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The dynamics of redistribution, inequality and growth across China's regions

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Abstract

China's experience has triggered debate over a trade-off between aggregate growth and regional equity. We develop a three-region model of China where local government decisions are driven by central government tax transfer instruments. These affect local TFP dynamics and regional inequality. We find regional asymmetry in how transfers are awarded. Transfer policies pursued since the 1994 tax-sharing reform prevented a 15% rise in regional inequality, at an 8% cost to aggregate GDP. Temporarily reducing local government non-tax fees on private firms in poorer regions lowers regional inequality permanently at no aggregate growth cost, as would imposing uniformity in central transfer rules.

JEL classification: E60; H30; H70; O40

Keywords: Regional inequality; China; Fiscal decentralization; Redistribution; Local Government; Growth

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1. Introduction

China's fast growth during the 1980 s was led by rapid growth in the east coastal region and accompanied by a persistent rise in inequality across space, triggering a major policy debate in China over a possible trade-off between growth and regional equity (Figure 1).[2] The existence of such a trade-off is of general policy interest around the world, and the inequality-growth relationship has been debated in various forms since Kuznets (1955).[3] China's sustained aggregate growth in the 1980 s has been attributed in part to a fiscal decentralization system which rewarded local governments for good local economic performance and hence reinforced spatial patterns of inequality as they emerged, but concerns over increasing regional inequality in the 1990 s led to fiscal system reforms, with even greater redistributive emphasis after the 2005 National People's Congress. How this fiscal system has evolved to balance aggregate growth maintenance with regional inequality mitigation is the subject of this paper.

The popularity of fiscal decentralization across low-income countries since the 1980 s has inspired empirical research into its macroeconomic impacts but there is often scant attention paid to underlying theoretical processes, a gap this study aims to address by outlining a formal model which is then estimated and tested by indirect inference methods. Public spending responsibility in China is devolved to local government, a move often proposed as efficiency-enhancing.[4] Conversely, revenues are mostly collected and owned by the central government under the tax-sharing system in place since 1994. Central government then decides how public money should be allocated across regional authorities. The model proposed here links this central government decision to local government behavior, with resultant impacts on local private sector environments.

The significant contribution of the private sector to China's economic growth over the reform period is widely recognized (Zhu, 2012). Entrepreneurship drives economic growth either via knowledge spillovers, or improvements in organizational management. The negative impact of various forms of tax burden on entrepreneurship is well established and recent research on the Chinese economy also finds that tax incentives significantly increase firms' investment and productivity (Brandt et al., 2020). We focus on the imposition of non-tax barriers to firm creation and expansion by local government in China. In the dynamic regional model of China set out below, increased local fiscal pressure—a greater difference between central transfers received and local spending obligations—leads these barriers to worsen.

This interdependence between central transfers, local government and the local private sector makes China's fiscal redistribution system an important determinant of aggregate and regional growth and inequality in income per capita, the stylized facts of which our study aims to explain. While the idea that fiscal arrangements influence local government behavior is supported by studies on China and in the development literature more broadly, one contribution of this paper is to bring these components together in a dynamic general equilibrium framework where mechanisms are clearly articulated. That theory is estimated and tested on Chinese post-1994 data using indirect inference, and the estimated model is then used to find the quantitative

[2] Fuller discussion of the sizeable, inconclusive empirical literature on regional convergence in China is provided in Kanbur et al. (2021) and Luintel et al. (2020).

[3] Salvatore (2007), Stiglitz (2016) and Yang and Zhou (2022) are recent examples. Walker (2007) finds no clear link between income inequality and income levels or income growth. On China, see Qin et al. (2009).

[4] Decentralized spending may overcome central-local information asymmetries, promote better resource allocation via jurisdictional competition, and induce local governments to promote market incentives through fiscal discipline (Martinez-Vazquez et al., 2017).

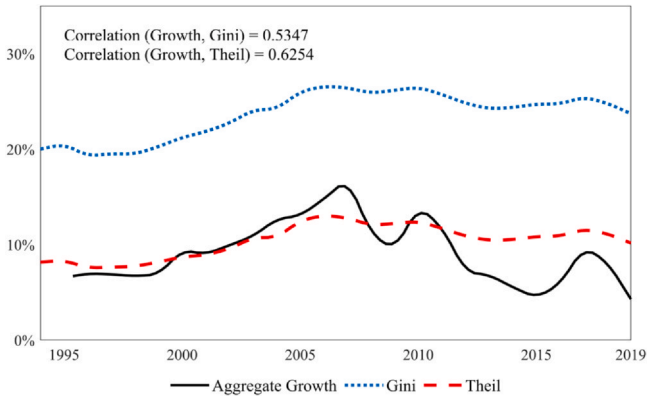

Figure 1. China's growth in GDP per capita shows broad comovement with inequality across three regions (east, central and west).

impacts of reforms to fiscal transfer policies. We compare these simulated outcomes to the status quo regime and propose some reforms that would achieve regional inequality reductions with no loss to aggregate growth according to our estimated model.

Again, though this study is focused on China, the issues dealt with are of first order importance to governments around the world (see Walker, 2007 and Salvatore and Campano, 2022). Regional inequality often drives income inequality across the general population (vertical inequality) and has certainly been linked to political instability (Kanbur and Venables, 2005). The role of local governments in promoting economic development is also emphasized heavily in the literature. The fiscal system linking central and local governments in China has been through three fundamental reorganizations. Full centralization of 1949–1979 (known informally as 'eating from one big pot') was replaced by the highly decentralized fiscal contracting system in 1980 ('eating from separate kitchens'). The 'tax-sharing system' in place since 1994 is moderately centralized: the 1994 reform kept the broad responsibilities formed under fiscal contracting for local governments, which gradually became unbalanced with their revenues, increasing budget pressure. Meanwhile the central financial surplus generated under this system has promoted the use of central-to-local transfers. The model we estimate is firmly based on this post-1994 fiscal arrangement and so our sample begins in 1994. The study window ends in 2016 to control for the impact of the policy reform to tax-sharing proportions of revenues from VAT. Similar policy windows appear in many regional studies on the Chinese economy (e.g., Hao et al., 2020 and Jia et al., 2021).

The rest of the paper is structured as follows. Section 2 discusses related literature. Section 3 presents an overview of the model, and we discuss the data and empirical approach in Section 4. Estimation and test results are discussed in Section 5. The estimated model is then used to explore the dynamic macroeconomic impacts of transfer system reforms (Section 6). Section 7 presents conclusions and policy implications.

2. Regional inequality, growth and fiscal decentralization in China

The existence of a trade-off between regional equality and aggregate economic growth has long been suspected in China, with the growth take-off following Deng Xiaoping's prioritization of the latter sometimes viewed as an informal confirmation (Chen and Groenewold, 2018; Qiao et al., 2008). The recognition of equality as a policy priority at the 2005 National

People's Congress was greeted with warnings that regional inequality was "the inevitable price to be paid for the high rates of growth," (Kanbur et al., 2021). The theoretical underpinnings of a trade-off or indeed any systematic relationship between aggregate growth and regional inequality are often less than clear, however. Relying on exogenous TFP, the neoclassical model predicts convergence in income per capita if all regions are similar aside from initial factor endowments. To account for persistent regional income inequality, Gennaioli et al. (2014) add exogenous institutional frictions to human and physical capital movement across regions.[5] Allowing for endogenous TFP at the local level on top of such barriers makes regional convergence in income per capita more unlikely: if technological progress occurs at different rates across regions, due to location-specific shocks, endowments or policy environments, then spatial inequality evolves accordingly unless there is a strong process of technology diffusion (Barrios and Strobl, 2009; Comin and Mestieri, 2018). Sufficient TFP diffusion cannot be assumed across large regions as dealt with here, and in China the evidence supports the existence of provincial convergence clubs i.e., regional groups of provinces: while members of a club are conditionally converging to a shared path, clubs' paths diverge (Baumol et al., 1989; Quah, 1996; Liu et al., 2020). In these circumstances it becomes worthwhile to consider region-level TFP processes, as we do, focusing on their relationship to fiscal arrangements and local private sector activity.

Fiscal decentralization has attracted attention in the development literature as a growth driver (Ezcurra and Rodriguez-Pose, and Feldstein, 2011, 2017), but empirical work on the relationship between fiscal decentralization and growth in China provides no consensus and the relationship to regional inequality is also unclear.[6,7] The focus of this paper is on the revenue assignments of China's tax-sharing system.[8] While the tax-sharing system has become the main means for the central government to correct regional inequality in GDP per capita and in the supply of basic public services through redistribution, it is also a key incentive mechanism used by the central government to promote economic growth (Fan et al., 2020; Chen and Groenewold, 2018).[9] Fiscal incentive theories propose that retention of locally generated tax revenues encourages local governments to operate with fiscal discipline and promote market incentives, supporting the private sector.[10] This in turn is considered to drive economic growth due to private sector investment and expansion. An implication is that redistribution softens local government budget constraints and 'rewards failure' in the form of poor resource management and corruption among local officials (Blanchard and Shleifer, 2001). This logic underpins the tax rebate formula through which most tax revenues are transferred back to the province. The rebate is strongly proportional to revenues collected in province (Shen et al., 2012), and is regressive in the presence of fixed bureaucracy costs of provincial governments, more so if significant components of local spending are countercyclical. The system is linked to

[5] See Fleisher et al. (2010) on institutional barriers to human capital movement in China; see also Gordon and Li (2011) and our discussion of labor mobility later in this section.

[6] Yang (2016); Ding et al. (2019); Qin et al. (2009)

[7] Empirical ambiguity is due to identification problems with reduced-form regressions, e.g., omitted factors and reverse causation between economic growth (or inequality) and decentralization (Martinez-Vazquez et al., 2017).

[8] A growth driver often proposed for China is productive provincial government spending (Barro, 1990)—see e.g., Yin and Zhu (2012) and Luintel et al. (2020). This is not incompatible with our model, as discussed in Section 3. On the role of decentralized spending in Chinese growth, see Martinez-Vazquez et al. (2017).

[9] For a thorough description of China's fiscal arrangements see Section 3 and Qiao et al. (2008).

[10] For China, see Jin et al. (2005); Qian and Roland (1998); Weingast (2009); Blanchard and Shleifer (2001). For Russia, Zhuravskaya (2000).

persistent fiscal and (consequently) socio-economic disparities across provinces in Zhang (2006). The rebate and other transfer types are discussed further in Section 4.

We pursue the idea that the tax-sharing system sets up incentives for local governments and impacts regional economies through the policy choices those officials make in response. Local governments are assumed to increase predation on local businesses as a result of a larger fiscal gap, employing the 'grabbing hand' (Frye and Shleifer, 1997). The behavioral responses of China's subnational governments to fiscal decentralization reform are documented in existing literature (Han and Kung, 2015). Under the tax-sharing system, provincial governments have a limited ability to affect official tax rates and may turn to other revenue sources which prove more distortionary (Besley and Persson, 2013). In China these take the form of discretionary fees levied on firms on various pretexts and at various levels of legitimacy, with charges for sewage renovation, tree planting and sanitation at one end of the scale and miscellaneous administrative levies at the other (Liu, 2018). These are informal taxes in the sense that there are no official rules on how they are collected; revenues show up in provincial government accounts as 'revenue from funds' and are a key determinant of the business environment in our model. Liu (2018) shows that increased predation on business (in the form of higher levies) was a local government response to reductions in local tax revenue retention.

The theoretical literature modelling Chinese regions in general equilibrium is relatively sparse, especially regarding fiscal transfers and regional inequality. Chen and Groenewold (2010) use a small model of China with two regions, migration subject to frictions and some key tax and expenditure instruments. They use a calibrated model to investigate policy reforms: policies boosting interior region productivity are (predictably) the most effective at closing regional output and welfare gaps. Others have tended to focus on labor market distortions and rural-urban inequality, excluding central-local government and inter-regional redistribution policy (Hertel and Zhai, 2006; Hu, 2002). While China's migrant population has attracted attention in the regional literature, population mobility in China has manifested mainly in cross-city flow, rather than cross-province or cross-region.[11] Recent studies from Chinese scholars on domestic population mobility and its effect on regional economic growth (and growth differences) draw two basic conclusions: first, population mobility mainly stems from within regions rather than between regions (Shen and Shen, 2020); second, the effect of population inflow on regional economic growth is insignificant (Sun et al., 2021) and dominated by the effect of fiscal decentralization (Zhang and Lv, 2021). Heavy emphasis on labor mobility across regions therefore seems misplaced in explanations of China's growth and regional inequality experience.

In a related study, Brandt et al. (2020) use wedge analysis in a calibrated general equilibrium model to understand differences in private sector manufacturing firms' productivity across Chinese prefectures, inferring that entry barriers imposed by local government were the key source of distortion in TFP convergence since 1995, capital and output market distortions playing a much lesser role. This entry barrier is explained through the political economy motives of local governments. In a calibrated DSGE model of China, Liu et al. (2021) explore the effect of private sector firms on aggregate TFP in the presence of state-sector induced capital

[11] 2010, c. 220 million people had city of residence different from city of *hukou* registration—16.6% of the total population based on the most recent census (Sixth Census, 2010). However, for cross-region mobility the proportion drops to 5.0% (compared with 6.4% for cross-province mobility). Defining migrant population as those with province of residence different from five years ago, the population proportion would be 0.4%.

distortions. For China specifically we have not found existing DSGE models incorporating central fiscal transfers and their dynamic impacts across regions.[12] DSGE literature incorporating fiscal federalism, where it exists, tends to emphasize monetary policy interactions and does not seek to investigate the interaction of the fiscal system with a TFP growth-inequality mechanism as we do here.[13] Our focus is not on short-term business cycle corrections or the potential of fiscal redistribution to stabilize short-term GDP fluctuations, but on whether longer growth and inequality episodes are propagated or dampened by fiscal transfers via their effects on local government behavior towards business. To that end we present a DSGE model of China made up of three regional economies, linking the tax-sharing system to regional and aggregate growth and inequality dynamics. We then test the model's ability to match the data using indirect inference methods (Le et al., 2011), matching the moments of key aggregate variables and regional inequality ratios.[14]

3. Model

The aggregate economy is made up of three large regions. In the DSGE model we focus on certain features of the Chinese system of fiscal decentralization in place since its reorganization in 1994. The 1994 reforms recentralized collection of tax revenues to address the central government's lack of funds under the previous fiscal contracting system. As a result, the central government now controls most of China's fiscal revenue and its reallocation across regional authorities. This decision must take account of numerous considerations at the microeconomic level. Our study focuses on the macroeconomic impacts of center-to-region transfers in relation to the government objectives of aggregate growth and regional equality. To this end we build and evaluate a model in which the impacts of fiscal transfers are felt ultimately by the private sector, transmitted via local government behavior, which in turn affects the local propensity to innovate.

The model embeds a link between local government responses to fiscal pressure and the local entrepreneurial environment. More specifically, we assume that a local government experiences fiscal pressure when the gap increases between its spending obligations and the funds received through central transfers. The local government behavioral response to this pressure is to use their discretionary instrument, the local private sector non-tax fee, $\pi_{i,t}$; they increase informal fees on private sector firms.[15] Since 1994, tax revenues raised in the province are shared with the central government in fixed proportions: most of the VAT, company income tax and

[12] Le et al. (2021) provide a general discussion of DSGE literature for China.

[13] New Keynesian models with fiscal federalism for the Eurozone are e.g., Verstegen and Meijdam (2016) and Evers (2015). Varga and in't Veld (2011) simulate impacts of EU structural and cohesion fund transfers using the calibrated QUEST III model with semi-endogenous growth.

[14] Structural estimation methods like those used here are increasingly chosen when reduced form methods are infeasible or good instruments scarce (common for economic growth studies). Other applications of indirect inference include Akcigit and Kerr (2018), Aronsson et al. (2022) and Fu and Gregory (2019). Small sample properties and the high statistical power of this method are discussed in Le et al. (2011). Possible advantages relative to Bayesian methods are discussed in Meenagh et al. (2021).

[15] Land-leasing revenue is a source of finance for local governments in China (Han and Kung, 2015), but land finance is driven not by local financial pressure but by investment objectives (Fan, 2015). Discretionary use of land-leasing fees is also limited, total land supply being tightly controlled by central government (Rithmire, 2017). This also applies to local bond issuance. Hence following Liu (2018), this paper focuses on non-tax revenues that are flexibly controlled by local governments.

personal income tax is owned by the central government and although business tax levied on the firm's sales was almost entirely retained by the provincial government until 2018 (Appendix A, Table A1), business tax rates themselves are controlled centrally. Local governments do have discretion to levy non-tax fees and retain that revenue in full, however, and so we focus on this aspect of local government behavior in the model (Table 2). The rate $\pi_{i,t}$ is applied to time spent by the local representative agent in entrepreneurial activity, which contributes to next period's local total factor productivity (TFP) on the basis that time spent in starting, running and expanding private sector firms puts these entrepreneurs in a good position to generate organizational and management innovation shown to be a significant driver of measured TFP (Bloom and Van Reenen, 2010). TFP generated from private entrepreneurial activity is fully appropriable and there are no regional spillovers.

The agent's decision over entrepreneurial activity is sensitive to the local government's private sector non-tax fee $\pi_{i,t}$ and so these fees worsen the local business innovation environment, forming the basis for fiscal decentralization to affect local TFP growth in the model and hence dynamic regional inequality. Another mechanism in the model compounds these effects (cf. Yang et al., 2021): relative poverty magnifies the impact of the fee on the local entrepreneur—the fee imposes a greater loss in utility terms because this entrepreneur is at a lower level of consumption. Within the model, informal fees on the private sector therefore have a greater frictional effect on innovation in poorer regions. Richer regions are more likely to innovate and enjoy higher TFP growth, acquiring comparative advantage in innovation as they do so. Once inequality emerges it tends to widen unless the fiscal transfer system intervenes.

Turning to the central government's policy rules which determine how central-to-regional transfers are awarded, we focus on two transfer instruments which differ in the way they are allocated across regions and also in their aims: the equalization transfer, $ET_{i,t}$, (also known as the 'general transfer') aims to counteract regional inequality while the tax rebate, $TR_{i,t}$, aims to reward good economic performance, stimulating the fiscal incentives growth channel and funnelling tax revenues back to more economically productive regions. Though the central government's transfer rules are not observable or transparent, consistent with the literature we specify the rules to respond to regional inequality, later relying on the estimation and testing process to comment on their validity.[16] The parameters of the transfer rules are not assumed to be uniform across regions; that is, the relative generosity (in response to some given inequality margin) is allowed to vary across regions in the estimation, on the basis that other political economy factors may enter the central government decision on how to award regional transfers. The mix of these transfers has moved gradually away from the tax rebate and towards the equalisation transfer over the sample period. We model these two transfer instruments (one redistributive, the other regressive) and their dynamic impacts on the aggregate economy and regional inequality in China.

The flow chart in Figure 2 describes the key mechanisms in the model. The two main central government transfers, $TR_{i,t}$ and $ET_{i,t}$, respond to regional GDP inequality; the local government adjusts the penalty on business innovation based on the transfers they receive; that penalty in

[16] Shen et al. (2012) model the equalization transfer to local government i as proportional to the total spending of central government on equalization transfers for all provinces, TET_t (freely available data), approximating the proportion for place i by the share of the local fiscal deficit in the total fiscal deficits across all provinces. We use the lagged ratio of per-capita income in province i to aggregate per capita income to approximate the province's share of TET_t; an error term allows for other factors.

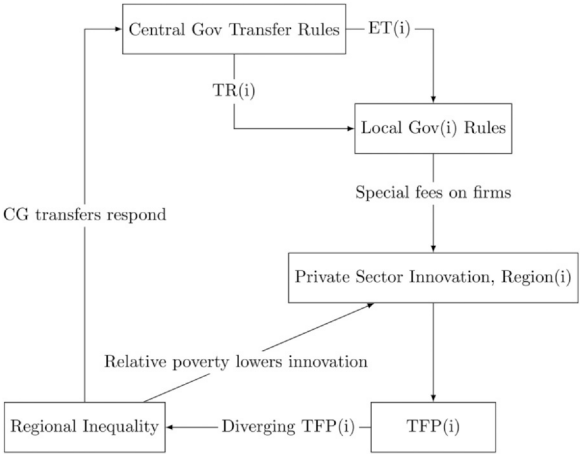

Figure 2. Flow chart describing mechanisms in the DSGE model.

turn affects innovation, more so in a relatively poorer province; and the resulting local TFP divergence contributes to widening regional inequality.

The full linearized model is provided below, where $i = 1,2,3$ indicates the east (coastal), center and west region, respectively; all details and derivations are in Yang et al. (2023).[17] It is made up of local representative agent optimality conditions in each of the three regions for the choices of consumption and leisure, labor and capital inputs, bond holdings and entrepreneur time, as well as local production functions, aggregation and market clearing identities. The decision rule for local entrepreneurship implies a relationship between local TFP growth, lagged non-tax fees and lagged regional income inequality (10). Finally, the system specifies relations for each local government's non-tax fee-setting behavior (11)), and central government's rules for redistributing revenues using $TR_{i,t}$ and $ET_{i,t}$ in each of the three regions (12 and 13).

We estimate the key parameters of the model using indirect inference, including:

- Parameters σ_i^{TR} and σ_i^{ET} in central government rules for the tax rebate and equalization transfers;
- Elasticities φ_i^a and φ_i^b of local government private sector non-tax fees to tax rebate and equalization transfers, respectively;
- Responses of local TFP to the local government's non-tax levy rate on entrepreneurs, and to regional inequality.

Heterogenous response parameters to the tax rebate and the equalization transfer are allowed for in the behavioral rules of local governments in different regions. Further, for each region we estimate the local government response to $TR_{i,t}$ distinctly from its response to $ET_{i,t}$. This difference in response to two different forms of central transfer could reflect a lack of fungibility

[17] Variables in the model list are defined in Table 1.

Table 1
Data for 1994–2016.

Variable	Definition	Mean	1994	2016
Y_1	Real GDP for JiangSu	18102	4675	41457
Y_2	Real GDP for HuNan	8504	2119	19990
Y_3	Real GDP for YunNan	6067	2026	13607
K_1	Real capital stock for JiangSu	29687	13288	76219
K_2	Real capital stock for HuNan	13077	4076	41133
K_3	Real capital stock for YunNan	12181	5687	40443
C_1	Real consumption for JiangSu	5682	1557	15613
C_2	Real consumption for HuNan	3447	1135	7612
C_3	Real consumption for YunNan	2770	1027	6325
N_1	Labor ratio for JiangSu	0.814	0.901	0.753
N_2	Labor ratio for HuNan	0.825	0.815	0.802
N_3	Labor ratio for YunNan	0.821	0.837	0.847
π_1	Private sector non-tax fees for JiangSu	6966	12882	12097
π_2	Private sector non-tax fees for HuNan	16822	23250	15457
π_3	Private sector non-tax fees for YunNan	25207	107388	12936
A_1	Regional TFP for JiangSu	111	42.7	173
A_2	Regional TFP for HuNan	79	36.8	110
A_3	Regional TFP for YunNan	60	29.4	73.5
TR_1	Real tax rebate for JiangSu	195	56	293
TR_2	Real tax rebate for HuNan	104	72	176
TR_3	Real tax rebate for YunNan	220	233	293
ET_1	Real equalization transfer for JiangSu	58	7.9	191
ET_2	Real equalization transfer for HuNan	368	3.7	1162
ET_3	Real equalization transfer for YunNan	394	28.6	1298
r	Real interest rate	0.023	-0.080	0.031
TET	Real equalization transfers for all provinces	332	15.5	1008

across these transfers, arising for example due to mental accounting (Hines and Thaler, 1995) or specific administrative constraints around the transfers.

$$\ln Y_{i,t} = \alpha \ln K_{i,t-1} + (1-\alpha)\ln N_{i,t} + \ln A_{i,t} \tag{1}$$

$$\ln K_{i,t} = E_t \ln Y_{i,t+1} - \left[\frac{K_i}{Y_i}\cdot\frac{1}{\alpha(1-\tau)}\right] r_t + \varepsilon_{i,t}^{K} \tag{2}$$

$$\ln C_{j,t} = E_t \ln C_{j,t+1} - \frac{1}{\Psi_1}(r_t + \ln\beta) + \varepsilon_{j,t}^{C},\ j = 1, 2 \tag{3}$$

$$\ln C_{3,t} = \frac{1}{\omega_{c,3}}(\ln C_t - \omega_{c,2}\ln C_{1,t} - \omega_{c,2}\ln C_{2,t}) \tag{4}$$

$$r_t = \Psi_1(E_t \ln C_{j,t+1} - \ln C_{j,t}) - \ln\beta \tag{5}$$

$$\ln C_t = \frac{Y}{C}\ln Y_t - \frac{K}{Y}[\ln K_t - (1-\delta)\ln K_{t-1}] \tag{6}$$

$$\ln Y_t = \ln[\mu_1 \exp(\ln Y_{1,t}) + \mu_2 \exp(\ln Y_{2,t}) + \mu_3 \exp(\ln Y_{3,t})] \tag{7}$$

$$\ln K_t = \ln[\mu_1 \exp(\ln K_{1,t}) + \mu_2 \exp(\ln K_{2,t}) + \mu_3 \exp(\ln K_{3,t})] \tag{8}$$

$$\ln N_{i,t} = \frac{1}{1+\Psi_2}\left[\ln Y_{i,t} - \Psi_1 \ln C_{i,t} + \frac{2\Psi_2}{\theta_2}\left(\rho_i^{\pi} \ln \pi_{i,t} - \rho_i^{Y} \ln \frac{Y_{i,t}}{Y_t}\right)\right] + \varepsilon_{i,t}^{N} \tag{9}$$

$$\ln A_{i,t+1} = \ln A_{i,t+1} + \rho_i^{Y} \ln \frac{Y_{i,t}}{Y_t} - \rho_i^{\pi} \ln \pi_{i,t} + \varepsilon_{i,t}^{A} \tag{10}$$

$$\ln \pi_{i,t} = -\varphi_i^{a} \ln TR_{i,t-1} - \varphi_i^{b} \ln ET_{i,t-1} + \varepsilon_{i,t}^{\pi} \tag{11}$$

$$\ln ET_{i,t} = \ln TET_t - \sigma_i^{ET} \ln \frac{Y_{i,t}}{Y_t} + \varepsilon_{i,t}^{ET} \tag{12}$$

$$\ln TR_{i,t} = \sigma_i^{TR} \ln \frac{Y_{i,t}}{Y_t} + \varepsilon_{i,t}^{TR} \tag{13}$$

$$\varepsilon_{i,t}^{k} = c_i^{k} + \beta_i^{k} t + \rho_i^{k} \varepsilon_{i,t-1}^{k} + \eta_{i,t}^{k} \tag{14}$$

Parameter estimates are presented and discussed in Section 5, after a brief discussion of data and methods.

4. Data and methodology

4.1. Data

The model above proposes three closed regional economies intended to correspond to the three regions of China: east (coastal), central and west. This division of provinces into regions follows the central government classification since 1985. The sample is annual Chinese data for 1994–2016 due to our focus on fiscal federalism under the tax-sharing system established in 1994. The model cannot be calibrated at the region level (aggregating over provinces in each region) since there are many missing years on private enterprise employer data in many provinces, a statistic necessary to estimate local entrepreneurship time. We therefore use province level data (real per capita) for 3 representative provinces—JiangSu on the coast, HuNan in the mid-region and Yunnan in the western interior—scaled up by their relative population shares to account for their respective region. These three representative provinces are chosen, among other considerations, on the closeness of these provinces' relative shares for both GDP and population to the relative shares of their regions in the whole country.[18,19]

The population-scaled regional variables together account for the national average per capita values. Table 1 presents a snapshot of the data. The data is unfiltered to preserve information

[18] Ratios of regional to national per capita GDP are 1.5, 0.7 and 0.7 respectively, close to the three province to national per capita GDP ratios: 1.6, 0.7 and 0.6. Average population proportions of east, central and west regions from 1994 to 2016 were 40%, 32% and 28%, while average population shares of JiangSu, Hunan and Yunnan in their regions were 41%, 35% and 24%.

[19] We must also exclude provinces with special cities. China's local governments have various classifications, with five cities classed as 'City Specifically Designated in The State Plan' (different from 'Municipalities Directly under the Central Government'). The fiscal policies of special cities with large economic scale are highly independent from their local provincial governments. Provinces containing the five special cities (Guangdong/Canton, Shandong, Zhejiang, Fujian and Liaoning) are therefore not representative of their region.

Table 2
Real business cost from non-tax fees on private firms (per capita, 1993 prices).

	Non-tax revenue ratio			Private entrepreneur density			Real non-tax fees on firms		
Province	JiangSu	HuNan	YunNan	JiangSu	HuNan	YunNan	JiangSu	HuNan	YunNan
1994	0.6%	3.1%	4.5%	0.99	1.10	0.24	12882	23250	107338
2000	8.7%	4.9%	16.8%	7.66	1.53	1.74	2726	23864	18670
2008	16.6%	32.7%	21.4%	28.71	7.72	8.99	5863	16771	11249
2016	19.6%	42.5%	35.2%	65.62	22.57	28.04	12097	15457	15457

Note: Non-tax revenue ratio is the proportion of total local government revenue ('revenue in the general public budgets') including all transfers from central government.

and due to its non-stationarity, some residuals ($\varepsilon_{i,t}^{j}$) are trend stationary or non-stationary. For trend stationary residuals, the trends are removed. Only the productivity residuals $\ln A_{i,t}$ are found to be non-stationary and these are modelled as ARIMA (1,1,0)—see model listing, Section 3.[20]

Our modelling draws on the following features of the tax-sharing system established in 1994. While most revenues collected in the province from VAT and income tax are shared back to the center for redistribution, non-tax revenues from levies imposed on local firms are raised and managed at the local government's discretion with minimal scrutiny from the center.[21] We proxy $\pi_{i,t}Z_{i,t}$ using annual data taken from the National Bureau of Statistics of China and Local Bureau of Statistics on main non-tax revenues in each province.[22] As is clear from Table 2, non-tax revenue has become an increasingly important source of revenue for local governments. We focus on specific project income, administrative fees and 'Other Non-tax Income', excluding items of non-tax revenues related to state-owned companies as well as fines for lawlessness. These items constitute the data for non-tax revenues. Following Liu (2018), we focus on private enterprises, partly because state-owned enterprises (SOEs) do not reflect the entrepreneurial attitude of individuals, and partly because private enterprises have become the largest contributor to China's economy (e.g., the proportion of profits of SOEs in total profits of all industrial enterprises has fallen from 55% in 2000 to 17% in 2016; National Bureau of Statistics of China). We construct a real effective local penalty rate on business (what we term the private sector non-tax fee) by dividing nominal revenues by the number of private enterprise employers as a proportion of the local working age population. The 14th CPC National Congress in 1992 proposed that the goal of China's economic restructuring was to establish a socialist market economy. The proportion of private economy in China's national economy has gradually increased since the 1990 s Table 2 indicates that the private entrepreneur density defined by the

[20] Total factor productivity is the Solow residual calculated from the regional production function given in equation (*10*). Usual caveats apply to this measure, though we interpret it loosely as a measure of productivity.

[21] Shares of major tax rates listed in Appendix A, Table A1. Central government rules allow local governments to vary local business tax rates via threshold adjustments and industry-category specific rates, but in practice there is little variation across provinces in business tax rates.

[22] Local government non-tax revenue (also known as extrabudgetary revenue or revenue from funds) contains revenue from 'penalty revenue', 'Administrative fee income', 'resources tax' (applies to resources like mineral, oil and water, etc.), 'urban land use tax', 'Vehicle and vessel use and license tax', 'slaughtering tax' and some other less important incomes. Note that these fees are classed as non-tax revenues despite being called 'tax'.

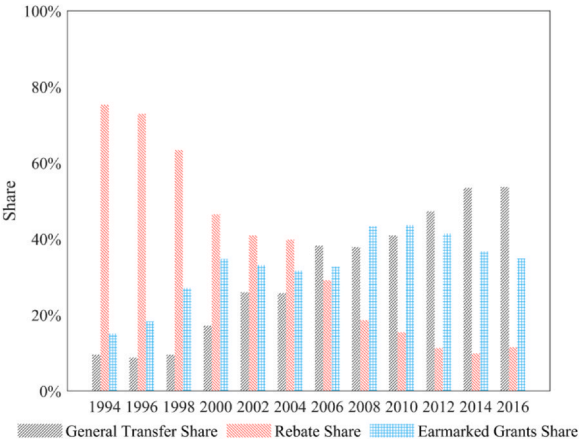

Figure 3. Composition of central-to-local transfers.

number of private entrepreneurs in every one thousand working age people was low in all provinces before the tax-sharing system reform.[23] With the deepening of the influence of tax-sharing reform and the growth of the private sector, the gap between regions has widened resulting in cross-regional differences in real (non-tax) business costs at the firm level. This real business cost is the lowest in JiangSu, with convergence with the other provinces only at the end of the sample period.

Other key features of the fiscal system here are the central to local transfers. Figure 3 presents data on these for the whole of China, showing the relative shares of funds transferred through the tax rebate, earmarked grants (grants tied to specific use), and the 'general transfer' (or equalization transfer). Over the sample period the share of the tax rebate has decreased substantially, while shares of earmarked grants and the equalization transfers have increased. This marks a significant shift towards redistribution across provinces and away from the strongly pro- 'fiscal incentive' regime of the 1990 s. Figure 4 plots the real per capita tax rebate and the real per capita equalization transfer for the three representative provinces. While the tax rebate is increasingly generous to JiangSu over the period, the equalization transfer is increasingly redistributive from rich to poor regions.

4.2. Indirect Inference method

Preference-related and fiscal parameters are estimated by indirect inference methods (Le et al., 2016). For the role of fiscal decentralization in inequality the magnitudes of σ_i^{ET}, the responsiveness of the equalization transfer to relative inequality in province i, and σ_i^{TR}, the responsiveness of the tax rebate to relatively good (poor) economic performance, are of special importance. In turn, the effects of these transfers in easing (creating) pressure on local government and so reducing (increasing) local government predation on business through $\pi_{i,t}$ is reflected in parameters φ_i^a and φ_i^b (the responsiveness of the local business environment to the

[23] Sources and further detail in Appendix C.

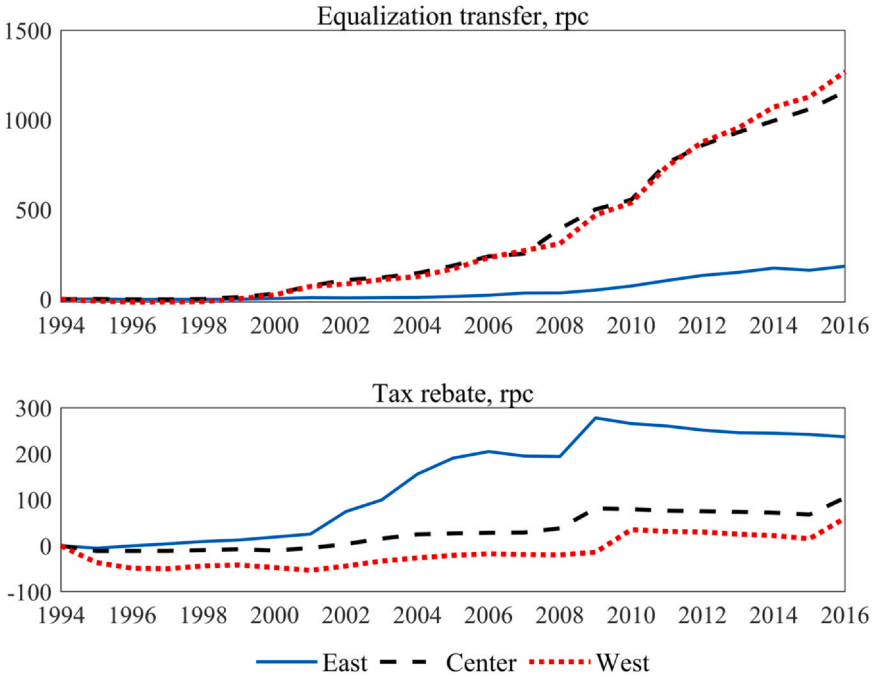

Figure 4. Real per capita equalization transfers and tax rebate transfers to representative provinces JiangSu (East), HuNan (Centre), YunNan (West); Base year 1993.

tax rebate and the equalization transfer, respectively). θ_2 is the parameter governing the role of entrepreneurial activity in local TFP growth. The parameters governing the effects of inequality, measured by the ratio $\ln(Y_{i,t}/Y_t)$, and of local government informal taxes on total factor productivity growth next period are also estimated: ρ_i^Y and ρ_i^π, respectively. Preference parameters estimated are Ψ_1 and Ψ_2, the coefficients of relative risk aversion for consumption and leisure, assumed shared across regions. Other parameters fixed throughout the investigation are listed in Table B1 in Appendix B.

The methodology of model testing and parameter estimation applied here, developed by Le et al. (2011), uses the idea that if the structural model is accurate in terms of both specification and parameters, the properties of the actual data should come from the distribution of the properties of the simulated data with some critical minimum probability. To capture the data properties an auxiliary model is used; here we use the moments to construct the indirect inference Wald statistic and its distribution. The procedure bootstraps the set of innovations implied by the structure of the model and its residuals as computed from the observed data.[24,25] Indirect estimation involves varying parameters until the Wald percentile is minimized. The

[24] Regional Solow residuals are treated as I(1). Otherwise residuals ε_t and $\varepsilon_{i,t}$ are modelled as exogenous AR(1) trend stationary, subject to orthogonal innovations η_t and $\eta_{i,t}$—see listing.

[25] Innovations reflect the DSGE model restrictions for a given set of structural parameters (unlike innovations drawn from an assumed distribution) so the Wald distribution for the auxiliary parameters describing the simulated data is also 'restricted', lending the method greater statistical power than Likelihood Ratio tests (Le et al., 2016).

Table 3
Estimated Structural Coefficients.

Parameter	Definition	Value
Ψ_1	Elasticity of consumption in utility function	0.5010
Ψ_2	Elasticity of leisure in utility function	0.5905
θ_2	Marginal effect of entrepreneurship on productivity growth	1.0136
ρ_1^Y	Marginal effect of log of regional output share on productivity growth (East)	0.0173
ρ_2^Y	Marginal effect of log of regional output share on productivity growth (Central)	0.0160
ρ_3^Y	Marginal effect of log of regional output share on productivity growth (West)	0.0197
ρ_1^π	(Negative) Marginal effect of $\ln \pi_1$ on productivity growth (East)	0.0101
ρ_2^π	(Negative) Marginal effect of $\ln \pi_2$ on productivity growth (Central)	0.0114
ρ_3^π	(Negative) Marginal effect of $\ln \pi_3$ on productivity growth (West)	0.0115
φ_1^a	(Negative) Elasticity of π_1 to tax rebate (East)	0.1209
φ_2^a	(Negative) Elasticity of π_2 to tax rebate (Central)	0.1033
φ_3^a	(Negative) Elasticity of π_3 to tax rebate (West)	0.1667
φ_1^b	(Negative) Elasticity of π_1 to equalization transfer (East)	0.1837
φ_2^b	(Negative) Elasticity of π_2 to equalization transfer (Central)	0.3504
φ_3^b	(Negative) Elasticity of π_3 to equalization transfer (West)	0.2038
σ_1^{TR}	Marginal effect of log of regional output share on tax rebate (East)	3.7984
σ_2^{TR}	Marginal effect of log of regional output share on tax rebate (Central)	3.1367
σ_3^{TR}	Marginal effect of log of regional output share on tax rebate (West)	2.8340
σ_1^{ET}	(Negative) Marginal effect of log of regional output share on equalization transfer (East)	5.4872
σ_2^{ET}	(Negative) Marginal effect of log of regional output share on equalization transfer (Central)	3.6230
σ_i^{ET}	(Negative) Marginal effect of log of regional output share on equalization transfer (West)	3.8781
Wald p-value		0.1607

Wald percentile is also the criterion for model evaluation. In our estimation we use the second moments of aggregate output and capital as well as the regional inequality ratios as the auxiliary model description of the facts we are trying to match. Due to the non-stationarity of the data, moments of detrended series are compared.

5. Estimation results

Key parameter estimates are reported in Table 3. In the central government's transfer rules, parameters σ_i^{TR} and σ_i^{ET} control how central transfers respond to a region's economic performance relative to the average. Variation across regions in σ_i^{TR} indicates variation in the relative generosity (or punitiveness) of the tax rebate—the carrot-stick characterized here as the fiscal incentives mechanism that keeps local governments fiscally motivated and accountable. These estimates reflect that the tax rebate is inclined to reward the coastal east most generously (punish it most harshly) when its GDP is high (low) relative to the country average. Fiscal incentives therefore seem designed to work most strongly in the east region. For the west region, which would tend to receive the stick-side of fiscal incentives rather than the carrot, σ_3^{TR} is smaller in magnitude; its tax rebate does fall when the west GDP is below average, but not as fast as it would if σ_3^{TR} equaled σ_1^{TR}. Overall, fiscal incentives do seem to be in operation but they are asymmetric in how they punish or reward regions for recent relative performance. There is

similar heterogeneity in σ_i^{ET} across regions: an increase in the east region's GDP relative to the average is met by a steeper fall in its equalization transfer than an equivalent increase would be if it occurred in the west.

Turning to the local government behavioral rules (equation 11), the estimates for φ_i^a, which capture the tax rebate's effect on local government behavior, are different in magnitude to the estimates for φ_i^b, the effect of equalization transfers on local government. Also, estimates for φ_i^b show some appreciable heterogeneity across regions. These parameters imply that private sector non-tax fees tend to respond more strongly to equalization transfers than to changes in the tax rebate, particularly in the Central and West regions. For instance, a 1% point increase in equalization transfers for the central region results in a 0.35% point reduction in private sector non-tax fees there, while an equivalent increase in the east region leads to a 0.18% point reduction in that region. Provincial governments have limited ability to borrow in capital markets and so fiscal gaps are made up from business levies, land sales, bond issues or the shadow banking system since the tightening of credit policy in 2009–10. Heterogeneity in the exact manner of closing fiscal gaps across regions and indeed across individual officials is therefore reasonable. Since the real business cost plays a small but important role in local TFP growth in all three regions, the heterogeneity across φ_i^a and φ_i^b may have quantitative consequences which we return to in the next section, in conjunction with heterogeneity across ρ_i^Y and ρ_i^π.

With this parameter set the model is not rejected by the indirect inference Wald test with a p-value of 16.07%, which evaluates the joint closeness of the simulated moments to the moments in the data. Table D1 in the Appendix D provides the results of the variance-covariance

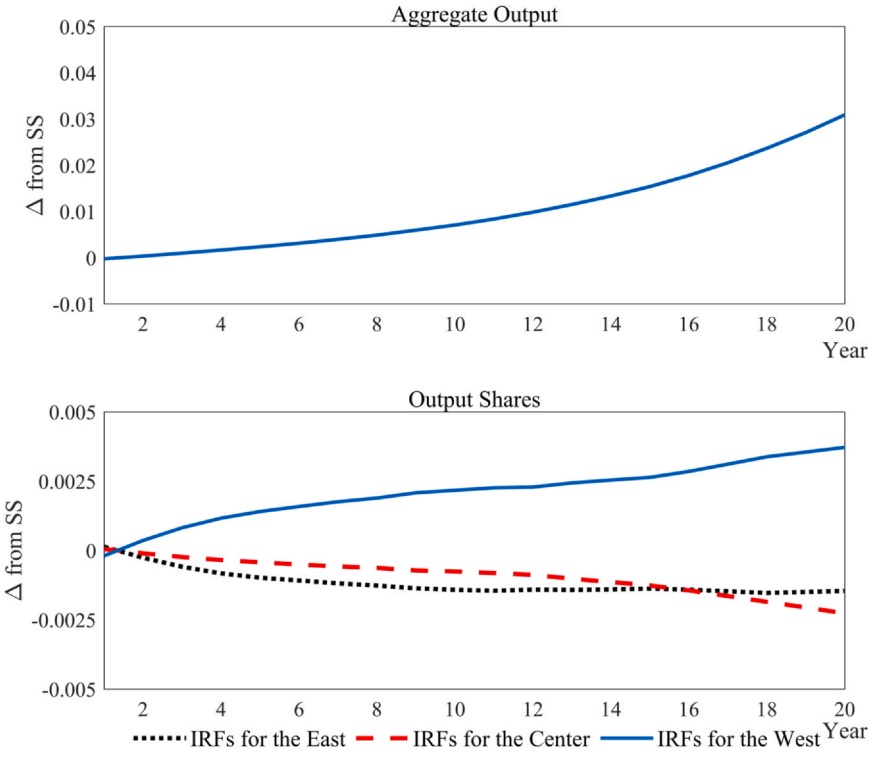

Figure 5. Output responses to a 1 standard deviation. reduction in private sector non-tax fees, West region.

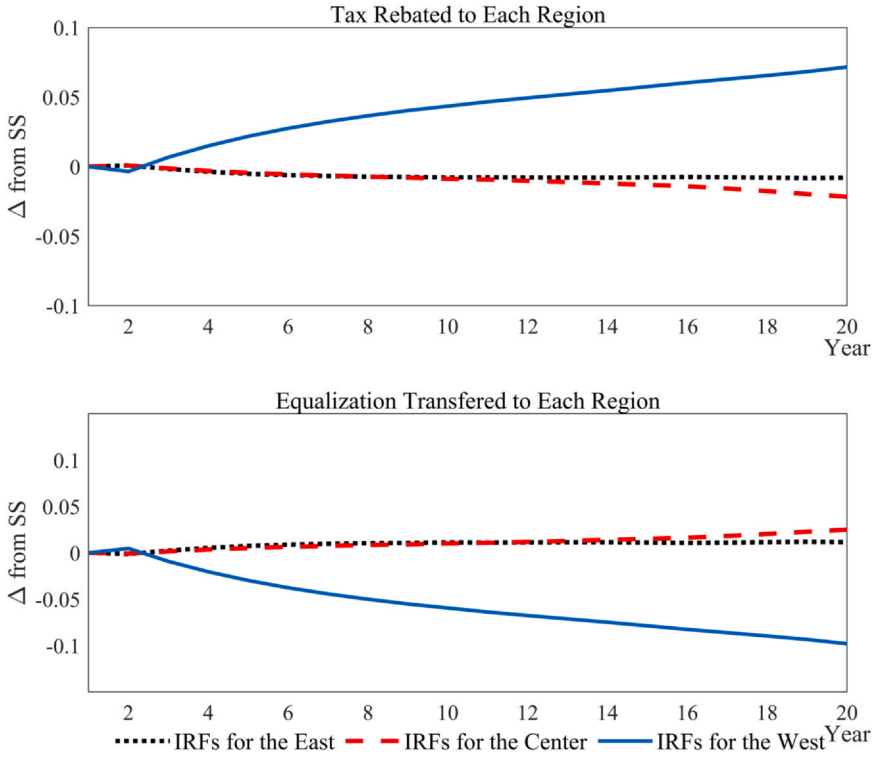

Figure 6. Responses to 1 sd. reduction in private sector non-tax fees, West: central transfers.

auxiliary model, showing that the individual second moments are also matched. All the actual coefficients lie within the 95% confidence interval apart from $Cov\left(\mu_1 Y_{1,t}/Y_t, \mu_2 Y_{2,t}/Y_t\right)$ in the last row. We proceed to use the model for simulation exercises conditional on this structural parameter set.

6. Model properties and policy simulation

Key features of the model are illustrated below using impulse response functions (IRFs) for a shock to private sector non-tax fees. We also present results of a policy simulation showing what happens when the government unlinks transfers from the regions' relative economic performance.

Figure 5 to 7 show IRFs for a temporary one standard deviation reduction to private sector non-tax fees in the west region, $\pi_{3,t}$. The shock results in an overall increase in aggregate output (Figure 5). As the western region starts at a lower GDP per capita level than the other two regions, this shock therefore brings about a reduction in regional inequality overall without implying an aggregate growth penalty.[26] Achieving even a temporary reduction in private sector non-tax fees in the western region appears to be policy with little downside at the country level.

[26] Hence, we show IRFs for the west region $\pi_{3,t}$ shock rather than for e.g., the east region, the IRFs for which have similar properties but imply increased regional inequality together with higher aggregate output.

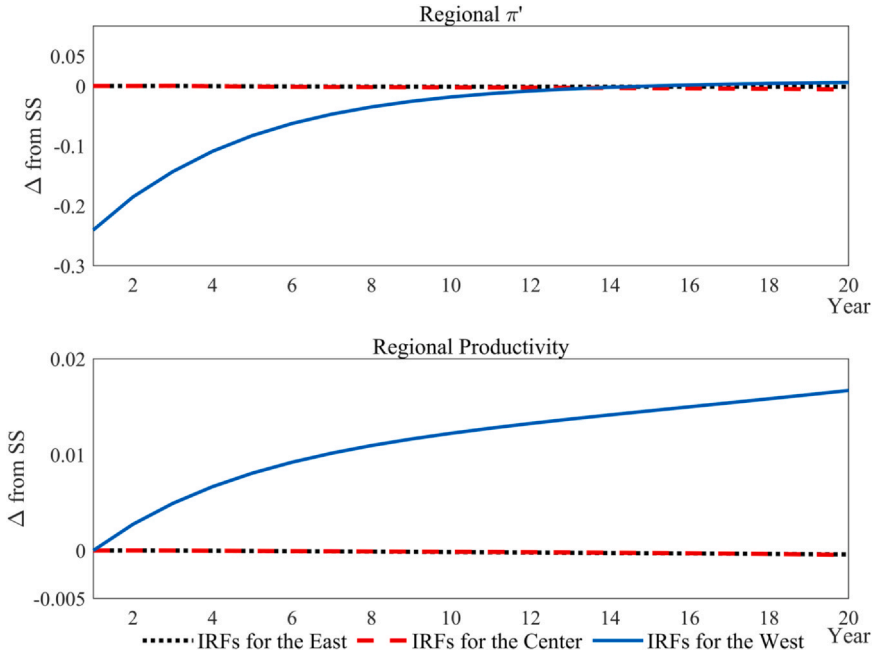

Figure 7. Responses to 1 sd. reduction in π_3, West: TFP and real business costs.

The west's output share increases relative to other regions because the reduction in π_3 drives TFP growth there (Figure 7). The small decline in the eastern and central regions' productivity (due to their declining income ratios relative to the country average) is dominated by the west's productivity improvement. Transfers adjust too because of the changing regional GDP ratios: fiscal incentives work through the tax rebate as they reward the western region for its success, while equalization transfers work in an offsetting manner—more generous to the east and middle regions and less to the west (Figure 6). The reduction to real business costs in the west therefore induces marginal reductions in the other two regions.

A variance decomposition of the key aggregate variables and regional economy shares shows productivity shocks and shocks to the factors of production contribute the most to the variance of output, but the combined shocks to the informal tax rates add a further 10%. Similarly with the regional shares, the own-regional informal tax rate shocks dominate the fiscal transfer shocks; see Yang et al. (2023).

The model is also used to simulate the effects of adjusting the central government transfer rules awarding equalization transfers (ET) and tax rebate (TR) to the three regions. This experiment involves shutting down the parts of these central government transfers that depend on relative income, one at a time and then both together. This illustrates the basic mechanisms at work in the model (Figure 8). We conduct three exercises:

- A1: The tax rebate (fiscal incentive channel) is shut down by setting $\sigma_i^{TR} = 0$ for all three regions simultaneously, leaving all other aspects of the model unchanged. In Figure 8 the dashed line plots the difference between the average simulated behavior of the status quo (estimated) model and the average simulated behavior of the model with this parameter

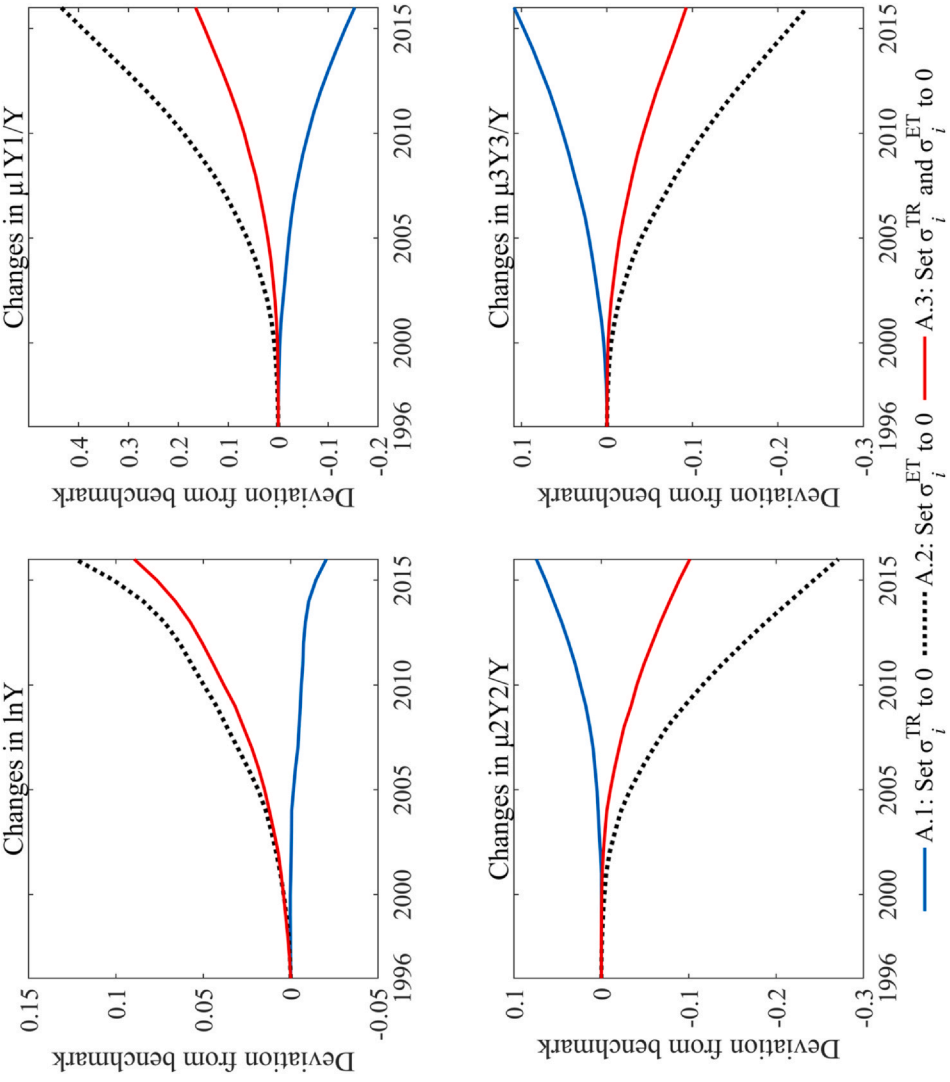

Figure 8. Shutting down fiscal instruments.

change imposed, for aggregate GDP per capita and for the inequality ratios across the three regions. Simulated behavior is averaged across 1000 simulations in each case.

- A2: The equalization transfer (regional redistribution channel) is shut down by setting $\sigma_i^{ET} = 0$ for all three regions simultaneously. Dotted line in Figure 8.
- A3: Both tax rebate and equalization transfer shut down simultaneously; central transfers no longer respond to relative GDP performance. Unbroken line on Figure 8.

Shutting down the fiscal incentives channel (A1) marginally reduces aggregate GDP relative to the status quo. At the same time, regional inequality falls: the population-weighted ratio of region 1′s GDP to the country average decreases and those of regions 2 and 3 increase. Shutting down the equalization transfer (A2) stimulates aggregate growth as the fiscal incentives channel operates more strongly: region 1 pulls further ahead of the country average, while regions 2 and 3 fall further behind and regional inequality rises. Finally, A3 removes the systematic relation between central transfers and local GDP performance entirely, so all regions receive an equal transfer in every period. This indicates that if transfers for each region had been wholly unresponsive to relative GDP throughout the sample period, the relative position of the Eastern region would have been approximately 15% higher by 2015 (the end of the 20-year period); and the relative positions for the Central and Western regions would have been 10% lower in 2015 than under the status quo transfer regime. However, real GDP per capita in 2015 would have been some 8% higher than it was in 2015. The central government's policy of centralized transfers has apparently reduced regional income inequality, albeit at the cost of lower aggregate GDP growth.

In a further policy experiment, we modify the parameters of the central transfer rules to be homogenous across regions (setting first $\sigma_i^{TR} = \sigma_1^{TR}$, then $\sigma_i^{ET} = \sigma_1^{ET}$, then both at once). Setting tax rebate rules uniformly to region 1′s parameterization leads to a moderate fall in aggregate GDP and increased regional inequality after 20 years, a universally worse scenario. However, imposing homogeneity in the equalization transfer rules (leaving heterogeneity in the tax rebate rules) delivers the best of both worlds: much reduced inequality at no aggregate GDP cost. The effective boost to transfers in the west and central regions is large enough to trigger a strong growth episode in both places; again, the key channel is the impact on local real business costs which are reduced by the transfer increase, more so in regions 2 and 3 given their local government behavioral parameters (equation 11).

7. Conclusions and discussion

The stylized facts of China's regional economy show divergence in GDP per capita across the east, central, and west regions since the 1980 s. Official policy has been to address this regional disparity through the fiscal transfer system. Since central transfers affect the extractive policies of provincial governments towards the private sector, they impact economic incentives in the individual regions. This paper outlines a DSGE model of the three economic regions of China, linking the tax-sharing system to regional and aggregate growth and inequality dynamics. Central transfers are awarded through two distinct instruments: the tax rebate which follows the logic of 'fiscal incentives', and equalization transfers which redistribute from richer

to poorer regions. The gap between local government spending and central transfer revenue is filled partly through private sector non-tax fees, affecting incentives to private sector innovation. While the literature features numerous models of regional inequality with exogenous growth, our model of China allows regional TFP to respond endogenously to aspects of fiscal decentralization. In the absence of suitable priors for Bayesian estimation, we employ the method of indirect inference and show that the estimated model is strongly data consistent.

We find that fiscal incentives operate through the transfer system, though there is asymmetry in how they apply across regions: they work most strongly in the east region, penalizing poorer regions less for falling behind on economic performance. There is similar regional asymmetry in how equalization transfers are awarded. In the east, an increase in relative GDP performance triggers a sharper reduction in this transfer than an equivalent increase occurring in the west. We also find that local government behavior responds differently to central transfers by region, in terms of how much private sector non-tax fees rise after a reduction in transfer income.

Lowering private sector non-tax fees generates local GDP growth via a TFP growth episode within the model.[27] Impulse responses therefore show straightforwardly that even a temporary reduction in such costs in the west permanently lowers regional inequality at no aggregate output cost.

The results shed light on the trade-off between aggregate growth and regional inequality across China. We use the estimated model to illustrate three counterfactual tax-transfer regimes, considering how aggregate growth and regional inequality would have responded if central transfers were entirely insensitive to a region's relative economic state. After 20 years aggregate GDP would have been approximately 8% higher than under the status quo regime, but inequality would have been more than 15% higher. We also investigate central transfer rules with uniform parameters across regions, where a given increase in relative economic performance is met by a given transfer response regardless of location, keeping all other model parameters constant. This modification in the tax rebate alone worsens both inequality and aggregate output. However, modifying just the equalization transfer rules in this way reduces inequality at no aggregate cost to GDP.

The policy message is clear. An increase in transfers offers more 'bang for buck' in the central and west regions, bringing about a greater reduction to local real business costs there due to region-specific and transfer-specific behavioral responses from local government. This creates relatively more GDP growth overall while also closing regional gaps.

The results of this paper tie into a wider research agenda around inequality and growth management in China including the exploration of welfare implications, and whether greater redistribution would speed up convergence in China in the presence of greater regional labor mobility as in the USA. Nevertheless, this study contributes an empirically supported and quantitatively useful framework for exploring the role of fiscal transfer policy in mitigating regional inequality alongside aggregate growth maintenance in China.

Declaration of Competing Interest

None.

[27] Bootstrap simulations confirm that shocks to private sector non-tax fees play a noticeable role in output variation.

Appendix A. Tax-sharing proportions since 1994

Table A1
Central-local sharing rules for major taxes.

	VAT shares		Business Tax shares		Company Income shares		Personal Income Tax shares	
Year	Central	Local	Central	Local	Central	Local	Central	Local
2002	75.0%	25.0%	6.3%	93.7%	61.1%	38.9%	50.0%	50.0%
2003	75.0%	25.0%	2.7%	97.3%	59.6%	40.4%	60.0%	40.0%
2004	73.3%	26.7%	3.1%	96.9%	59.7%	40.3%	60.0%	40.0%
2005	73.5%	26.5%	3.1%	96.9%	60.0%	40.0%	60.0%	40.0%
2006	75.0%	25.0%	3.1%	96.9%	61.9%	38.1%	60.0%	40.0%
2007	75.0%	25.0%	3.1%	96.9%	64.3%	35.7%	60.0%	40.0%
2008	75.0%	25.0%	3.0%	97.0%	64.2%	35.8%	60.0%	40.0%
2009	75.3%	24.7%	1.9%	98.1%	66.0%	34.0%	59.9%	40.1%
2010	75.4%	24.6%	1.4%	98.6%	60.7%	39.3%	60.0%	40.0%
2011	75.3%	24.7%	1.3%	98.7%	59.8%	40.2%	60.0%	40.0%
2012	74.5%	25.5%	1.3%	98.7%	61.5%	38.5%	60.0%	40.0%
2013	71.3%	28.7%	0.5%	99.5%	64.4%	35.6%	60.0%	40.0%
2014	68.4%	31.6%	0.4%	99.6%	64.2%	35.8%	60.0%	40.0%
2015	67.5%	32.5%	0.8%	99.2%	65.0%	35.0%	60.0%	40.0%
2016	**53.9%**	46.1%	**11.6%**	88.4%	64.9%	35.1%	60.0%	40.0%

Appendix B. Fixed aspects of calibration

Calibration of α, β andδ follows Chang et al. (2019). All other steady-state values are approximated by sample averages. The effective income tax rate on household-firms, τ, is set at 0.36 (the sum of the tax rate of 0.2 on personal income of 20,000 Yuan per month, and the VAT rate of 0.16).

Table B1
Calibration.

Parameter	Definition	Calibration
α	Capital share in production function	0.48
β	Utility discount rate	0.99
δ	Annual capital discount rate	0.14
K/C	Steady state ratio of aggregate capital over aggregate consumption	4.19
Y/C	Steady state ratio of aggregate output over aggregate consumption	2.46
τ	Proportional income tax rate	0.36
μ_1	Steady state population share for the East	0.41
μ_2	Steady state population share for the Central	0.35
μ_3	Steady state population share for the West	0.24
ω_1	Steady state output share for the East	0.54
ω_2	Steady state output share for the Central	0.30
ω_3	Steady state output share for the West	0.16
K_1/Y_1	Steady state ratio of regional capital over regional output for the East	1.69
K_2/Y_2	Steady state ratio of regional capital over regional output for the Central	1.42
K_3/Y_3	Steady state ratio of regional capital over regional output for the West	1.88

Appendix C. Data description

Statistics are sourced from the National Bureau of Statistics of China and the Local Bureau of Statistics.

Y	Real GDP per capita (national aggregate for China). Annual, constant price (base year 1993).
Y_i	Real GDP per capita for province i, i = 1; 2; 3 (in order: Jiangsu, Hunan and Yunnan).
μ_i	Share of the region's population in the country total population, approximated by the share of province i in the population summed over the three representative provinces.
R	Real interest rate for China (annual loan rate minus GDP deflator).
K	Real aggregate capital stock (national aggregate for China). Initial stock is approximated by total investment infixed asset formation for 1993 multiplied by 10. Stock in following period estimated using the capital accumulation equation, where annual depreciation rate is 5.65%.
K_i	Real capital stock for province i, i = 1; 2; 3.
C	Real aggregate consumption.
C_i	Real consumption for province i, i = 1; 2; 3.
π_i	Entrepreneurship cost, measured as the sum of non-tax revenue and business tax revenue per capita collected by provincial government i; divided by entrepreneurship time. Entrepreneurship time is proxied by the number of legal enterprises divided by the working age population (age 15-64).
TR	Real tax rebate to the province government.
ET	Real equalization transfer to provincial government in province i, approximated by the 'general Transfer'.
TET	Total amount redistributed by central government among all provinces in the form of equalization transfers.

Appendix D. Coefficients of the auxiliary model

Table D1
Coefficients of the auxiliary model.

Auxiliary Coefficients	Actual	Mean	Lower 2.5%	Upper 2.5%
$Var(\Delta \ln K_t)$	0.001258	0.001314	0.000265	0.003378
$Var(\Delta \ln Y_t)$	0.000970	0.000777	0.000355	0.001464
$Var(\mu_1 Y_{1,t}/Y_t)$	0.002229	0.002935	0.000125	0.012501
$Var(\mu_2 Y_{2,t}/Y_t)$	0.000517	0.001583	0.000063	0.005956
$Cov(\Delta \ln K_t, \Delta \ln Y_t)$	0.000539	0.000616	0.000113	0.001630
$Cov(\Delta \ln K_t, \mu_1 Y_{1,t}/Y_t)$	0.000927	0.000034	− 0.001698	0.001762
$Cov(\Delta \ln K_t, \mu_2 Y_{2,t}/Y_t)$	0.000183	0.000120	− 0.000956	0.001787
$Cov(\Delta \ln Y_t, \mu_1 Y_{1,t}/Y_t)$	0.000169	0.000045	− 0.001305	0.001385
$Cov(\Delta \ln Y_t, \mu_2 Y_{2,t}/Y_t)$	− 0.000258	− 0.000068	− 0.001248	0.000763
$Cov(\mu_1 Y_{1,t}/Y_t, \mu_2 Y_{2,t}/Y_t)$	0.000887	− 0.001926	− 0.008409	0.000010

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