

Yang, Xiaoliang; Barros, Lucy; Matthews, Kent; Meenagh, David

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*Xiaoliang Yang, Lucy Barros, Kent Matthews and David
Meenagh*

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Cardiff Business School
Cardiff University
Colum Drive
Cardiff CF10 3EU
United Kingdom
t: +44 (0)29 2087 4000
f: +44 (0)29 2087 4419
business.cardiff.ac.uk

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

Xiaoliang Yang¹, Lucy Barros^{*2}, Kent Matthews^{†3}, and David Meenagh⁴

¹Zhongnan University of Economics and Law, China

²Swansea University, UK

³Cardiff University, UK; University of Nottingham Ningbo, China

⁴Cardiff University, UK

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Abstract

China's fast growth has been accompanied by rising regional inequality, triggering debate over a policy trade-off between aggregate growth and equity. We set out a three-region model of China in which local government behavior affects local TFP dynamics, and regional inequality itself generates more regional productivity divergence. These dynamics can also be affected by central government transfers to regions. Two kinds of fiscal transfers are investigated: equalization transfers and the tax rebate. We estimate and test the model by indirect inference, and explore transfer policy reforms. The results suggest that transfer policies pursued since 1994 have prevented a 15% rise in regional inequality, though at an 8% cost to aggregate GDP.

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

JEL Codes: E60, H30, H70, O40

Declarations of interest: none

***Corresponding Author.** Email: lucy.barros@swansea.ac.uk

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1 Introduction

China's fast growth during the 1980s, led by rapid growth in the east coastal region, was 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).¹ 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). While China's sustained aggregate growth in the 1980s has been attributed in part to a fiscal decentralization system which rewarded local governments for good local economic performance, concerns over increasing regional inequality in the 1990s 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 1980s has inspired much empirical research into its macroeconomic impacts, but little theoretical work modelling the underlying processes, a gap this study aims to address. Public spending responsibility in China is devolved to local government, a move often proposed as efficiency-enhancing.² 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 entrepreneurial form of innovation. 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. We focus on the imposition of non-tax barriers to firm creation and expansion by local government in China (Brandt

¹For fuller discussion of the sizeable and inconclusive empirical literature on regional convergence in China, see Kanbur et al. (2021) and Luintel et al. (2020).

²Decentralized spending may overcome information asymmetries between central government and local citizens, promote better resource allocation by local officials through jurisdictional competition, and induce local governments to promote market incentives through fiscal discipline. Martinez-Vazquez et al. (2017) provide a theoretical overview.

et al., 2020). 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. Moreover, 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 impacts of reforms to fiscal transfer policies. Again, though this study is focused on China, the issues dealt with are of first order importance to governments around the world since 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 rest of the paper is structured as follows. Section 2 discusses related literature. Section 3 presents the model, with discussion of the data and empirical approach in Section 4. Indirect inference estimation and test results are presented in Section 5. The estimated model is then used to explore the dynamic macroeconomic impacts of reforms to the transfer system (Section 6). Section 7 presents conclusions and ideas for further work.

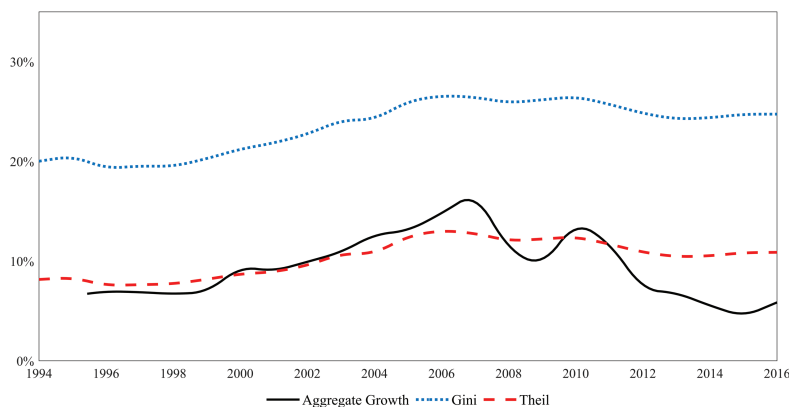


Figure 1: China’s aggregate growth in GDP per capita shows broad comovement with inequality across three regions (east, central and west)

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, p. 467). The theoretical underpinnings of a tradeoff 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.³ 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, 2011), 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.^{4,5} The focus of this paper is on the revenue assignments of China’s tax-sharing system.⁶ While the tax-sharing system has

³See discussion in Fleisher et al. (2010) of institutional barriers to human capital movement in China due to the *hukou* registration system; see also Gordon and Li (2011) and our discussion of labor mobility later in this section.

⁴Yang (2016); Ding et al. (2019).

⁵This reflects broader empirical ambiguity linked to identification problems with the reduced-form regression approach often taken to these questions, mainly the potential for omitted factors and reverse causation between economic growth (or regional inequality) and decentralization (Martinez-Vazquez et al., 2017).

⁶A growth driver often proposed for China is productive provincial government spending following Barro (1990) – see e.g.

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).⁷ 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.^{8,9} 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 persistent fiscal and (consequently) socio-economic disparities across provinces in Zhang (2006) and Zhao (2009). 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

Yin and Zhu (2012). Luintel et al. (2020) find local government spending allocations play a significant role in China’s provincial convergence at regional club level. This is not incompatible with our theoretical approach, as discussed in Section 3. For studies emphasizing the role of decentralized spending responsibilities in Chinese growth (Martinez-Vazquez et al., 2017).

⁷For a thorough description of China’s fiscal arrangements see Section 3.6 and Qiao et al. (2008).

⁸In the context of China, see Jin et al. (2005); Qian and Roland (1998); Weingast (2009); Blanchard and Shleifer (2001)

⁹Predatory behavior of local governments in Russia towards private firms has likewise been attributed to the lack of fiscal incentives (Zhuravskaya, 2000).

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.¹⁰

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 the 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 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 cap-

¹⁰Specifically, a response to significant decreases in local revenue retention share of corporate income tax.

¹¹In 2010, the number of people whose city of residence was different from the city of ‘Hukou’ registration was about 220 million, accounting for 16.6% of the total population in China (based on the most recent release of the population census, *The Sixth Census*, 2010). In contrast, when mobility is defined as that cross-region, the proportion dropped to only 5.0% (compared with 6.4% for cross-province mobility). Furthermore, if migrant population is measured as those whose province of residence differed from his/her province of permanent residence five years ago, the migrant population proportion would be as low as 0.4%

ital 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 Chinese data behavior since 1994 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. Capital and bonds are mobile and there is a single economy-wide interest rate, with labor mobile within but not across regions for the reasons discussed above. Each region indexed by i comprises a representative agent with backyard production facility, and a local government whose behavior affects the local business environment. Central government interacts with local governments and agents, raising revenues through distortionary and lumpsum taxes and transferring these back to regional governments for local spending.¹⁵

¹²Le et al. (2020) provide a general discussion of DSGE literature for China.

¹³For New Keynesian models with fiscal federalism for the Eurozone, see e.g. Versteegen and Meijdam (2016) and Evers (2015). For simulated impacts of EU structural and cohesion fund transfers using the calibrated QUEST III model with semi-endogenous growth, see Varga and in ’t Veld (2011).

¹⁴Structural estimation methods like those applied here to understand the model’s quantitative predictions are increasingly chosen in cases where reduced form methods are infeasible or where good instruments are scarce (as is common when dealing with economic growth). Others adopting indirect inference methods in the literature 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).

¹⁵All variables subscripted i denote per capita values in the data.

3.1 Households

The agent's objective is to choose a path for consumption $C_{i,t}$ and leisure $x_{i,t}$ to maximize the sum of expected lifetime utility with discount factor β , subject to the budget constraint (2).

$$U(C_{i,t}, x_{i,t}) = \Phi \frac{(C_{i,t})^{1-\Psi_1}}{1-\Psi_1} + (1-\Phi) \frac{(x_{i,t})^{1-\Psi_2}}{1-\Psi_2} \quad (1)$$

$$Y_{i,t}(1-\tau) + \Gamma_{i,t} - \pi_{i,t}Z_{i,t} + (1+r_t)B_{i,t-1} = C_{i,t} + B_{i,t} + K_{i,t} - (1-\delta)K_{i,t-1} + T_{i,t} \quad (2)$$

where $Y_{i,t}$, $\Gamma_{i,t}$, $B_{i,t}$, and $T_{i,t}$ are final goods production, lump-sum welfare payments, bonds issued by central government and lump-sum tax respectively, and τ is a proportional income tax rate set nationally. $\pi_{i,t}Z_{i,t}$ is the total entrepreneurship cost¹⁶ and the levy $\pi_{i,t}$ is predetermined at the beginning of period t , and $Z_{i,t}$ represents time spent on entrepreneurial activity; this is discussed further in the next section. The agent's time endowment is normalized at one.

$$x_{i,t} + N_{i,t} + Z_{i,t} = 1 \quad (3)$$

The household in region i produces final output of a homogeneous product, employing capital, $K_{i,t-1}$, and labor, $N_{i,t}$, up to the point where the marginal products of these inputs equal their opportunity costs in terms of consumption and leisure respectively. Region i 's production technology takes the Cobb-Douglas form of (4). Individual total factor productivity evolution follows (5), where $v_{A,it}$ is a regional productivity shock.

$$Y_{i,t} = A_{i,t} (K_{i,t-1})^\alpha (N_{i,t})^{1-\alpha} \quad (4)$$

$$\frac{A_{i,t+1}}{A_{i,t}} = \theta_1 + \theta_2 Z_{i,t} + v_{A,it} \quad (5)$$

¹⁶In reality levies cannot be imposed on entrepreneurial time. We have used a modelling simplification to bring the effect of levies into the management innovation process. $\pi_{i,t}$ is the real cost paid annually by a business in region i to local government, scaled by population, as elaborated further in Section 3.6.

The production setup is deliberately simple in order to place the focus on the relationship between the fiscal system and regional inequality. The innovation process is thus rather loosely specified – rather than product or process innovation, this is better understood as organizational or management innovation generated by those engaged in business activity, shown to be a significant driver of measured TFP; see Bloom and Reenen (2010) among others.

Each agent modelled above as representative for their region must have their per capita activity scaled by the relative size of the region before being summed to obtain the national average per capita values. The regions differ markedly in terms of population. Parameter μ_i gives the population share of region i , where $\sum_i \mu_i = 1$; see Section 4 for the calibration of μ_i .

3.2 Central Government Budget

The Chinese system of fiscal decentralization has undergone significant changes since 1978. The fully centralized system of 1949-1979, known informally as *chi daguofan* or ‘eating from one big pot’, was replaced by a ‘fiscal contracting system’ in 1980 (‘eating from separate kitchens’), superseded in turn by the ‘tax-sharing system’ in 1994. The highly decentralized fiscal contracting system has been credited with stimulating economic growth in regions through incentive effects on local governments, since they retained much of the revenue generated in their provinces (see Section 2). However, despite buoyant growth rates in the 1980s and early 1990s, China experienced fiscal decline in overall tax revenues as a proportion of GDP and the central government’s share of total revenue fell low by international standards. The system allowed for little redistribution from rich to poor provinces and the period saw significant increases in regional income inequality.¹⁷ The 1994 reforms recentralized collection of tax revenues to address the central government’s lack of funds. As a result, the central government now controls over half of China’s fiscal revenue but only undertakes a quarter of fiscal spending responsibility, most of which remained with local governments. The tax-sharing system mandates that tax revenues raised in the province are shared with the central government in fixed proportions: most of the VAT, company income tax and 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

¹⁷Differences in endowments as well as preferential development policy towards coastal provinces fostered diverging regional growth rates which were not offset through the fiscal system (Zhang, 2006)

government until 2018 (Appendix B, Table 9), 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 (Section 3.6). We lay out a simplified version of the system in this and the following subsections.

Central government revenues R_t comprise the total tax revenues raised from individuals via lump-sum and proportional taxes.

$$R_t = \tau \sum_{i=1}^3 \mu_i Y_{i,t} + \sum_{i=1}^3 \mu_i T_{i,t} \quad (6)$$

We assume the full amount is retained by the central government (ignoring the proportion retained at local level) and then redistributed back to the provinces in the form of the tax rebate $TR_{i,t}$ and the equalization transfer $ET_{i,t}$. Outgoings of central government (net of debt servicing) are thus $\sum_{i=1}^3 \mu_i TR_{i,t} + \sum_{i=1}^3 \mu_i ET_{i,t}$ plus other discretionary spending by the central government, $G_{c,t}$. The central government budget constraint is then:

$$\tau \sum_{i=1}^3 \mu_i Y_{i,t} + \sum_{i=1}^3 \mu_i T_{i,t} + \sum_{i=1}^3 \mu_i B_{i,t} = \sum_{i=1}^3 \mu_i TR_{i,t} + \sum_{i=1}^3 \mu_i ET_{i,t} + G_{c,t} + (1 + r_t) \sum_{i=1}^3 \mu_i B_{i,t-1} \quad (7)$$

or

$$\tau Y_t + T_t + B_t = TR_t + ET_t + G_{c,t} + (1 + r_t) B_{t-1} \quad (8)$$

3.3 Local Government Budget

We assume that $\pi_{i,t} Z_{i,t}$ is collected and retained fully by local government while lump-sum tax revenue $T_{i,t}$ and revenue from τ is fully owned by the central government. Local government outgoings enter the household budget constraint as lump-sum welfare transfers, $\Gamma_{i,t}$. The local government budget constraint is

$$\Gamma_{i,t} - \pi_{i,t} Z_{i,t} - (TR_{i,t} + ET_{i,t}) - NOF_{i,t} = 0 \quad (9)$$

where $NOF_{i,t}$ is net other finance consisting of revenues raised from land leasing and from informal local government debt issued to the shadow banking sector.¹⁸ This holds as an identity, because spending is always paid for, though not entirely with tax revenues and funds redistributed from the center. Local government debt cannot be accurately observed as it has for much of our sample been forbidden under Chinese budget law, nor is data consistently available on land leasing at the province level. We return to this equation in the section on local government and growth below.

3.4 Aggregation and Market Clearing

The aggregate market clearing equation (in per capita terms) is obtained by summing the three individual representative agents' budget constraints, each weighted by the share of its region in the total population.

Capital evolves as follows

$$I_{i,t} = K_{i,t} - (1 - \delta) K_{i,t-1} \quad (10)$$

and so

$$(1 - \tau)Y_t = (1 - \tau) \sum_{i=1}^3 \mu_i Y_{i,t} = \sum_{i=1}^3 \mu_i I_{i,t} + \sum_{i=1}^3 \mu_i C_t + \sum_{i=1}^3 \mu_i (\pi_{i,t} Z_{i,t} + T_{i,t} - \Gamma_{i,t}) - \sum_{i=1}^3 \mu_i (1 + r_t) B_{i,t-1} + \sum_{i=1}^3 \mu_i B_{i,t} \quad (11)$$

Since $\Gamma_t - \sum_{i=1}^3 \mu_i \pi_{i,t} Z_{i,t} = TR_t + ET_t + NOF_t$, we have

$$(1 - \tau)Y_t = I_t + C_t + T_t - (TR_t + ET_t) - NOF_t - (1 + r_t)B_{t-1} + B_t \quad (12)$$

¹⁸It is well known that non-tax revenue is not the only source of finance besides tax revenue for local governments in China, and land-leasing revenue cannot be ignored (Han and Kung (2015)). However, the important study by Fan (2015) reveals land finance in China by local government is driven not by local financial pressure but by investment objectives. 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. Thus following Liu (2018), this paper focuses on non-tax revenues that are flexibly controlled by local governments.

The central government budget constraint is:

$$\tau Y_t = TR_t + ET_t + G_{c,t} - T_t + (1 + r_t)B_{t-1} - B_t \quad (13)$$

Using that relationship to simplify the aggregate equation leaves the market clearing constraint as follows:

$$Y_t = I_t + C_t + G_{c,t} - NOF_t \quad (14)$$

Net other finance NOF_t is approximated to discretionary spending from the central government, tantamount to assuming that state owned enterprises do most of the informal lending and rent or buy the majority of local government land. Thus if $G_{c,t} = NOF_t$, the market clearing constraint is:

$$Y_t = I_t + C_t \quad (15)$$

3.5 Optimal Conditions

First order conditions for $C_{i,t}$, $B_{i,t}$ and $K_{i,t}$ yield the individual Euler equation and link the net marginal product of capital to the return on the bond.

$$(C_{i,t})^{-\Psi_1} = (1 + r_t) \beta E_t \left[(C_{i,t+1})^{-\Psi_1} \right] \quad (16)$$

$$(C_{i,t})^{-\Psi_1} = \beta E_t \left[(C_{i,t+1})^{-\Psi_1} \left(\alpha(1 - \tau) \frac{Y_{i,t+1}}{K_{i,t}} + (1 - \delta) \right) \right] \quad (17)$$

Optimization with respect to leisure $x_{i,t}$ yields the individual rule for labor supply.

$$(1 - \Phi) (1 - N_{i,t} - Z_{i,t})^{-\Psi_2} = \Phi (C_{i,t})^{-\Psi_1} (1 - \alpha)(1 - \tau) \frac{Y_{i,t}}{N_{i,t}} \quad (18)$$

The first order condition for $Z_{i,t}$ yields the decision rule for entrepreneurship.

$$\frac{(1 - \Phi)}{(1 - N_{i,t} - Z_{i,t})^{\Psi_2}} + \Phi C_{i,t}^{-\Psi_1} \pi_{i,t} = \Phi \theta_2 \frac{A_{i,t}}{A_{i,t+1}} E_t \left[\sum_{s=1}^{\infty} \beta^s (C_{i,t+s})^{-\Psi_1} (1 - \tau) Y_{i,t+s} \right] \quad (19)$$

As mentioned earlier, this entrepreneurial form of innovation is modelled as a driver of 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, and that this contributes significantly to TFP. TFP generated from private entrepreneurial activity is treated as fully appropriable and there are no spillovers. As $Y_{i,t}/C_{i,t}$ can be approximated to a random walk before steady state,¹⁹ we assume $E_t (Y_{i,t+s}/C_{i,t+s}) = Y_{i,t}/C_{i,t}$ and (19) can be approximated as:²⁰

$$(1 - \alpha)(1 - \tau) \frac{Y_{i,t}}{N_{i,t}} + \pi_{i,t} = (1 - \tau) \eta_i \theta_2 \frac{A_{i,t}}{A_{i,t+1}} Y_{i,t} \quad (20)$$

The individual backyard producer supplies labor until the marginal product (in terms of utility from consumption) equals its opportunity cost in leisure (18). We rewrite the relationship as:

$$\frac{A_{i,t+1}}{A_{i,t}} = \frac{(1 - \tau) \beta \theta_2 Y_{i,t}}{(1 - \beta) [(1 - \tau) (1 - \alpha) Y_{i,t}/N_{i,t} + \pi_{i,t}]} \quad (21)$$

3.6 Local Government Behavior

Above, a nonlinear relationship was derived between TFP growth in the region and local $\pi_{i,t}$, which raises the agent's costs of engaging in $Z_{i,t}$. We now turn to the behavior of $\pi_{i,t}$ itself, observing that revenues from $\pi_{i,t}$ are collected and managed entirely by the local government, rather than being shared with the central government and then redistributed like general tax revenues. Our hypothesis is that greater fiscal pressure on local governments (i.e. a wider gap between funds from centrally redistributed tax revenues and local spending obligations) leads the local government to use this revenue-raising instrument in a more predatory way, resulting in a less business-friendly environment. A local government experiencing lower fiscal pressure,

¹⁹Proof in Yang et al. (2021)

²⁰ $\eta_i = \beta / [(g_{ci})^{\Psi_1 - 1} - \beta]$. We also use the approximation $C_{i,t}/C_{i,t+s} \approx (g_{ci})^{-s}$ where g_{ci} is the steady-state gross growth rate of the individual consumption. We assume $g_{ci} = g_{cj}$ for any $i \neq j$

due to a more generous tax rebate for example, could afford to be more supportive towards business and this would show up in a lower $\pi_{i,t}$ rate.²¹

Given the local government budget identity (equation 9), all else equal we infer that higher transfers from the center reduce pressure on local government to raise revenues from local household firms via its instrument $\pi_{i,t}$ (non-tax fees levied on local businesses) in the following period.

$$\pi_{it} = f(\Gamma_{i,t-1}, TR_{i,t-1}, ET_{i,t-1}, NOF_{i,t-1}, e_{i,t}) \quad (22)$$

To begin with, the simplifying assumption is made that movements in local planned government spending $\Gamma_{i,t}$ are approximately covered by answering movements in $NOF_{i,t}$, the government managed funds discussed earlier. The relevant variables affecting the extent of local government predation on business are then the tax rebate and the equalization transfer from the central government. If the local government is myopic and considers business activity fixed in response to changes in its levies then a reduction in transfers from the center last period could lead this government to increase $\pi_{i,t}$ in order to extract higher revenues (which would help to pay off any debt incurred in the past through NOF_i). The response of $\pi_{i,t}$ to earlier changes in transfers is not one-to-one of course, but we consider the possibility that a fixed relationship exists, and estimate the parameters in question for each of the three regions in Section 5. Thus we investigate the following relation:

$$\pi_{i,t} = f(TR_{i,t-1}, ET_{i,t-1}, e_{i,t}) \quad (23)$$

$$\ln \pi_{i,t} = -\varphi_i^a \ln TR_{i,t-1} - \varphi_i^b \ln ET_{i,t-1} + \varepsilon_{i,t}^\pi \quad (24)$$

This cost, $\pi_{i,t}$, is pre-determined when individuals make optimal decisions and we suppose it is determined by the log-linear local government policy rule above.²²

²¹Thus while the model does not explicitly consider a productive role for local government spending here, such as investments in local infrastructure, it could implicitly be captured as a reduction in $\pi_{i,t}$ i.e. a government-induced reduction of operating costs of local enterprises.

²²Estimating parameters φ_i^a and φ_i^b distinctly allows for a difference in response to two different forms of central transfer. Such a difference could reflect a lack of fungibility across these transfers, in that they are not perceived by local governments to be equivalent when it comes to raising extra funds using local levies on businesses. This could arise for various reasons in practice including the ‘flypaper effect’ of Hines and Thaler (1995) or due to specific constraints arising from administrative rules around the transfers.

3.7 Central Government Policy Rules

Having outlined above the rule governing local government responses to fiscal transfers from the center, we now turn to central-to-local transfers themselves. We focus on two transfer instruments which differ in the way they are allocated across regions and also in their aims: the equalization transfer aims to counteract regional inequality, while the tax rebate aims to stimulate the fiscal incentives growth channel, funneling tax revenues back to more economically productive regions. Though these central government transfer rules are not observable or transparent, consistently with the literature we specify the rules to respond to regional inequality as follows, later relying on the estimation and testing process to comment on their validity.

Shen et al. (2012) model the equalization transfer to local government i , $ET_{i,t}$, as proportional to the total spending of central government on equalization transfers for all provinces, TET_t (which is freely available data). In Shen et al. (2012), the proportion redistributed to province i is approximated by the share of the local fiscal deficit out of the total fiscal deficits summed across all provinces²³. We use the lagged ratio of per-capita income in province i to aggregate per capita income, $Y_{i,t-1}/Y_{t-1}$, to approximate the province's share of TET as follows:

$$\ln ET_{i,t} = \ln TET_t - \sigma_i^{ET} (\ln Y_{i,t-1} - \ln Y_{t-1}) + \varepsilon_{i,t}^{ET} \quad (25)$$

The error term $\varepsilon_{i,t}^{ET}$ allows for other factors and since all measures are in per capita terms, population is already accounted for.²⁴ σ_i^{ET} is left free to vary across regions, so equalization transfers to local governments from the center respond differently to relative income. This non-uniformity in σ_i^{ET} allows for the central government to be systematically more (or less) generous to one region than another with this instrument; the estimated parameters are reported in Section 5 below. $\ln TET_t$ is modelled as exogenous, following a persistent AR(1) process.

Conversely, the tax rebate is modelled as proportional to province income per capita relative to the

²³Fiscal deficit meaning government spending minus fiscal transfers excluding the equalization grant.

²⁴According to the 'Notice of the State Council on printing and distributing income tax revenue sharing reform plan' issued in 2001, equalization transfers are set with regard to local population size, population density, altitude, temperature and ethnic minorities, in addition to the local financial deficit relative to other provinces.

national average. It rewards a relatively good GDP performance in the previous year, so σ_i^{TR} is positive.

$$\ln TR_{i,t} = \sigma_i^{TR} (\ln Y_{i,t-1} - \ln Y_{t-1}) + \varepsilon_{i,t}^{TR} \quad (26)$$

In the empirical work, these σ parameters are estimated separately for each region on the basis that the central government's policy rules for setting these transfers do in practice differ across provinces during our sample period for reasons of political economy. We later conduct policy experiments investigating the impacts of adjusting these parameters on regional growth and inequality.

3.8 Linking fiscal decentralization to regional growth

Nonlinear equation 21 derived above describes the relation between regional productivity growth and the real business cost $\pi_{i,t}$, via the management channel of innovation increasingly acknowledged as a key driver of productivity growth (Bloom and Reenen, 2010). This equation provides the link between fiscal redistribution across regions and local productivity. Regardless of changes in $N_{i,t}$ and $Y_{i,t}$, the derivative with respect to $\pi_{i,t}$ is:

$$\frac{\partial \frac{A_{i,t+1}}{A_{i,t}}}{\partial \pi_{i,t}} = - \frac{(1-\tau)\beta\theta_2}{(1-\beta)} \frac{1}{[(1-\tau)(1-\alpha)Y_{i,t}/N_{i,t} + \pi_{i,t}]^2} < 0 \quad (27)$$

That is, $\frac{A_{i,t+1}}{A_{i,t}}$ is negatively correlated to the non-tax business cost. As outlined above, the impact of a change in $\pi_{i,t}$ on TFP growth happens due to its behavioral impact on the marginal unit of entrepreneurship. However, this behavioral change occurs not simply due to $\pi_{i,t}$ but to the opportunity cost of $\pi_{i,t}$ in terms of foregone consumption utility, $MUC_{i,t} * \pi_{i,t}$ (equation 19). A given level of $\pi_{i,t}$ is then more of a deterrent to an agent with less income in a poorer region i than it would deter an agent in a wealthier region j , as the marginal utility of consumption decreases with consumption. Based on this observation, and considering the strong relationship between current income and current consumption in the model, we take the derivative of

equation 27 with respect to current income.

$$\partial \left(\frac{\partial \frac{A_{i,t+1}}{A_{i,t}}}{\partial \pi_{i,t}} \right) / \partial Y_{i,t} = 2 \cdot \frac{\beta \theta_2}{(1-\beta)} \frac{(1-\tau)^2 (1-\alpha) / N_{i,t}}{[(1-\tau)(1-\alpha) Y_{i,t} / N_{i,t} + \pi_{i,t}]^3} > 0 \quad (28)$$

The marginal effect on TFP growth of an increase in $\pi_{i,t}$ is negative, but increasing towards zero as the level of income rises. The model further embeds an effect of relative income (cf. Yang et al. (2021)). Equation 28 indicates that 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. The inequality ratio in (29) captures this greater advantage of relatively richer regions in innovation due for instance to better local endowments and infrastructure. Based on the first order condition for $Z_{i,t}$, equation 21, the following log-linear equation then determines local productivity growth in model simulations, featuring both $\ln \pi_{i,t-1}$ and the log ratio of local income to the national average:

$$\ln A_{i,t+1} = \ln A_{i,t} + \rho_i^Y (\ln Y_{i,t} - \ln Y_t) - \rho_i^\pi \ln \pi_{i,t} + \varepsilon_{A,i,t} \quad (29)$$

A full model listing can be found in Appendix A. Figure 2 describes the key mechanisms in the model. It shows how the two main central government transfers respond to regional GDP inequality; the local government adjusts the non-tax levy on business based on the transfers they receive; that in turn affects innovation, more so in a relatively poorer province; and the resulting local TFP divergence contributes to widening regional inequality.

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

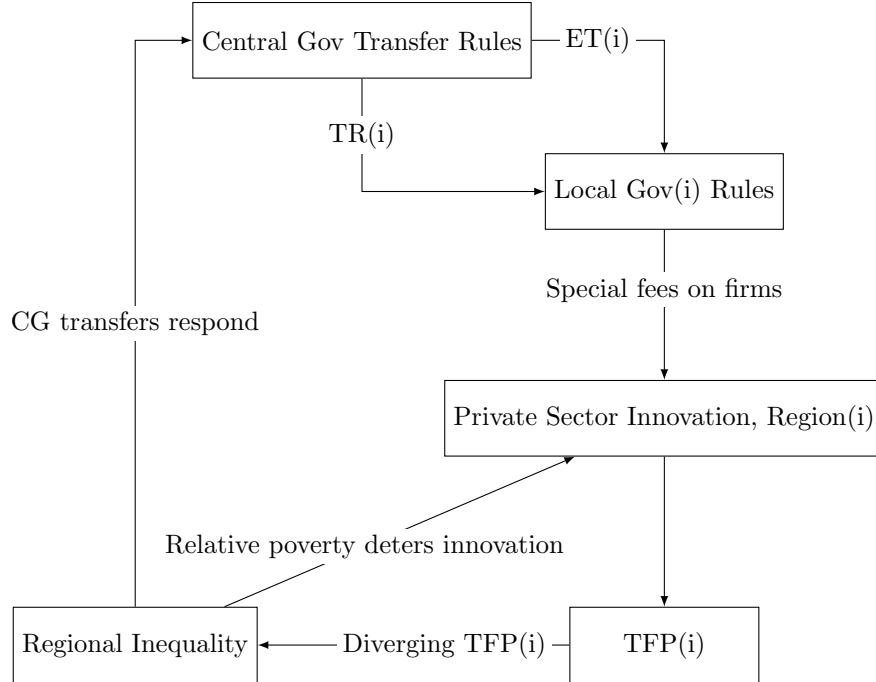


Figure 2: Flow chart describing mechanisms in the DSGE model

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 employers 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.²⁵²⁶

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. Due to the non-stationarity of the data, some residuals ($\epsilon_{i,t}^j$) are trend stationary or non-stationary. For trend stationary

²⁵The relative ratios of per capita GDP of the three regions to the national per capita GDP are 1.5, 0.7 and 0.7 respectively, close to the relative ratios of per capita GDP of the three provinces to the national: 1.6, 0.7 and 0.6. The average population proportions of eastern, central and western regions from 1994 to 2016 were 40%, 32% and 28% respectively, while average population shares of JiangSu, Hunan and Yunnan in their regions were 41%, 35% and 24% respectively.

²⁶These provinces also exclude special cities. China’s local governments have various classifications, with five cities classed as ‘City Specifically Designated in The State Plan’ (different from the ‘Municipalities Directly under the Central Government’). The fiscal policies of these special cities with large economic scale and separate planning are highly independent from the provincial governments where they are located. Provinces containing the five special cities (Guangdong/Canton, Shandong, Zhejiang, Fujian and Liaoning) are therefore not representative of their region for our purposes.

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, Appendix A.²⁷

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	Real business cost for JiangSu	6966	12882	12097
π_2	Real business cost for HuNan	16822	23250	15457
π_3	Real business cost for YunNan	25207	107338	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

Table 1: Data for 1994–2016. Sources and further detail in Appendix C

Province	Non-tax revenue ratio			Private entrepreneur density			Real business cost		
	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

Table 2: Real business cost from non-tax levies on private firms (per capita, 1993 prices). Non-tax revenue ratio is the proportion of total local government revenue (‘revenue in the general public budgets’) including all transfers from central government.

Our modelling draws on the following features of the tax-sharing system established in 1994. As discussed, 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

²⁷Total factor productivity is the Solow residual calculated from the regional production function given in equation 4. The usual caveats apply to this residual measure and though we interpret it loosely as a measure of productivity, it may be sensitive to the production function specification or to sectoral differences across regions.

government’s discretion with minimal scrutiny from the center.²⁸ 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.²⁹ 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 local ‘informal tax rate’) 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 1990s. Table 2 indicates that the private entrepreneur density defined by the number of private entrepreneurs in every one thousand working age people was fairly low in all provinces before the tax-sharing system reform. 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 equalization transfer (also known as the ‘general transfer’) used by the central government to redistribute tax revenues from rich to poor provinces, and the tax rebate which rewards past economic success. Fig. 3 presents data on central to local transfers for the

²⁸Shares of major tax rates are listed in Appendix B, Table 9. Revenue from business tax was retained and managed almost in full by the local government until 2018 reforms. While central government recommendations on business taxation allow leeway for local governments to vary local business tax rates via threshold adjustments and industry-category specific rates, in practice there is little variation across provinces in business tax rates. We focus on revenue raising activities fully free to vary across provinces, i.e. non-tax levies.

²⁹Local 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 licence tax’, ‘slaughtering tax’ and some other less important incomes. Note that these fees are classed as non-tax revenues despite being called ‘tax’.

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. 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 1990s. Fig. 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 Fixed aspects of calibration

The parameters fixed throughout the investigation are listed in Table 3. Calibration of α , β , and δ 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).

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

Table 3: Calibration

4.3 Indirect Inference

Other preference-related and fiscal parameters are estimated by indirect inference methods (Le et al., 2016). Of special importance for the role of fiscal decentralization in inequality are 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

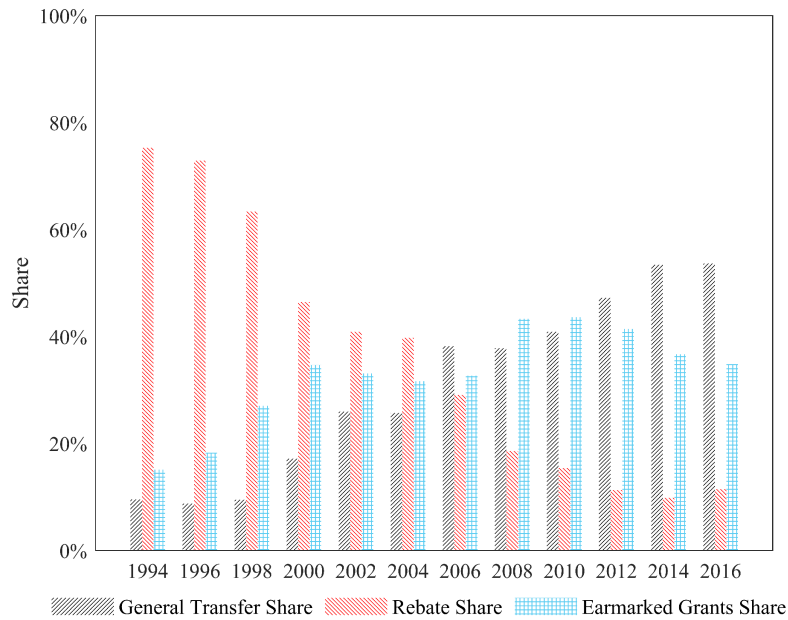


Figure 3: Composition of central-to-local transfers

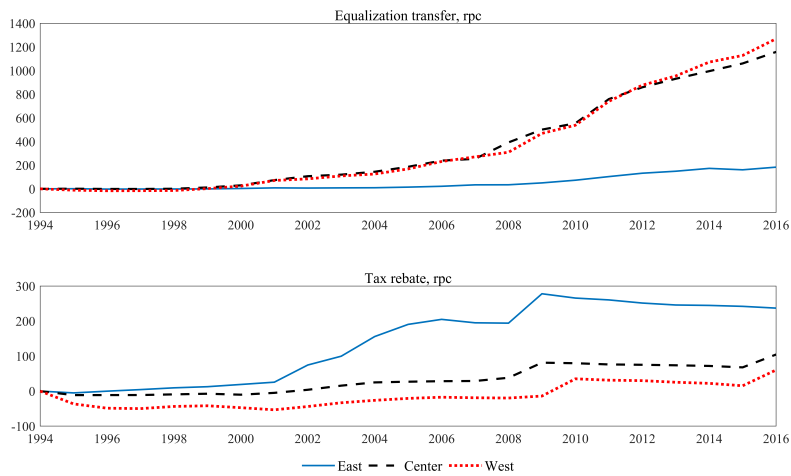


Figure 4: Real per capita equalization transfers and tax rebate transfers to representative provinces JiangSu (East), HuNan (Centre), YunNan (West); Base year 1993

the tax rebate to relatively good (poor) economic performance. 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 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.

This section sets out the methodology of model testing and parameter estimation applied here, developed by Le et al. (2011). The method 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 such as a VAR, impulse response functions or moments. In this paper we use the moments. Define the parameters of the structural model and the auxiliary model as θ and β respectively. First the auxiliary parameters, $\hat{\beta}$, are estimated on the actual data. Given the null hypothesis $H_0 : \theta = \theta_0$, we simulate S samples using the structural model and estimate the auxiliary parameters using each simulated sample to obtain estimators $\tilde{\beta}_s(\theta_0); s = 1, \dots, S$. To evaluate whether $\hat{\beta}$ comes from the distribution of $\{\tilde{\beta}_s(\theta_0)\}$, we compute the Wald statistic

$$Wald_a = \left[\hat{\beta} - \overline{\tilde{\beta}_s(\theta_0)} \right]' \sum(\theta_0)^{-1} \left[\hat{\beta} - \overline{\tilde{\beta}_s(\theta_0)} \right]$$

where $\sum(\theta_0)$ is the variance-covariance matrix of $\hat{\beta}_s - \tilde{\beta}_s(\theta_0)$. If $Wald_a$ is less than the 95th percentile value of the Wald statistics from the simulated data, $Wald_s$, sorted from smallest to largest, H_0 cannot be rejected at the 95% confidence interval; otherwise the model is false. Unlike the simulated method of moments, where stochastic simulations result from random draws of shocks from assumed distributions, this indirect inference procedure bootstraps the set of innovations implied by the structure of the model and its residuals as computed from the observed data.³⁰ The innovations reflect the DSGE model restrictions for

³⁰With the exception of regional Solow residuals which are treated as I(1), the residuals ε_t and $\varepsilon_{i,t}$ are modelled as exogenous AR(1) trend stationary processes, subject to orthogonal innovations η_t and $\eta_{i,t}$ – see listing in Appendix A.

a given θ_0 (unlike innovations drawn from an assumed distribution) and so the Wald distribution for the auxiliary parameters describing the simulated data is also ‘restricted’.³¹

Indirect estimation involves varying parameters until the Wald percentile is minimized. The 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 4. 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. We find some parameter heterogeneity across regions in the local government behavioral rules (equations 49 to 51 in model listing, Appendix A). 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 ET on local government. Also, estimates for φ_i^b show some appreciable variation across regions. These parameters imply that local real business costs 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 percentage point increase in ET for the central region results in a 0.35 percentage point reduction in local real business costs there, while an equivalent increase in the east region leads to a 0.18 percentage point reduction in that region. 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 come back to in the next section, particularly in conjunction with heterogeneity across ρ_i^π and ρ_i^Y .

The estimates of parameters in the central government’s transfer rules are also interesting. σ_i^{TR} and σ_i^{ET} show how central transfers respond to a region’s economic performance relative to the average. Variation across regions in σ_i^{TR} indicates 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

³¹This lends the method greater statistical power than Likelihood Ratio tests (Le et al., 2016).

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

Table 4: Estimated Structural Coefficients

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.

Table 5 provides the results of the variance-covariance auxiliary model. The Wald test shows that jointly the model could match the second moments as the model was not rejected. Table 5 shows that the individual second moments are also matched. All of the actual coefficients lie within the 95% confidence interval apart from $Cov(\mu_1 Y_{1,t}/Y_t, \mu_2 Y_{2,t}/Y_t)$ in the last row.

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

Table 5: Coefficients of the auxiliary model

6 Model properties and policy simulation

This section key features of the model are illustrated using impulse response functions for a selected shock, and a full variance decomposition for regional GDP. We also present results of a policy simulation showing what happens when the government unlinks transfers from the regions' relative economic performance.

Figures 5 to 7 show IRFs for a temporary one standard deviation reduction to real business costs in the west region, $\pi_{3,t}$.³² The western region's output share increases relative to the other regions because the reduction in π_3 drives TFP growth in that region (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 productivity improvement in the west. Notably, although the output shares of regions 1 and 2 are reduced, the shock results in an overall increase in aggregate output (Figure 5). 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. Bearing in mind that 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. For this reason we show the IRFs for the western region $\pi_{3,t}$ shock rather than for e.g. the eastern region, the IRFs for which have similar properties but imply an increase in regional inequality together with higher aggregate output. Achieving even a temporary reduction in real business costs in the western region appears to be policy with little

³²The IRFs for shocks to the other two regions display similar properties.

downside at the country level.

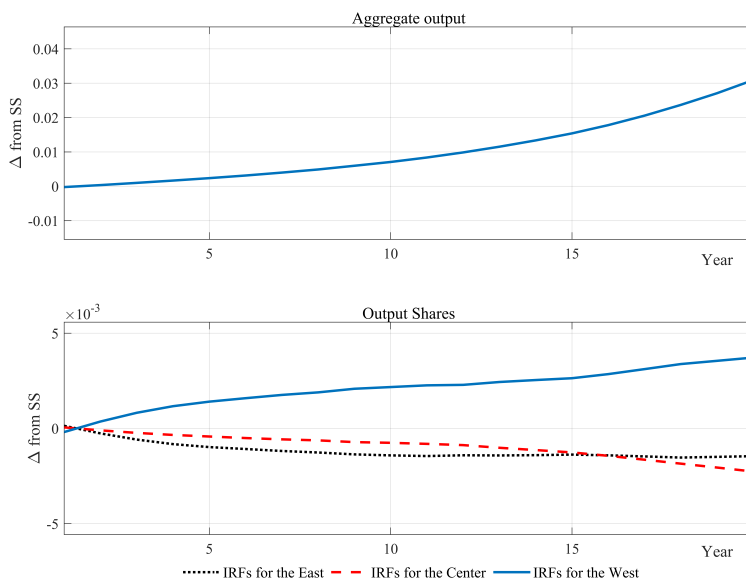


Figure 5: Output responses to a 1 s.d. reduction in local informal tax rate on business, West region

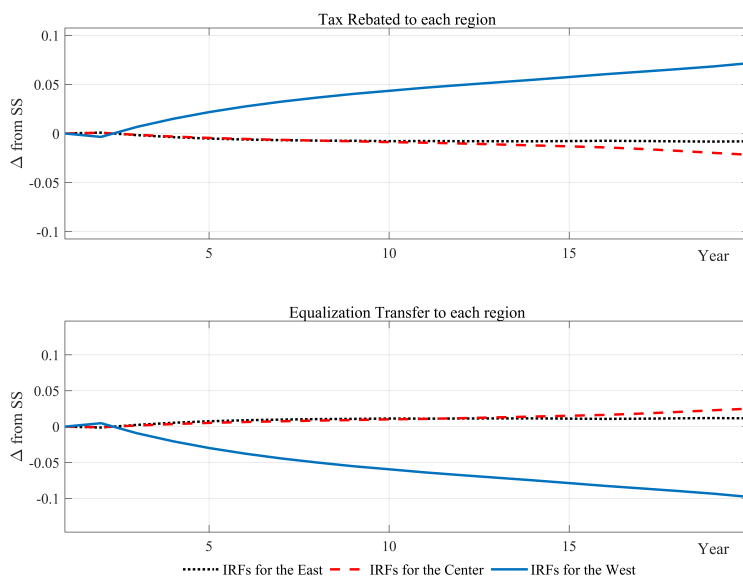


Figure 6: Responses to 1 s.d. reduction in local informal tax rate on business, West: central transfers

A variance decomposition of the key aggregate variables and regional economy shares is shown in Table 6. To the variance of output, productivity shocks and shocks to the factors of production contribute the most, 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.

The model is then used to simulate the effects of adjusting the central government transfer rules awarding

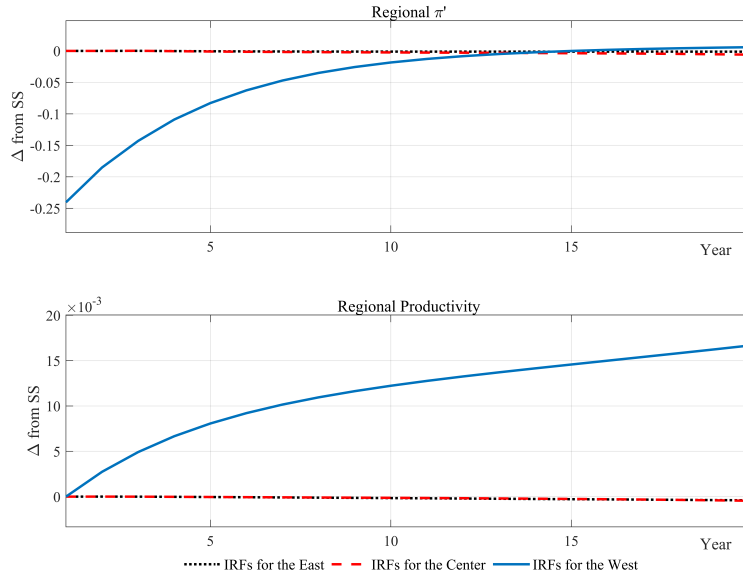


Figure 7: Responses to 1 s.d. reduction in local informal tax rate on business, West: TFP and informal tax rate

Shocks	K1	K2	K3	C1	C2	N1	N2	N3	A1	A2	A3
lnY	11.01	6.03	4.14	5.36	2.85	11.84	2.56	0.70	14.73	13.57	10.18
lnK	10.05	11.86	6.82	4.53	5.88	3.12	11.89	2.81	0.72	12.36	13.10
lnC	12.58	4.78	3.61	5.37	2.77	12.33	1.45	0.33	21.09	14.63	12.19
$\mu 1Y1/Y$	14.06	8.21	6.14	1.10	0.73	7.82	1.12	0.43	27.18	14.95	13.64
$\mu 2Y2/Y$	11.81	13.84	2.83	1.17	1.28	7.46	1.90	0.23	22.46	23.92	7.65
$\mu 3Y3/Y$	9.83	3.23	14.40	0.95	0.43	4.68	0.50	0.98	23.18	5.82	31.64

Shocks	P1	P2	P3	TR1	TR2	TR3	ET1	ET2	ET3	lnTET
lnY	4.88	2.79	2.19	0.83	0.16	0.18	1.39	1.43	0.36	2.82
lnK	4.88	2.80	2.20	0.81	0.15	0.17	1.36	1.40	0.36	2.73
lnC	2.77	1.47	1.17	0.37	0.07	0.08	0.66	0.68	0.16	1.46
$\mu 1Y1/Y$	1.35	0.97	0.81	0.19	0.05	0.05	0.33	0.48	0.10	0.29
$\mu 2Y2/Y$	1.47	1.48	0.64	0.21	0.07	0.04	0.37	0.73	0.09	0.33
$\mu 3Y3/Y$	0.64	0.33	2.31	0.07	0.01	0.14	0.13	0.15	0.30	0.26

Table 6: Variance Decomposition

equalization transfers (ET) and tax rebate (TR) to the three regions. This experiment involves simply 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).

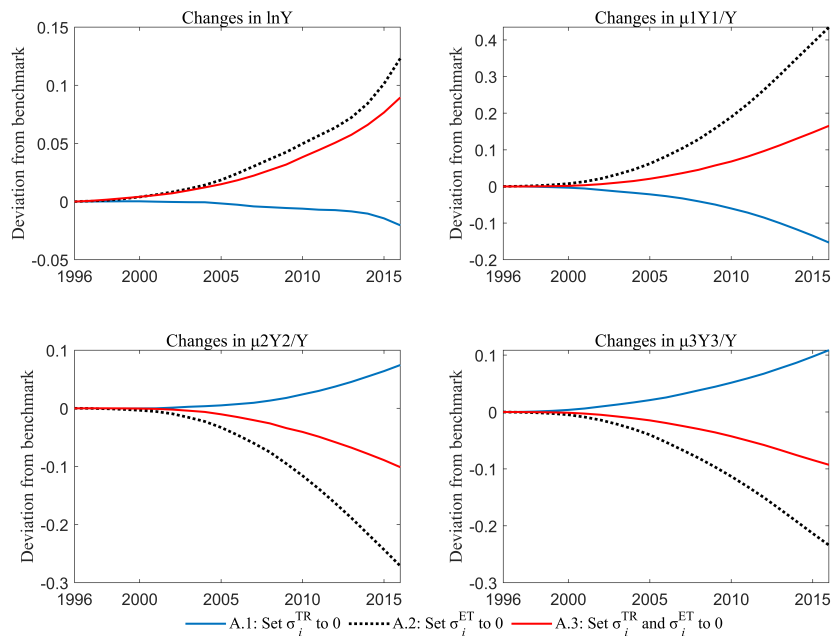


Figure 8: Shutting down fiscal instruments. A3 sets both sigma parameters to 0 across all regions.

We conduct the following three exercises:

- A1: The tax rebate, or fiscal incentive channel, is shut down by setting $\sigma_i^{TR} = 0$ for all three regions simultaneously, while 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 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, or regional redistribution channel, is shut down by setting $\sigma_i^{ET} = 0$ for all three regions simultaneously. Shown by the dotted line in Figure 8.
- A3: Both the tax rebate and the equalization transfer are shut down simultaneously, so that no central transfers respond to relative GDP performance any longer. Shown by unbroken line on Figure 8.

These results show that shutting down the fiscal incentives channel (A1) marginally reduces aggregate GDP relative to the status quo. At the same time, regional inequality falls relative to the status quo: 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) in the model stimulates aggregate growth since the fiscal incentives channel operates more strongly. This is driven by region 1 which pulls further ahead of the country average, while regions 2 and 3 fall further behind; there is rising inequality across regions. Finally, A3 involves removing the systematic relation between central transfers and local GDP performance entirely. In this simulation the response of the center to relative differences is removed and all regions receive an equal transfer in every period under this regime. The simulation shows qualitatively similar effects to the removal of the equalization transfer, though the quantitative impacts are lower due to the removal of the reinforcement effect of the fiscal incentive (the tax rebate). This simulation 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. We can interpret this simulation as a vindication of the central government's policy of centralized transfers to reduce regional income inequality, albeit at the cost of lower aggregate GDP growth.

7 Conclusions and discussion

The stylized facts of China's regional economy show divergence in GDP per capita across the eastern, central, and western regions. Official policy has been to address this regional disparity through the mechanism of central fiscal transfers to each region. Since central transfers affect the extractive policies of provincial governments towards the private sector, they impact economic incentives in the individual regions.

This paper constructs a theoretical framework to analyze the effects of central fiscal transfers on regional growth performance and GDP inequality. Central transfers are made up of two components. The tax rebate rewards provincial governments for good economic performance. The equalization transfer is the

redistributive component and aims to close the gap between poorer and richer provinces in terms of income per capita. The gap between provincial government spending obligations and central transfer revenue is filled partly through non-tax levies on local businesses, affecting incentives to innovate through business activity.

We outline a DSGE model of the three economic regions of China, featuring these processes linking the tax-sharing system to regional and aggregate growth and inequality dynamics. 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 here employ the method of indirect inference and show that the estimated model is strongly data consistent, matching the moments of key aggregate variables and regional inequality ratios.

The results shed light on the trade-off between aggregate growth and regional inequality across the economic regions of China. Bootstrap simulations show that a wide variety of shocks explain real GDP in the regions, and in terms of the policy contributions to output variation, shocks to non-tax real business costs dominate. We have also shown how three alternative tax-transfer regimes compare relative to the simulated status quo. The third regime provides fixed transfers to each region that do not vary with economic performance or the cycle; overall there is less redistribution from rich to poor regions under this regime. The simulation reveals that after 20 years aggregate GDP is approximately 8% higher than under the status quo regime, but that inequality – in terms of the ratio of the east coastal region to the country average – is higher by more than 15%.

We find considerable heterogeneity in the response of the central authorities to local economic performance and inequality. The estimated parameters show that the poorest (western) region is less penalized for poor economic performance than the richer (eastern) region rewarded for its economic success. The overarching policy goal of the China Communist Party has been social stability. In the eyes of the CCP, the poorer provinces of China are more likely to exhibit social instability and deserve greater fiscal attention. There is also a difference across regions in the way tax-transfers affect real business costs imposed by local government. A possible explanation is the response of the party officials whose promotion up the ranks of the party system depends on their demonstration of administrative and economic competence at the provincial level. Provincial governments have limited ability to borrow in the capital markets and therefore fiscal gaps are

made up from business levies (modelled here), land sales, bond issues or the shadow banking system since the tightening of credit policy in 2009-10. It is reasonable to expect heterogeneity in the exact manner of closing fiscal gaps across provinces and regions, and indeed across individual officials.

This paper is the first step in a wider research agenda. First, our findings suggest that central government transfer rules currently exhibit regional heterogeneity. Initial simulations suggest that greater regional equality could be gained with little loss of aggregate economic output, by the imposition of regional homogeneity in the central transfer rules. Second, an exploration of the welfare implications of a marginal reduction in aggregate GDP for a marginal increase in regional equality would be useful for policy. A third question is whether greater redistribution would speed up convergence in China in the presence of greater regional labor mobility. Factor mobility was a key feature in regional convergence within the USA, though in China labor mobility across large regions has been fairly low (as discussed in Section 2). These and other questions are left for future research.

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A Full Model Listing

$$r_t = \Psi_1 (E_t \ln C_{3,t+1} - \ln C_{3,t}) - \ln \beta \quad (30)$$

$$\ln Y_t = \ln [\mu_1 \exp(\ln Y_{1,t}) + \mu_2 \exp(\ln Y_{2,t}) + \mu_3 \exp(\ln Y_{3,t})] \quad (31)$$

$$\ln K_t = \ln [\mu_1 \exp(\ln K_{1,t}) + \mu_2 \exp(\ln K_{2,t}) + \mu_3 \exp(\ln K_{3,t})] \quad (32)$$

$$\ln C_t = \frac{Y}{C} \ln Y_t - \frac{K}{C} [\ln K_t - (1 - \delta) \ln K_{t-1}] \quad (33)$$

$$\ln Y_{1,t} = \alpha \ln K_{1,t-1} + (1 - \alpha) \ln N_{1,t} + \ln A_{1,t} \quad (34)$$

$$\ln Y_{2,t} = \alpha \ln K_{2,t-1} + (1 - \alpha) \ln N_{2,t} + \ln A_{2,t} \quad (35)$$

$$\ln Y_{3,t} = \alpha \ln K_{3,t-1} + (1 - \alpha) \ln N_{3,t} + \ln A_{3,t} \quad (36)$$

$$\ln K_{1,t} = E_t \ln Y_{1,t+1} - \left[\frac{K_1}{Y_1} \cdot \frac{1}{\alpha(1 - \tau)} \right] r_t + \varepsilon_{1,t}^K \quad (37)$$

$$\ln K_{2,t} = E_t \ln Y_{2,t+1} - \left[\frac{K_2}{Y_2} \cdot \frac{1}{\alpha(1 - \tau)} \right] r_t + \varepsilon_{2,t}^K \quad (38)$$

$$\ln K_{3,t} = E_t \ln Y_{3,t+1} - \left[\frac{K_3}{Y_3} \cdot \frac{1}{\alpha(1 - \tau)} \right] r_t + \varepsilon_{3,t}^K \quad (39)$$

$$\ln C_{1,t} = E_t \ln C_{1,t+1} - \frac{1}{\Psi_1} (r_t + \ln \beta) + \varepsilon_{1,t}^C \quad (40)$$

$$\ln C_{2,t} = E_t \ln C_{2,t+1} - \frac{1}{\Psi_1} (r_t + \ln \beta) + \varepsilon_{2,t}^C \quad (41)$$

$$\ln C_{3,t} = \frac{1}{\omega_{c,3}} (\ln C_t - \omega_{c,2} \ln C_{1,t} - \omega_{c,2} \ln C_{2,t}) \quad (42)$$

$$\ln N_{1,t} = \frac{1}{(1 + \Psi_2)} \left[\ln Y_{1,t} - \Psi_1 \ln C_{1,t} + \frac{2\Psi_2}{\theta_2} \left(\rho_1^\pi \ln \pi_{1,t} - \rho_1^Y \ln \frac{Y_{1,t}}{Y_t} \right) \right] + \varepsilon_{1,t}^N \quad (43)$$

$$\ln N_{2,t} = \frac{1}{(1 + \Psi_2)} \left[\ln Y_{2,t} - \Psi_1 \ln C_{2,t} + \frac{2\Psi_2}{\theta_2} \left(\rho_2^\pi \ln \pi_{2,t} - \rho_2^Y \ln \frac{Y_{2,t}}{Y_t} \right) \right] + \varepsilon_{2,t}^N \quad (44)$$

$$\ln N_{3,t} = \frac{1}{(1 + \Psi_2)} \left[\ln Y_{3,t} - \Psi_1 \ln C_{3,t} + \frac{2\Psi_2}{\theta_2} \left(\rho_3^\pi \ln \pi_{3,t} - \rho_3^Y \ln \frac{Y_{3,t}}{Y_t} \right) \right] + \varepsilon_{3,t}^N \quad (45)$$

$$\ln A_{1,t} = \ln A_{1,t-1} + \rho_1^Y (\ln Y_{1,t-1} - \ln Y_{t-1}) - \rho_1^\pi \ln \pi_{1,t-1} + \varepsilon_{A,1,t} \quad (46)$$

$$\ln A_{2,t} = \ln A_{2,t-1} + \rho_2^Y (\ln Y_{2,t-1} - \ln Y_{t-1}) - \rho_2^\pi \ln \pi_{2,t-1} + \varepsilon_{A,2,t} \quad (47)$$

$$\ln A_{3,t} = \ln A_{3,t-1} + \rho_3^Y (\ln Y_{3,t-1} - \ln Y_{t-1}) - \rho_3^\pi \ln \pi_{3,t-1} + \varepsilon_{A,3,t} \quad (48)$$

$$\ln \pi_{1,t} = -\varphi_1^a \ln TR_{1,t-1} - \varphi_1^b \ln ET_{1,t-1} + \varepsilon_{1,t}^\pi \quad (49)$$

K_1 shock	K_2 shock	K_3 shock	C_1 shock	C_2 shock	N_1 shock	N_2 shock
0.6589	0.7299	0.7830	0.3305	0.3101	0.9990	0.7623
N_3 shock	A_1 shock	A_2 shock	A_3 shock	π_1 shock	π_2 shock	π_3 shock
0.2625	0.2550	0.2733	0.3710	0.6628	0.6449	0.7699
TR_1 shock	TR_2 shock	TR_3 shock	ET_1 shock	ET_2 shock	ET_3 shock	TET shock
0.8584	0.7647	0.8014	0.8185	0.8052	0.8296	0.8431

Table 7: Estimated AR coefficients of the structural shocks

$$\ln \pi_{2,t} = -\varphi_2^a \ln TR_{2,t-1} - \varphi_2^b \ln ET_{2,t-1} + \varepsilon_{2,t}^\pi \quad (50)$$

$$\ln \pi_{3,t} = -\varphi_3^a \ln TR_{3,t-1} - \varphi_3^b \ln ET_{3,t-1} + \varepsilon_{3,t}^\pi \quad (51)$$

$$\ln TR_{1,t} = \sigma_1^{TR} (\ln Y_{1,t-1} - \ln Y_{t-1}) + \varepsilon_{1,t}^{TR} \quad (52)$$

$$\ln TR_{2,t} = \sigma_2^{TR} (\ln Y_{2,t-1} - \ln Y_{t-1}) + \varepsilon_{2,t}^{TR} \quad (53)$$

$$\ln TR_{3,t} = \sigma_3^{TR} (\ln Y_{3,t-1} - \ln Y_{t-1}) + \varepsilon_{3,t}^{TR} \quad (54)$$

$$\ln ET_{1,t} = \ln TET_t - \sigma_1^{ET} (\ln Y_{1,t-1} - \ln Y_{t-1}) + \varepsilon_{1,t}^{ET} \quad (55)$$

$$\ln ET_{2,t} = \ln TET_t - \sigma_2^{ET} (\ln Y_{2,t-1} - \ln Y_{t-1}) + \varepsilon_{2,t}^{ET} \quad (56)$$

$$\ln ET_{3,t} = \ln TET_t - \sigma_3^{ET} (\ln Y_{3,t-1} - \ln Y_{t-1}) + \varepsilon_{3,t}^{ET} \quad (57)$$

$$\ln TET_t = \rho^{TET} \ln TET_{t-1} + \varepsilon_t^{TET} \quad (58)$$

For more on linearization and derivation, see next subsection. Exogenous processes (aggregate ε_t^j and regional $\varepsilon_{i,t}^j$) are modelled as AR(1) trend stationary processes.

$$\varepsilon_{i,t}^k = c_i^k + \beta_i^k t + \rho_i^k \varepsilon_{i,t-1}^k + \eta_{i,t}^k \quad (59)$$

where i indicates region and k indicates the relevant endogenous variable. $\eta_{i,t}^k$ are zero mean i.i.d. innovations which are bootstrapped when simulating the model. The ρ_i parameters for the estimated model used in policy simulations are given in Table 7

Linearizing the intratemporal condition

$$(1 - \Phi) (1 - N_{i,t} - Z_{i,t})^{-\Psi_2} = \Phi (C_{i,t})^{-\Psi_1} (1 - \alpha)(1 - \tau) \frac{Y_{i,t}}{N_{i,t}} \quad (60)$$

Taking logarithms on both sides yields:

$$\ln(1 - \Phi) - \Psi_2 \ln(1 - N_{i,t} - Z_{i,t}) = \ln \Phi - \Psi_1 \ln C_{i,t} + \ln[(1 - \alpha)(1 - \tau)] + \ln Y_{i,t} - \ln N_{i,t} \quad (61)$$

$\ln(1 - N_{i,t} - Z_{i,t})$ can be linearized by

$$\ln(1 - N_{i,t} - Z_{i,t}) = \ln(1 - N_i - Z_i) - \frac{N_i}{1 - N_i - Z_i} (\ln N_{i,t} - \ln N_i) - \frac{1}{1 - N_i - Z_i} (Z_{i,t} - Z_i)$$

As $N_i + Z_i \approx \frac{1}{2}$ and Z_i are tiny, Eq. # can be written (ignoring the constant terms) as:

$$\ln N_{i,t} = \frac{1}{(1 + \Psi_2)} (\ln Y_{i,t} - \Psi_1 \ln C_{i,t}) - \frac{2\Psi_2}{(1 + \Psi_2)} Z_{i,t} \quad (62)$$

To linearize the equation of $Z_{i,t}$, i.e. $A_{i,t+1}/A_{i,t} = (1 - \tau)\eta_i\theta_2/Y_{i,t}w_{i,t}(1 - \tau + \pi'_{i,t})$ For simplicity, taking logarithm on both sides yields:

$$\ln A_{i,t+1} - \ln A_{i,t} = \ln [(1 - \tau)\eta_i\theta_2] + \ln (Y_{i,t}/w_{i,t}) - \ln(1 - \tau + \pi'_{i,t})$$

$$\ln A_{i,t+1} - \ln A_{i,t} = \ln [(1 - \tau)\eta_i\theta_2] + \ln (Y_{i,t}/w_{i,t}) - \left[\ln(1 - \tau + \pi'_i) + \frac{\pi'_i}{(1 - \tau + \pi'_i)} (\ln \pi'_{i,t} - \ln \pi'_i) \right] \quad (63)$$

We treat $\ln (Y_{i,t}/w_{i,t})$ as an error term. Then, Eq. # can be written as below (ignoring constant terms), which defines the linearized equation of individual productivity.

$$\ln A_{i,t+1} - \ln A_{i,t} = -\frac{\pi'_i}{(1 - \tau + \pi'_i)} \ln \pi'_{i,t} + \varepsilon_{A,t} \quad (64)$$

Given $A_{i,t+1}/A_{i,t} = \theta_1 + \theta_2 Z_{i,t} + v_{A,t}$, $Z_{i,t}$ can be expressed by:

$$Z_{i,t} = \frac{(1 - \theta_1)}{\theta_2} + \frac{1}{\theta_2} (\ln A_{i,t+1} - \ln A_{i,t} - v_{A,t}) = \frac{(1 - \theta_1)}{\theta_2} - \frac{1}{\theta_2} \frac{\pi'_i}{(1 - \tau + \pi'_i)} \ln \pi'_{i,t} \quad (65)$$

Substituting out $Z_{i,t}$ by (ref 3) and (5) and ignoring the constant term yields:

$$\ln N_{i,t} = \frac{1}{(1 + \Psi_2)} \left[\ln Y_{i,t} - \Psi_1 \ln C_{i,t} + \frac{2\Psi_2\pi'_i}{\theta_2(1 - \tau + \pi'_i)} \ln \pi'_{i,t} \right] + \varepsilon_{i,t}^N \quad (66)$$

A.1 Note on long run growth

This model generates in the short and medium term highly divergent regional growth. To achieve long-run balanced growth would require equilibrium TFP growth rates to equalize across regions (otherwise the relative size of the regions would change, with the fastest-growing region taking over entirely in the limit). This would require the government to intervene with equalization transfers to fully offset the effects of any income inequality on π_i . At equilibrium when all regions grow at the same rate, the regional-to-average income ratios must stabilize to constant levels, and these might induce π_i to differ across i if fiscal transfers did not adjust to neutralize any such differences. This sort of transversality condition is justified by a political economy mechanism eventually forcing perfect redistribution from rich to poor regions. The model's balanced growth path is consistent with this perfectly redistributive long run policy intervention (under this assumption, the model reduces to a simple one region exogenous growth model). The focus of this paper is then on modelling regional growth dynamics over some decades under recent Chinese policies, relative to this long run behaviour.

B Tax-Sharing Proportions since 1994

Table 1

Year	VAT shares		Business Tax shares		Company Income Tax shares		Personal Income Tax shares	
	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%

Figure 9: Central-local sharing rules for major taxes

C Data Description

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

Y Y is real GDP per capita (national aggregate for China). Annual, constant price (base year 1993).

Yi Y_i is real GDP per capita for province i , $i = 1, 2, 3$ (in order: Jiangsu, Hunan and Yunnan).

Mu μ_i is the 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 R is the real interest rate for China (annual loan rate minus GDP deflator).

K K is the real aggregate capital stock (national aggregate for China). Initial stock is approximated by total investment in fixed asset formation for 1993 multiplied by 10. Stock in following period estimated using the capital accumulation equation, where annual depreciation rate is 5.65%.

Ki K_i is real capital stock for province i , $i = 1, 2, 3$.

C C is real aggregate consumption.

Ci C_i is real consumption for province i , $i = 1, 2, 3$.

Pi π_i is 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 TR_i is the real tax rebate to the province government.

ET ET_i is the real equalization transfer to provincial government in province i , approximated by the 'general transfer.'

TET TET is the total amount redistributed by central government among all provinces in the form of equalization transfers.