notice that for any interior solution of $D_{t+1} > 0$, we can combine equations (38) and (39) and obtain

$$\begin{aligned}1 + MRG_{t+1} = (1+\hat{r})\left(1 - \kappa \frac{C_t^G}{G_{t+1}}\right) + \frac{\gamma + \alpha_G}{1-\alpha_K} \frac{\omega e_{t+1}}{1-e_{t+1}} \frac{C_t^G}{G_{t+1}} \frac{W_{t+1}^G}{D_{t+1}} \\ + \left(1 - \frac{\gamma+\alpha_G}{1-\alpha_K}\right)(1-\delta_G) \frac{\omega e_{t+1}}{1-e_{t+1}} \frac{C_t^G}{D_{t+1}},\end{aligned} \tag{A12}$$

since $W_{t+1}^G > \bar{W} > 0$, for sufficiently small κ, $\hat{r} < MRG_{t+1}$ is a necessary condition for equation (A12) to hold true.

For corner solution $D_{t+1} = 0$, the optimality conditions imply

$$\frac{1}{C_t^G}\left(\hat{r} - MRG_{t+1}\right) \leq \frac{\kappa}{G_{t+1}}(1+\hat{r}).$$

As $\kappa \downarrow 0$, the inequality cannot hold unless $\hat{r} \leq MRG_{t+1}$.

A.9.3 Proof of Proposition 2

For notational ease, we define

$$\bar{\omega} = \bar{\omega}(\kappa, \hat{r}) \equiv \frac{\hat{r}}{(\theta+\hat{r})\Phi(\hat{r})(1-\Pi(\kappa))},$$

$$\bar{\kappa} = \bar{\kappa}(\hat{r}) \equiv \frac{\gamma+\alpha_G}{1-\alpha_K}\frac{1}{\Phi(\hat{r})},$$

$$\tilde{\theta} = \delta_G \frac{\gamma+\alpha_G}{1-\alpha_K} \frac{1-\beta_G}{(1-\beta_G) + \beta_G\delta_G\left(1 - \frac{\gamma+\alpha_G}{1-\alpha_K}\right)} \in \left(0, \bar{\theta}\right),$$

where

$$\Pi(\kappa) \equiv \frac{\kappa + \beta_G \frac{\gamma+\alpha_G}{1-\alpha_K}}{\kappa + \frac{1-\beta_G(1-\delta_G)}{\delta_G}} \in (0,1), \quad \Phi(\hat{r}) \equiv \frac{\hat{r}}{1-\beta_G(1+\hat{r})} > 0.$$

We first analyze the case with $\omega < \bar{\omega}$. We start with the first-order conditions (38) and (39) under $\lambda^D = 0$, and then show that $\omega < \bar{\omega}$ ensures an interior solution in the steady state. Denote $c_* \equiv \frac{C_*^G}{Y_*}$ and $g_* \equiv \frac{G_*}{Y_*}$. In the steady state, equations (38), (39) and the government budget constraint become

$$1 = \frac{\omega\Phi(\hat{r})}{1-e_*}\frac{\theta+\hat{r}}{\hat{r}}\frac{c_*}{\tau}, \tag{A13}$$

$$(1-\beta_G(1-\delta_G))\, g_* = \left(\kappa + \frac{\omega e_*}{1-e_*}\frac{\gamma+\alpha_G}{1-\alpha_K}\right) c_* + \beta_G \tau \frac{\gamma+\alpha_G}{1-\alpha_K}, \tag{A14}$$

$$c_* + \delta_G g_* = \tau\left(1 - \frac{\hat{r}}{\theta+\hat{r}} e_*\right). \tag{A15}$$

By pluging equations (A13) and (A15) into equation (A14), we obtain

$$e_*(\hat{r}) = \frac{\bar{\omega}-\omega}{\bar{\omega}-\omega+\omega\frac{\theta-\tilde{\theta}}{\theta+\hat{r}}}, \tag{A16}$$

We have assumed $\theta > \bar{\theta}$ in Lemma 1, so $\tilde{\theta} < \bar{\theta}$ implies $\theta > \tilde{\theta}$. When $\omega < \bar{\omega}$, equation (A16) implies $e_* \in (0,1)$.

By substituting e_* into equation (A13), we obtain

$$c_*(\hat{r}) = \tau(1-\Pi(\kappa))\left(1 - \frac{\tilde{\theta}+\hat{r}}{\theta+\hat{r}} e_*\right) > 0, \tag{A17}$$

and by substituting e_* and c_* into equation (A15), we obtain

$$g_*(\hat{r}) = \tau\frac{1}{\delta_G}\left(\left(1 - \frac{\hat{r}}{\theta+\hat{r}} e_*\right)\Pi(\kappa) + (1-\Pi(\kappa))\frac{\tilde{\theta}}{\theta+\hat{r}} e_*\right) > 0. \tag{A18}$$

hence there is an interior solution in the steady state.

Differentiating equation (A16) yields

$$\frac{\partial e_*(\hat{r})}{\partial \omega} = -\frac{\bar{\omega}\frac{\theta-\tilde{\theta}}{\theta+\hat{r}}}{\left(\bar{\omega}-\omega\frac{\tilde{\theta}+\hat{r}}{\theta+\hat{r}}\right)^2} < 0,$$

$$\frac{\partial e_*(\hat{r})}{\partial \kappa} = \frac{\omega\frac{\theta-\tilde{\theta}}{\theta+\hat{r}}}{\left(\bar{\omega}-\omega\frac{\tilde{\theta}+\hat{r}}{\theta+\hat{r}}\right)^2}\frac{\partial \bar{\omega}(\kappa,\hat{r})}{\partial \kappa},$$

$$\frac{\partial e_*(\hat{r})}{\partial \hat{r}} = -\frac{\omega\frac{\theta-\tilde{\theta}}{(\theta+\hat{r})^2}\left(\frac{\beta_G}{1-\Pi(\kappa)}+\omega\right)}{\left(\bar{\omega}-\omega\frac{\tilde{\theta}+\hat{r}}{\theta+\hat{r}}\right)^2} < 0.$$

Since $\frac{\partial \bar{\omega}(\kappa,\hat{r})}{\partial \kappa} > 0$, we obtain $\frac{\partial e_*(\hat{r})}{\partial \omega} < 0$, $\frac{\partial e_*(\hat{r})}{\partial \kappa} > 0$ and $\frac{\partial e_*(\hat{r})}{\partial \hat{r}} < 0$.

Moreover, equation (A18) can be rewritten as

$$g_*(\hat{r}) = \frac{\tau}{\delta_G}\left(\Pi(\kappa) + \frac{\hat{r}}{\theta+\hat{r}}\frac{\bar{\kappa}(\hat{r})-\kappa}{\kappa+\frac{1-\beta_G(1-\delta_G)}{\delta_G}} e_*\right), \tag{A19}$$

where $\frac{\hat{r}}{\theta+\hat{r}}(\bar{\kappa}(\hat{r})-\kappa)$ is decreasing in $\hat{r}$. When $\kappa < \bar{\kappa}$, this equation implies $\frac{\partial g_*(\hat{r})}{\partial \omega} < 0$ and $\frac{\partial g_*(\hat{r})}{\partial \hat{r}} < 0$. To see the sign of $\frac{\partial g_*(\hat{r})}{\partial \kappa}$, we combine equations (A13) and (A15) and obtain

$$g_*(\hat{r}) = \frac{\tau}{\delta_G}\left(1 - \frac{\hat{r}}{\theta+\hat{r}}\frac{1}{\omega\Phi(\hat{r})}\right) + \frac{\tau}{\omega\delta_G}\frac{\hat{r}}{\theta+\hat{r}}\left(\frac{1}{\Phi(\hat{r})}-\omega\right) e_*(\hat{r}). \tag{A20}$$

When $\kappa < \bar{\kappa}$, we have $\bar{\omega} < \frac{1}{\Phi(\hat{r})}$, thus $\omega < \frac{1}{\Phi(\hat{r})}$. Therefore, equation (A20) implies that $\frac{\partial g_*(\hat{r})}{\partial \kappa} > 0$.

To see the 2nd-order derivative, we further differentiate $\frac{\partial e_*(\hat{r})}{\partial \kappa}$ w.r.t. ω and obtain

$$\frac{\partial^2 e_*(\hat{r})}{\partial \kappa \partial \omega} = \frac{\theta - \tilde{\theta}}{\theta + \hat{r}} \frac{\partial \bar{\omega}(\kappa, \hat{r})}{\partial \kappa} \frac{\bar{\omega} + \omega \frac{\tilde{\theta}+\hat{r}}{\theta+\hat{r}}}{\left(\bar{\omega} - \omega \frac{\tilde{\theta}+\hat{r}}{\theta+\hat{r}}\right)^3} > 0.$$

Moreover, equation (A18) implies $\frac{\partial g_*(\hat{r})}{\partial \omega} = \tau \frac{\hat{r}}{\theta+\hat{r}} \frac{\bar{\kappa}(\hat{r}) - \kappa}{\delta_G\left(\kappa + \frac{1-\beta_G(1-\delta_G)}{\delta_G}\right)} \frac{\partial e_*(\hat{r})}{\partial \omega}$, and we further differentiate it w.r.t. κ and obtain

$$\frac{\partial^2 g_*(\hat{r})}{\partial \kappa \partial \omega} = \tau \frac{\hat{r}}{\theta + \hat{r}} \frac{\frac{1-\beta_G(1-\delta_G)}{\delta_G} + \frac{\gamma+\alpha_G}{1-\alpha_K}\frac{1}{\Phi(\hat{r})}}{\delta_G\left(\kappa + \frac{1-\beta_G(1-\delta_G)}{\delta_G}\right)^2} \underbrace{\left(-\frac{\partial e_*(\hat{r})}{\partial \omega}\right)}_{+} + \tau \frac{\hat{r}}{\theta + \hat{r}} \frac{\bar{\kappa}(\hat{r}) - \kappa}{\delta_G\left(\kappa + \frac{1-\beta_G(1-\delta_G)}{\delta_G}\right)} \underbrace{\frac{\partial e_*(\hat{r})}{\partial \kappa \partial \omega}}_{+} > 0.$$

We now analyze the case with $\omega \geq \bar{\omega}$. Define

$$\underline{W}^+ \equiv \left(\tau \check{A}\right)^{\frac{1-\alpha_K}{1-\gamma-\alpha_G-\alpha_K}} \Pi(\kappa)^{\frac{\gamma+\alpha_G}{1-\gamma-\alpha_G-\alpha_K}} \left(\omega(\theta + \hat{r})(1 - \Pi(\kappa)) + \beta_G(1 + \hat{r})\right)^{-\frac{1-\alpha_K}{1-\gamma-\alpha_G-\alpha_K}} > 0.$$

We first show $\underline{W}^+ \in \left(\underline{W}, \bar{W}\right)$. $\underline{W}^+ > \underline{W}$ is obvious. $\underline{W}^+ < \bar{W}$ is guaranteed by $\omega > \bar{\omega}$ and $\kappa < \frac{\frac{\gamma+\alpha_G}{1-\alpha_K}(1-\beta_G(1+\hat{r}))}{1+\hat{r}-\frac{\gamma+\alpha_G}{1-\alpha_K}}$:

$$\underline{W}^+ < \left(\tau \check{A}\right)^{\frac{1-\alpha_K}{1-\gamma-\alpha_G-\alpha_K}} \Pi(\kappa)^{\frac{\gamma+\alpha_G}{1-\gamma-\alpha_G-\alpha_K}} < \bar{W}.$$

We next show that $\forall W_t^G \in \mathbb{W}^+$, $\mathcal{H}^D\left(W_t^G\right) = 0$. We guess $\mathcal{H}^D\left(W_t^G\right) = 0$. Since $D_{t+1} < 0$ has been ruled out by Lemma 1, we can use equation (39) to obtain $\mathcal{H}^G\left(W_t^G\right) = \Pi(\kappa) W_t^G$, which further implies $\mathcal{H}^{CG}\left(W_t^G\right) = (1 - \Pi(\kappa)) W_t^G$ and $\mathcal{H}^W\left(W_t^G\right) \equiv \tau \check{A} \Pi(\kappa)^{\frac{\gamma+\alpha_G}{1-\alpha_K}} {W_t^G}^{\frac{\gamma+\alpha_G}{1-\alpha_K}}$. We then plug the policy functions into equation (38) and back out the multiplier:

$$\begin{aligned}
\lambda_t^D &= -\frac{1}{C_t^G} + \omega \frac{1}{1 - e_{t+1}} \frac{\theta + \hat{r}}{W_{t+1}^G} + \frac{\beta_G(1 + \hat{r})}{W_{t+1}^G - G_{t+2}} \\
&= \frac{-\tau \check{A} \Pi(\kappa)^{\frac{\gamma+\alpha_G}{1-\alpha_K}} \left(W_t^G\right)^{\frac{\gamma+\alpha_G}{1-\alpha_K}} + \omega(1 - \Pi(\kappa)) W_t^G(\theta + \hat{r}) + \beta_G W_t^G(1 + \hat{r})}{(1 - \Pi(\kappa)) W_t^G \tau \check{A} \Pi(\kappa)^{\frac{\gamma+\alpha_G}{1-\alpha_K}} \left(W_t^G\right)^{\frac{\gamma+\alpha_G}{1-\alpha_K}}}.
\end{aligned}$$

Therefore, $\lambda_t^D > 0$ if and only if $W_t^G > \underline{W}^+$, which verifies our guess of $\mathcal{H}^D\left(W_t^G\right) = 0$.

The last step is to show $\forall W_t^G \in \mathbb{W}^+$, $\mathcal{H}^W\left(W_t^G\right) \in \mathbb{W}^+$. $\mathcal{H}^W\left(W_t^G\right) \leq \bar{W}$ is immediate from Lemma 1 as $\mathbb{W}^+ \subseteq \mathbb{W}$. We then show $\mathcal{H}^W\left(W_t^G\right) > \mathcal{H}^W\left(\underline{W}^+\right) > \underline{W}^+$. The first inequality comes from the monotonicity of $\mathcal{H}^W\left(W_t^G\right)$ and the second inequality is ensured by the condition $\omega > \bar{\omega}$.

With the closed-form policy functions, it is straightforward to derive the steady state.

A.9.4 Proof of Proposition 3

We build on the proof of Proposition 2, which treats interest rate at an exogenous level. In the steady state, $\frac{K_*}{Y_*} = \frac{\alpha_K\left(1-\tau^Y\right)}{r_*+\delta_K}$, $\frac{D_*}{Y_*} = \frac{\tau e_*}{\theta + r_*}$, and the capital market constraint (33) requires

$$\frac{\alpha_K\left(1 - \tau^Y\right)}{r_* + \delta_K} + \frac{\tau}{\theta + r_*} e_*(r_*) \leq s, \tag{A21}$$

where $e_*(\cdot)$ is given by equation (A16). Proposition 2 shows that $e_*(r_*)$ is decreasing in r_*. So, the left-hand side of equation (A21) is monotonically decreasing in r_*. Since $r_* \geq r^w$, the maximum of the left-hand side of the equation is obtained at $r_* = r^w$, which we define as

$$s^1 \equiv \frac{\alpha_K \left(1 - \tau^Y\right)}{r^w + \delta_K} + \frac{\tau}{\theta + r^w} e_*(r^w).$$

Therefore, if the saving rate $s > s^1$, the inequality in equation (A21) will strictly hold, implying that the capital market constraint is slack in the steady state and $r_* = r^w$.

When $s < s^1$, equation (A21) becomes equality, and this equation determines the interest rate $r_*(s)$, which is decreasing with s. Since $\bar{\omega}$ is monotonically decreasing in r_*, to ensure $\omega < \bar{\omega}$ we need

$$r_* < \bar{r}_* \equiv \frac{1 - \left(\beta_G + \omega \left(1 - \Pi\left(\kappa\right)\right) \theta\right)}{\beta_G + \omega \left(1 - \Pi\left(\kappa\right)\right)}$$

This condition, together with equation (A21), implies a lower bound on s:

$$s > s^0 \equiv \frac{\alpha_K \left(1 - \tau^Y\right)}{\bar{r}_* + \delta_K}.$$

We assume r^w is sufficiently low such that $\bar{\omega}\left(\kappa, r^w\right) > \omega > 0$, which implies $\bar{r}_* \in \left(r^w, \frac{1}{\beta_G} - 1\right)$ and ensures $s^0 < s^1$.

Equation (A21), together with equations (A13), (A14) and (A15), can jointly pin down r_*, g_*, c_* and e_*. We can rewrite equation (A21) as

$$\left(s - \frac{\alpha_K \left(1 - \tau^Y\right)}{r_* + \delta_K}\right) \frac{\theta + r_*}{\tau} = e_*\left(r_*\right),$$

where the left-hand side is monotonically increasing in r_*. Proposition 2 shows that the right-hand side of the equation is monotonically decreasing in ω and r_* but increasing in κ. This gives $\frac{\partial r_*}{\partial \kappa} > 0$ and $\frac{\partial r_*}{\partial \omega} < 0$. Moreover, since $\frac{\partial\left(s - \frac{\alpha_K\left(1-\tau^Y\right)}{r_* + \delta_K}\right)\frac{\theta + r_*}{\tau}}{\partial r_*} > 0$, we have $\frac{\partial e_*}{\partial \kappa} = \frac{\partial\left(s - \frac{\alpha_K\left(1-\tau^Y\right)}{r_* + \delta_K}\right)\frac{\theta + r_*}{\tau}}{\partial r_*} \frac{\partial r_*}{\partial \kappa} > 0$ and $\frac{\partial e_*}{\partial \omega} = \frac{\partial\left(s - \frac{\alpha_K\left(1-\tau^Y\right)}{r_* + \delta_K}\right)\frac{\theta + r_*}{\tau}}{\partial r_*} \frac{\partial r_*}{\partial \omega} < 0$.

A.9.5 Proof of Proposition 4

Setting up the governor's optimization at t:

$$\max_{C_t^G, G_{t+1}, \phi_t} \log C_t^G + \kappa \log G_{t+1} + \kappa_\phi \phi_t + \beta_G V^G\left(W_{t+1}^G | G_{t+1}, Y_{t+1}\right) - \lambda_t (C_t^G + G_{t+1} - Y_t(\tau - \tau_c e^{\phi_t}))$$

where λ_t is the Lagrangian multiplier of the governor's budget constraint. The first order condition for ϕ_t gives

$$e^{\phi_t} = \frac{\kappa_\phi}{\lambda_t \tau_c Y_t}.$$

The envelop condition gives that $\lambda_t \propto \frac{1}{W_t^G} = \frac{1}{Y_t(\tau - \tau_c e^{\phi_t})}$, which in turn implies

$$e^{\phi_t} = \frac{\kappa_\phi}{\lambda_t \tau_c Y_t} = \frac{\kappa_\phi}{\tau_c}\tau - \kappa_\phi e^{\phi_t}.$$

Thus,

$$e^{\phi_t} = \frac{\tau}{\tau_c}\frac{\kappa_\phi}{1+\kappa_\phi}.$$

A.9.6 Optimization Problem for Institutional Accounting

Denote by $\tilde{X}_t \equiv \frac{X_t}{(1+g)^t}$ the detrended variable X_t, where $X_t \in \left\{Y_t, C_t^G, G_t, D_t\right\}$ and $g = (1+g^A)^{\frac{1}{1-\alpha_K-\alpha_G-\gamma}} - 1$ is the trend growth rate of X_t. Assuming perfect foresight for local governors, their optimization problem can be formulated as follows.

$$\max_{\left\{\tilde{C}_{t+\iota}^G, \tilde{G}_{t+\iota+1}, e_{t+\iota+1}\right\}_{\iota=0}^{\infty}} \sum_{\iota=0}^{\infty} \beta_G^\iota U_{t+\iota}^G \left(\tilde{C}_{t+\iota}^G, \tilde{G}_{t+\iota+1}, e_{t+\iota+1}\right),$$

subject to the budget constraint:

$$\tilde{C}_t^G + q_t^G \left((1+g)\,\tilde{G}_{t+1} - (1-\delta_G)\,\tilde{G}_t\right) = \tau_t \tilde{Y}_t - (1+r_t)\,\tilde{D}_t + (1+g)\,\tilde{D}_{t+1},$$

where $\tilde{D}_{t+1}$ for $t \in \{1,2,3\}$ are exogenously determined by the central government, Y_t follows equation (2), and $\tilde{A}_t \equiv \frac{A_t}{(1+g^A)^t}$. The initial condition is $\{\tilde{G}_1, \tilde{D}_1\}$.

We only consider interior solution in the accounting exercise. So, $U_t^G\left(\tilde{C}_t^G, \tilde{G}_{t+1},, e_{t+1}\right) = \log\tilde{C}_t^G + \kappa_t \log \tilde{G}_{t+1} + \omega_t \log(1-e_{t+1})$ for $e_{t+1} \in [0,1)$. For $t \le 3$, the first-order conditions w.r.t. $\tilde{G}_{t+1}$ gives equation (46). For $t \ge 4$, the first-order conditions w.r.t. $\tilde{D}_{t+1}$ and $\tilde{G}_{t+1}$ establish equations (47) and (48).

A.9.7 First-best Allocation

Same as in Appendix A.9.6, the detrended variable of X_t is denoted by $\tilde{X}_t$. The social planner's optimization problem is given by:

$$\max_{\{\tilde{G}_{t+1}, \tilde{K}_{t+1}, \tilde{F}_{t+1}\}_{t=1}^{\infty}} \frac{\rho\beta}{\beta_C} \log \tilde{C}_{0,1}^H + \sum_{t=1}^{\infty} \beta_C^{t-1}\left(\log \tilde{C}_t^G + \rho\left(\log \tilde{C}_{t,t}^H + \beta \log \tilde{C}_{t,t+1}^H\right)\right), \tag{A22}$$

subject to the resource constraint:

$$\tilde{C}_t^G + \tilde{C}_{t,t}^H + \tilde{C}_{t-1,t}^H + q_t^G \tilde{I}_t^G + q_t^K \tilde{I}_t^K + (1+g)\,\tilde{F}_{t+1} = \tilde{Y}_t + (1+r^w)\tilde{F}_t, \tag{A23}$$

and the borrowing constraint $\tilde{F}_t \ge \tilde{F}_t^*$, where $\tilde{I}_t^G = (1+g)\,\tilde{G}_{t+1} - (1-\delta_G)\,\tilde{G}_t$, $\tilde{I}_t^K = (1+g)\,\tilde{K}_{t+1} - (1-\delta_K)\,\tilde{K}_t$, $\tilde{Y}_t = \tilde{A}_t \tilde{G}_t^{\gamma+\alpha_G} \tilde{K}_t^{\alpha_K} L_t^{1-\alpha_G-\alpha_K}$, and the initial state $\{\tilde{G}_1, \tilde{K}_1, \tilde{Y}_1, \tilde{F}_1\}$ is given.