Growth with Regional Redistribution

Lieyuan Yang *

Department of Economics, University of Minnesota

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Abstract

This paper studies interregional fiscal redistribution and regional economic growth. In China, the central government takes substantial tax revenue from local governments and reallocates resources across regions. I model this redistribution as a progressive tax on local fiscal revenue and document a sharp rise in progressivity. Exploiting the 2002 tax reform in an event-study design, I show that the increased central tax claims reduced local infrastructure investment and slowed regional growth. To quantify the effects of increased redistribution, I develop a general equilibrium growth model featuring local fiscal policy under progressive redistribution. Rising progressivity accounts for 43% of the decline in the cross-provincial variance of log GDP per capita, while reducing aggregate TFP by 0.5 percentage points. Finally, I use this framework to characterize the determinants of optimal progressivity.

Key words: Redistribution, Tax Progressivity, Ramsey Taxation, Fiscal Policy, Regional Economic Growth, Capital Misallocation, Efficiency, Social Welfare, Chinese Economy.

JEL codes: E60, H20, H50, H70, O11, O23, O40, R13, R50

*University of Minnesota, 4-101 Hanson Hall, 1925 Fourth Street South, Minneapolis, MN 55455. Email: yang7481@umn.edu. I am deeply grateful to Kjetil Storesletten for his invaluable guidance and support. I also thank Anmol Bhandari, Katerina Gribbin, Jonathan Heathcote, Kyle Herkenhoff, Loukas Karabarbounis, Hannes Malmberg, Vincenzo Quadrini, Simon Mongey, Todd Schoellman, Kurt See, Zheng (Michael) Song, Bo Zhao, and seminar participants at CES annual conference, The University of Queensland, and Singapore Management University for helpful comments.

1 Introduction

Fiscal federalism and intergovernmental transfers are prevalent in major economies.[1] Over the past three decades, China has significantly expanded intergovernmental and interregional fiscal redistribution. Prior to 1994, the central government collected only about 3% of gross domestic product (GDP) in taxes, while most revenue was retained by local governments. The 1994 tax reform marked a turning point by allocating 75% of value-added taxes and all excise taxes to the central government. In 2002, the redistribution system was further centralized by reallocating 50% of personal and corporate income taxes from local to the central government. Meanwhile, most of the increased central revenue was transferred to less-developed regions. By 2010, the central government collected roughly 10% of GDP in taxes, 80% of which was redistributed to local governments. Notably, transfers as a share of local GDP were more than five times larger in poor provinces than in rich ones.

Motivated by the largest tax reform in China, this paper studies the economic effects of increased regional redistribution. The aim is twofold. First, I provide novel empirical evidence on the evolution of China's regional redistribution system and its implications for local fiscal policy and economic development. In particular, I exploit the 2002 tax reform in an event-study design to identify the causal effects of the increased central tax claim on local infrastructure investment and regional economic growth. Second, building on the empirical findings, I develop a general equilibrium framework of local fiscal policy under a progressive redistribution scheme. The model is calibrated to the Chinese economy to quantify the impact of increased redistribution on regional convergence and aggregate productivity. I also use this framework to characterize the determinants of optimal redistribution policy.

This paper contributes to the literature on redistribution policy and economic growth. Since Alesina and Rodrik (1994), a large body of work has studied how redistributive policies—such as taxes and transfers—distort household and firm decisions and, in turn, shape economic growth and social welfare. By contrast, redistribu-

[1] For example, the U.S. federal government channels large grants to states for health care, education, and transportation; Canada transfers equalization payments to provinces with less fiscal capacity; India provides Finance Commission transfers to address fiscal imbalances; and the EU provides Structural and Investment Funds to disadvantaged regions.

tion across regions and governments remains less understood. Productive government spending is a key driver of long-run growth as in Barro (1990), so distortions to local governments' incentives have natural implications for economic development. Despite this, there are few papers that relate intergovernmental redistribution at the regional level to local fiscal policy and at the aggregate level to economic growth. China offers an ideal setting to study these issues: major tax reforms generated large policy shocks and a sustained transition toward an increasingly progressive redistribution system. Using this setting, I provide, to the best of my knowledge, the first systematic empirical and quantitative analysis of how increased regional redistribution distorts local fiscal incentives and shapes long-run macroeconomic outcomes.

I begin my analysis by modeling regional redistribution as a progressive tax on local fiscal income and estimating the degree of progressivity using the log-linear tax function from Benabou (2002) and Heathcote, Storesletten and Violante (2017) (BHSV hereafter): $T(x) = x - \lambda x^{1-\phi}$, where $T(x)$ is the net central tax, x is pre-redistribution local fiscal income, ϕ governs the degree of progressivity, and λ determines the average tax level. A higher ϕ implies a more progressive scheme, with the marginal tax rate increasing in fiscal income. The BHSV function provides a good description of China's regional redistribution system both before and after the tax reform. I document a novel empirical fact: the estimated progressivity ϕ rises substantially from around 0.2 in 1998 to 0.5 in 2017, raising average marginal tax rates from 28% to 40%.

Alongside this rise in progressivity, several stylized facts emerge. Redistribution compresses fiscal disparities between rich and poor provinces but also distorts local fiscal policy. Local governments allocate spending between government consumption, which provides current utility, and infrastructure investment, which supports long-run growth and future fiscal revenue. As progressivity increases, marginal tax rates rise and the return to investment falls. In response, local governments shift spending away from infrastructure investment and toward government consumption, especially in rich provinces facing higher marginal tax rates. As a result, infrastructure capital grows faster in less-developed provinces, contributing to regional convergence but also generating capital misallocation.

To identify the causal effects of increased redistribution on local fiscal policy and economic growth, I exploit the 2002 income-tax sharing reform in an event-study design. In 2002, the central government began to take 50% of personal and corporate income taxes from local governments. Local governments invest in infrastructure to promote economic growth and expand their future tax base. However, by appropriating a large share of income taxes, the reform reduced the fiscal returns to infrastructure investment, thereby weakening local governments' incentives to invest. I use the pre-reform share of income taxes in total tax revenue as a treatment variable to measure local governments' exposure to the reform. This share varies across provinces due to differences in the composition of the local tax base. Provinces with higher income-tax shares experienced larger revenue losses after the reform and responded by cutting infrastructure investment more sharply. The event study shows that provinces with higher pre-reform income-tax shares experienced slower post-reform growth in both infrastructure capital and GDP per capita.

The empirical evidence motivates a theoretical framework for studying how regional redistribution shapes macroeconomic outcomes. Following the 2002 tax reform, China experienced rapid economic convergence—the cross-provincial variance of log GDP per capita declined from 0.25 to 0.16 by 2020—and a marked slowdown in aggregate total factor productivity (TFP) growth, from 5% to 1% after 2010. To what extent can these trends be explained by increased redistribution? To answer this question, I develop a general equilibrium model of local fiscal policy under progressive regional redistribution, building on Song and Xiong (2023) and Heathcote, Storesletten and Violante (2017). Local governments trade off current public goods against infrastructure investment, where infrastructure raises future output and the local tax base. Regional redistribution is modeled as a progressive tax on local fiscal income using the log-linear tax scheme.

The main novelty of my model is that local fiscal policy is distorted by regional redistribution policy, with implications for capital misallocation and economic growth. I analytically characterize the equilibrium allocation and derive two key results. First, rising progressivity reduces the marginal return to infrastructure investment and thereby shifts fiscal spending away from investment toward public goods, depressing aggregate output. Second, progressive redistribution reallocates resources from high- to low-productivity regions, which compresses output dispersion but induces misallocation of infrastructure capital across regions.

Since local infrastructure investment is the main channel through which regional redistribution affects regional economic growth, quantifying this mechanism requires estimating the output elasticity of infrastructure capital. Prior studies typically infer this elasticity from capital shares, which implicitly assume optimal allocation. In contrast, my framework allows for fiscal distortions induced by redistribution policy. To address this identification challenge, I propose a novel instrumental variable (IV) strategy that uses the pre-reform share of income taxes as an IV for growth in infrastructure capital. The identifying assumption is that the central-local division of tax revenue affects regional economic performance only through its impact on local fiscal incentives and is uncorrelated with other structural error terms. Because statutory tax rates remained unchanged, the reform should not directly affect household or firm behavior. This assumption is supported by the parallel pre-trends in the event study. The IV estimate of the output elasticity is 0.185, exceeding both the OLS estimate and the value implied by capital shares. This gap suggests substantial distortions and underinvestment in infrastructure.

I calibrate the model to match key empirical moments in the Chinese economy from 1998 to 2017. The quantitative model replicates local government investment patterns, the weaker correlation between output and infrastructure capital, the rapid regional economic convergence, and the decline in aggregate TFP. To quantify the effects of increased redistribution, I conduct a counterfactual experiment by holding the progressivity of the redistribution scheme fixed at its 1998 level. The results imply that the rise in progressivity accounts for 43% of the decline in the cross-provincial variance of log GDP per capita and reduces aggregate TFP by 0.5 percentage points.

Finally, I use the model to study the determinants of optimal progressivity. My framework highlights several competing forces. On the one hand, to finance its own expenditure, the central government needs to moderate progressivity to preserve local governments' incentives to invest and sustain the aggregate tax base. On the other hand, a utilitarian social planner values redistribution for its role in reducing regional inequality. Meanwhile, redistribution introduces capital misallocation across regions and generates aggregate inefficiency. I derive the closed-form social welfare function and characterize the condition under which increasing progressivity improves social welfare. In the calibrated model, the welfare-maximizing degree of progressivity is 0.575 for the utilitarian social planner. The current level, 0.485, lies close to the optimum: moving from the current system to the optimal one achieves negligible welfare gains.

Related Literature. This paper contributes to several strands of literature. First, my work relates to a growing literature on intergovernmental and interregional transfers. Empirical studies often find that transfers from the central government can crowd out local tax collection (Knight, 2002; Buettner, 2006), and expand local government spending (Card and Payne, 2002; Gordon, 2004; Leduc and Wilson, 2017). Quantitative work further shows that regional redistribution can reduce spatial disparities, but often at the cost of aggregate productivity. Tombe and Winter (2021) and Henkel, Seidel and Suedekum (2021) find that interregional transfers shift employment toward lower-productivity regions. Fernández-Villaverde et al. (2023) find that regional redistribution is the second-largest contributor, after TFP, to the disparity between the North and the South in Italy.

I contribute to this literature by providing a systematic empirical and quantitative analysis of regional redistribution. My analysis differs in several respects. While existing empirical work focuses on grant receipts, the 2002 reform increased the central claim on local tax revenue, generating different incentive effects. China's limited local tax autonomy also allows the analysis to focus on the expenditure margin, especially the tradeoff between public goods and infrastructure investment. Moreover, existing quantitative studies typically abstract from local government decision-making and model intergovernmental redistribution as lump-sum transfers or region-specific rules. I instead model redistribution as a progressive tax on local government revenue and quantify its distortionary effects.

This paper also contributes to the literature on government spending and long-run growth. Following Barro (1990), a large literature embeds productive government spending or infrastructure capital in growth frameworks. Most closely, Song and Xiong (2023) emphasize government-led infrastructure investment as a key driver of China's economic growth and study how such investment can be distorted by local governors' political incentives and debt constraints. I contribute by introducing a distinct distortionary channel: regional redistribution weakens the fiscal return to local infrastructure investment and thereby slows long-run economic growth. Methodologically, I model regional redistribution using the log-linear tax schedule of Benabou (2000) and Heathcote, Storesletten and Violante (2017), who provide a tractable framework for studying the effects of progressive taxation. The log-linear tax schedule has been widely applied in subsequent research. While most studies focus on redistribution across households and firms, I extend it to redistribution across regions and to estimate the progressivity of China's intergovernmental fiscal system.

Quantifying the growth effects of public investment requires disciplining the output elasticity of infrastructure capital in the production function. Many quantitative studies, such as Baxter and King (1993); Leeper, Walker and Yang (2010); Brandt, Tombe and Zhu (2013); Ramey (2020), rely on values inferred from capital shares. This approach implicitly assumes that infrastructure capital is allocated optimally, so that its output elasticity can be recovered from its observed share. Local government investment, however, can be systematically distorted by financial constraints, political competition, and—central to this paper—redistribution policy. I therefore propose a novel instrument that corrects for this bias and delivers a credible estimate of the output elasticity.

This paper also connects to the broader literature on distortions, misallocation, and their implications for aggregate productivity and economic convergence, pioneered by Chari, Kehoe and McGrattan (2007), Restuccia and Rogerson (2008) and Hsieh and Klenow (2009). More recent work has examined misallocation across regions (Desmet and Rossi-Hansberg, 2013; Hsieh et al., 2019; Fajgelbaum et al., 2019). In the Chinese context, Tombe and Zhu (2019) and Hao et al. (2020) find that declining migration costs are a key driver of labor productivity growth and regional convergence in China between 2000 and 2015. Brandt, Kambourov and Storesletten (2025) identify changes in entry barriers as a main driver of regional convergence in the manufacturing sector between 1995 and 2008. These studies mainly focus on firm- and household-level distortions. I contribute by identifying regional redistribution as a distinct source of distortions operating through local fiscal policy and quantifying its effects on regional convergence and aggregate productivity.

The remainder of the paper proceeds as follows. Section 2 describes China's tax-sharing system and documents key stylized facts. Section 3 conducts an event study to estimate local government responses to the 2002 tax reform. Motivated by this evidence, Section 4 develops a theoretical framework to study how progressive redistribution distorts local fiscal policy and shapes economic growth. Section 5 parameterizes the model and quantifies its implications for fiscal distortions, regional convergence, and aggregate productivity. Section 6 formulates the closed-form social welfare function and explores the determinants of optimal policy. Section 7 calculates the optimal degree of progressivity in various model scenarios. Section 8 concludes.

2 Institutional Background and Stylized Facts

This section first describes institutional features of China's tax reforms and the tax-sharing system. To track the evolution of the redistribution system, I model regional redistribution as a progressive tax on local fiscal income and estimate its degree of progressivity. I then present time-series evidence on how the reforms affected local governments' fiscal policy and regional economic growth, which motivates the theoretical framework.

2.1 The Rise of Intergovernmental Redistribution

China established its modern intergovernmental fiscal redistribution system through two major tax reforms in 1994 and 2002. Prior to 1994, the allocation of fiscal revenue between central and local governments followed a patchwork of region-specific contracts.[2] These ad hoc rules imposed uneven fiscal burdens on local governments and, more importantly, limited the central government's fiscal capacity. As shown in the top panel of Figure 1, local governments collected over 10% of GDP in revenue, while the central government's share stagnated near 5%, severely constraining its ability to

[2]According to Zhou (2012), some provinces paid a fixed share of fiscal revenue to the central government, such as Tianjin (46.5%), Shanxi (87.55%), and Anhui (77.5%). Others made lump-sum payments, like Shanghai (10.5 billion RMB), Shandong (0.3 billion), and Heilongjiang (0.29 billion). Some provinces paid lump-sum transfers with annual increases. Guangdong paid 1.4 billion in 1988 with a 9% annual increase, and Hunan paid 0.8 billion in 1988 with a 7% annual increase. Other provinces contributed a share of incremental revenue. For example, Beijing paid half of any increase in fiscal revenue above 4% to the central government

manage fiscal deficits and implement nationwide programs.

To address these fiscal shortfalls, the central government launched the tax-sharing reform in 1994. The reform restructured tax ownership: the central government received all revenue from excise taxes, tariffs, taxes from centrally administered state-owned enterprises (SOEs), and 75% of the value-added tax (VAT); local governments retained the business tax, local income taxes, and the remaining 25% of VAT.[3] During this period, VAT and excise taxes accounted for roughly 5% and 1% of GDP, respectively (Figure A1). Reassigning these broad-based taxes to the central government significantly increased its revenue share. The 2002 tax reform marked a further step toward redistribution. It reallocated 50% of corporate and personal income taxes from local to central governments, with the share rising to 60% in 2003. These taxes constituted stable and sizable revenue sources: corporate income taxes averaged 3% of GDP and personal income taxes over 1% (Figure A1). Importantly, the central government committed to transferring all centrally collected income tax revenues to underdeveloped regions, rather than using them to finance its own expenditures. In the top panel of Figure 1, transfers to local governments rose simultaneously alongside central revenues after 2002, consistent with this commitment.

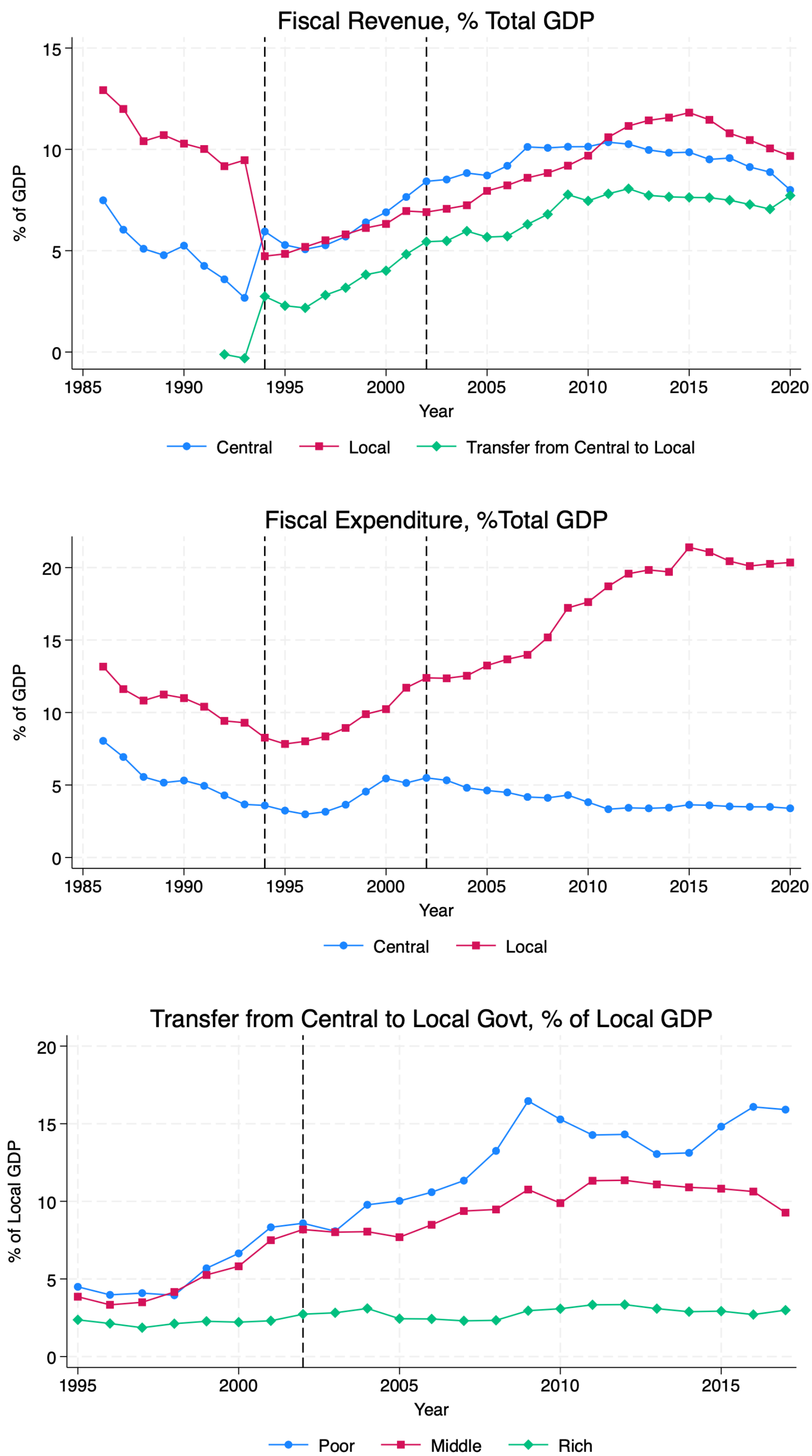
The bottom panel of Figure 1 illustrates the resulting redistribution across regions. Following the 1994 reform, transfers as a share of local GDP were only modestly higher in poor and middle-income provinces than in rich ones. But after 2002, the gap widened substantially. Transfers to rich provinces remained stable at around 3% of local GDP, while transfers to poor and middle-income provinces rose to 15% and 10%, respectively. These shifts fundamentally reshaped the regional distribution of fiscal resources and altered central–local relations. The next subsection develops a unified framework to model this redistribution system and discuss its impact on local fiscal policy.

2.2 Estimating Progressivity

To track the evolution of the redistribution system, I estimate the degree of progressivity using the widely applied BHSV tax function. I define the per capita net central tax as

[3] VAT is broadly applied to production and circulation; excise taxes target a narrow set of goods (e.g., tobacco, alcohol, autos); business taxes cover specific services, real estate, and intangible asset transfers.

Figure 1: Fiscal Receipts and Expenditure for the Central and Local Governments and Net Transfer from the Central to Local Governments



Note: The dashed lines marked the 1994 and the 2002 tax reforms. Data source: the NBS website. Provincial data on public finance are not available before 1995.

a function of total per capita fiscal revenues collected within each province, including tax revenues, non-tax revenue, extra-budgetary revenue, and land sales. Appendix A.1 provides details on data and measurement. Appendix A.2 provides an alternative specification where the net central tax is modeled as a function of GDP per capita, which yields similar estimates.

Let x_i denote per capita pre-redistribution fiscal income, and let $\tilde{x}_i$ denote per capita post-redistribution local fiscal income, defined as pre-redistribution income minus per capita central taxes plus per capita transfers from the central government. Following Heathcote, Storesletten and Violante (2017), I assume that post-redistribution income is log-linear in pre-redistribution income. Therefore, per capita net taxes paid to the central government can be expressed as:

$$T(x) = x - \tilde{x} = x - \lambda x^{1-\phi} \tag{1}$$

where ϕ governs the degree of progressivity and λ sets the average tax level. The term $1 - \phi$ captures the pass-through from pre- to post-redistribution fiscal revenue. Higher values of ϕ indicate greater progressivity. The tax function nests two extreme cases: when $\phi = 0$, the tax is linear; when $\phi = 1$, post-redistribution revenues are uniform across regions. For $\phi > 0$, the marginal tax rate $T'(x)$ is increasing in x.

Equation (1) can be estimated via the log-linear OLS regression:

$$\log \tilde{x}_{it} = \log \lambda + (1 - \phi) \log x_{it} + \epsilon_{it} \tag{2}$$

where ϵ_{it} is the error term. I exclude Tibet and Qinghai from the estimation because they receive substantial policy-driven ethnic transfers. Their inclusion results in substantially higher estimates of ϕ.

The top panel of Figure 2 plots the log of post-redistribution local fiscal revenue against the log of pre-redistribution fiscal revenue, along with the fitted regression line. The dotted 45-degree line represents equality between pre- and post-redistribution revenue. Provinces above (below) the 45-degree line receive net subsidies from (pay net taxes to) the central government. Two features stand out. First, the log-linear BHSV tax function provides a good description of the actual regional redistribution system, with R^2 around 0.9. Second, the fitted line in 2016-2017 is considerably flatter than that in 1998-1999, reflecting a stronger redistribution system and more equalized post-redistribution revenues across regions. The bottom panel reports year-by-year estimates of progressivity, with dotted lines denoting the 95% confidence interval. Estimated progressivity rose from 0.23 in 1998 to 0.48 in 2017, more than doubling over twenty years. The rising progressivity increased the average marginal tax rate on local fiscal income from 28% to 40%. [4]

The alternative estimate of progressivity in Appendix A.2 models the net central tax as a function of GDP per capita. This alternative approach yields similar but smoother and more stable results. The corresponding results are presented in Figure A2. The fitted line becomes increasingly flat over time and the estimated progressivity increases from 0.05 in 1998 to 0.26 in 2017.

2.3 Local Fiscal Policy

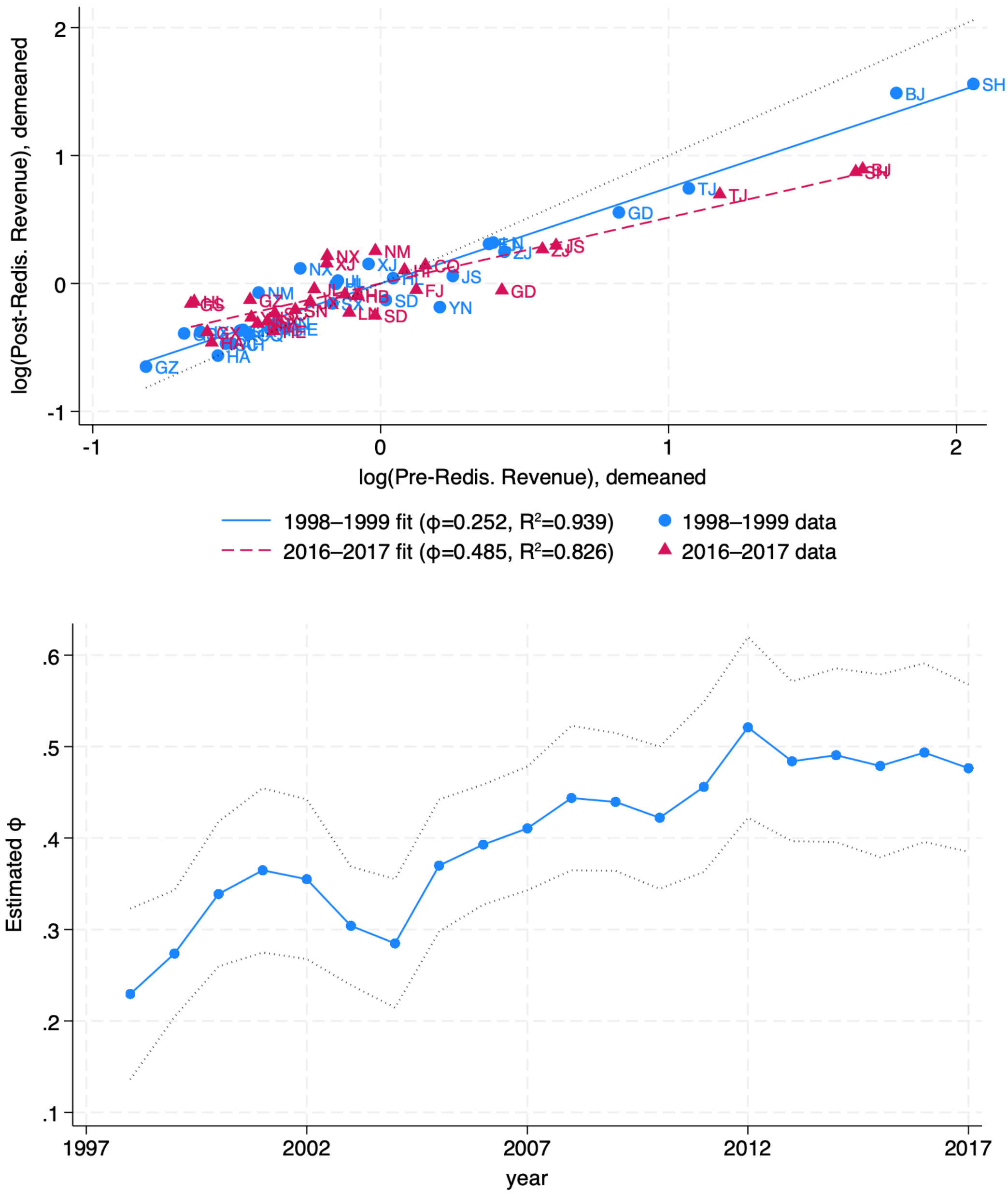
How did rising progressivity affect local fiscal policy? This subsection presents illustrative time-series evidence. Figure 3 displays the evolution of per-capita local fiscal revenue and expenditure, each normalized by annual national GDP per capita to ensure comparability across years.

When the central government redistributes fiscal resources from richer to poorer provinces, the disparity in post-redistribution government revenues shrank. The top panel of Figure 3 compares pre- and post-redistribution fiscal revenue over time. Although substantial differences persist in pre-redistribution revenues, the post-redistribution gap has narrowed markedly, indicating enhanced fiscal equality across regions. Figure A3 further confirms these patterns expressed as a share of local GDP. Rich provinces exhibit higher ratios of pre-redistribution fiscal revenue to local GDP due to stronger tax capacity and more profitable industries. After redistribution, however, low-income regions receive transfers that raise their revenue-to-GDP ratios.

Next, I broadly classify fiscal spending into government consumption and infras-

[4] Progressivity did not rise immediately after the 2002 tax reform. To stabilize fiscal conditions, the central government temporarily expanded transfers to the provinces that lost revenue, leading to a short-term decline in progressivity during 2002-2003. Subsequently, transfers to poorer provinces increased while those to richer provinces declined, generating a steady rise in progressivity after 2004 that stabilized around 0.5 after 2013. This pattern can also be observed in Figure A2.

Figure 2: Representation of the Regional Redistribution System through the BHSV Tax Function and Rising Progressivity



Note: The top panel plots the log of post-redistribution revenue per capita against the log of pre-redistribution revenue per capita across different periods. To ensure annual comparability, both pre- and post-redistribution are demeaned within each period. The bottom panel presents the OLS estimation of ϕ using Equation (2) for each year. The dotted lines represent the 95% confidence interval. Tibet and Qinghai are excluded.

tructure investment.[5] Local governments invest in infrastructure to promote regional growth, anticipating higher future fiscal revenues. However, increased progressivity raises the marginal tax rate and reduces the return to investment, particularly for rich provinces. Consequently, wealthier local governments are expected to shift more fiscal spending away from investment toward consumption. As shown in the bottom panel of Figure 3, while large cross-provincial differences in government consumption persist, the disparity in infrastructure investment diminishes over time and nearly vanishes by 2017.[6]

2.4 Economic Outcomes

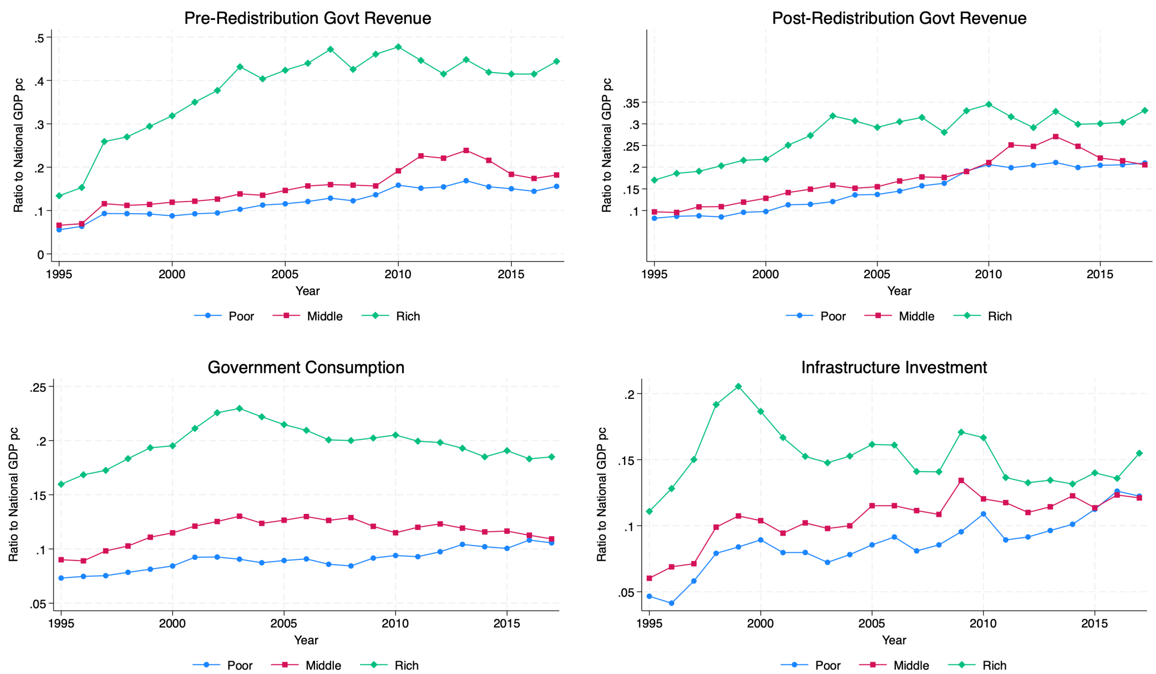
As the central government redistributes fiscal resources from rich to poor local governments, regions experienced uneven growth in infrastructure capital. The left panel of Figure 4 shows the evolution of infrastructure capital, measured in logs of per-capita terms and grouped by income levels. In the early 1990s, per capita infrastructure capital in rich provinces was significantly larger than that in poor provinces. As high-income regions gradually reduced infrastructure investment, this gap narrowed steadily and nearly disappeared by 2015.

Following the literature on capital misallocation, under the Cobb-Douglas production function, the efficiency of capital allocation can be assessed using the dispersion of capital-output ratios across regions. In the efficient allocation, the capital-output ratio should be uniform across regions. Higher dispersion indicates greater misallocation. The right panel of Figure 4 displays the ratio of infrastructure capital to GDP. Initially, these ratios were similar across income groups, suggesting efficient allocation. Over

[5] There are no official data on Chinese government investment or capital outlay as defined in the National Income and Product Accounts (NIPA). Following Song and Xiong (2023), I proxy government investment with infrastructure investment. Further details on data and measurement are provided in Appendix A.1.

[6] The sum of government consumption and infrastructure investment may not match the post-redistribution government revenues for several reasons: (1) Official NBS data do not separate central and local government consumption, which leads to an overstatement of local government consumption. The measure used here is regional government consumption from the provincial GDP expenditure-approach table. (2) Infrastructure investment, used as a proxy for government investment, may include SOE investment, potentially overestimating actual government investment. (3) Before 2009, although local governments were officially prohibited from borrowing, they launched local government financial vehicles (LGFVs) to fund infrastructure investment, creating discrepancies between fiscal revenues and observed expenditures.

Figure 3: Local Government Fiscal Revenue and Spending per capita, Grouped by GDP per capita



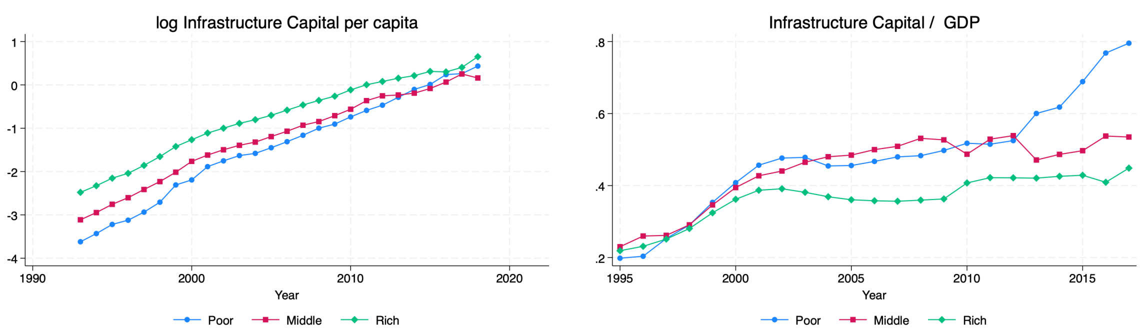
Note: The figure plots local government pre-redistribution revenue (top-left), post-redistribution revenue (top-right), government consumption (bottom-left), and infrastructure investment (bottom-right). Provinces are grouped by GDP per capita: poorest (circles), middle (squares), and richest (diamonds). The y-axis represents each variable divided by national GDP per capita.

time, however, poorer regions experienced rapid growth in their capital-output ratios due to sizable transfers from the central government, while richer regions underinvested. The resulting rising dispersion signals growing capital misallocation.

Figure 5 further highlights two salient growth patterns: rapid regional economic convergence and a pronounced slowdown in aggregate TFP growth following the tax reform. The top panels show that the variance of log provincial GDP per capita declined from 0.26 in 2005 to 0.16 by 2020, indicating strong σ-convergence. Using a Barro-style convergence regression (Barro, 1991), I estimate an annual convergence rate of 2.4% during 2004-2013, implying that it takes less than 30 years to reduce GDP differences by half between any two provinces.

The bottom panels plot aggregate TFP, measured as the Solow residual. Two alternative TFP measures are shown: one that distinguishes between infrastructure and non-infrastructure capital (circles), and one that aggregates total capital (diamonds). Both exhibit pronounced slowdown in TFP growth after the mid-2000s. The annual TFP growth rate fell from about 5% around 2005 to below 1% after 2015.

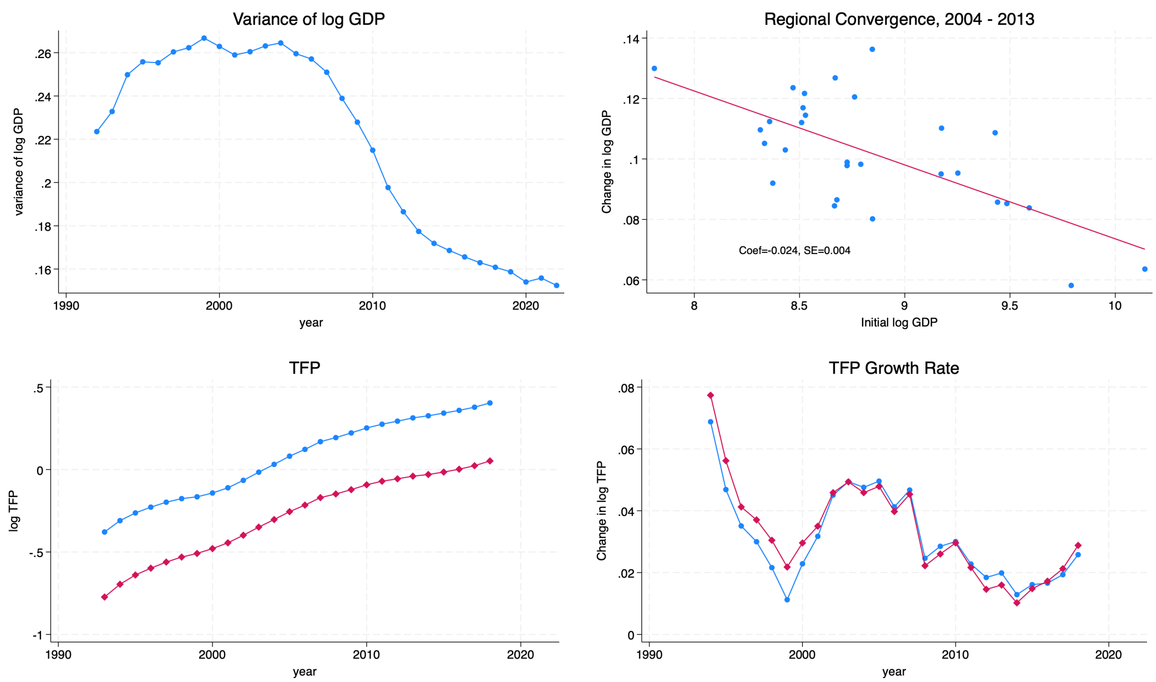
Figure 4: Infrastructure Capital: Log Per Capita Level and Share of GDP



3 Identifying Responses to the 2002 Tax Reform

So far, I have documented a sharp rise in progressivity, accompanied by a decline in local fiscal spending on infrastructure investment and a narrowing regional disparity. While these trends coincide temporally, time-series patterns alone cannot establish causality. The goal of this section is to identify the causal relationships among regional redistribution, local fiscal policy, and regional economic growth. I proceed by outlining the

Figure 5: Regional Economic Convergence and Aggregate TFP Growth Slowdown



Note: This figure displays the declining variance of log provincial GDP per capita (top-left), the β-convergence regression (top-right), measured aggregate TFP (bottom-left), and the TFP growth rate (bottom-right). In the bottom panels, circles plot $\log(\text{GDP}) - 0.185\log(\text{Infrastructure Capital}) - 0.315\log(\text{Non-infrastructure Capital})$; diamonds plot $\log(\text{GDP}) - 0.5\log(\text{Capital})$.

event-study empirical strategy and presenting the main results of local fiscal responses to the 2002 tax reform. Robustness checks are reported in Appendix B.

3.1 Empirical Strategy

Although the 2002 tax reform was implemented nationwide, its fiscal impact varied systematically across provinces due to pre-existing differences in their tax structure. The reform reallocated 50% of corporate and personal income taxes from local to central governments, thereby reducing local governments' fiscal returns to infrastructure investment. Since local governments invest in infrastructure to expand their future tax bases, this reallocation weakened their incentives to invest, especially in provinces that relied heavily on income taxes.

The reform could reduce infrastructure investment through two channels. First, by transferring more revenue to the center, it lowered local governments' post-redistribution fiscal income and thus their fiscal capacity to invest, which I refer to as the *income channel*. Second, because local governments could retain a smaller share of the future tax revenue generated by local growth, it also reduced the return to infrastructure investment and induced them to reallocate spending away from investment toward consumption, which I refer to as the *incentive channel*. I exploit cross-provincial heterogeneity in exposure to these effects using an event-study design, with the pre-reform share of income taxes in total tax revenue as the treatment variable. Provinces with higher shares experienced larger effective revenue losses after the reform, making them more adversely affected by the policy shock. This design allows me to identify the causal impact of the reform on provincial infrastructure investment and economic growth. Appendix B.1 discusses the historical and institutional factors that shape heterogeneity in the pre-reform tax composition.

Although the reform was officially implemented in 2002, discussions began and policy details were announced in 2001. The central government also committed to compensating local governments based on their 2001 income tax collections, leading to strategic anticipation by local governments.[7] To avoid such anticipation effects, I use 2000 as

[7]For example, corporate income tax collection spiked in the fourth quarter of 2001 as local governments front-loaded tax collections to raise the baseline for future transfers (Lan, 2021).

the baseline year. Formally, I define the treatment variable Z_i as:

$$Z_i = \frac{\text{Corporate Income Tax}_{it_0} + \text{Personal Income Tax}_{it_0}}{\text{Total Tax Revenue}_{it_0}} \tag{3}$$

where $t_0 = 2000$.

I estimate a difference-in-differences (DiD) model with continuous treatment:

$$\text{outcome}_{it} = \zeta_i + \nu_t + \sum_{\iota \neq t_0} \beta_\iota Z_i \times \mathbb{1}\{t = \iota\} + \varepsilon_{it} \tag{4}$$

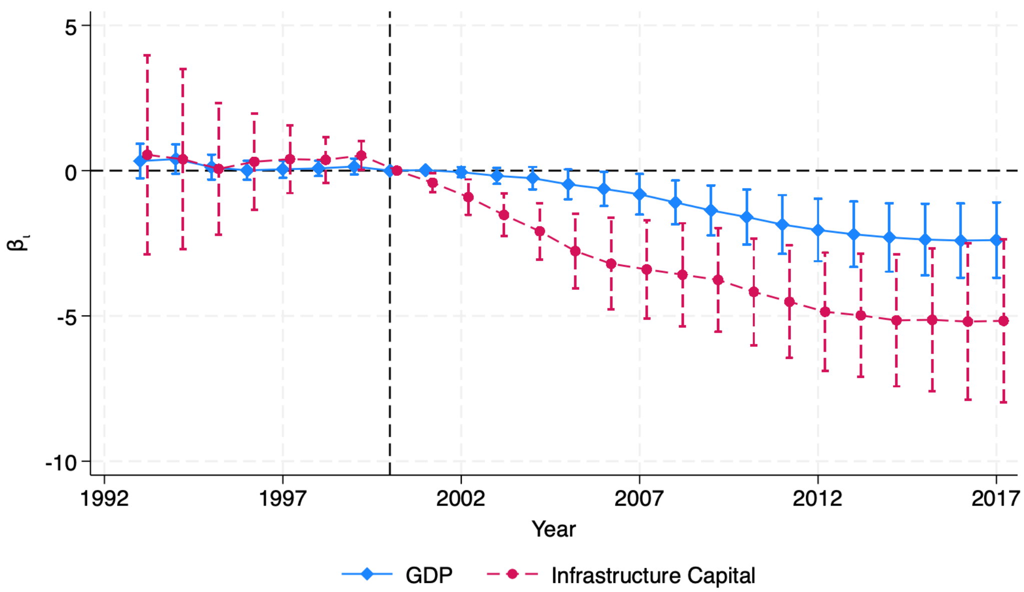
where outcome_{it} is the log of output per capita or the log of infrastructure capital stock per capita of province i in year t. The regression includes province fixed effects ζ_i, year fixed effects ν_t, the interaction of the treatment variable Z_i with year dummies, and the error term ε_{it}. The time dummy for the baseline year t_0 is omitted. Each coefficient β_ι captures changes in the relationship between the outcome variable and the treatment variable in year ι relative to the baseline year 2000. The identifying assumption is that, in the absence of the 2002 tax reform, provinces with different pre-reform shares of income taxes would have experienced the same growth patterns of infrastructure capital and output.

3.2 Main Results

Figure 6 plots the estimated coefficients β_ι from Equation (4), along with 95% confidence intervals. Diamonds (solid line) represent results for log GDP, while circles (dashed line) show log infrastructure capital. The vertical dashed line marks the baseline year $t_0 = 2000$.

The pre-trends are flat and statistically indistinguishable from zero for both outcome variables, supporting the parallel trends assumption. Following the reform, the estimated coefficients become significantly negative, consistent with the time-series evidence that the reform reduced local governments' incentives to invest in infrastructure and slowed regional economic growth. In a static two-way fixed-effects regression, the coefficients are -3.90 (s.e. 1.19) for infrastructure capital and -1.44 (s.e. 0.42) for output. A one standard deviation increase in the pre-reform share of income taxes reduces

Figure 6: Treatment Effects of the Tax Reform on Regional GDP and Infrastructure Capital.



Note: This figure presents the estimated coefficients β_ι from Equation (4), with 95% confidence intervals. Each coefficient captures the differential relationship between the outcome variable and the pre-reform income tax share, relative to the year 2000. Diamonds (solid line) plot results for log GDP; circles (dashed line) for log infrastructure capital. The sample includes 30 provinces over the period 1993–2017. Standard errors are clustered at the provincial level.

infrastructure capital by 17% and GDP by 6%.

Figure B4 presents the effects on local fiscal revenue and government consumption. The reform significantly reduced post-redistribution government revenue in provinces with high income-tax shares, but had no significant effect on pre-redistribution revenue or government consumption. The lack of response in pre-redistribution revenue suggests that local governments did not offset the reform by increasing tax effort or tax collection. The decline in post-redistribution revenue is consistent with the income channel, under which the reform reduced local fiscal resources available for investment. The absence of a significant response in government consumption further suggests that this income effect was offset by an incentive effect: the reform lowered the return to infrastructure investment, inducing local governments to shift spending away from investment and toward consumption. Although the data do not allow me to separately identify the two channels, both imply lower infrastructure investment following the reform.

Appendix B discusses the historical origins of the treatment variable and presents a set of robustness checks and placebo tests. Table B1 shows that the pre-reform income-tax share is uncorrelated with a wide range of provincial characteristics. Figure B4 confirms that other economic variables, such as local government debt, land sales, and trade-related outcomes, were unaffected by the reform. Figure B5 reports a placebo test showing that the treatment effects are specific to the targeted tax categories and are not driven by other unrelated fiscal instruments or reforms. Together, these results help rule out alternative explanations related to land finance, the emergence of local government financing vehicles, WTO accession, structural change, and the SOE reform.

Overall, the event-study analysis establishes a causal link among regional redistribution, local fiscal policy, and regional economic growth. The 2002 tax reform significantly reduced infrastructure investment and slowed regional economic growth in provinces that were more exposed to the reform. These findings motivate the theoretical framework developed in the next section.

An important by-product of this analysis is validation for using the pre-reform share of income taxes as an instrument to estimate the output elasticity of infrastructure capital in Section 5.1. As discussed above, the central-local tax-sharing rule affects regional economic performance exclusively through local government investment. The event-study results support the assumption of parallel trends, lending credibility to the exclusion restriction that the pre-reform share is uncorrelated with the structural error term in the growth of infrastructure and output.

4 A Model of Local Fiscal Policy under Regional Redistribution

This section introduces the economic environment and characterizes the steady-state equilibrium allocation. The model does not admit a closed-form solution for transitional dynamics, which will instead be computed numerically in the quantitative analysis. The theoretical framework is intended to clarify the mechanism through which regional redistribution distorts local fiscal policy and influences regional economic outcomes, and to derive further implications for optimal policy design.

4.1 Economic Environment

The economy consists of a unit measure of regions, indexed by $i \in [0, 1]$. Each region is a small open economy comprising a representative household, a representative firm, and a local government. A single central government governs the entire economy. Regions differ with respect to regional TFP A and the public capital stock k_G. At this stage, TFP is the sole source of the innate heterogeneity. In the quantitative analysis, I will introduce wedges on the firm's capital rent rate to better match the data.

Timeline. The interaction between the central government and local governments is modeled as a Stackelberg game, where the central government is the leader that sets the redistribution policy, and local governments are followers. The timing is as follows:

1. The central government announces the redistribution policy $\{\phi_t, \lambda_t\}_t$, the output tax rate $\{\tau_{yt}\}_t$, and central government consumption $\{G_t^C\}_t$. For convenience, define $g_t = G_t^C/Y_t$ as the ratio of central government consumption to aggregate output. The output tax rate is uniform across regions.[8]

[8] In Sections 4 and 5, central policies are treated as exogenously given in the positive analysis. In Section 6, these policies are endogenized in the normative analysis.

2. Given central fiscal policies $\{\phi_t, \lambda_t, \tau_{yt}, g_t\}_t$, each local government chooses its own consumption G_{it} and next-period public capital k_{Git+1}, subject to the post-redistribution fiscal income.

3. Given local fiscal policies, firms rent private capital k_{it} and hire labor n_{it} to produce and pay taxes $\tau_{yt} y_{it}$. Households inelastically supply unit labor.

Hereafter, I omit the time subscript t and use recursive notation, with x' denoting the next-period x.

Technology and Firm. The production function is Cobb-Douglas:

$$y_i = A_i k_{Gi}^{\alpha} k_i^{\theta} n_i^{1-\alpha-\theta} \tag{5}$$

where α and θ are output elasticities of public and private capital, respectively. The production function exhibits constant returns to scale on the aggregate level but decreasing returns to scale at the firm level.

Each region is a small open economy with a unit measure of representative firms. Taking the world interest rate R and local wage rate w_i as given, each firm rents private capital k_i from the world capital market and hires labor n_i from the local labor market to maximize profits π_i. The firm's problem is given by:

$$\max_{k_i, n_i} \pi_i = (1 - \tau_y) y_i - R k_i - w_i n_i \tag{6}$$

subject to the production function (5). Profits are fully distributed to the representative household.

First-order conditions with respect to n_i and k_i, along with the labor-market clearing condition $n_i = 1$, yield the local firm's production plan and the expressions for local wage rate:

$$
\begin{aligned}
k_i &= \left(\frac{\theta(1-\tau_y)}{R}\right)^{\frac{1}{1-\theta}} A_i^{\frac{1}{1-\theta}} k_{Gi}^{\frac{\alpha}{1-\theta}} \\
y_i &= \left(\frac{\theta(1-\tau_y)}{R}\right)^{\frac{\theta}{1-\theta}} A_i^{\frac{1}{1-\theta}} k_{Gi}^{\frac{\alpha}{1-\theta}} \\
w_i &= (1-\alpha-\theta)\left(\frac{\theta}{R}\right)^{\frac{\theta}{1-\theta}} (1-\tau_y)^{\frac{1}{1-\theta}} A_i^{\frac{1}{1-\theta}} k_{Gi}^{\frac{\alpha}{1-\theta}} \\
\pi_i &= \alpha\left(\frac{\theta}{R}\right)^{\frac{\theta}{1-\theta}} (1-\tau_y)^{\frac{1}{1-\theta}} A_i^{\frac{1}{1-\theta}} k_{Gi}^{\frac{\alpha}{1-\theta}}
\end{aligned}
\tag{7}
$$

The redistribution policy (ϕ, λ) and central government consumption g do not directly enter the firm's decisions. Although redistribution affects public capital k_G, firms treat it as exogenous. Intuitively, firms respond only to the effective output tax rate τ_y, not to how tax revenue is redistributed.

Corollary 1 (Firm behavior)**.** *The redistribution policy (ϕ, λ) does not directly affect the firm's production plan.*

Household. The representative household supplies unit labor inelastically and receives both wages and firm profits. I assume the logarithmic utility function:

$$
\begin{aligned}
u(c_i, G_i, G^C) &= \log c_i + \chi^L \log G_i + \chi^C \log G^C \\
\text{s.t.} \quad c_i &= w_i + \pi_i
\end{aligned}
\tag{8}
$$

where w_i and π_i are determined in equilibrium. The household derives utility from household consumption c_i, local government consumption G_i, and central government consumption G^C. The parameters χ^L and χ^C govern the relative preference for local and central public goods, respectively. Government consumption G_i and G^C are exogenous to the household. Since capital accumulation is not modeled at the household level, households are assumed to be hand-to-mouth, consuming all income each period: $c_i = w_i + \pi_i = (1-\theta)(1-\tau_y)y_i$.

Local Governments. The local government discounts the future utility at β and chooses current local government consumption G_i and next-period public capital k'_{Gi} to maximize the local household welfare subject to the post-redistribution fiscal income $\lambda(\tau_y y_i)^{1-\phi}$. Local governments are not allowed to save or borrow. The Bellman equation is:

$$\begin{aligned} v(A_i, k_{Gi}) &= \log c_i + \chi^L \log G_i + \beta v(A_i', k_{Gi}') \\ \text{s.t.} \quad G_i + k_{Gi}' &\leq \lambda(\tau_y y_i)^{1-\phi} + (1-\delta)k_{Gi} \end{aligned} \tag{9}$$

where y_i is determined by the firm's problem (6), and c_i follows from the household problem in Equation (8).

Central Government. The central government's budget constraint is then given by

$$\tau_y \int y_i di = \lambda \int (\tau_y y_i)^{1-\phi} di + g \int y_i di \tag{10}$$

where c_i, y_i, and G_i are determined by the local government problem (9). Given the policy parameters (ϕ, τ_y, g) and the optimal responses of local governments, λ is endogenously determined in equilibrium. The budget constraint ensures that total central tax revenue equals the sum of redistributed transfers to local governments and central government consumption.

Resource Constraint. Aggregate output in this economy is used for household consumption, local government consumption, central government consumption, and the rental payments on firms' capital to foreign lenders. The aggregate resource constraint is:

$$\int (c_i + G_i + Rk_i) di + G^C = \int y_i di \tag{11}$$

4.2 Discussion of the Model

The goal of the model is to study how regional redistribution distorts local fiscal policy and regional economic growth. Before characterizing the equilibrium allocation, I briefly discuss key modeling choices.

The model builds on the Mandarin growth model of Song and Xiong (2023), in which local officials promote GDP growth through infrastructure investment to increase their likelihood of promotion. While my framework abstracts from explicit promotion incentives, it captures this motivation in reduced form through a trade-off between public goods and infrastructure investment, governed by the parameter χ^L. Stronger political incentives, which encourage infrastructure investment, are equivalent to placing a lower weight on public goods. In the baseline model, I also abstract from local government debt and land finance. This assumption simplifies the analysis and helps maintain tractability and generality. It is also consistent with the event-study evidence, which shows little systematic response of local government debt or land finance to the 2002 tax reform (Figure B4). Appendix D extends the framework to include local government debt and land finance. When local governments have access to debt, optimal public capital is chosen so that the post-redistribution marginal return to public investment equals its marginal cost, R. This extension delivers the same qualitative implications as the baseline model. I therefore use the no-debt model as the baseline and focus on how redistribution distorts the composition of local spending between public goods and infrastructure investment.

The model also abstracts from interregional migration. While Tombe and Zhu (2019) and Hao et al. (2020) emphasize the declining migration costs as a driver of convergence, Brandt, Kambourov and Storesletten (2025), using the Chinese Industry Census, find limited effects of migration on convergence. The focus of the model is the distortionary effect of regional redistribution on local public investment and, in turn, the misallocation of infrastructure capital across regions. I therefore rule out migration and normalize the population in each region to one.

In the positive analysis in Sections 4 and 5, I take central government policy $\{\tau_y, \phi, g\}$ as given and quantify its economic effects. In the normative analysis in Sections 6 and 7, I endogenize these policy parameters.

4.3 Equilibrium

This section characterizes the equilibrium allocations under the redistribution policy. I first formally define the equilibrium.

Definition 1 (Competitive equilibrium). *Given the TFP sequence $\{A_{it}\}_{i,t}$, the world interest rate R, and the policy sequence $\{\phi_t, \lambda_t, g_t, \tau_{yt}\}_t$, a competitive equilibrium consists of local government fiscal policy $\{k_{Git+1}, G_{it}\}_{i\in[0,1],t}$, household consumption $\{c_{it}\}_{i\in[0,1],t}$, firm production plans $\{y_{it}, k_{it}, n_{it}, \pi_{it}\}_{i\in[0,1],t}$, and local wage rates $\{w_{it}\}_{i\in[0,1],t}$, such that*

1. *Given (k_{Git}, w_{it}, R), $(y_{it}, k_{it}, n_{it}, \pi_{it})$ solves the firm's problem in (6).*

2. *The household consumes all labor income and profits each period: $c_{it} = w_{it} + \pi_{it}$.*

3. *Given the central government policy $\{\phi_t, \lambda_t, g_t, \tau_{yt}\}_t$, firm production plan y_{it}, and household consumption c_{it}, (k_{Git+1}, G_{it}) solves the local government problem in (9).*

4. *The local labor market clears: $n_{it} = 1$.*

5. *The central government budget constraint (10) holds.*

6. *The resource constraint (11) holds.*

Definition 2 (Steady-state equilibrium)**.** *A steady state is a competitive equilibrium with time-invariant productivity $\{A_i\}_i$ and policy $(\phi, \lambda, \tau_y, g)$ such that $k_{Git} = k_{Git+1}$ for all i.*

To illustrate the mechanism through which regional redistribution distorts local fiscal policy and regional economic growth, I characterize the steady-state equilibrium allocation in a simplified economy. I assume no TFP growth, and that productivity and central policy are time-invariant in the steady state, with the cross-sectional distribution $\log A_i \sim \mathcal{N}(-\sigma_a^2/2, \sigma_a^2)$. Proposition 1 characterizes regional output in the steady state.

Proposition 1 (Steady-state equilibrium allocation)**.** *Given the time-invariant TFP A and central policy (ϕ, g, τ_y), the equilibrium output in the steady state is given by*

$$\log y(A; \phi, \tau_y, g) = \log Y^R(\phi, \tau_y, g) + \frac{1}{1-\theta-\alpha(1-\phi)} \log A + \log \Omega^y(\sigma_a^2; \phi) \tag{12}$$

where Y^R is the output of the representative region:

$$\begin{aligned} \log Y^R(\phi, \tau_y, g) = \frac{\alpha}{1-\theta-\alpha} \log \left(\frac{\alpha\beta(1+\chi^L(1-\phi))}{\chi^L(1-\theta)(1-\beta(1-\delta)) + \alpha\beta\delta} \right) \\ + \frac{\theta}{1-\theta-\alpha} \log \left(\frac{\theta(1-\tau_y)}{R} \right) + \frac{\alpha}{1-\theta-\alpha} \log(\tau_y - g) \end{aligned} \tag{13}$$

and Ω^y is constant and defined in Appendix C.1

The steady-state equilibrium output consists of three terms. The first term of Equation (12) reflects the output level of the representative region. Specifically, the first line of Equation (13) captures the effect that higher progressivity ϕ reduces the marginal return to government investment, inducing local governments to shift spending away from investment toward government consumption. With logarithmic utility, this effect is invariant to TFP levels and uniform across regions, reducing both public capital and output levels. The second term captures the role of regional heterogeneity in TFP A. Output is increasing in TFP, but as ϕ rises, the responsiveness of output y to TFP A declines. This reflects the redistributive channel: higher progressivity shrinks the pass-through from regional TFP to regional output by reallocating fiscal resources from high- to low-productivity regions. The third term reflects the residual effects of the cross-sectional distribution of productivity.

Corollary 2 delivers the ratio of government consumption to public investment. This ratio is uniform across regions and is increasing in ϕ because higher progressivity reduces the marginal return to investment, which motivates local governments to allocate a larger share of resources to consumption.

Corollary 2 (Local government spending share). *The ratio of local government consumption to investment is given by*

$$\frac{G_i}{\delta k_{Gi}} = \frac{\chi^L(1-\theta)(1-\beta(1-\delta)) - \alpha\beta\delta\chi^L(1-\phi)}{\delta\alpha\beta(1+\chi^L(1-\phi))} \tag{14}$$

Corollary 3 characterizes how redistribution shapes the distribution of regional output. Higher progressivity compresses the dispersion in regional output. This follows directly from Equation (12) that progressivity dampens the responsiveness of regional output to TFP.

Corollary 3 (Output dispersion). *The variance of log regional output is given by*

$$\text{var}(\log y(A;\phi,\tau_y,g)) = \frac{\sigma_a^2}{(1-\theta-\alpha(1-\phi))^2}$$

Next, Proposition 2 derives the closed-form expression of aggregate quantities in the steady state. Let $Y = \int y_i di$, $K_G = \int k_{Gi} di$, and $K = \int k_i di$ denote the aggregate output, public capital, and private capital, respectively. Aggregate TFP is calculated as the Solow residual: $\log Y - \alpha \log K_G - \theta \log K$.

Proposition 2 (Steady-state aggregate quantities)**.** *The aggregate output is given by*

$$\log Y(\sigma_a^2; \phi, \tau_y, g) = \log Y^R(\phi, \tau_y, g) + \frac{1}{1-\theta-\alpha} \log \mathrm{TFP}$$

where $\log Y^R(\phi, \tau_y, g)$ *is output in the representative region given by Equation* (13) *and* $\log \mathrm{TFP}$ *is the aggregate TFP given by:*

$$\log \mathrm{TFP}(\sigma_a^2; \phi) = \frac{\theta+\alpha}{1-\theta-\alpha}\frac{\sigma_a^2}{2} - \underbrace{\frac{\alpha(1-\theta)\phi^2}{(1-\theta-\alpha(1-\phi))^2(1-\theta-\alpha)}\frac{\sigma_a^2}{2}}_{\text{Distortion}} \tag{15}$$

Aggregate output is composed of two main terms. The first term is the output of the representative region, which, as discussed before, is decreasing in progressivity ϕ as progressivity shifts local fiscal spending away from public investment. The second term is aggregate productivity scaled by the technology parameters. Aggregate TFP is composed of two terms. The first term captures the effects of the TFP dispersion in a *non-redistribution* economy. When $\phi = 0$, aggregate efficiency is increasing in TFP dispersion. This occurs because both output and capital are convex in TFP. A mean-preserving spread in TFP causes capital to reallocate disproportionately toward high-productivity regions, raising aggregate efficiency. The second term captures the distortionary effects of redistribution policy. Any deviation from $\phi = 0$ introduces capital misallocation. When $\phi > 0$, high-productivity regions are underinvested relative to efficiency. Conversely, under regressive redistribution ($\phi < 0$), they are overinvested. Both situations lead to capital misallocation and reduce aggregate TFP.

Corollaries 4 and 5 summarize the impact of progressivity on aggregate output and efficiency. Corollary 4 states that higher progressivity always reduces steady-state aggregate output. This occurs through two channels: first, it distorts capital allocation by reallocating resources from high- to low-productivity regions; second, it induces local governments to shift spending from productive investment toward unproductive consumption. Corollary 5 shows that aggregate efficiency is maximized precisely at $\phi = 0$; any deviation induces capital misallocation and reduces aggregate TFP.

Corollary 4 (Progressivity and output)**.** *When* $\phi \geq 0$*, aggregate output is strictly decreasing in* ϕ *in the steady state.*

Corollary 5 (Progressivity and efficiency). *Aggregate TFP in the steady state is maximized precisely at $\phi = 0$.*

5 Model Implications for Fiscal Distortion, Output Dispersion, and Aggregate Productivity

This section examines the model's quantitative implications for regional convergence and aggregate efficiency. I start by describing the parameterization strategy, with particular attention to estimating the output elasticity of infrastructure capital. I then evaluate the model performance by comparing untargeted moments from the model to their empirical counterparts. I also conduct counterfactual experiments to quantify the effects of rising progressivity on local fiscal policy, output dispersion, and aggregate TFP.

5.1 Parameterization

This subsection outlines the model parameterization strategy. The core mechanism is that redistribution influences regional growth by distorting local fiscal spending on infrastructure. Therefore, it is crucial to estimate the output elasticity of infrastructure capital.

Output Elasticity. I estimate the output elasticity of infrastructure capital using the pre-reform share of income tax as an IV. As discussed in Section 3, this share measures local government exposure to the 2002 tax reform. Provinces with higher shares experienced significantly lower post-reform growth in both infrastructure capital and output. More importantly, the central-local revenue-sharing rule influences only local government policy, without directly affecting household or firm behavior. This is consistent with Corollary 1.

For any variable x_{it}, define average growth in x from the base year t_0 to year t as $\Delta x_{it} = (x_{it} - x_{it_0})/(t - t_0)$. The reduced-form specification is:

$$\Delta \log y_{it} = \alpha_0 + \alpha \Delta \log k_{Git} + \upsilon_{it}$$

with the first stage:

$$\Delta \log k_{Git} = \rho_0 + \rho Z_i + \xi_{it}$$

where y_{it} and k_{Git} are output and infrastructure capital per capita, consistent with their theoretical counterparts in Section 4. The instrument Z_i is the pre-reform share of income tax defined by Equation (3).

The exclusion restriction requires that Z_i is uncorrelated with both υ_{it} and ξ_{it}. Although this assumption is not directly testable, it is supported by the parallel pre-trends in Figure 6. Table B1 confirms that Z_i is uncorrelated with a broad set of confounders, and Figure B4 shows that Z_i affects only local fiscal policy, with no significant influence on other economic outcomes.[9] Together, these findings support the exclusion restriction. For the relevance condition, we expect $\rho < 0$: provinces more exposed to the reform invested less in infrastructure. Under a valid instrument, the two-stage least squares estimate $\hat{\alpha}$ recovers the causal effect of infrastructure capital on output.

Notably, Figure B4 shows that high-share provinces experience a decline in non-infrastructure capital after 2010, suggesting a long-run crowd-in effect from infrastructure investment on private capital. While this constitutes an indirect channel through which infrastructure improves output, it may upwardly bias the estimated elasticity. In addition, standard errors in Figure 6 increase over time, likely reflecting attenuation of the reform's effect. To address this concern, I restrict the IV estimation sample to 2001–2010.

Table 1 summarizes the results of IV estimation. All regressions include year fixed effects, and standard errors are clustered by provinces. Columns (1) and (2) use pre-reform data (1993–2000) to regress growth in infrastructure capital and GDP on the pre-reform share of income taxes. The coefficients are statistically insignificant, supporting the exclusion restriction. Columns (3) and (4) present OLS estimates of the output elasticity of infrastructure capital, around 0.10. Columns (5) and (6) present the first stage: a one percentage point increase in Z_i reduces infrastructure capital growth by roughly 0.5 percentage points, with an F-statistic above 20. Columns (7) and (8) show significant reduced-form effects on GDP. Columns (9) and (10) present the IV

[9] In particular, the lack of association with other policy instruments—such as tax cuts, government consumption, or debt issuance—helps rule out alternative channels.

estimates: the estimated output elasticity of infrastructure capital lies between 0.185 and 0.189 and is statistically significant. Controlling for growth in non-infrastructure capital improves the precision of the estimates without altering the magnitude.

The magnitude of the IV estimate is broadly consistent with existing estimates in the literature. The meta-analysis by Bom and Ligthart (2014) reports an average elasticity of 0.106, which rises to 0.193 in settings involving regional government investment in core infrastructure. 0.185–0.189 falls within this range and aligns especially well with the subset of studies focused on regional infrastructure investment.

Table 1: Output Elasticity of Infrastructure Capital, IV Estimation

	1993-2000		2001-2010							
	OLS		OLS		OLS First Stage		OLS Second Stage		IV	
	$\Delta \log k_G$	$\Delta \log y$	$\Delta \log y$		$\Delta \log k_G$		$\Delta \log y$		$\Delta \log y$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Z_i	-0.153	-0.048			-0.476***	-0.473***	-0.090**	-0.087***		
	(0.200)	(0.050)			(0.105)	(0.104)	(0.041)	(0.032)		
$\Delta \log k_G$			0.117**	0.095**					0.189**	0.185***
			(0.051)	(0.044)					(0.080)	(0.065)
$\Delta \log k$				0.167***		0.184		0.183***		0.149***
				(0.044)		(0.127)		(0.050)		(0.049)
Constant	0.233***	0.088***	0.080***	0.065***	0.217***	0.196***	0.111***	0.091***	0.051***	0.041***
	(0.040)	(0.010)	(0.007)	(0.008)	(0.023)	(0.023)	(0.008)	(0.008)	(0.014)	(0.011)
R^2	0.026	0.078	0.316	0.475	0.307	0.328	0.268	0.467	0.271	0.407
Observations	210	210	300	300	300	300	300	300	300	300
F-stat					20.33	20.69				

Note: y, k_G, and k denote GDP per capita, infrastructure capital per capita, and non-infrastructure capital per capita, respectively. Z_i is the share of income taxes in 2000. All regressions include year fixed effects. Standard errors are clustered by 30 provinces.

A recent study, Su (2023), proposes an alternative instrument for local government spending: the share of unoccupied urban land prior to the expansion of land finance. In the 2000s, the central government authorized local governments to finance expenditures through land-use right sales. Unoccupied land—where compensation to occupants is not required—was cheaper to expropriate, making its sale more profitable. As a result, regions with a higher share of unoccupied land could more easily raise funds, relaxing their fiscal constraints and enabling greater spending. Su (2023) uses this variation to estimate the local fiscal multiplier. However, budget data reveal that net revenues from land sales were used almost exclusively for infrastructure investment and were generally not allocated to other forms of public goods provision.[10] Therefore, I argue

[10]See "The Budget and Final Account of Local Government-Managed Fund" in Finance Yearbook of

that the fraction of unoccupied land is more appropriately interpreted as an instrument for infrastructure investment, rather than for broader government spending.

I include the pre-reform fraction of unoccupied land as an additional instrument for the robustness check. Table B2 presents the results. Columns (1) and (2) verify the exclusion restriction that the fraction is uncorrelated with changes in government consumption and non-infrastructure capital. This is consistent with its narrow channel of influence through infrastructure spending.[11] Columns (3) and (4) report the first-stage regressions. A one percentage point increase in the fraction of unoccupied land raises infrastructure capital growth by 0.118 percentage points. Including the original instrument—the pre-reform share of income taxes—does not alter the coefficient or its statistical significance. Columns (5) and (6) report the results of IV estimation. Column (5) uses only the land fraction instrument, while Column (6) includes both instruments. The estimated coefficients range from 0.168 to 0.181, closely matching the benchmark estimate of 0.185 from Table 1. With two instruments, I conduct an overidentification test. The Hansen J statistic is 0.029 (p = 0.864), indicating that we cannot reject the null of instrument validity. This supports the joint use of both instruments in identifying the causal effect of infrastructure capital on output.

Based on my IV estimation, I set $\alpha = 0.185$ in the quantitative analysis. $\theta = 0.315$ is set to match the 50% labor income share in China.[12]

Other Parameters. I set $\beta = 0.96$, $\delta = 0.13$, and $R = r + \delta = 0.18$.[13] Policy parameters are estimated directly from the data. Specifically, the degree of progressivity ϕ_t is estimated each year using Equation (2), as shown in Figure 2. The output tax rate τ_{yt} is computed as the ratio of aggregate government revenue to aggregate GDP. I assume that net central taxes are entirely used to finance central government consumption. Thus, the share of central government consumption in GDP, g_t, is measured as the share of central taxes net of transfers to aggregate GDP. I abstract from the fact that

China (2010–2014). These are the only years in which the disaggregated land fund account is available.

[11]For additional analysis and results on this instrument, see Su (2023).

[12]Figure B6 employs the Bartik-style instruments to jointly estimate the output elasticity of non-infrastructure capital. It supports the assumption of constant returns to scale.

[13]The depreciation rate follows Bai, Hsieh and Qian (2006) and Song and Xiong (2023), who compute it using official depreciation schedules for "Construction and Installation", "Purchase of Equipment and Instruments", and "Others" categories across industries. Both studies report depreciation rates above 10%. Since capital stock is calculated using the perpetual inventory method, the quantitative results are robust to alternative specifications.

a portion of central government spending is financed through government debt. Figure E7 shows the time path of τ_y and g.

In the quantitative analysis, I empirically calculate regional TFP as the Solow residual:

$$\log A_{it} = \log y_{it} - \alpha \log k_{Git} - \theta \log k_{it}$$

where y_{it}, k_{Git}, and k_{it} are per capita measurements.

To capture the observed dispersion of private capital-output ratio, I allow firms to face region-specific wedges on capital rental rates. The firm's problem becomes:

$$\max_{k_i, n_i} \pi_i = (1 - \tau_y) y_i - (1 + \tau_{ki}) R k_i - w_i n_i$$

This extension follows Hsieh and Klenow (2009) and Brandt, Kambourov and Storesletten (2025), and captures distortions such as differential borrowing costs or state-sector favoritism. The capital wedge, $1 + \tau_{kit}$, is identified from the firm's first-order condition:

$$\log(1 + \tau_{kit}) = \log\left(\frac{\theta(1 - \tau_{yt})}{R}\right) + \log\left(\frac{y_{it}}{k_{it}}\right)$$

Figure E8 presents the joint distribution of TFP and capital wedges. In Appendix E.3, Table E4 reports quantitative results without capital wedges.

Finally, $\chi^L = 0.230$ is calibrated using simulated moments to match the aggregate ratio of infrastructure investment to output. As shown in Equation (14), a higher spending share of investment can arise from either a higher discount factor or lower utility from public goods. Given a different value of β, χ^L can be recalibrated to target the same ratio. Hence, the quantitative results are robust to alternative parameterizations.

5.2 Quantitative Results

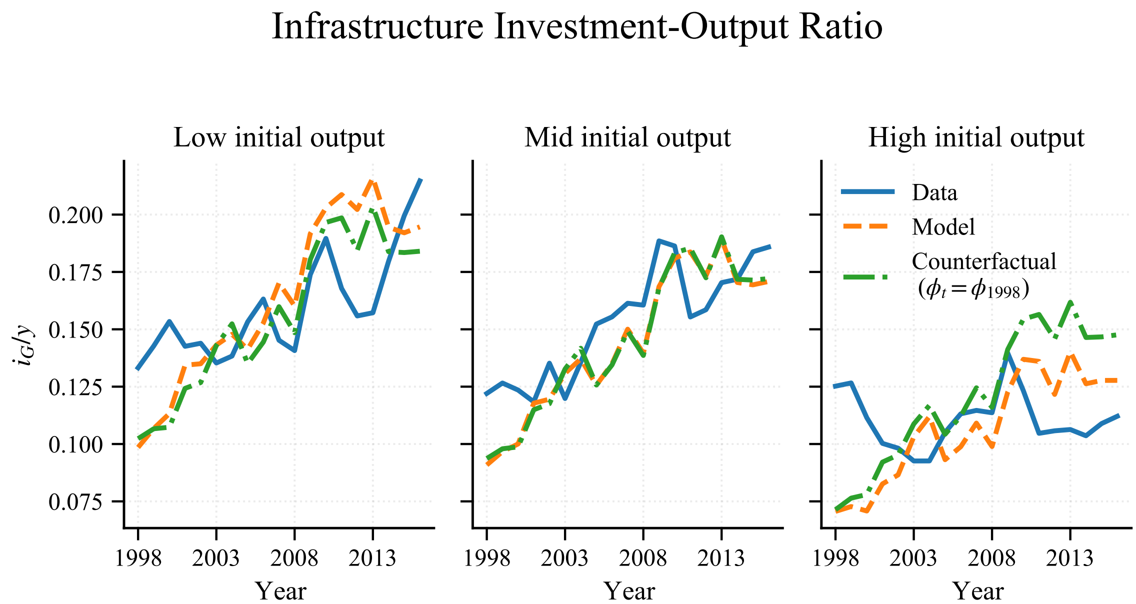
This subsection numerically solves the transitional dynamics under the regional redistribution policy. Data are available from 1998 to 2017. The full sequence of policy and exogenous variables, $\{\phi_t, \tau_{yt}, g_t, A_{it}, \tau_{kit}\}_{t \geq 1998}$, is assumed to be perfectly foreseen and announced in 1998. After 2017, all shocks and policy are held constant at their 2017 values. I conduct a counterfactual experiment that holds redistribution progressivity at its initial level, $\phi_t = \phi_{1998}$ for all t, while keeping all other variables at their observed values. This exercise quantifies the impact of the observed increase in progressivity over 1998–2017 on regional convergence and aggregate productivity. For comparison, in Appendix E.3, Figures E11 to E13 present results for the scenario where only progressivity ϕ_t evolves over time while TFP and capital wedges are fixed at their initial values.

To evaluate the model's ability to capture local fiscal behavior, Figure 7 compares the infrastructure investment-to-output ratio in the data (solid lines) and in the model simulation (dashed lines). While the model matches the aggregate ratio by construction, it is not calibrated to target cross-regional heterogeneity. In Figure 7, regions are grouped by initial output levels. The model closely matches the investment patterns for low- and middle-output regions but slightly overstates the upward trend for high-output regions. This rising trend in the model is largely driven by the increase in output tax rate τ_y. To isolate the role of redistribution, I conduct a counterfactual experiment where progressivity is fixed at its initial level. This scenario is depicted by the dash-dotted lines. In the absence of rising progressivity, low-output regions would have invested less, high-output regions would have invested more, and middle-output regions would have remained largely unchanged. This pattern illustrates the redistributive mechanism that rising progressivity weakens the pass-through from regional productivity to infrastructure investment.

Figure 8 plots the correlation between output and infrastructure capital, estimated from a sequence of regressions of the log of infrastructure capital per capita in the next period on the log of output per capita. The model closely matches both the level and declining trend in the correlation observed in the data: the empirical coefficient falls from 1.02 to 0.41, while the model counterpart declines from 0.97 to 0.52. In the counterfactual experiment where progressivity is fixed at its initial level, the correlation also declines, driven by convergence in productivity, but to a lesser extent. Rising progressivity accounts for 54% of the decline in the correlation by redistributing fiscal resources from high- to low-productivity regions.[14]

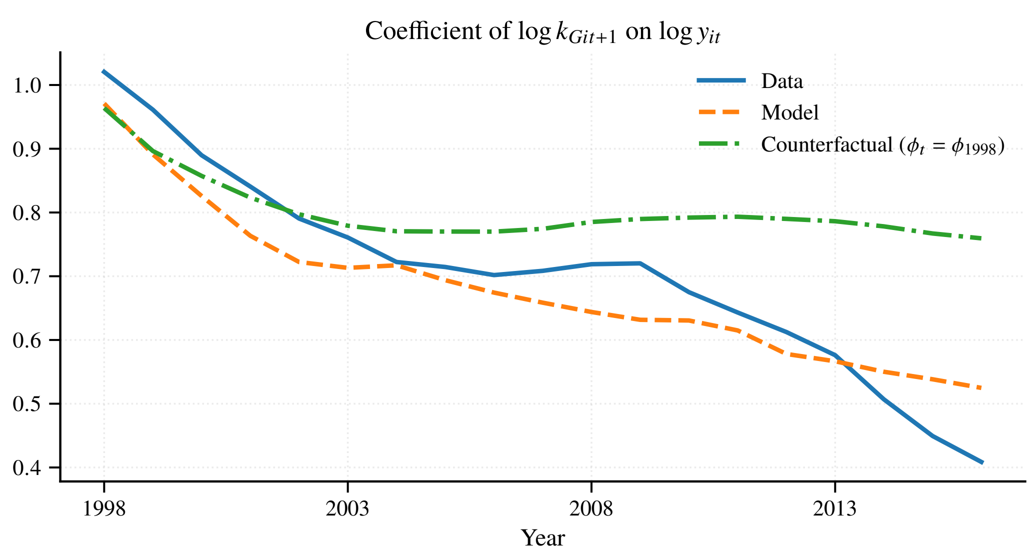
[14]The contribution is calculated as follows: the model-implied decline is 0.446, while the decline in the counterfactual experiment without rising progressivity is 0.204. Therefore, the contribution of rising progressivity is calculated as $1 - 0.204/0.446 = 54\%$. Contributions reported below follow the same calculation.

Figure 7: Infrastructure Investment-to-Output Ratio: Data, Model, and Counterfactual



Note: Regions are grouped by initial output. Solid lines represent data, dashed lines represent the baseline model, and dash-dotted lines represent the counterfactual.

Figure 8: The Correlation between Output and Infrastructure Capital: Data, Model, and Counterfactual

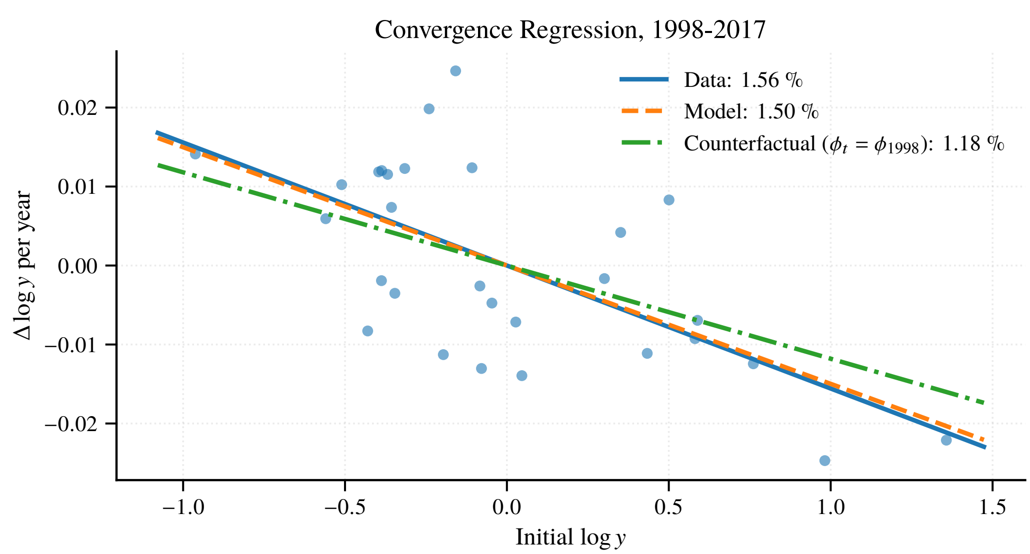


Note: Each line is based on the regression of the log of infrastructure capital per capita (next period) on the log of output per capita (current period).

Next, I use the model to quantify the effects of increased redistribution on regional convergence. As more resources are reallocated toward low-productivity regions with a rising degree of progressivity, the model implies convergence in regional output. I measure convergence using two complementary methods: β-convergence, estimated by a Barro-style convergence regression of the growth in log output on initial log output (Barro, 1991), and σ-convergence, defined as the cross-regional variance of log output.

Figure 9 compares the unconditional β-convergence estimated from the data with that generated by the model. Each line represents a Barro-style convergence regression, and each dot corresponds to a province in the data. The x-axis represents the log of GDP per capita in the initial period and the y-axis represents the average annual growth rate. The data imply a convergence rate of 1.56%, indicating that it takes about 44 years to cut the difference in output between any two provinces. The model closely matches this convergence rate. In the counterfactual experiment with progressivity fixed at the initial level, the convergence rate falls to 1.18%, implying that without the rise in progressivity, it would take 58 years to halve the output gap between any two provinces. Rising progressivity thus accounts for 21% of the observed β-convergence.

Figure 9: β-Convergence Regression 1998-2017: Data, Model, and Counterfactual

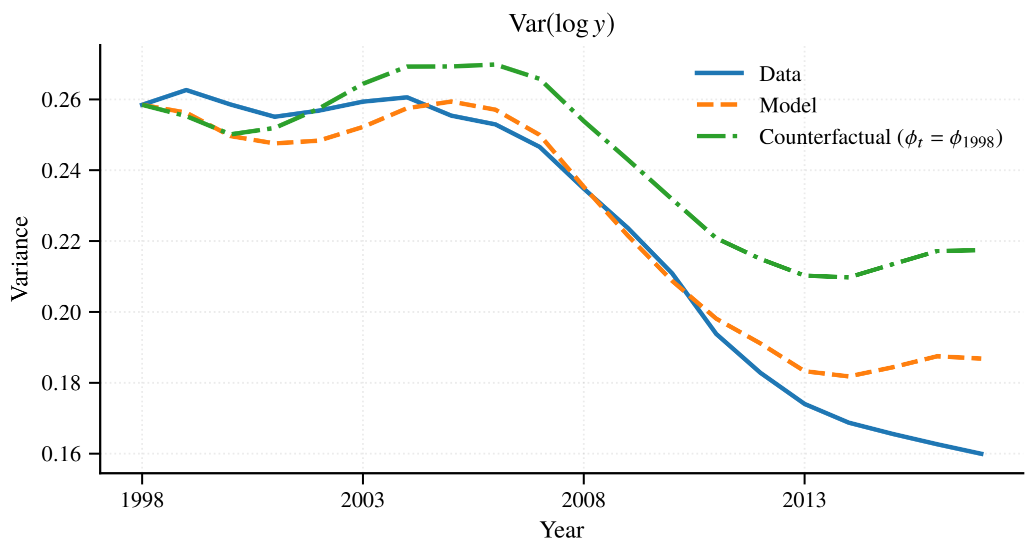


Note: Each fitted line is a Barro-style convergence regression. The x-axis represents log of output per capita in the initial period and the y-axis represents the annual growth rate. Each dot represents a province in the data.

The regional convergence during 1998 to 2017 is strong enough to yield observable

σ-convergence. Figure 10 shows the variance of log GDP per capita. The data exhibit a sharp decline in variance from 0.26 to 0.16, while the model closely tracks the decline from 0.26 to 0.19. The model closely replicates both the level and the downward trend of output dispersion before 2010, while slightly overstating the variance afterward. In the counterfactual experiment with fixed progressivity, output dispersion remains higher and declines more slowly, stabilizing around 0.22 by 2017. Rising progressivity explains 43% of the observed decline in cross-regional output dispersion.

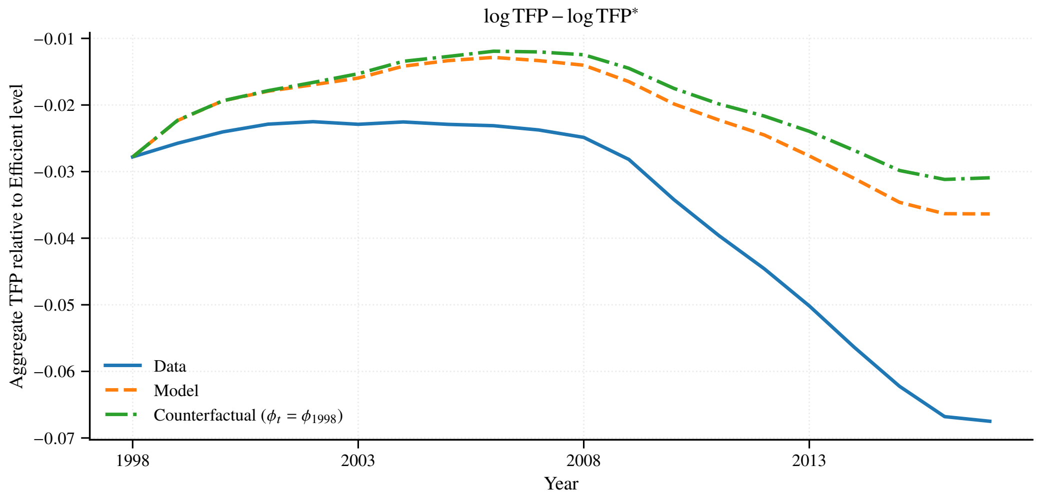
Figure 10: The Variance of log GDP per capita: Data, Model, and Counterfactual



Finally, I use the model to quantify the effects of increased redistribution on aggregate efficiency. Figure 11 displays aggregate TFP, calculated as the Solow residual, relative to its efficient level.[15] In the data, TFP declines from -2.3 to -6.7 percentage points relative to the efficient level, indicating increasing capital misallocation. The baseline model caputures nearly half of this decline, from -1.6 to -3.6 percentage points. Although redistribution is the only fiscal distortion modeled in my framework, the baseline model still accounts for a sizable share of the observed misallocation. In the counterfactual experiment, fixing ϕ at the initial level raises aggregate TFP by 0.5 percentage points by the end of the period.[16]

[15] In literature on capital misallocation, efficient allocation requires equal marginal products across regions. In the theoretical framework, this corresponds to aggregate TFP in Equation (15) when $\phi = 0$. In the quantitative analysis, the efficient TFP is calculated as $\frac{1}{N}\left(\sum_i A_i^{\frac{1}{1-\alpha-\theta}}\right)^{1-\alpha-\theta}$. See Appendix

Figure 11: Aggregate TFP relative to the Efficient Level: Data, Model, and Counterfactual



Note: TFP* denotes aggregate TFP at the efficient level, which in the quantitative analysis is defined as $\frac{1}{N}\left(\sum_i A_i^{\frac{1}{1-\alpha-\theta}}\right)^{1-\alpha-\theta}$.

To summarize the model's quantitative implications under different specifications, Table 2 reports the aggregate responses during the transitional dynamics. Full results are reported in Appendix E.3, Table E3. Each row corresponds to a counterfactual in which only the listed element(s) evolve over time, while all others are fixed at the initial levels. The first row serves as a reference case where all elements are fixed. In this scenario, the economy converges to the steady state under the initial condition. The second line reports the scenario where only progressivity evolves over time.

Several patterns emerge. First, rising progressivity plays a dominant role in shaping the relationship between output and infrastructure capital. When all elements are fixed, the elasticity of infrastructure capital with respect to output declines by 0.20. Allowing only progressivity to evolve nearly doubles this decline to 0.43, closely matching the baseline value of 0.45. Hence, the increase in progressivity alone accounts for almost the entire weakening of this relationship. Second, progressivity substantially contributes to regional convergence. When all elements are held constant, the β-convergence rate is 0.5% and the cross-regional variance of log GDP per capita falls by 0.04. Allowing only progressivity to change over time increases the β-convergence rate to 0.86%—over

E.2 for details.

[16]Moreover, in Appendix E.3, Figure E10 shows that the model tracks aggregate output and infrastructure capital well, and the impacts of redistribution on aggregate quantities are modest.

half of the baseline 1.5%—and reduces the variance of log output by 0.07, explaining almost all of the observed decline in output dispersion. Figures E11 and E12 confirm that a model with only rising progressivity replicates the baseline trends in both the weakening correlation between output and infrastructure capital and the reduction in regional output inequality. Finally, turning to aggregate efficiency, rising progressivity alone induces a 0.3 percentage point decline in aggregate TFP relative to the scenario where all elements are fixed.

Table 2: Aggregate Response During the Transitional Dynamics: 1998-2017

		(1) Δ Coef $\log k_G$ on $\log y$	(2) Convergence Rate, %	(3) Δvar$(\log y)$	(4) $\Delta\log(\text{TFP}/\text{TFP}^*)$
1	Fix all at 1998	-0.197	0.525	-0.041	0.010
2	ϕ	-0.426	0.856	-0.071	0.007
3	A	-0.245	0.318	0.093	0.005
4	τ_k	-0.175	1.377	-0.083	-0.004
5	τ_k, A & ϕ (Baseline)	-0.446	1.498	-0.072	-0.009

Note: Each row reports a counterfactual in which only the element(s) listed are allowed to evolve over time; all other elements are fixed at their 1998 values.

Overall, the quantitative analysis implies that the increase in redistribution from 1998 to 2017 reallocated capital toward low-productivity regions and substantially promoted regional convergence. The rise in progressivity explains 21% of the observed β-convergence and 43% of the σ-convergence. However, this redistribution comes at the cost of a 0.5 percentage point reduction in aggregate TFP.

6 Welfare Analysis and Optimal Policy

This section analyzes the welfare implications of redistribution and explores the determinants of the optimal progressivity. Several forces in our framework shape the design of optimal policy. First, the central government relies on taxes levied on regional output to finance its expenditure. This creates an incentive to stimulate local infrastructure investment and output, which discourages optimal progressivity. Second, due to the concavity of household utility, social inequality is costly. This creates a motive to redistribute toward low-productivity regions, pushing optimal progressivity upward. Third, reallocating fiscal resources across regions causes capital misallocation and reduces aggregate TFP. The need to limit this inefficiency pushes optimal progressivity toward 0.

I proceed in several steps. I first define the central planner's problem under the assumption $\beta \to 1$, in which case the government maximizes steady-state household utility. This assumption admits a closed-form expression of social welfare, avoiding the need to numerically solve the full transitional dynamics.[17] Then, I derive the condition for optimal progressivity and examine the economic forces that shape it. Following Heathcote and Tsujiyama (2021), the framework also allows for an inverse-optimum analysis that the observed redistribution policy can be used to infer the central government's social preferences.

6.1 Social Welfare Function

Let $\{c_i, G_i\}_i$ denote the steady-state allocations under central policy $(\phi, \lambda, \tau_y, g)$. Taking $\beta \to 1$, the central government solves

$$\max_{\phi,\tau_y,g} \quad \mathcal{W}(\phi, \tau_y, g) = \int W(a_i)u(c_i, G_i, G^C)dF_a(a) \tag{16}$$

λ is determined by the central government budget constraint (10). $W(a)$ is the Pareto weight function, and $F_a(a)$ is the cumulative density function of productivity. Follow Heathcote and Tsujiyama (2021), I assume that the Pareto weight function takes the form of

$$W(a;\gamma) = \frac{\exp(-\gamma a)}{\int \exp(-\gamma a)dF_a(a)}, \quad a = \log A \tag{17}$$

where the parameter γ governs the central government's taste for redistribution. A positive (negative) value of γ implies greater weight placed on less (more) productive regions. The utilitarian case corresponds to $\gamma = 0$.

Proposition 3 derives a closed-form expression for social welfare as a function of the central government's policy instruments (ϕ, τ_y, g), with λ endogenously determined to

[17] Appendix D considers an extension with local government debt. In that environment, if the central government announces a new progressivity parameter ϕ, local governments can adjust public capital immediately to the new optimal level at which the post-redistribution marginal return to public investment equals its marginal cost. If productivity A is constant, the economy then remains at the corresponding steady-state allocation. This provides an additional rationale for focusing on steady-state welfare in the normative analysis.

satisfy the central government's budget constraint in equilibrium. Constant terms that are independent of policy choices are omitted.

Proposition 3 (Closed-form social welfare function)**.** *With the social welfare function defined in Equation (16), the social welfare of implementing policy* (ϕ, τ_y, g) *is given by*

$$\mathcal{W}(\phi,\tau_y,g) =$$

$$\begin{cases} \dfrac{1}{1-\theta-\alpha}[(\alpha(1+\chi^C)+\chi^L(1-\theta))\log(\tau_y-g)+(1-\alpha+\theta(\chi^L+\chi^C))\log(1-\tau_y)]+\chi^C\log g & \text{(a)} \\ +\dfrac{(1-\theta)\chi^L+\alpha(1+\chi^C)}{1-\theta-\alpha}\log\left(\dfrac{\alpha(1+\chi^L(1-\phi))}{\alpha+\chi^L(1-\theta)}\right)+\chi^L\log\left(\dfrac{\chi^L(1-\theta-\alpha(1-\phi))}{\alpha(1+\chi^L(1-\phi))}\right) & \text{(b)} \\ +\dfrac{1+\chi^L+\chi^C}{1-\theta-\alpha}\left[\dfrac{\theta+\alpha}{1-\theta-\alpha}\dfrac{\sigma_a^2}{2}-\dfrac{\alpha(1-\theta)\phi^2}{(1-\theta-\alpha)(1-\theta-\alpha(1-\phi))^2}\dfrac{\sigma_a^2}{2}\right] & \text{(c)} \\ -\dfrac{1}{(1-\theta-\alpha(1-\phi))^2}\dfrac{\sigma_a^2}{2}-\dfrac{\chi^L(1-\phi)^2}{(1-\theta-\alpha(1-\phi))^2}\dfrac{\sigma_a^2}{2} & \text{(d)} \\ -\dfrac{(1+\chi^L(1-\phi))}{1-\theta-\alpha(1-\phi)}\gamma\sigma_a^2 & \text{(e)} \end{cases} \tag{18}$$

Equation (18) expresses social welfare as a function of preference, technology, productivity dispersion, and policy parameters. The welfare function exhibits two important properties. First, Appendix C.3 shows that the twice differentiations of the social welfare function with respect to τ_y and g are negative, establishing global concavity in these two arguments. For ϕ, all components of the twice differentiation are negative except for Line (c) of Equation (C12), which becomes negative when $1-\alpha-\theta > 2\alpha\phi$. This condition is satisfied in the calibration. For a concave function, the first-order conditions are sufficient to deliver the optimal solution. Second, in Equation (18), ϕ enters the welfare function separately from (τ_y, g), implying that the optimal degree of progressivity is independent of any choices of τ_y and g, even if these are suboptimal. Therefore, one can derive the optimal tax rate and central government consumption share by taking the first-order conditions of the social welfare function with respect to τ_y and g without solving for the optimal value of ϕ. Corollary 6 characterizes the optimal choice of these two instruments.

Corollary 6 (Optimal government size)**.** *The optimal output tax rate* τ_y *and the central* *government consumption to output ratio g are given by*

$$\tau_y^* = \frac{\alpha + (1-\theta)(\chi^L + \chi^C)}{1 + \chi^L + \chi^C}, \quad g^* = \frac{(1-\alpha-\theta)\chi^C}{1+\chi^L+\chi^C} \tag{19}$$

The optimal output tax rate τ_y^* is increasing in α, χ^L, and χ^C. A higher α raises the return to public capital, encouraging more investment by local governments. Higher values of χ^L and χ^C reflect stronger household preferences for local and central government consumption, motivating greater tax revenue to finance these expenditures. In contrast, τ_y^* is decreasing in θ because the output tax distorts the firm's production plan and reduces aggregate output.

The optimal central government consumption share g^* is increasing in χ^C: when households place greater value on central government goods, it is optimal to allocate more fiscal revenue to them. In contrast, g^* decreases with α, θ, and χ^L. Higher output elasticities raise the productivity of local spending, and stronger preferences for local public goods tilt the allocation of fiscal resources toward local governments to support local public goods provision.

6.2 Decomposition of Social Welfare Function

This subsection interprets each term of Equation (18) and explores the economic forces that determine the optimal degree of progressivity. I decompose the social welfare into the welfare of the representative region and the welfare from heterogeneity. The latter consists of the trade-off between gains from efficiency and costs from inequality.

6.2.1 Welfare of the Representative Region

To isolate the motive for central tax collection, a convenient approach is to examine the optimal policy in a representative-region economy, where heterogeneity is absent and thus there is no rationale for redistribution or concern about misallocation. In this setting, the planner's objective reduces to maximizing the welfare of a representative region. Lines (a) and (b) of Equation (18) correspond to this component of social welfare:

$$
\begin{aligned}
&\mathcal{W}^R(\phi, \tau_y, g) \\
&= \frac{1}{1-\alpha-\theta}[(\alpha(1+\chi^C) + \chi^L(1-\theta))\log(\tau_y - g) + (1-\alpha+\theta(\chi^L+\chi^C))\log(1-\tau_y)] + \chi^C \log g \\
&+ \frac{(1-\theta)\chi^L + \alpha(1+\chi^C)}{1-\alpha-\theta}\log\left(\frac{\alpha(1+\chi^L(1-\phi))}{\alpha+\chi^L(1-\theta)}\right) + \chi^L \log\left(\frac{\chi^L(1-\theta-\alpha(1-\phi))}{\alpha(1+\chi^L(1-\phi))}\right)
\end{aligned} \tag{20}
$$

1. Welfare from central fiscal policy (τ_y, g). The first line of Equation (20) captures the welfare effects of the central government's fiscal instruments (τ_y, g). A higher output tax rate increases fiscal capacity and enables greater public spending, but distorts firm behavior, lowering wages and output. Similarly, increasing g raises utility from central government consumption but reduces resources available for local public goods and infrastructure investment. The optimal values of τ_y and g are characterized in Corollary 6.

2. Welfare from the local government fiscal policy. The second line of Equation (20) captures the welfare contribution of local government fiscal policy. Two key ratios characterize this channel:

$$
\frac{\delta k_{Gi}}{\lambda(\tau_y y_i)^{1-\phi}} = \frac{\alpha(1+\chi^L(1-\phi))}{\alpha+\chi^L(1-\theta)} \tag{21}
$$

$$
\frac{G_i}{\delta k_{Gi}} = \frac{\chi^L(1-\theta-\alpha(1-\phi))}{\alpha(1+\chi^L(1-\phi))} \tag{22}
$$

Equation (21) gives the ratio of local government investment to post-redistribution revenue. This ratio declines with ϕ and enters the first term of Line (b) in Equation (18) scaled by preference parameters. It shows that higher progressivity reduces household and government consumption by lowering equilibrium public investment. Equation (22) gives the ratio of local government consumption to investment, which increases with ϕ. This term enters the second part of Line (b), scaled by χ^L, reflecting household utility from local public goods.

Together, these two terms capture a key motive for redistribution: central tax collection. Since central government consumption is exogenous from the perspective of households and local governments, a positive value of χ^C creates a free-rider problem. Local governments do not internalize that increased investment raises household utility not only directly, but also indirectly by expanding central tax revenue and, hence, central government consumption. This externality calls for additional incentives to stimulate local investment through a regressive tax scheme. Proposition 4 derives the optimal progressivity in a representative region model.

Proposition 4 (Representative region model)**.** *In a representative region economy, i.e.* $\sigma_a^2 = 0$*, the welfare-maximizing* ϕ^{R*} *should be negative and is given by*

$$\phi^{R*} = -\frac{(1-\theta-\alpha)\chi^C}{\alpha(1+\chi^C)+(1-\theta)\chi^L} \tag{23}$$

With τ_y^* *and* g^* *given by Equation* (19)*, the marginal tax rate is 0 and the average tax rate is* g^*/τ_y^**.*

When heterogeneity is eliminated, the redistributive motivation disappears and the only objective is to finance central government consumption. In a representative-region economy, with ϕ^{R*} given by Equation (23) and (τ_y^*, g^*) given by Equation (19), the marginal tax rate (MTR) on local fiscal income is exactly 0, which replicates a lump-sum transfer and introduces no distortions to local fiscal policy. Meanwhile, the average tax rate (ATR) is g/τ_y, which is exactly sufficient to finance central government consumption. When ATR > MRT, the tax-transfer system is regressive.

6.2.2 Welfare from Heterogeneity

Lines (c), (d), and (e) in Equation (18) correspond to welfare effects from heterogeneity.

1. Welfare from efficiency. Line (c) of Equation (18) captures the effects of heterogeneity on aggregate efficiency under redistribution because

$$\log \mathrm{TFP} = \frac{\theta+\alpha}{1-\theta-\alpha}\frac{\sigma_a^2}{2} - \frac{\alpha(1-\theta)\phi^2}{(1-\theta-\alpha(1-\phi))^2(1-\theta-\alpha)}\frac{\sigma_a^2}{2}$$

Line (c) is the log of aggregate TFP scaled by the preference parameters. As discussed in Section 4, dispersion in TFP improves aggregate efficiency, while redistribution diminishes such efficiency gain. This adverse effect is minimized precisely at $\phi = 0$.

2. Welfare cost from inequality. Line (d) captures the welfare cost from inequality in household consumption and local government consumption:

$$\text{var}(\log c_i) = \frac{1}{(1-\theta-\alpha(1-\phi))^2}\sigma_a^2$$

$$\text{var}(\log G_i) = \frac{(1-\phi)^2}{(1-\theta-\alpha(1-\phi))^2}\sigma_a^2$$

The terms in Line (d) are the variance of log household consumption and the variance of log local government consumption scaled by the preference parameters. Due to the concavity of the log utility function, inequality reduces social welfare. Notably, both variances are strictly decreasing in ϕ, indicating that more redistribution reduces regional inequality and thus enhances social welfare.

3. The central government's social preference. Finally, Line (e) captures the central government's attitude toward innate inequality. A higher value of γ implies greater Pareto weights on less productive regions, amplifying the welfare cost of inequality due to TFP dispersion. As a result, the central government's incentive to redistribute increases. Line (e) is also strictly increasing in ϕ when $\gamma > 0$.

6.3 Condition for Optimal Progressivity

When is a progressive redistribution scheme welfare-improving? Proposition 4 provides a benchmark: in a representative-region economy, the optimal redistribution scheme should be regressive and the optimal ϕ should be negative. In the presence of heterogeneity, however, progressivity can improve social welfare by reducing social inequality. Since the social welfare function is continuous in ϕ, there must exist a threshold beyond which increasing progressivity improves social welfare. To identify this threshold, I evaluate the differentiation of the social welfare function with respect to ϕ at $\phi = 0$. Proposition 5 characterizes the sufficient and necessary condition under which a marginal increase in progressivity improves social welfare.

Proposition 5 (Condition for optimal progressivity)**.** *The optimal level of ϕ should be* *strictly positive if and only if*

$$\underbrace{\frac{\chi^L(1-\theta)+\alpha}{(1-\theta-\alpha)^2}\sigma_a^2}_{\text{(a) less inequality due to TFP dispersion}} + \underbrace{\frac{\chi^L(1-\theta)+\alpha}{1-\theta-\alpha}\gamma\sigma_a^2}_{\text{(b) more redistribution}} + \underbrace{\alpha\chi^L}_{\text{(c) more local govt. cons.}} > \underbrace{\frac{\alpha\chi^L}{1+\chi^L}(1+\chi^C+\chi^L)}_{\text{(d) less hh. and govt. cons. due to less } k_G} \tag{24}$$

The left-hand side of Inequality (24) captures the marginal benefit of increasing progressivity at $\phi = 0$. A more progressive tax scheme raises social welfare through three channels: (a) reducing regional inequality due to TFP dispersion, (b) reallocating resources toward less productive regions when the central government places higher Pareto weights to them, and (c) motivating local governments to provide more public goods. The right-hand side captures the marginal cost of increasing progressivity at $\phi = 0$: by weakening local governments' incentives to invest, higher progressivity depresses aggregate output, wages, and government consumption. [18]

Several economic forces shape the desirability of a progressive redistribution scheme. First, Inequality (24) always holds when either $\chi^C = 0$ or $\chi^L = 0$. When $\chi^C = 0$, there is no free-rider problem associated with central government consumption, eliminating the need to correct it via a regressive scheme. When $\chi^L = 0$, local governments allocate fiscal income entirely to investment, so progressivity no longer distorts local fiscal choices. On the contrary, a larger χ^C makes the inequality more difficult to satisfy, as the welfare loss from reduced central government consumption becomes more salient. The effects of χ^L are ambiguous: higher χ^L increases both the welfare loss from less local government consumption and the welfare gain from reducing its inequality.

Second, higher dispersion in TFP makes the inequality more likely to satisfy, as the marginal welfare gain from reducing inequality in household and local government consumption becomes larger. Similarly, a higher γ strengthens the redistributive motive by placing more weight on low-productivity regions.

[18] Notably, Inequality (24) does not include the effects of progressivity on aggregate efficiency. This effect is captured by Line (c) in Equation (18), the differentiation of which with respect to ϕ is 0 at $\phi = 0$. That is, the negative effect of redistribution on aggregate efficiency is minimized exactly at $\phi = 0$.

Finally, the effects of output elasticities differ. A higher output elasticity of public capital (α) amplifies both the efficiency losses from distorted investment and the welfare gains from reduced inequality, making the net effect ambiguous. In contrast, a higher elasticity of private capital (θ) unambiguously strengthens the desirability of progressivity: it increases inequality due to TFP dispersion, yet does not affect the distortionary channel, since firms do not internalize the effects of redistribution.

6.4 Social Preference

So far, I have examined the economic determinants of optimal progressivity. Among these, the central government's redistributive preference, captured by γ, plays a pivotal role. Conversely, one can ask: What value of γ would rationalize the observed degree of progressivity? This approach parallels the inverse optimal taxation method developed by Bourguignon and Spadaro (2012), Lockwood and Weinzierl (2016), and Heathcote and Tsujiyama (2021), where observed policy outcomes are used to back out the implicit social preferences. Proposition 6 characterizes the value of γ that makes the observed policy $\hat{\phi}$ optimal.

Proposition 6 (Social preference)**.** *The social preference parameter $\hat{\gamma}$, which rationalizes the redistribution policy $\hat{\phi}$, is a solution to the following linear equation*

$$\begin{aligned}\frac{\chi^L(1-\theta)+\alpha}{(1-\theta-\alpha(1-\hat{\phi}))^2}\sigma_a^2\hat{\gamma} = & \frac{\alpha(1+\chi^L+\chi^C)}{1-\theta-\alpha}\frac{\chi^L}{1+\chi^L(1-\hat{\phi})} - \frac{\alpha\chi^L}{1-\theta-\alpha(1-\hat{\phi})} \\ & + \frac{(1+\chi^L+\chi^C)\alpha(1-\theta)}{1-\theta-\alpha}\frac{\hat{\phi}}{(1-\theta-\alpha(1-\hat{\phi}))^3}\sigma_a^2 \\ & - \frac{\alpha+\chi^L(1-\hat{\phi})(1-\theta)}{(1-\theta-\alpha(1-\hat{\phi}))^3}\sigma_a^2\end{aligned} \tag{25}$$

where $\hat{\phi}$ is the observed progressivity.

Equation (25) is just the first-order condition of the social welfare function (18) with respect to ϕ. If the observed progressivity $\hat{\phi}$ solves the Ramsey problem defined by (16), then $\hat{\gamma}$ and $\hat{\phi}$ must satisfy Equation (25). As Equation (25) is linear in $\hat{\gamma}$, it has a unique solution. This formulation allows the researcher to recover the central planner's implicit redistributive motive from observed policy.

7 Model Implications for Optimal Progressivity

Having quantified the effects of rising progressivity on regional output dispersion and aggregate efficiency in Section 5, this section turns to the normative analysis and evaluates the optimal degree of progressivity. I focus on the period 2013-2017 when observed progressivity approaches 0.5. In the normative analysis, preference parameters $\chi^L = 0.23$, $\chi^C = 0.05$, and $\gamma = -0.28$ are calibrated to rationalize the observed policy (ϕ, τ_y, g) using Equations (19) and (25). Notably, the negative value of γ implies that the central government places relatively greater Pareto weights on high-productivity regions. To clarify the mechanisms underlying optimal redistribution, I conduct two exercises. First, I decompose the social welfare function to separate different motivations that discipline redistribution policy. Then, I solve for the optimal progressivity parameter ϕ^* across a range of scenarios, shedding light on the economic forces that shape optimal policy.

7.1 Decompose Social Welfare Function

What explains the high level of progressivity observed in recent years? To answer this question, I decompose the social welfare into its key components. After substituting the optimality condition of g^* and τ_y^* into Equation (18), the social welfare $\mathcal{W}(\phi)$ can be expressed as a single-valued function of the progressivity parameter ϕ.

The top panel of Figure 12 plots the components of the social welfare as a function of progressivity. The y-axis represents the welfare change relative to the current redistribution system, measured as the percentage of consumption equivalents. The decomposition proceeds in three steps: starting from the representative-region model in (1), I sequentially incorporate heterogeneity in regional TFP in (2), which is analogous to the utilitarian case, and the central government's social preference in (3), which rationalizes the current redistribution system.

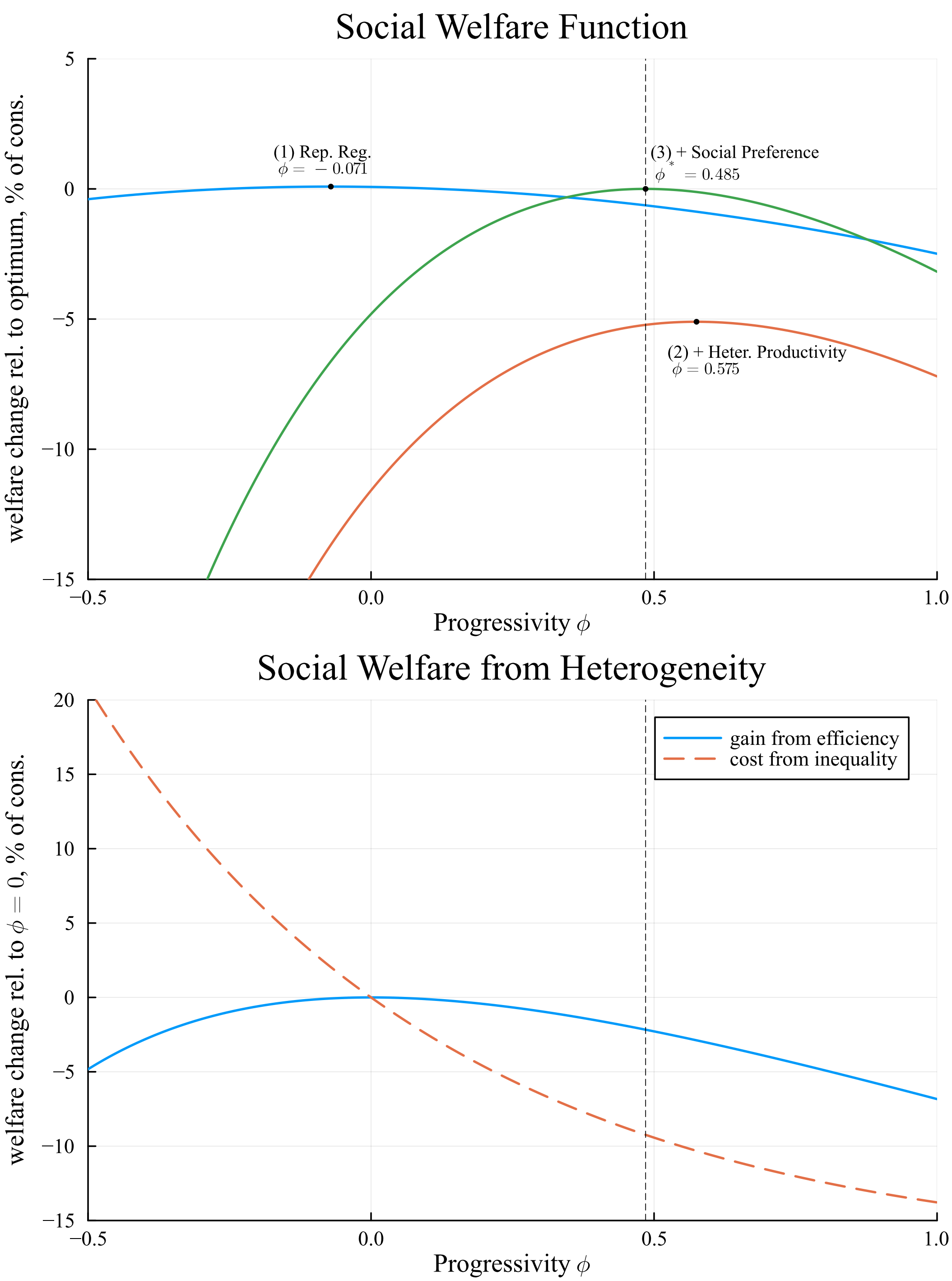
In the representative region model (1), redistribution serves only to finance central government consumption. Given the relatively small calibrated value of χ^C, the planner optimally chooses a mildly regressive scheme, with $\phi^{R*} = -0.071$. This reflects limited incentives to collect central taxes when the welfare gain from central public goods is modest. This scenario highlights the distortionary effect of reallocating local fiscal resources away from productive investment toward government consumption.

In scenario (2), introducing heterogeneity in regional TFP sharply raises the optimal degree of progressivity to $\phi = 0.575$. The increase reflects sizable welfare gains from narrowing regional disparities in fiscal capacity and output. To illustrate this, the bottom panel of Figure 12 compares the welfare gain from efficiency and the welfare cost of inequality, relative to the non-redistribution scenario ($\phi = 0$). The welfare gain from efficiency corresponds to Line (d) in Equation (18), which is maximized precisely at $\phi = 0$. The welfare cost of inequality corresponds to Line (e), which declines with progressivity. As a function of ϕ, the welfare gain curve is flatter than the cost curve, implying that increasing progressivity from zero can substantially improve welfare by reducing regional inequality at a relatively small efficiency loss. Relative to the no-redistribution benchmark, reducing inequality yields a welfare gain equivalent to 9.2% of consumption, while the associated welfare loss from inefficiency is 2.2%. This scenario captures the welfare effects of reallocating resources from high- to low-productivity regions.

A utilitarian social planner would optimally choose a progressivity of 0.575, slightly above the actual progressivity of the current system, 0.485. This suggests that the Chinese central government places slightly higher Pareto weight on more productive regions. One possible justification is the population size: more productive regions tend to have larger populations and thus receive greater Pareto weights. Even under the utilitarian assumption, the current system is nearly optimal in the sense that moving from the current system to the utilitarian optimum delivers negligible welfare gains, equivalent to 0.11% of consumption. Relative to the non-redistribution scenario, the current system yields a welfare gain equivalent to 4.8% of consumption.

In summary, three factors account for the high optimal progressivity. First, central government spending is relatively small during this period, reducing the need for central tax collection and making the optimal regressivity in the representative-region case close to zero. Second, as shown in Figure E8, productivity dispersion has steadily increased over time, amplifying the welfare gains from reducing regional inequality. Third, although the IV estimates imply a higher output elasticity of infrastructure

Figure 12: Social Welfare as a Function of ϕ and Welfare from Heterogeneity



Note: The vertical dashed line marked progressivity of the current redistribution system.

capital, the estimated elasticity remains modest relative to that of non-infrastructure capital. The small value of α mitigates the distortionary effects of progressivity. The next subsection explores these mechanisms further by evaluating optimal progressivity under alternative calibrations.

7.2 Optimal Progressivity Under Different Parameter Values

This subsection explores the optimal degree of progressivity under alternative parameter values. The specification of the Pareto weight function in Equation (17) nests several canonical cases. When $\gamma = 0$, the planner is utilitarian, assigning equal weights to all regions. When $\gamma \to \infty$, the planner becomes Rawlsian, placing all weight on the least productive region. When $\gamma = -1/(1-\theta-\alpha)$, the implied weights are inversely proportional to the marginal utility from TFP in the absence of redistribution, corresponding to a laissez-faire social planner.

Table 3, Column (1), summarizes the main results. Row 1 reports the baseline model, where the current redistribution system is rationalized by setting $\gamma = -0.28$. Row 2 presents the utilitarian case with $\gamma = 0$. Row 3 shows the Rawlsian case, $\gamma \to \infty$, in which the planner maximizes the welfare of the least productive region and therefore always sets $\phi = 1$ to achieve maximum redistribution. Row 4 corresponds to the laissez-faire case, where the planner chooses not to redistribute and sets optimal ϕ close to zero. Row 5 sets $\gamma = 0.5$, which places greater weight on less productive regions, and the optimal ϕ rises to 0.741. In contrast, Row 6 sets $\gamma = -0.5$, assigning more weight to high-productivity regions, and the optimal ϕ falls to 0.416.

I also examine the optimal progressivity under alternative model specifications. The baseline model nests several special cases. When $\chi^L = 0$, local government consumption is not valued by households. In this case, local governments allocate all disposable income to investment, and their fiscal decisions are undistorted. When $\chi^C = 0$, central government spending is exogenous. Without the free-rider problem, there is no longer an additional incentive needed to encourage local government investment.

Columns (2)–(6) report the optimal progressivity under alternative parameter values. Compared to the baseline model, both the $\chi^L = 0$ and $\chi^C = 0$ cases yield higher optimal progressivity. In Column (4), greater TFP dispersion raises optimal progressivity, as the marginal welfare gain from reducing regional inequality increases. Columns (5) and (6) vary the output elasticity of infrastructure capital by setting $\alpha = 0.05$ and $\alpha = 0.3$, respectively, while adjusting θ to maintain $1 - \alpha - \theta = 0.5$. A smaller α attenuates the efficiency cost of redistribution and thus increases the optimal ϕ (indeed, when $\alpha = 0$ and $\gamma > 0$, the optimum is $\phi = 1$). Conversely, a larger α amplifies the distortionary effects, lowering the optimal degree of progressivity.

Table 3: Optimal Progressivity Under Alternative Values for Different Pareto Weights

γ	(1) Baseline	(2) $\chi^L = 0$	(3) $\chi^C = 0$	(4) Larger σ_a^2	(5) $\alpha = 0.05$	(6) $\alpha = 0.3$
1. -0.28 (Baseline)	0.485	0.577	0.508	0.531	0.714	0.379
2. 0 (Utilitarian)	0.575	0.695	0.601	0.633	0.838	0.450
3. ∞ (Rawlsian)	1.000	1.000	1.000	1.000	1.000	1.000
4. $-1/(1-\alpha-\theta)$ (LF)	-0.007	0.000	0.000	-0.003	-0.005	-0.006
5. 0.5	0.741	0.928	0.774	0.827	1.000	0.582
6. -0.5	0.416	0.490	0.436	0.453	0.617	0.324

Notes: LF = laissez-faire. In Columns (5)–(6), θ is adjusted so that $1 - \alpha - \theta = 0.5$ is fixed. Positive (negative) γ assigns higher weight to less (more) productive regions.

8 Conclusion

This paper examines the role of regional redistribution in shaping regional economic growth following China's tax reforms. The first major contribution is to provide novel empirical evidence on the evolution of the redistribution system, local fiscal responses, and their economic consequences. I model regional redistribution as a progressive tax-transfer scheme and document a substantial increase in progressivity. Exploiting the 2002 tax reform as a natural experiment, I conduct an event study and show that local governments responded to the increased central tax claim by cutting infrastructure investment, thereby slowing economic growth.

Motivated by these findings, the second contribution is to develop a general equilibrium framework to study the implications of regional redistribution for economic growth and social welfare. The model captures two key distortions: a shift in fiscal spending from productive infrastructure investment to government consumption, and a reallocation of resources from high- to low-productivity regions. The calibrated model matches key moments during the transition. Quantitatively, the rise in progressivity can explain 43% of the observed decline in the variance of log GDP per capita while reducing aggregate TFP by 0.5 percentage points due to misallocation of infrastructure capital.

Consistent with Song and Xiong (2023), this paper highlights the pivotal role of local governments in driving regional economic growth. I contribute by identifying regional redistribution as a central fiscal distortion. When quantifying its effects on capital misallocation through local fiscal investment, I propose a novel instrument from China's tax reform to estimate the output elasticity of infrastructure capital.

The framework developed in this paper lends itself to several extensions. First, the analysis abstracts from household-level tax progressivity and focuses solely on intergovernmental redistribution. A natural next step is to compare household- and region-level redistribution within a unified framework. Second, by equalizing infrastructure and public services across space, regional redistribution may reshape labor migration and industrial agglomeration patterns. Future research could extend the model to incorporate spatial dynamics and study how fiscal transfers influence the geographic distribution of economic activity.

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Supplemental Online Appendix

A Data, Measurement, and Additional Stylized Facts

A.1 Data and Measurement

All data used in this paper come from the published statistical yearbooks and the official website of the National Bureau of Statistics (NBS), https://data.stats.gov.cn/easyquery.htm?cn=C01. The sample period ranges from 1998 to 2017.

Data on national and regional GDP, population, price index, government budgetary revenue and budgetary spending, tax categories, the fixed capital formation, and government consumption come from the NBS website.

Data on central and local taxes by region comes from the Taxation Yearbook of China.

Data on transfers from the central government, non-budgetary revenue comes from the Finance Yearbook of China.

Data on investment comes from the Statistical Yearbook of the Chinese Investment in Fixed Assets (SYCIFA) and the China Statistical Yearbook (CSY).

In order to measure progressivity using Equation (2), x represents the pre-redistribution government revenue. I follow Song and Xiong (2023) and define pre-redistribution revenue as the sum of taxes, non-tax revenue, non-budgetary revenue, and land sales. $\tilde{x}$ represents the post-redistribution government revenue, defined as x minus central taxes plus net transfers from the central government. Both x and $\tilde{x}$ are normalized by population size and by national GDP per capita.

I follow Song and Xiong (2023) to construct the regional infrastructure investment and infrastructure capital. Infrastructure investment includes investment in (1) Production and supply of electricity, gas, and water; (2) Management of water conservancy, environment, and public facilities; and (3) Transportation. SYCIFA and CSY only provide provincial and sectoral information on investment in fixed assets instead of fixed capital formation. Therefore, we assume the share of each sectoral capital formation is the same as the share in investment in fixed assets. In 1992-1995 and 1999-2001, CSY and SYCIFA only provide investment in capital construction and innovation. We assume the share of the corresponding sector is constant. See Song and Xiong (2023) for details.

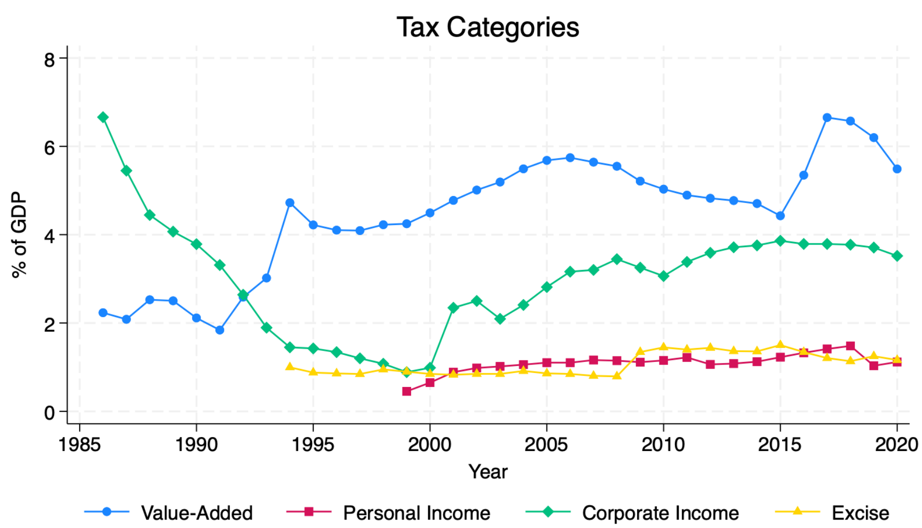
A.2 Measuring Progressivity

I alternatively measure progressivity using Equation (2). x is defined as GDP per capita. $\tilde{x}$ is defined as GDP per capita central taxes per capita plus net transfers from the central government per capita. Again, both x and $\tilde{x}$ are demeaned. Figure A2 estimate progressivity using GDP per capita.

A.3 Additional Empirical Details on Institutional Background

Figure A1 shows the evolution of major tax categories taken by the central government as shares of GDP.

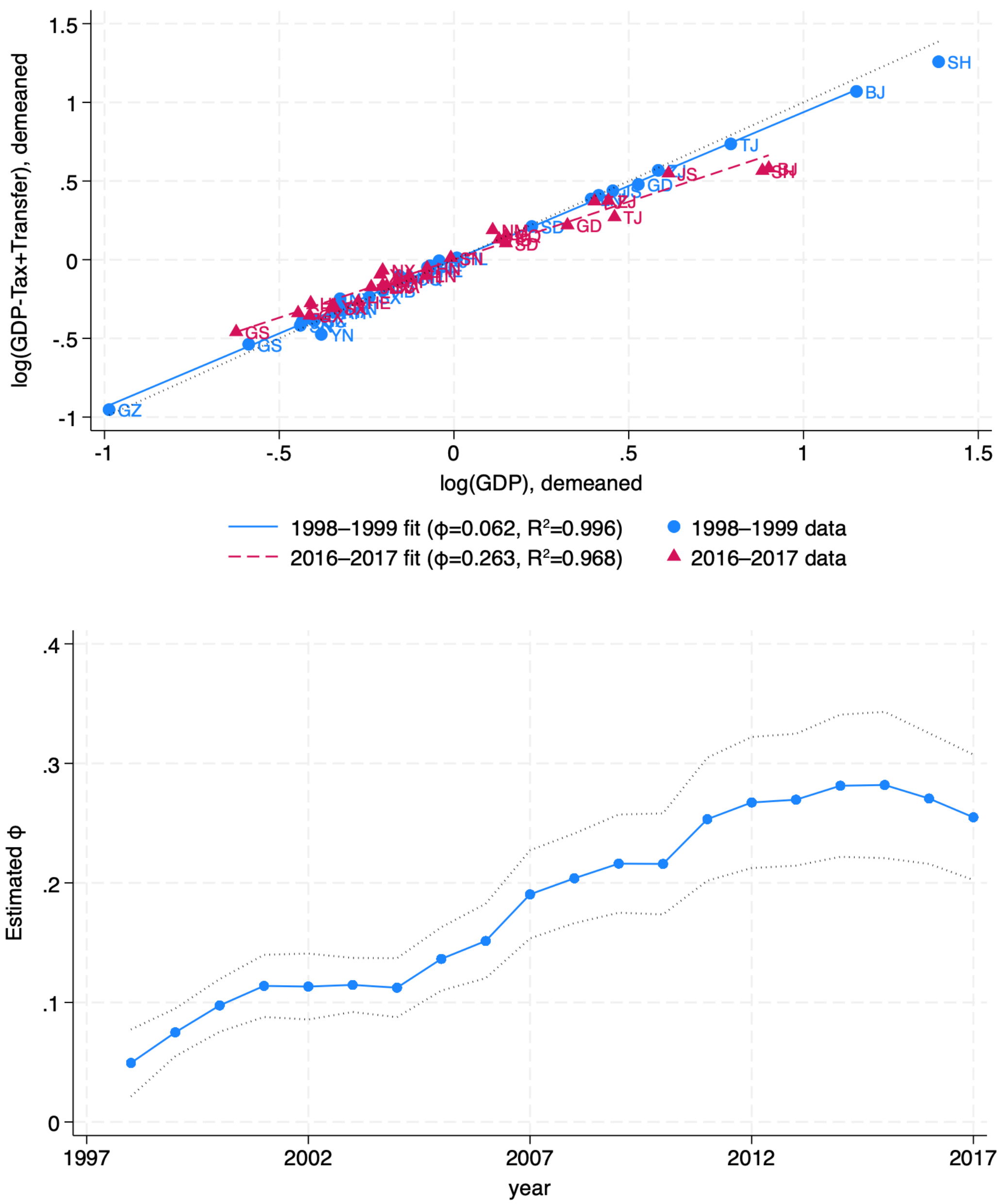
Figure A1: Tax Categories Belong to or Shared by the Central Government



Note: Before 2000, corporate income taxes include only those from SOEs and collective enterprises; starting in 2001, they cover all firms. From 1985 to 1993, corporate income taxes also include SOE profits. Data source: the NBS website.

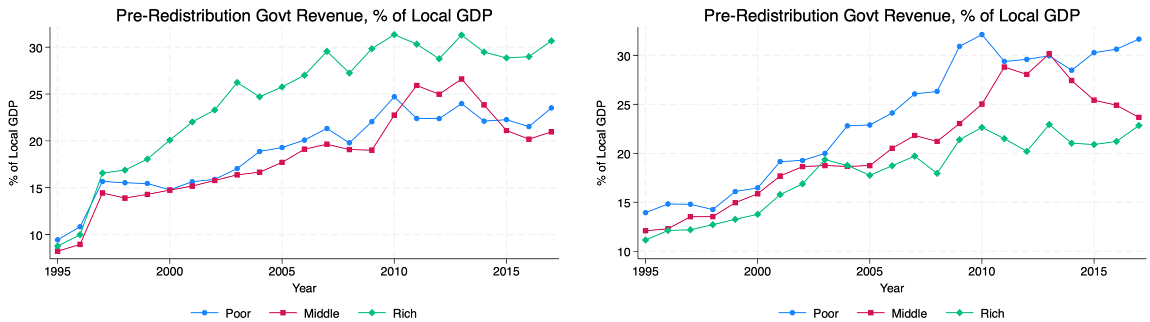
Figure A3 displays pre- and post-reform local fiscal revenue in the share of regional GDP.

Figure A2: Representation of the Regional Redistribution System through the BHSV Tax Function and Rising Progressivity



Note: This figure plots results corresponding to Figure 2. The top panel plots the log of (GDP - central taxes + net transfers) capita against the log of GDP in different periods. Both are in the measure of per capita and are demeaned. The bottom panel presents the OLS estimation of the corresponding progressivity for each year.

Figure A3: Pre- and Post-Redistribution Fiscal Revenue in the Share of Local GDP, Grouped by GDP per capita



B Discussions and Additional Empirical Results of the Event Study and IV

B.1 Historical Origins of the Industrial Location and the Corporate Tax Base

The cross-province distribution of the corporate income tax base in China prior to the 2002 reform reflects deep institutional and historical legacies, rather than purely regional comparative advantage or contemporary industrial policy. This path dependence provides a compelling basis for treating the pre-reform share of corporate income taxes as plausibly exogenous to post-reform infrastructure capital and output growth.

Before the founding of the People's Republic of China (PRC) in 1949, the industrial geography was shaped by historical disruptions. During the Japanese invasion, the northeast region (Manchuria) underwent rapid military industrialization under Japanese sponsorship. These heavy industries were later seized by the Soviet Army and eventually passed to the Chinese government. At the same time, Sichuan was developed as an industrial base following the Japanese occupation of Shanghai and Manchuria (Naughton, 2007; Bramall, 2008). These patterns were driven by wartime contingencies rather than economic fundamentals.

After 1949, large enterprises were nationalized and reorganized into centrally administered SOEs. Their headquarters were typically located in or near Beijing, reflecting priorities of administrative convenience and political control.

In 1960s-70s, geopolitical tensions led to further industrial relocation. In response to deteriorating relations with the Soviet Union and the growing American military presence in Vietnam, the government launched the "Third Front" campaign to build up industrial capacity in the interior. During this period, the government spent 20.52 billion RMB on more than 1,100 Third Front projects, resulting in the establishment of 1,945 industrial enterprises and scientific research institutes (Meyskens, 2020; Fan and Zou, 2021).[19]

In the 1980s-90s, the emergence of Township and Village Enterprises (TVEs) contributed to further spatial heterogeneity in the tax base. TVEs emerged from the rural surplus released by the Household Responsibility System, which began spontaneously in places such as Xiaogang Village, Anhui, following a series of natural disasters. During this period, China was transitioning from the centrally planned economy to the market economy. The spatial pattern of TVEs was shaped by local initiative, informal finance, and village-level governance capacity, rather than national planning (Oi, 1992; Park and Shen, 2003).

Taken together, these institutional and historical forces shaped the evolution of China's industrial landscape and thereby the pre-reform corporate tax base in ways that are plausibly orthogonal to short-run economic fundamentals.

B.2 Correlates of the Share of Income Taxes

I begin by examining whether the share of income taxes prior to the reform is systematically related to other observable local characteristics. Table B1 reports the results from a series of cross-sectional regressions, where the dependent variable is the share of income taxes in 2000 and the covariates are measured before the reform.

Column (1) regresses the instrument on provincial levels of GDP, infrastructure capital, non-infrastructure capital, and employment. None of these variables are significantly correlated with the instrument, suggesting that the level of economic development does not predict exposure to the reform.

Column (2) examines the sectoral composition of GDP. The value-added shares of the secondary and tertiary sectors are not significantly related to the instrument,

[19] The Third Front campaign targeted provinces including Sichuan, Guizhou, Yunnan, Gansu, Ningxia, Qinghai, southern Shaanxi, northwestern Guangxi, and western parts of Hubei and Hunan.

implying that cross-province differences in industrial structure are unlikely to violate the exclusion restriction.

Column (3) considers fiscal capacity by including government revenue and government consumption. Again, no evidence shows that these variables are correlated with the share of income taxes.

Column (4) adds indicators of economic openness, including FDI and total imports and exports. These are also uncorrelated with the instrument.

To further explore potential spillover concerns, we test whether a province's income tax share is correlated with the characteristics of its neighbors. In Columns (5)–(8), we define the nearest province (NP) using two criteria: the province sharing the longest land border (Columns 5–6), and the province with the smallest centroid distance (Columns 7–8). In both cases, we test whether the share of income taxes is related to either the NP's instrument or its level of economic development. The results consistently show that neither the instrument nor the development level of the nearest province predicts a region's instrument value. These findings suggest that spatial spillovers are unlikely to drive the identification.

Taken together, the evidence in Table B1 indicates that our instrument is uncorrelated with a wide range of potential confounders. This supports the plausibility of the exclusion restriction and strengthens the case for using income tax share as an exogenous source of variation in local government investment incentives.

B.3 Additional Results of the Event Study

B.3.1 Potential Effects of the Tax Reform on Other Economic Variables

One pitfall of the DID estimation is that the observed treatment effects on GDP and infrastructure capital are confounded by concurrent changes in other variables. To address this, I estimate Equation (4) using a range of alternative outcomes. Figure B4 summarizes the results.

A primary concern is that the tax reform may have affected other fiscal instruments, thereby violating the exclusion restriction. The top two rows of Figure B4 examine the local fiscal response. I define pre-redistribution government revenue as total fiscal revenue collected within the province (including both local and central taxes), and post-

Table B1: Correlates between the Share of Corporate Income Taxes and Characteristics before the Tax Reform

	Dependent Variable: the Share of Income Taxes in 2000, Z_i							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP	0.022							
	(0.050)							
Infra. capital	0.013							
	(0.019)							
Non-infra. capital	-0.009							
	(0.034)							
Employment	-0.004							
	(0.012)							
Value-added Share: Secondary		0.029						
		(0.110)						
Value-added Share: Tertiary		0.322						
		(0.267)						
Govt Revenue			0.012					
			(0.034)					
Govt Consumption			0.019					
			(0.019)					
FDI				0.007				
				(0.010)				
Import & Export				-0.002				
				(0.011)				
Z_j, NP					-0.006	-0.065	0.022	-0.038
					(0.342)	(0.360)	(0.149)	(0.171)
Infra. Capital, NP						0.005		-0.003
						(0.020)		(0.022)
GDP, NP						0.008		0.015
						(0.026)		(0.023)
Constant	0.257*	0.045	0.271***	0.157**	0.169***	0.208***	0.165***	0.188***
	(0.132)	(0.115)	(0.098)	(0.059)	(0.050)	(0.074)	(0.023)	(0.054)
R^2	0.119	0.184	0.102	0.038	0.000	0.009	0.001	0.019

Note: Each column reports results of a single regression of the IV on regional characteristics before the tax reform. The sample period covers 1993 to 2000. Years fixed effects are controlled. Standard errors are clustered by 30 provinces. *** p<0.01, ** p<0.05, * p<0.1.

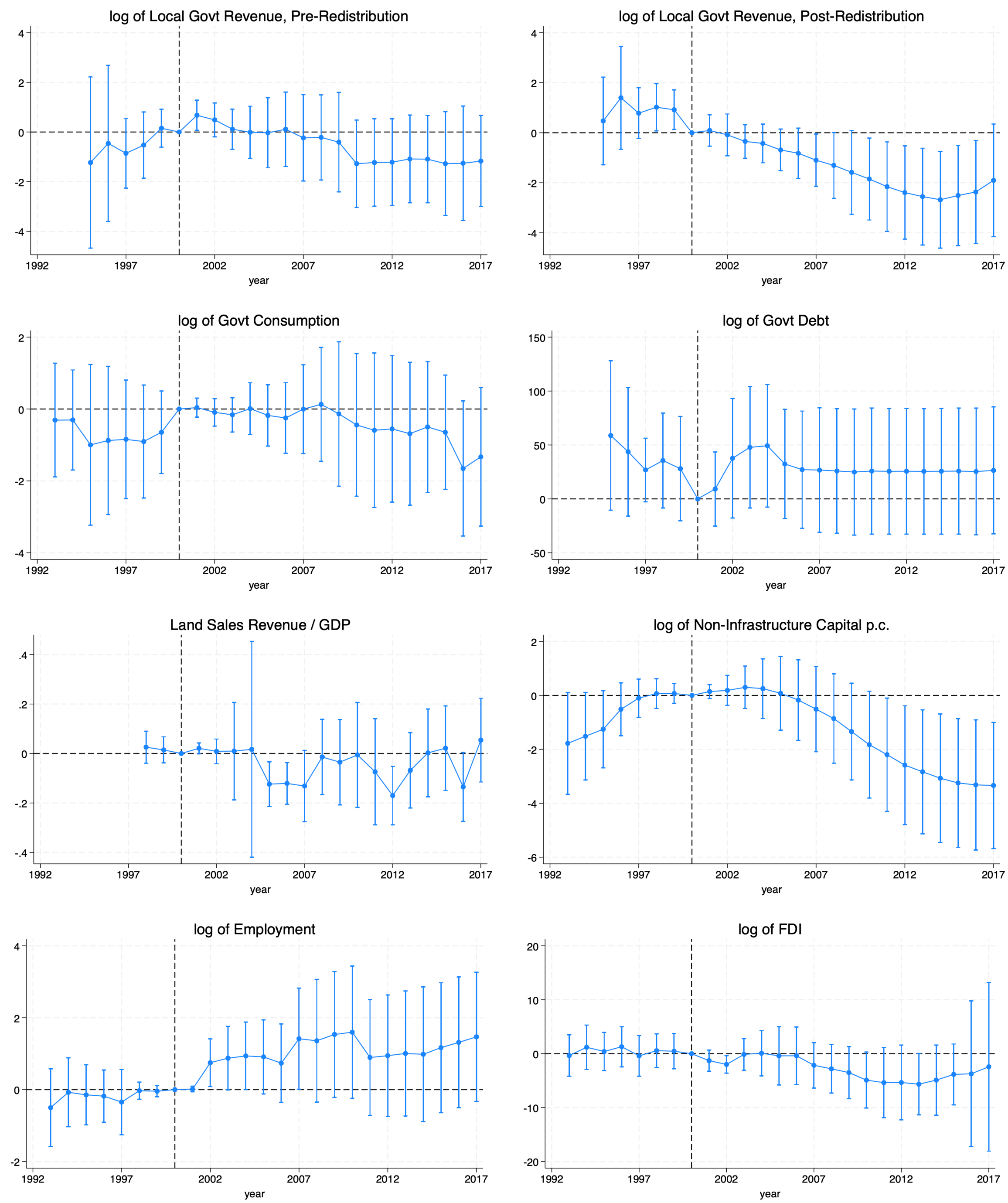
redistribution revenue as pre-redistribution revenue net of central taxes plus transfers from the central government. While the reform significantly reduces post-redistribution government revenue (consistent with the central revenue reallocation), it does not affect pre-redistribution revenue, suggesting that pro-growth policies like tax cuts are unlikely to have changed.

The second row shows no significant changes in local government consumption or debt. Facing tighter budget constraints, local governments reduced investment and reallocated spending toward consumption. As a result, government consumption remained stable despite declining revenue. This helps to disentangle the effects of public capital from government consumption, which are often conflated in the fiscal multiplier estimates. A similar offsetting mechanism explains the stability in local government debt and land sales. While tighter constraints could have increased borrowing and land sales, the drop in investment demand mitigated the pressure. These patterns support the exclusion restriction by indicating that the reform primarily affected fiscal behavior through investment, with limited spillovers to other channels.

A further concern is that the tax reform may have affected other production inputs. The third row shows no immediate post-reform effects on non-infrastructure capital or employment.[20] However, after 2010, provinces with higher income tax shares experience a decline in non-infrastructure capital, likely reflecting the crowd-in effects of infrastructure investment on private capital in the long run. While this constitutes an indirect channel through which infrastructure affects output, it may upwardly bias the estimated output elasticity. To address this, in the IV estimation in Section 5.1, I restrict the estimation sample to 2001–2010 when non-infrastructure capital is unaffected, and later use a Bartik-style instrument to estimate the output elasticities of both capital types over the full sample. Finally, the bottom panel shows no significant effects on FDI.

[20]The employment data published by the NBS are considered less reliable, partly due to political sensitivity surrounding unemployment. For instance, reported unemployment rates remain unusually stable even during periods of economic recession. In addition, detailed provincial-level employment data are sometimes missing. Therefore, we use per capita measures instead of per worker to account for differences population size and employment. This data unreliability may also contribute to the unusual pattern in which infrastructure capital and output decrease with the income tax share, while reported employment rises, though the increase is not statistically significant.

Figure B4: The Treatment Effects of the Tax Reform on Other Economic Variables, DID Estimation



B.3.2 Placebo test

Having established the treatment effects of the 2002 tax reform, I further assess whether these effects are specific to the targeted tax categories. To do so, I conduct a placebo test by replacing the treatment variable Z_i in Equation (4) with the shares of other major tax categories and other reform-related variables. Figure B5 presents the results.

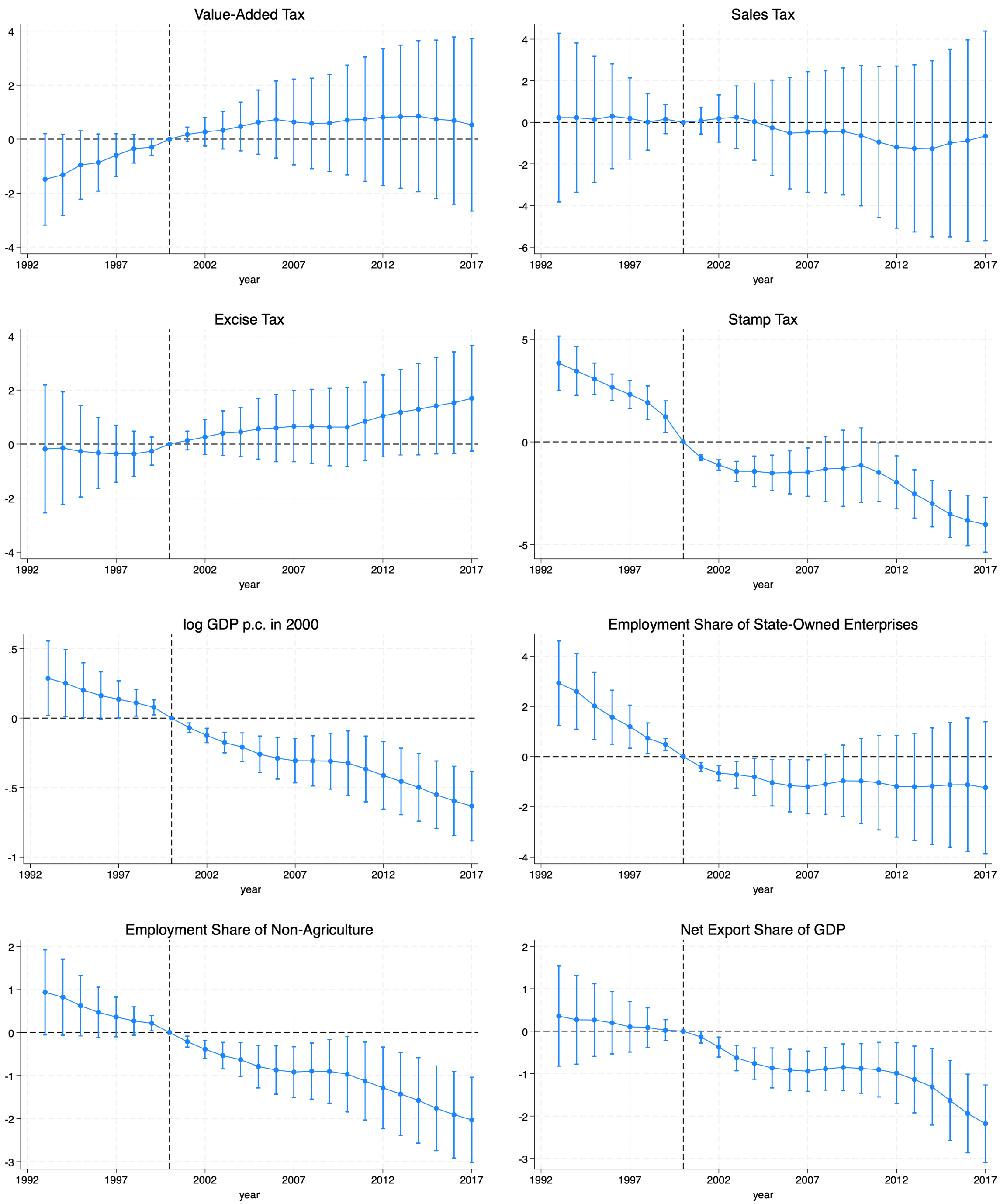
First, the panels in the first two rows show that the shares of value-added taxes, sales taxes, excise taxes, and stamp taxes—the other four major tax categories—have no significant effect on infrastructure capital growth after the tax reform. This illustrates that the treatment effects of the 2002 tax reform stem from the targeted tax categories.

Second, one may worry that the treatment effect is driven by underlying economic performance. For example, high-GDP regions, which tend to have a higher share of income taxes, may also have lower infrastructure investment. The right panel in the third row rules out this possibility by showing that replacing the treatment variable with the log of GDP per capita in 2000 yields no parallel pre-trend. Similar patterns emerge when the treatment variable is replaced with the employment share of state-owned enterprises (SOEs) or the employment share of the non-agricultural sector. These results confirm that the estimated treatment effects are not confounded by the SOE reform or structural change.

Third, when the share of net exports in GDP is used as the treatment variable, we observe both a parallel pre-trend and a declining trend after the reform. This suggests that provinces with higher net export shares experienced slower infrastructure growth following China's WTO accession, raising the possibility that the treatment effects of the 2002 tax reform are confounded by the WTO shock. I rule out this concern based on two pieces of evidence. First, the share of income taxes is uncorrelated with the share of net exports: regressing the former on the latter in 2000 yields an insignificant coefficient. Second, the event-study estimates display distinct patterns: the treatment effects of the 2002 tax reform weaken over time, whereas the WTO shock effects grow stronger. These patterns indicate that the two variables capture different sources of exogenous variation.

Overall, the placebo tests support the interpretation that the estimated treatment effects in the event study are indeed driven by the variation in income taxation.

Figure B5: Placebo Test: the Treatment Effects of the Share of Other Tax Categories on Infrastructure Capital, DID Estimation



Note: These figures display the estimated coefficients and the 95% confidence intervals from Equation (4), using log infrastructure capital as the outcome variable. The title of each panel indicates the treatment variable in 2000.

B.4 Discussions and Additional Results of IV Estimation

B.4.1 Discussion of the IV Estimation

The IV estimate is nearly twice the OLS estimate, suggesting a downward bias in OLS due to omitted variables. In particular, high-productivity provinces where local governments face higher distortions due to fiscal transfers may have weaker infrastructure incentives despite higher output. Meanwhile, the central government provides preferential policies and subsidies for investment in undeveloped regions. This introduces a negative correlation between unobserved distortions and infrastructure capital, biasing OLS estimates downward.

The IV estimate also exceeds the elasticity of 0.05 implied by infrastructure capital share, suggesting underinvestment relative to the social optimum. Despite frequent concerns of overinvestment by Chinese governments, infrastructure investment in China may remain suboptimal due to fiscal constraints. In 2010, total tax revenue amounted to only 14% of GDP, half of which was retained by the central government. Before 2009, local governments were legally forbidden to issue debt and borrow money from banks, forcing them to rely on land sales and local government financing vehicles (LGFVs) to finance infrastructure investment. The central redistribution scheme further disincentivizes investment in richer provinces. In such settings, estimates based on capital shares likely understate true output elasticities.

B.4.2 Robustness Check: Comparison with Su (2023)

Table B2 reports the estimate of output elasticity of infrastructure capital using the pre-reform praction of unoccupied land as an additional instrument variable. The estimate remains robust.

B.4.3 Returns to Scale

A number of studies assume that production functions with infrastructure capital exhibit increasing returns to scale.[21] We assess whether this assumption holds empirically.

[21] See, for example, Baxter and King (1993); Glomm and Ravikumar (1997); Leeper, Walker and Yang (2010); Boehm (2020); Henderson et al. (2022); Song and Xiong (2023). It is common to assume constant returns to scale in private inputs (labor and non-infrastructure capital), with infrastructure capital entering the production function through TFP with diminishing returns.

Table B2: Robustness Check: Estimating the Output Elasticity Using the Pre-reform Fraction of Unoccupied Land as an Additional Instrument Variable, 2001-2010

	OLS		OLS First Stage		IV	
	$\Delta \log G$	$\Delta \log K$	$\Delta \log K_G$		$\Delta \log Y$	
	(1)	(2)	(3)	(4)	(5)	(6)
Fraction of Unoccupied Land	0.051	-0.017	0.115***	0.090***		
	(0.030)	(0.023)	(0.034)	(0.028)		
Share of Income Taxes				-0.383***		
				(0.089)		
$\Delta \log K_G$					0.168*	0.181***
					(0.092)	(0.059)
$\Delta \log K$			0.240	0.222*	0.153***	0.149***
			(0.148)	(0.127)	(0.052)	(0.048)
Constant	0.092***	0.119***	0.046	0.126***	0.044***	0.042***
	(0.017)	(0.011)	(0.029)	(0.034)	(0.015)	(0.010)
R^2	0.255	0.291	0.311	0.437	0.431	0.413
First Stage F-stat			11.645	18.391		
Overidentification Test p-value						0.864

Note: This table reports robustness checks using the initial share of unoccupied urban land as an instrument. Y, K_G, G, and K denote GDP, infrastructure capital, government consumption, and non-infrastructure capital, respectively. Column (5) uses only the unoccupied land share as an instrument; Column (6) includes both the land share and the income tax share. Observations are 30 provinces for 10 years.

To test returns to scale, we must estimate the output elasticity of non-infrastructure capital alongside that of infrastructure capital, which requires additional instruments.

I construct Bartik-style instruments for non-infrastructure capital growth. Total investment comprises components such as agriculture, mining, manufacturing, construction, real estate, transportation, and others. I use the earliest available data—sectoral investment shares in 1996—to construct a vector of initial exposure shares. This approach follows Bartik (1991), Autor, Dorn and Hanson (2013), and Goldsmith-Pinkham, Sorkin and Swift (2020).[22] The key identifying assumption is that the 1996 investment structure is exogenous and predetermined, reflecting long-standing regional characteristics rather than endogenous responses. National investment patterns after 2000 were driven by some sector-specific shocks. For instance, the WTO accession spurred export-oriented manufacturing, while the 2008–2009 stimulus disproportionately boosted infrastructure and real estate. Provinces with different initial sectoral

[22] Goldsmith-Pinkham, Sorkin and Swift (2020) and Borusyak, Hull and Jaravel (2025) show that the 2SLS estimator using a Bartik instrument is numerically equivalent to a GMM estimator with the initial shares as instruments and a weight matrix based on national sectoral growth. Identification comes from the exogeneity of the initial shares, which reflect differential exposure to common shocks.

structures thus experienced varying exposure to these national shocks, validating the use of sector shares as instruments.

I estimate the elasticities year by year and report results in Figure B6.[23] The output elasticity of non-infrastructure capital is slightly larger than that of infrastructure capital. Once we control for both inputs, the estimated elasticity of infrastructure capital no longer rises above 0.4, as seen in Figure B6. On average, the elasticity of infrastructure capital is around 0.2, while that of non-infrastructure capital is slightly below 0.3.

Existing studies often set the labor elasticity at 0.5 to match the 50% labor share in China (Bai, Hsieh and Qian, 2006; Song, Storesletten and Zilibotti, 2011). Thus, we can test for increasing returns by examining whether the sum of capital elasticities exceeds 0.5. The bottom panel of Figure B6 shows that, during 2008–2015, the sum is statistically indistinguishable from 0.5, suggesting constant rather than increasing returns to scale.

C Proofs of Propositions and Corollaries in Sections 4 and 6

This Appendix section provides all the results and proofs of the main part of this paper.

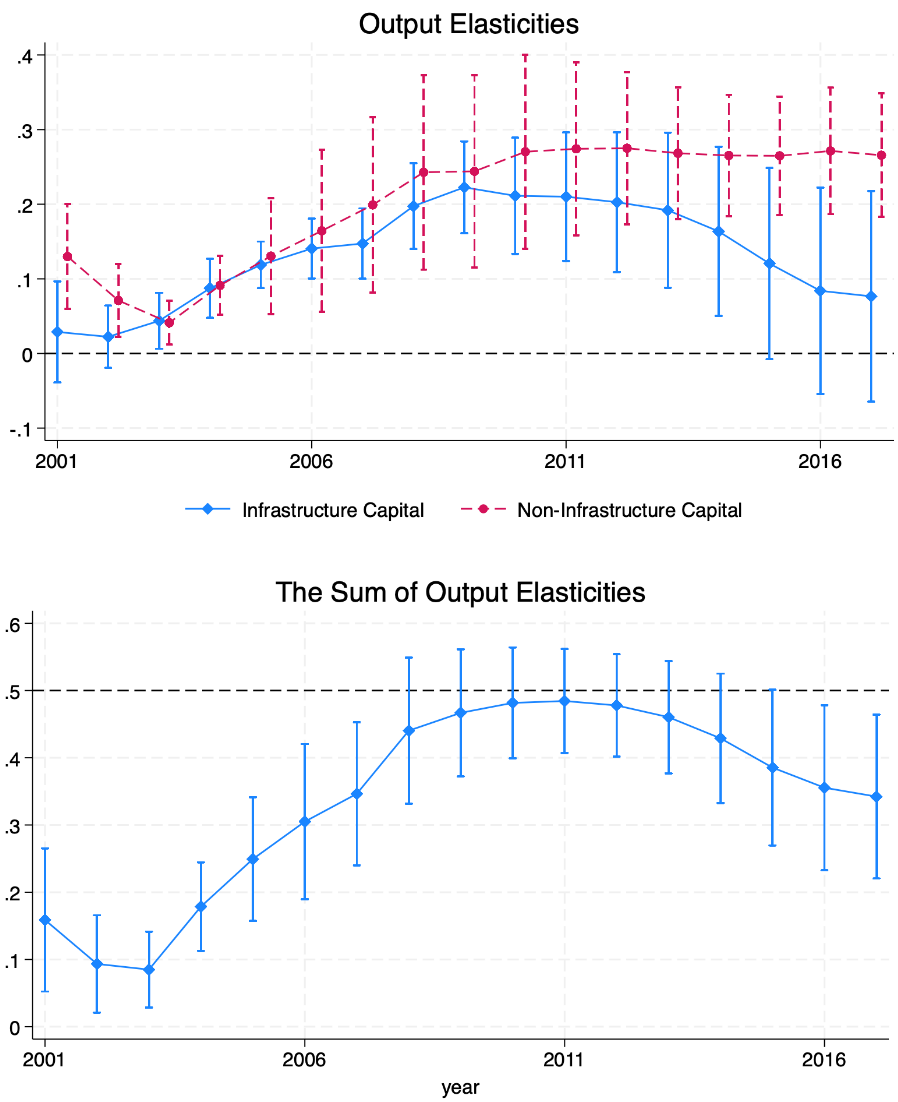
C.1 Proofs of Proposition 1, Corollaries 1, 2, 3

We start with solving the firm's problem. Plugging the production function Equation (5) into the firm's problem Equation (6) and taking first-order conditions with respect to k_i and n_i yields

$$\{k_i\}: \quad \theta(1-\tau_y)A_i k_{Gi}^{\alpha} k_i^{\theta-1} n_i^{1-\alpha-\theta} = (1+\tau_{ki})R$$
$$\{n_i\}: \quad (1-\alpha-\theta)(1-\tau_y)A_i k_{Gi}^{\alpha} k_i^{\theta} n_i^{-\alpha-\theta} = w_i$$

[23] The full-sample regression yields a first-stage F-statistic of 17.74. The Hansen J statistic is 15.47 (p = 0.28), indicating that the overidentifying restrictions are not rejected.

Figure B6: Output Elasticities of Infrastructure and Non-infrastructure Capital



This can pin down the firm's labor-capital ratio with the interest rate and wage rate. With $n_i = 1$ we have

$$\frac{\theta}{1-\alpha-\theta}\frac{n_i}{k_i} = \frac{(1+\tau_{ki})R}{w_i} \quad \Rightarrow \quad k_i = \frac{\theta}{1-\alpha-\theta}\frac{w_i}{(1+\tau_{ki})R} \tag{C1}$$

Plugging (C1) back into firm's FOCs can solve for the local wage rate w_i

$$w_i = (1-\alpha-\theta)\left(\frac{\theta}{(1+\tau_{ki})R}\right)^{\frac{\theta}{1-\theta}}(1-\tau_y)^{\frac{1}{1-\theta}}A_i^{\frac{1}{1-\theta}}k_{Gi}^{\frac{\alpha}{1-\theta}}$$

This can further pin down the firm's capital, output, and profit

$$\begin{aligned}
k_i &= \left(\frac{\theta(1-\tau_y)}{(1+\tau_{ki})R}\right)^{\frac{1}{1-\theta}}A_i^{\frac{1}{1-\theta}}k_{Gi}^{\frac{\alpha}{1-\theta}} \\
y_i &= \left(\frac{\theta(1-\tau_y)}{(1+\tau_{ki})R}\right)^{\frac{\theta}{1-\theta}}A_i^{\frac{1}{1-\theta}}k_{Gi}^{\frac{\alpha}{1-\theta}} \\
\pi_i &= \alpha\left(\frac{\theta}{(1+\tau_{ki})R}\right)^{\frac{\theta}{1-\theta}}(1-\tau_y)^{\frac{1}{1-\theta}}A_i^{\frac{1}{1-\theta}}k_{Gi}^{\frac{\alpha}{1-\theta}}
\end{aligned}$$

Corollary 1 is obvious as ϕ and λ do not directly appear in the firm's allocation given by Equation (7).

With the time-invariant productivity and policy in the steady state, plugging $c_i = w_i + \pi_i$ and y_i given by Equation (7) into the local government's problem, replacing G_i using the budget constraint, and taking the first-order condition with respect to k'_{Gi} yields:

$$\beta v_{k_G}(A'_i, k'_{Gi}) = \frac{\chi^L}{G_i} \tag{C2}$$

The envelope condition yields:

$$v_{k_G}(A_i, k_{Gi}) = \frac{\alpha}{1-\theta}\frac{1}{k_{Gi}} + \frac{\chi^L}{G_i}\left(\frac{\alpha(1-\phi)}{1-\theta}\lambda(\tau_y y)^{1-\phi}\frac{1}{k_G} + 1 - \delta\right) \tag{C3}$$

Combining the first-order condition and the envelope condition with the steady-state condition $k_{Gi} = k'_{Gi}$ yields the local fiscal policy k_{Gi} and output y_i as function of productivity A_i and policy (ϕ, λ, τ_y).

$$
\begin{aligned}
\log k_G = & \frac{1-\phi}{1-\theta-\alpha(1-\phi)} \log A \\
& + \frac{\theta(1-\phi)}{1-\theta-\alpha(1-\phi)} \log\left(\frac{\theta(1-\tau_y)}{R}\right) + \frac{(1-\theta)(1-\phi)}{1-\theta-\alpha(1-\phi)} \log \tau_y + \frac{1-\theta}{1-\theta-\alpha(1-\phi)} \log \lambda \\
& + \frac{1-\theta}{1-\theta-\alpha(1-\phi)} \log\left(\frac{\alpha\beta(1+\chi^L(1-\phi))}{\chi^L(1-\theta)(1-\beta(1-\delta))+\alpha\beta\delta}\right)
\end{aligned}
\tag{C4}
$$

$$
\begin{aligned}
\log y = & \frac{1}{1-\theta-\alpha(1-\phi)} \log A \\
& + \frac{\theta}{1-\theta-\alpha(1-\phi)} \log\left(\frac{\theta(1-\tau_y)}{R}\right) + \frac{\alpha(1-\phi)}{1-\theta-\alpha(1-\phi)} \log \tau_y + \frac{\alpha}{1-\theta-\alpha(1-\phi)} \log \lambda \\
& + \frac{\alpha}{1-\theta-\alpha(1-\phi)} \log\left(\frac{\alpha\beta(1+\chi^L(1-\phi))}{\chi^L(1-\theta)(1-\beta(1-\delta))+\alpha\beta\delta}\right)
\end{aligned}
\tag{C5}
$$

Here is a useful lemma when calculate the expectation of a log-normally distributed random variable.

Lemma 1. *If a random variable X is log-normally distributed,* $\log X \sim \mathcal{N}(\mu, \sigma_a^2)$*, we have*

$$
\log(\mathbb{E}[X]) = \mu + \frac{\sigma_a^2}{2}
$$

According to Lemma 1, it is straightforward to calculate the expecation of output, $\mathbb{E}[y]$. Then, using the central government's budget constraint

$$
\begin{aligned}
\log \lambda &= \log(\tau_y - g) + \log \mathbb{E}[y] - (1-\phi)\log \tau_y - \log \mathbb{E}[y^{1-\phi}] \\
&= \log(\tau_y - g) - \frac{(1-\theta-\alpha)(1-\phi)}{1-\theta-\alpha(1-\phi)} \log \tau_y \\
&+ \frac{\theta\phi}{1-\theta-\alpha(1-\phi)} \log\left(\frac{\theta(1-\tau_y)}{R}\right) + \frac{\alpha\phi}{1-\theta-\alpha(1-\phi)} \log \lambda \\
&+ \frac{\alpha\phi}{1-\theta-\alpha(1-\phi)} \log\left(\frac{\alpha\beta(1+\chi^L(1-\phi))}{\chi^L(1-\theta)(1-\beta(1-\delta))+\alpha\beta\delta}\right) \\
&- \frac{\phi(\theta+(1+\alpha)(1-\phi))}{[1-\theta-\alpha(1-\phi)]^2} \frac{\sigma_a^2}{2}
\end{aligned}
$$

we can pin down λ in the equilibrium:

$$\begin{aligned}\log\lambda = &\frac{1-\theta-\alpha(1-\phi)}{1-\theta-\alpha}\log(\tau_y-g)-(1-\phi)\log\tau_y\\&+\frac{\theta\phi}{1-\theta-\alpha}\log\left(\frac{\theta(1-\tau_y)}{R}\right)\\&+\frac{\alpha\phi}{1-\theta-\alpha}\log\left(\frac{\alpha\beta(1+\chi^L(1-\phi))}{\chi^L(1-\theta)(1-\beta(1-\delta))+\alpha\beta\delta}\right)\\&-\frac{\phi[\theta+(1+\alpha)(1-\phi)]}{(1-\theta-\alpha)[1-\theta-\alpha(1-\phi)]}\frac{\sigma_a^2}{2}\end{aligned}$$

Plugging $\log\lambda$ into Equations (C4) and (C5) yields

$$\begin{aligned}\log k_G = &\frac{1-\phi}{1-\theta-\alpha(1-\phi)}\log A\\&+\frac{\theta}{1-\theta-\alpha}\log\left(\frac{\theta(1-\tau_y)}{R}\right)+\frac{1-\theta}{1-\theta-\alpha}\log\left(\frac{\alpha\beta(1+\chi^L(1-\phi))}{\chi^L(1-\theta)(1-\beta(1-\delta))+\alpha\beta\delta}\right)\\&+\frac{1-\theta}{1-\theta-\alpha}\log(\tau_y-g)-\frac{(1-\theta)\phi[\theta+(1+\alpha)(1-\phi)]}{(1-\theta-\alpha)(1-\theta-\alpha(1-\phi))^2}\frac{\sigma_a^2}{2}\end{aligned} \tag{C6}$$

$$\begin{aligned}\log y = &\frac{1}{1-\theta-\alpha(1-\phi)}\log A\\&+\frac{\theta}{1-\theta-\alpha}\log\left(\frac{\theta(1-\tau_y)}{R}\right)+\frac{\alpha}{1-\theta-\alpha}\log\left(\frac{\alpha\beta(1+\chi^L(1-\phi))}{\chi^L(1-\theta)(1-\beta(1-\delta))+\alpha\beta\delta}\right)\\&+\frac{\alpha}{1-\theta-\alpha}\log(\tau_y-g)-\frac{\alpha\phi[\theta+(1+\alpha)(1-\phi)]}{(1-\theta-\alpha)(1-\theta-\alpha(1-\phi))^2}\frac{\sigma_a^2}{2}\end{aligned}$$

For convenience, let $Y^R(\phi,\tau_y,g)$ denote the output of the representative region:

$$\begin{aligned}\log Y^R(\phi,\tau_y,g) = &\frac{\theta}{1-\theta-\alpha}\log\left(\frac{\theta(1-\tau_y)}{R}\right)+\frac{\alpha}{1-\theta-\alpha}\log\left(\frac{\alpha\beta(1+\chi^L(1-\phi))}{\chi^L(1-\theta)(1-\beta(1-\delta))+\alpha\beta\delta}\right)\\&+\frac{\alpha}{1-\theta-\alpha}\log(\tau_y-g)\end{aligned}$$

and define $\Omega(\sigma_a^2;\phi)$ as

$$\Omega^y(\sigma_a^2;\phi) = -\frac{\alpha\phi[\theta+(1+\alpha)(1-\phi)]}{(1-\theta-\alpha)(1-\theta-\alpha(1-\phi))^2}\frac{\sigma_a^2}{2}$$

This concludes the proof of Proposition 1. Corollaries 2 and 3 can be obtained directly using the equilibrium allocations.

C.2 Proofs of Proposition 2, Corollaries 4, 5

As k_{Gi}, y_i, and k_i are log-normally distributed, it is straightforward to get the expectations following Lemma 1 and calculate TFP as the Solow residual in Proposition 2.

Taking the derivatives of $\log Y$ with respect to ϕ yields

$$\frac{\partial \log Y}{\partial \phi} = -\frac{\alpha(1-\theta)}{1-\theta-\alpha}\frac{2\phi}{(1-\theta-\alpha(1-\phi))^3}\frac{\sigma_a^2}{2} - \frac{\alpha}{1-\theta-\alpha}\frac{\chi^L}{1+\chi^L(1-\phi)}$$

$\partial \log Y/\partial\phi < 0$ when $\phi \geq 0$. This completes the proof of Corollary 4. The distortion term in $\log \mathrm{TFP}$ is negative for all $\phi \neq 0$ and is 0 precisely at $\phi = 0$. This makes $\phi = 0$ a global maximizer and establishes the proof Corollary 5.

It is convenient to derive $\mathbb{E}[G]/\mathbb{E}[y]$. By Corollary 2, we know that the ratio of local government consumption to investment is constant. Therefore, the ratio of local government consumption to the post-redistribution local government revenue should be constant as well. The post-redistribution local government revenue equals total tax revenue less central government consumption, which is $(\tau_y - g)\mathbb{E}[y]$. This leads to the expression of $\mathbb{E}[G]/\mathbb{E}[y]$ as:

$$\frac{\mathbb{E}[G_i]}{\mathbb{E}[y_i]} = (\tau_y - g) \times \frac{\chi^L(1-\theta-\alpha(1-\phi))}{\alpha+\chi^L(1-\theta)} \tag{C7}$$

C.3 Proofs of Propositions 3, 4, 5, Corollary 6

Before we derive the analytical expression of the social welfare function, we introduce some useful lemmas.

Lemma 2. *If a random variable X is log-normally distributed, $\log X \sim \mathcal{N}(\mu, \sigma_a^2)$, we have*

$$\mathbb{E}[\log(X)] = \log \mathbb{E}[X] - \frac{1}{2}\mathrm{var}(\log X)$$

Proof. This follows directly from the property of the log-normal distribution introduced in Lemma 1.

$$\mathbb{E}[X] = \exp(\mu + \frac{\sigma^2}{2})$$
$$\Rightarrow \quad \log \mathbb{E}[X] = \mu + \frac{\sigma^2}{2} = \mathbb{E}[\log X] + \frac{1}{2}\text{var}(\log X)$$

□

Lemma 3. *If* $X \sim \mathcal{N}(\mu, \sigma^2)$,

$$\mathbb{E}[X \exp(tX)] = (\mu + t\sigma^2)\mathbb{E}[\exp(tX)]$$

Proof.

$$\begin{aligned}
\mathbb{E}[X \exp(tX)] &= \int X \exp(tX) \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(\frac{(X-\mu)^2}{2\sigma^2}\right) dX \\
&= \int X \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{(X-\mu-t\sigma^2)^2 - 2\mu t\sigma^2 - t^2\sigma^4}{2\sigma^2}\right) dX \\
&= \int X \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{(X-\mu-t\sigma^2)^2}{2\sigma^2}\right) dX \exp\left(\frac{2\mu t\sigma^2 + t^2\sigma^4}{2\sigma^2}\right) \\
&= (\mu + t\sigma^2) \exp\left(\mu t + \frac{t^2\sigma^2}{2}\right) \\
&= (\mu + t\sigma^2)\mathbb{E}[\exp(tX)]
\end{aligned}$$

□

Following Lemma 3, $\int \exp(a_i) \log y_i di$ can be given by:

$$\frac{1}{\int \exp(-\gamma a) dF_a(a)} \int \frac{\exp(-\gamma a)a}{1-\theta-\alpha(1-\phi)} dF_a(a) = -\frac{\gamma\sigma_a^2}{1-\theta-\alpha(1-\phi)} - \frac{1}{1-\theta-\alpha(1-\phi)} \frac{\sigma_a^2}{2}$$

The second term is $\mathbb{E}[\log y]$. Following Leamma 2, we can rewrite it as

$$-\frac{\gamma\sigma_a^2}{1-\theta-\alpha(1-\phi)} + \log(\mathbb{E}[y]) - \frac{1}{2}\text{var}(\log y)$$

With $\log c_i = \log(w_i + \pi_i) = \log((1-\theta)(1-\tau_y)) + \log y_i$, $\log G^C = \log(g\mathbb{E}[y])$, and the aggregate local government consumption to output ratio given by Equation (C7), the welfare function can be expressed as the welfare from aggregate output and the welfare cost from inequality:

$$\mathcal{W}(\phi,\tau_y,g) = (1+\chi^L+\chi^C)\log\mathbb{E}[y_i] - \frac{1}{2}\text{var}(\log c_i) - \frac{\chi^L}{2}\text{var}(\log G_i) - \frac{\gamma\sigma_a^2}{1-\theta-\alpha(1-\phi)} + \log((1-\tau_y)(1-\theta)) + \chi^C\log g + \chi^L\left(\log\left(\frac{\chi^L(1-\theta-\alpha(1-\phi))}{\alpha+\chi^L(1-\theta)}\right) + \log(\tau_y - g)\right) \tag{C8}$$

With the assumption $\beta \to 1$, plugging the expression of $\log Y$ given by Equation 2 into Equation (C8), and omitting the redundant terms yields the expression of Equation (18) in Proposition 3.

Given the social welfare function in Equation (18), we can derive the first and the twice differentiations with respect to ϕ, τ_y, and g, respectively.

$$\frac{\partial\mathcal{W}(\phi,\tau_y,g)}{\partial g} = -\frac{\alpha(1+\chi^C)+\chi^L(1-\theta)}{1-\theta-\alpha}\frac{1}{\tau_y-g} + \frac{\chi^C}{g} \tag{C9}$$

$$\frac{\partial^2\mathcal{W}(\phi,\tau_y,g)}{\partial g^2} = -\frac{\alpha(1+\chi^C)+\chi^L(1-\theta)}{1-\theta-\alpha}\frac{1}{(\tau_y-g)^2} - \frac{\chi^C}{g^2} < 0$$

$$\frac{\partial\mathcal{W}(\phi,\tau_y,g)}{\partial \tau_y} = \frac{\alpha(1+\chi^C)+\chi^L(1-\theta)}{1-\theta-\alpha}\frac{1}{\tau_y-g} - \frac{1-\alpha+\theta(\chi^L+\chi^C)}{1-\theta-\alpha}\frac{1}{1-\tau_y} \tag{C10}$$

$$\frac{\partial^2\mathcal{W}(\phi,\tau_y,g)}{\partial \tau_y^2} = -\frac{\alpha(1+\chi^C)+\chi^L(1-\theta)}{1-\theta-\alpha}\frac{1}{(\tau_y-g)^2} - \frac{1-\alpha+\theta(\chi^L+\chi^C)}{1-\theta-\alpha}\frac{1}{(1-\tau_y)^2} < 0$$

These four equations establishes the global concavity of the social welfare function in τ_y and g. Corollary 6 is derived from letting $\partial\mathcal{W}(\phi,\tau_y,g)/\partial g = 0$ and $\partial\mathcal{W}(\phi,\tau_y,g)/\partial\tau_y = 0$ using Equations (C9) and (C10).

$$\frac{\partial\mathcal{W}(\phi,\tau_y,g)}{\partial \phi} = -\frac{\alpha(1+\chi^L+\chi^C)}{1-\theta-\alpha}\frac{\chi^L}{1+\chi^L(1-\phi)} + \frac{\alpha\chi^L}{1-\theta-\alpha(1-\phi)} - \frac{(1+\chi^L+\chi^C)\alpha(1-\theta)}{1-\theta-\alpha}\frac{\phi}{(1-\theta-\alpha(1-\phi))^3}\sigma_a^2 + \frac{\alpha+\chi^L(1-\phi)(1-\theta)}{(1-\theta-\alpha(1-\phi))^3}\sigma_a^2 + \frac{\chi^L(1-\theta)+\alpha}{(1-\theta-\alpha(1-\phi))^2}\gamma\sigma_a^2 \tag{C11}$$

$$
\begin{aligned}
\frac{\partial^2 \mathcal{W}(\phi, \tau_y, g)}{\partial \phi^2} = &-\frac{\alpha(1+\chi^L+\chi^C)}{1-\theta-\alpha}\frac{(\chi^L)^2}{(1+\chi^L(1-\phi))^2} - \frac{\alpha^2\chi^L}{(1-\theta-\alpha(1-\phi))^2} \\
&- \frac{(1+\chi^L+\chi^C)\alpha(1-\theta)}{1-\theta-\alpha}\frac{1-\theta-\alpha-2\alpha\phi}{(1-\theta-\alpha(1-\phi))^4}\sigma_a^2 \\
&- \frac{(1-\theta-\alpha(1-\phi))\chi^L(1-\theta)+3(\alpha+\chi^L(1-\phi)(1-\theta))}{(1-\theta-\alpha(1-\phi))^4}\sigma_a^2 \\
&- \frac{2(\chi^L(1-\theta)+\alpha)\alpha}{(1-\theta-\alpha(1-\phi))^3}\gamma\sigma_a^2
\end{aligned} \tag{C12}
$$

In Equation (C12), the first, third, and the last lines are negative. The second line is negative if $1-\theta-\alpha > 2\alpha\phi$, which is satisfied in the calibration.

For Proposition 4, ϕ^{R*} is derived from letting the first line of Equation (C11) equal to 0. To calculate the marginal tax rate and the average tax rate under the scheme $(\phi^{R*}, \tau_y^*, g^*)$, recall that in the representative model, λ is calculated as

$$
(\tau_y - g)y = \lambda(\tau_y y)^{1-\phi} \quad \Rightarrow \quad \lambda = \frac{\tau_y - g}{\tau_y^{1-\phi}} y^{\phi}
$$

Then, the marginal tax rate and the average tax rate are given by

$$
MTR = 1 - \lambda(1-\phi)(\tau_y y)^{-\phi} = 1 - (\tau_y - g)\tau_y^{-1}(1-\phi)
$$

$$
ATR = 1 - \lambda(\tau_y y)^{-\phi} = 1 - (\tau_y - g)\tau_y^{-1}
$$

From Equations (19) and (23), we can calculate

$$
\tau_y^* - g^* = \frac{\alpha(1+\chi^C) + (1-\theta)\chi^L}{1+\chi^L+\chi^C}
$$

$$
(\tau_y^*)^{-1} = \frac{1+\chi^L+\chi^C}{\alpha + (1-\theta)(\chi^L+\chi^C)}
$$

$$
1 - \phi^{R*} = \frac{\alpha + (1-\theta)(\chi^C+\chi^L)}{\alpha(1+\chi^C) + (1-\theta)\chi^L}
$$

These above three equations yield that $MTR = 0$ and

$$
ATR = 1 - (\tau_y^* - g^*)(\tau_y^*)^{-1} = \frac{(1-\alpha-\theta)\chi^C}{\alpha + (1-\theta)(\chi^L+\chi^C)} = \frac{g^*}{\tau_y^*}
$$

This completes the proof of Proposition 4.

Inequality (24) in Proposition 5 is derived from evaluating Equation (C11) at $\phi = 0$ and letting it be strictly larger than 0.

Moreover, $\partial \mathcal{W}(\phi, \tau_y, g)/\partial \phi = 0$ leads to Equation (25) in Proposition 6.

D A Model with Land Finance and Local Government Debt

In this section, I extend the framework in Section 4 to incorporate land finance and local government debt. Land is an input in firm production. The production function (5) becomes

$$y_i = A_i k_{Gi}^{\alpha} k_i^{\theta} l_i^{\eta} n_i^{1-\alpha-\theta-\eta}$$

and the local firm's problem (6) becomes

$$\pi_i = \max_{k_i, l_i, n_i} (1 - \tau_y) y_i - R k_i - R_i^L l_i - w_i n_i$$

where l_i is land and R_i^L is the region-specific land rent.

The firm's demand for the land as a function as proudctivity and factor prices is

$$l_i = \left[(1 - \tau_y) \eta A_i k_{Gi}^{\alpha} \left(\frac{\theta}{\eta R} \right)^{\theta} \left(\frac{1 - \theta - \alpha - \eta}{\eta w_i} \right)^{\gamma} (R_i^L)^{-\alpha-\eta} \right]^{\frac{1}{\alpha}}$$

which is decreasing in the land rent R_i^L.

I assume that land supply in each region is fixed and normalized to one, and that land rent is determined competitively. Alternatively, I can assume that land supply has an upper bound $\bar{l}_i$. It is easy to verify that total land rent is increasing in l_i. Therefore, local governments optimally supply $\bar{l}_i$. As before, I also normalize $n_i = 1$. Standard algebra yields

$$y_i = \left(\frac{\theta (1 - \tau_y)}{R} \right)^{\frac{\theta}{1-\theta}} A_i^{\frac{1}{1-\theta}} k_{Gi}^{\frac{\alpha}{1-\theta}}$$

$$R_i^L l_i = \eta (1 - \tau_y) y_i$$

Therefore, total local fiscal revenue becomes

$$R_i^L l_i + \tau_y y_i = [\tau_y + \eta(1 - \tau_y)]y_i = \tilde{\tau}_y y_i$$

where $\tilde{\tau}_y$ can be interpreted as the share of local fiscal revenue in local output. In this environment, k_{Gi} raises not only tax revenue but also land rent.

Let b_i denote local government borrowing in region i. I now assume that local governments maximize utility from local government consumption. The value function of local governments is

$$\begin{aligned} v(A_i, k_{Gi}, b_i) &= \max_{k'_{Gi}, b'_i} \log G_i + \beta v(A'_i, k'_{Gi}, b'_i) \\ \text{s.t.} \quad G_i + k'_{Gi} + (1+r)b_i &\leq \lambda(\tilde{\tau}_y y_i)^{1-\phi} + (1-\delta)k_{Gi} + b'_i \end{aligned}$$

Let μ_i denote the Lagrange multiplier. The first-order condition and the envelope condition with respect to debt imply

$$\mu_i = \beta \mu'_i (1 + r)$$

The first-order condition and the envelope condition with respect to public capital imply

$$\mu_i = \beta \mu'_i \left[\frac{\partial \lambda(\tilde{\tau}_y y'_i)^{1-\phi}}{\partial k'_{Gi}} + 1 - \delta \right]$$

Combining these two optimality conditions yields

$$\frac{\partial \lambda(\tilde{\tau}_y y'_i)^{1-\phi}}{\partial k'_{Gi}} = r + \delta = R$$

The left-hand side is the post-redistribution marginal return to public investment, while the right-hand side is the user cost of public capital when local governments have access to debt. This condition pins down the level of public capital in every period:

$$
\begin{aligned}
\log k'_G = & \frac{1-\phi}{1-\theta-\alpha(1-\phi)} \log A' \\
& + \frac{\theta(1-\phi)}{1-\theta-\alpha(1-\phi)} \log\left(\theta(1-\tau_y)\right) + \frac{(1-\theta)(1-\phi)}{1-\theta-\alpha(1-\phi)} \log \tilde{\tau}_y + \frac{1-\theta}{1-\theta-\alpha(1-\phi)} \log \lambda \\
& + \frac{1-\theta}{1-\theta-\alpha(1-\phi)} \log\left(\frac{\alpha(1-\phi)}{1-\theta}\right) - \frac{1-\theta\phi}{1-\theta-\alpha(1-\phi)} \log R
\end{aligned}
$$

This expression is similar to Equation (C4) and delivers the same qualitative implications of rising progressivity. First, rising progressivity reduces the pass-through from productivity to public capital by redistributing resources toward low-productivity regions. Second, progressivity reduces the marginal return to investment, inducing local governments to shift spending away from investment and toward government consumption. This effect is captured by the first term of the third line. After substituting the equilibrium value of λ, optimal public capital is

$$
\begin{aligned}
\log k^*_G(A') = & \frac{1-\phi}{1-\theta-\alpha(1-\phi)} \log A' \\
& + \frac{\theta}{1-\theta-\alpha} \log(\theta(1-\tau_y)) + \frac{1-\theta}{1-\theta-\alpha} \log\left(\frac{\alpha(1-\phi)}{1-\theta}\right) - \frac{1}{1-\theta-\alpha} \log R \\
& + \frac{1-\theta}{1-\theta-\alpha} \log(\tilde{\tau}_y - g) - \frac{(1-\theta)\phi[\theta+(1+\alpha)(1-\phi)]}{(1-\theta-\alpha)(1-\theta-\alpha(1-\phi))^2} \frac{\sigma_a^2}{2}
\end{aligned}
$$

which is similar to Equation (C6).

Now define net fiscal resources after investment in period $t+s$ as

$$
X_{i,t+s} = \lambda(\tilde{\tau}_y y_{i,t+s})^{1-\phi} + (1-\delta)k_{Gi,t+s} - k^*_G(A_{i,t+s+1})
$$

The Euler equation for government consumption is

$$
G_{it+1} = \beta(1+r)G_{it}
$$

Meanwhile, the intertemporal budget constraint is

$$
\sum_{s=0}^{\infty}(1+r)^{-s}G_{it+s} = \sum_{s=0}^{\infty}(1+r)^{-s}X_{i,t+s} - (1+r)b_i
$$

Using the Euler equation, the left-hand side can be written as $G_i \sum_{s=0}^{\infty} \beta = G_i/(1-\beta)$. Therefore, government consumption is

$$G_i = (1-\beta)\left[\sum_{s=0}^{\infty}(1+r)^{-s}X_{i,t+s} - (1+r)b_i\right]$$

and debt is determined by the one-period budget constraint:

$$b_i' = (1+r)b_i + G_i - X_i$$

In particular, suppose $A_i' = A_i$ forever and public capital starts at its optimal level, $k_G = k_G^*$. Then, the investment in every period is δk_{Gi}^*, and government consumption is

$$G_i = (1-\beta)(1+r)\left(\frac{X_i^*}{r} - b_i\right)$$

where X_i^* is given by:

$$X_i^* = \frac{(r+\delta)(1-\theta) - \alpha(1-\phi)\delta}{\alpha(1-\phi)} k_G^*$$

If $b_i = 0$, the spending share is

$$\frac{G_i}{\delta k_{Gi}} = \frac{(1-\beta)(1+r)[r(1-\theta) + (1-\theta-\alpha(1-\phi))\delta]}{r\delta\alpha(1-\phi)}$$

which is increasing in ϕ, consistent with Corollary Corollary 2.

E Details for Quantitative Results

E.1 Algorithm

The transitional dynamics is solved using shooting algorithm. For a sufficiently large T, we expect the economy has converged to the steady state before period T. Given the shocks and policy $\{\phi_T, \tau_{yT}, g_T, A_{iT}, \tau_{kiT}\}$, which is set at the 2017 values, solve for the steady state allocation for each region. Then, given the initial condition $\{k_{Gi0}\}_i$ and the final state $\{k_{GiT}\}_i$, guess the path $\{k_{Git}\}_{i,t}$. Given the guess $\{k_{Git}\}_{i,t}$, $\{\lambda_t\}_t$ can be pinned in the equilibrium. Then, starting from the last period, given $\{k_{Git+1}\}_{i,t}$, using the optimality conditions (C2) and (C3) and the local government budget constraint solve for the new path $\{k_{Git}\}_{i,t}^{new}$. Update the path for $\{k_{Git}\}_{i,t}$ and $\{\lambda_t\}_t$ and iterate until convergence.

E.2 Aggregate TFP in the Efficient Allocation

The static social planner problem is

$$\begin{aligned} &\max_{\{k_i,k_{Gi}\}_i} \sum_i A_i k_{Gi}^{\alpha} k_i^{\theta} \\ &\text{s.t.} \quad \sum_i k_i = K, \quad \sum_i k_{Gi} = K_G \end{aligned}$$

where K and K_G are fixed aggregate capital stocks. Let μ_k and μ_{k_G} denote the Lagrangian multipliers. First-order conditions impliy:

$$\alpha A_i k_{Gi}^{\alpha-1} k_i^{\theta} = \mu_{k_G}, \quad \theta A_i k_{Gi}^{\alpha} k_i^{\theta-1} = \mu_k$$

The within-region allocation must satisfy:

$$\frac{k_i}{k_{Gi}} = \frac{\theta}{\alpha}\frac{\mu_{k_G}}{\mu_k}$$

Plugging the ratio back to the first-order condition yields

$$\alpha A_i k_{Gi}^{\alpha-1}\left(\frac{\theta}{\alpha}\frac{\mu_{k_G}}{\mu_k}k_{Gi}\right)^{\theta} = \mu_{k_G} \quad \Rightarrow \quad k_{Gi} \propto A_i^{\frac{1}{1-\alpha-\theta}}$$

Therefore

$$\frac{k_{Gi}^*}{K_G} = \frac{A_i^{\frac{1}{1-\theta-\alpha}}}{\sum_i A_i^{\frac{1}{1-\theta-\alpha}}}, \quad \frac{k_i^*}{K} = \frac{A_i^{\frac{1}{1-\theta-\alpha}}}{\sum_i A_i^{\frac{1}{1-\theta-\alpha}}}$$

Therefore, the aggregate TFP under the efficient allocation is given by:

$$\begin{aligned} \text{TFP}^* &= \frac{Y^*}{K^{\theta}K_G^{\alpha}} = \frac{\sum_i A_i (k_i^*)^{\theta}(k_{Gi}^*)^{\alpha}}{K^{\theta}K_G^{\alpha}} = \sum_i A_i \left(\frac{k_i^*}{K}\right)^{\theta}\left(\frac{k_{Gi}^*}{K_G}\right)^{\alpha} \\ &= \sum_i A_i \left(\frac{A_i^{\frac{1}{1-\alpha-\theta}}}{\sum_i A_i^{\frac{1}{1-\alpha-\theta}}}\right)^{\theta+\alpha} = \frac{\sum_i A_i^{\frac{1}{1-\alpha-\theta}}}{(\sum_i A_i^{\frac{1}{1-\alpha-\theta}})^{\theta+\alpha}} = \left(\sum_i A_i^{\frac{1}{1-\alpha-\theta}}\right)^{1-\theta-\alpha} \end{aligned} \tag{E13}$$

When $\log A_i \sim \mathcal{N}(\sigma_a^2/2, \sigma_a^2)$, Equation (E13) coincides with the theoretical formula given by Equation (15) with $\phi = 0$ because

$$\mathbb{E}\left[A_i^{\frac{1}{1-\alpha-\theta}}\right] = \exp\left(\frac{\theta+\alpha}{(1-\theta-\alpha)^2}\frac{\sigma_a^2}{2}\right)$$

E.3 Additional Quantitative Results

This subsection provides additional quantitative results. Figure E7 presents the evolution of the tax rate τ_y and the central government spending share g. Figure E8 presents the joint distribution of productivity and capital wedges. Figure E9 shows the regional convergence in TFP that high-TFP regions have lower TFP growth.

Figure E7: Evolution of the Tax Rate τ_y and the Central Government Consumption Share g

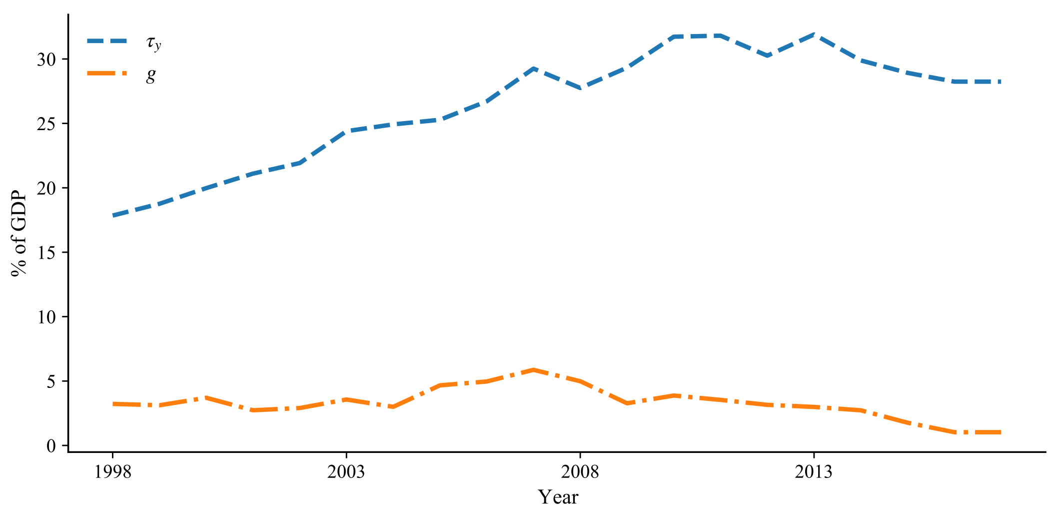


Figure E10 displays aggregate output and infrastructure capital. The model replicates the growth path. Setting ϕ at the initial level does not quantitatively change the profile.

In the quantitative analysis, we allow for region-specific capital wedges in the private capital market in order to match the capital-output ratio in the data. This sections provides counterfacutal experiments in different specifications.

Figure E8: Evolution of the Joint Distribution of TFP and Capital Wedges

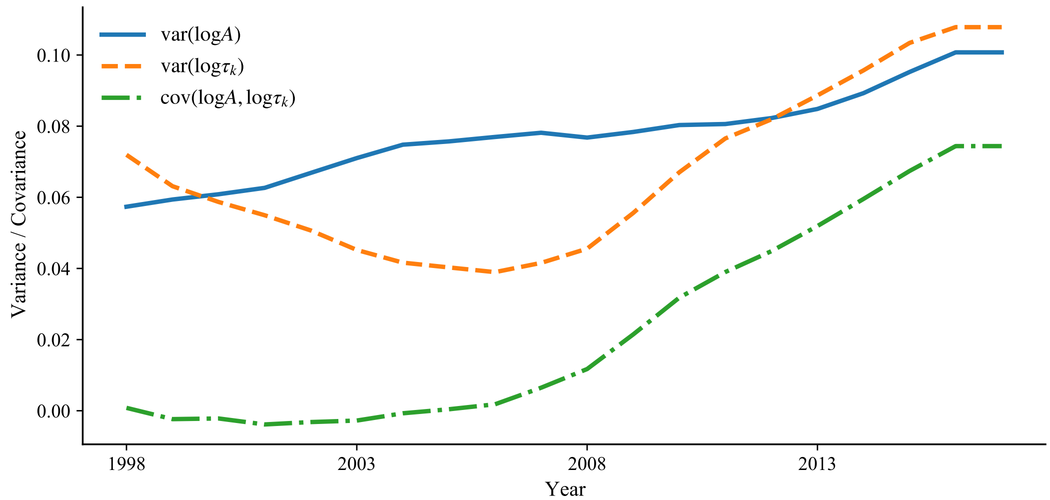


Figure E9: Regional Convergence of TFP: 1998-2017

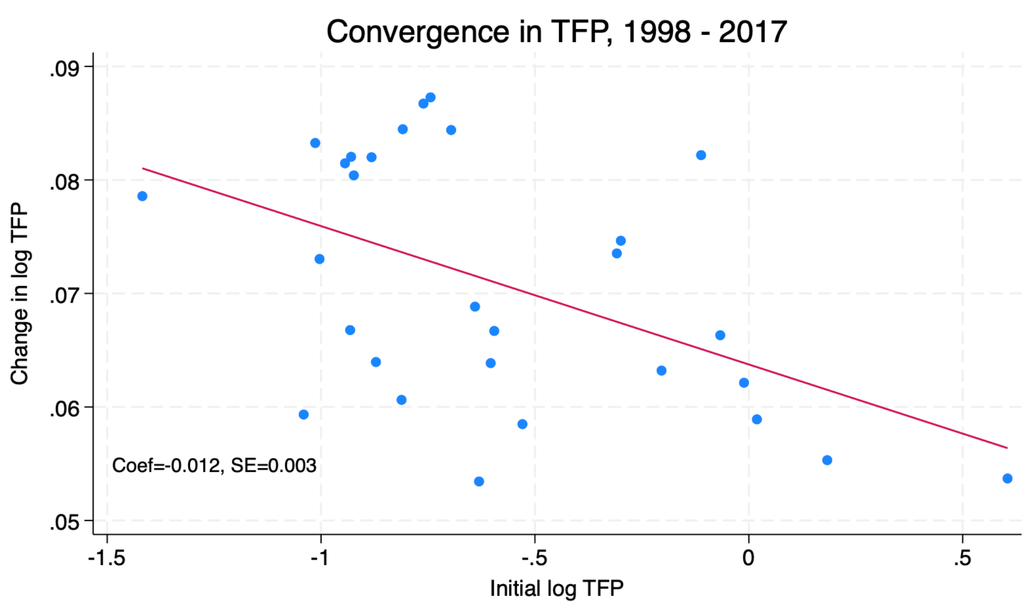


Figure E10: Aggregate Output and Infrastructure Capital: Data, Model, and Counterfactual

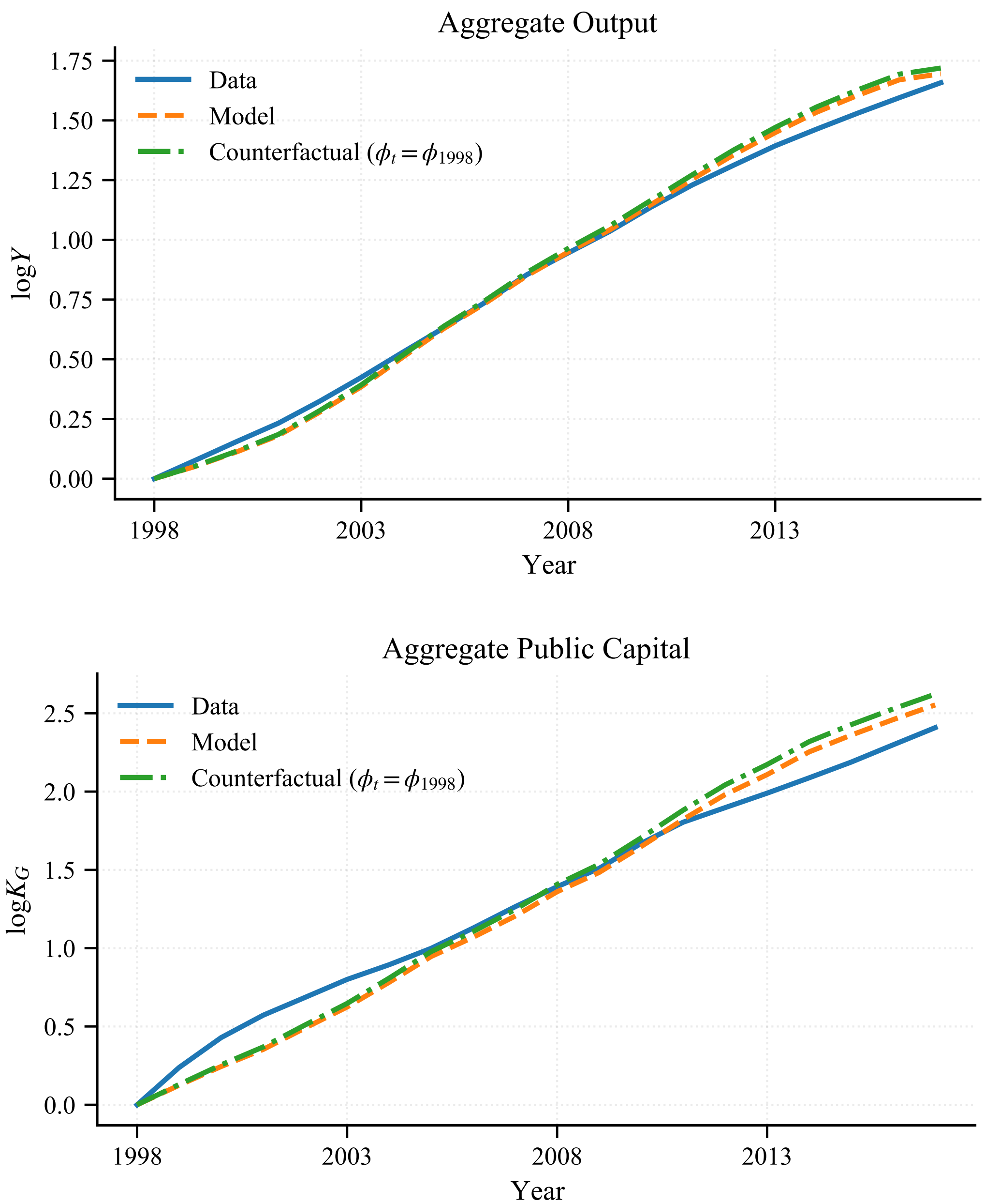
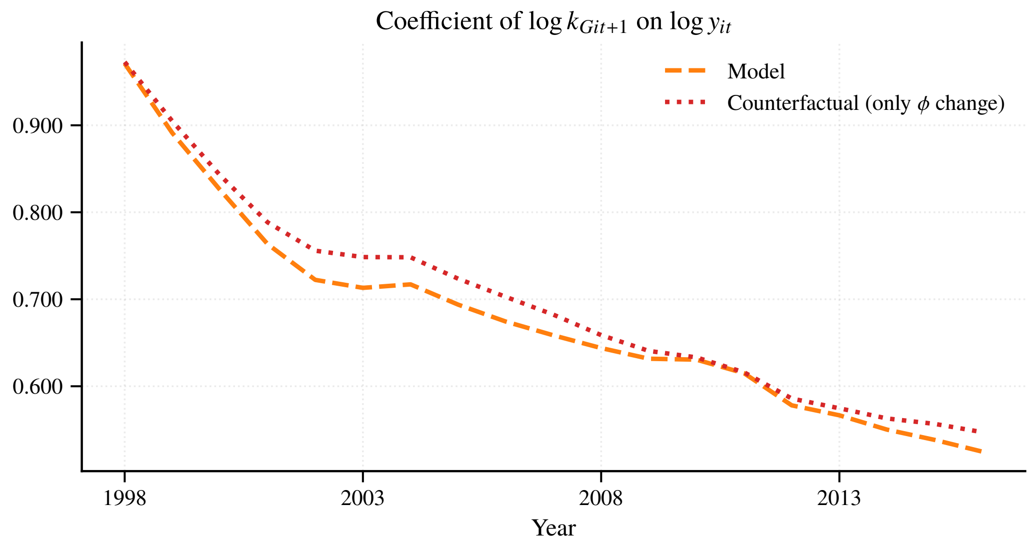


Figure E11: The Correlation between Output and Infrastructure Capital Stock: Model and Counterfactual with Only ϕ Evolving Over Time



Note: The dotted line represent the counterfactual experiment where only progressivity ϕ evolves over time while fixing productivity and capital wedges at the initial level.

Figure E12: The Variance of log GDP p.c.: Model and Counterfactual with Only ϕ Evolving Over Time

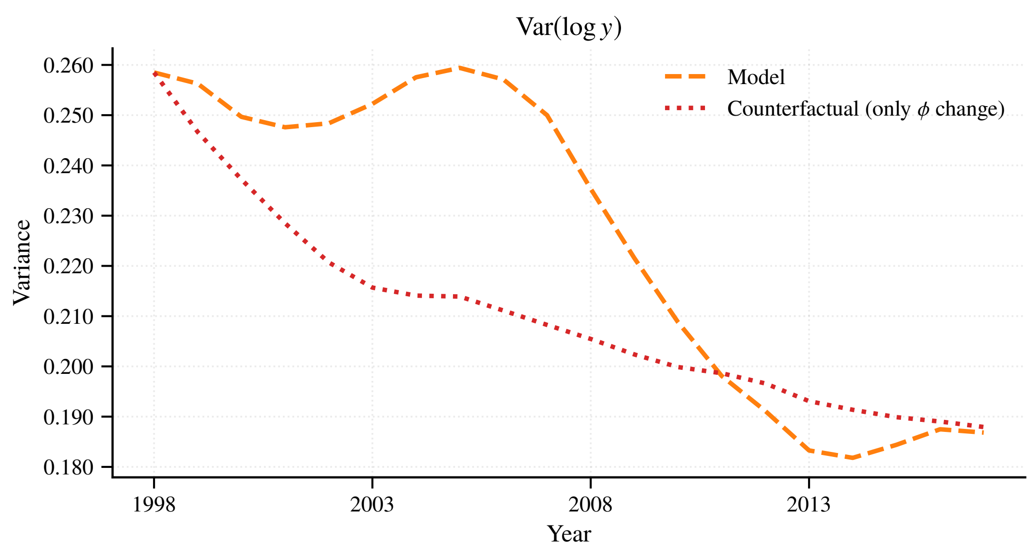


Figure E13: Aggregate TFP relative to the Efficient Level: Model and Counterfactual with Only ϕ Evolving Over Time

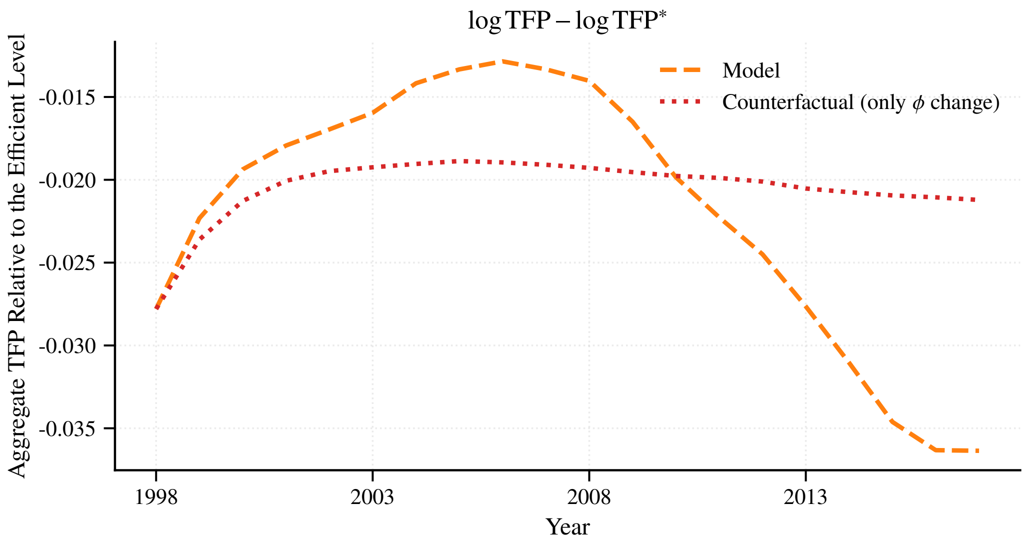


Table E3: Aggregate Response During the Transitional Dynamics: 1998-2017

		(1) Δ Coef $\log k_{Git+1}$ on $\log y_{it}$	(2) $\Delta\text{var}(\log y)$	(3) $\Delta \log(\text{TFP}/\text{TFP}^*)$	(4) Convergence Rate, %
1	Fix all at 1998	-0.197	-0.041	0.010	0.525
2	ϕ	-0.426	-0.071	0.007	0.856
3	A	-0.245	0.093	0.005	0.318
4	ϕ & A	-0.472	0.047	0.000	0.679
5	τ_k	-0.175	-0.083	-0.004	1.377
6	τ_k & ϕ	-0.416	-0.108	-0.006	1.672
7	τ_k & A	-0.204	-0.041	-0.003	1.180
8	τ_k, A & ϕ	-0.446	-0.072	-0.009	1.498

Note: Each row reports a counterfactual in which only the element(s) listed are allowed to evolve over time; all other elements are fixed at their 1998 values.

Table E4: Aggregate Response During the Transitional Dynamics while setting $\tau_k = 0$: 1998-2017

		(1) Δ Coef $\log k_{Git+1}$ on $\log y_{it}$	(2) $\Delta\text{var}(\log y)$	(3) $\Delta \log(\text{TFP}/\text{TFP}^*)$	(4) Convergence Rate, %
1	Fix all at 1998	-0.192	-0.034	0.010	0.544
2	ϕ	-0.422	-0.060	0.006	0.874
3	A	-0.251	0.099	0.007	0.332
4	ϕ & A	-0.475	0.057	0.002	0.688

Note: Each row reports a counterfactual in which only the element(s) listed in the first column are allowed to evolve over time; all other elements are fixed at their 1998 values.