Whether to decentralize and how to decentralize? The optimal fiscal federalism in an endogenous growth model

Xiaodong Chen[a], Haoming Mi[b], Peng Zhou[c,*]

[a] Xi'an Jiaotong University, China. Email: chenxiaodong@xjtu.edu.cn

[b] Xi'an Jiaotong University, China. Email: mihaoming@outlook.com

[c] Cardiff University, UK. Email: zhoup1@cardiff.ac.uk

[*] Corresponding author. D47 Aberconway Building, Cardiff, United Kingdom.

Abstract: We develop an endogenous growth model with public consumption and infrastructure services provided by two-tier governments. Growth performance and welfare implication are compared under the centralized and decentralized fiscal federal systems. In general, there is a trade-off between welfare and growth due to conflicts of interest and asymmetric information between central and local governments. By numerical simulations, we show that the optimal fiscal federalism should impose restrictions on expenditure-GDP ratio, rather than on expenditure-budget ratio or central-local expenditure ratio, because expenditure-GDP ratio can align the incentives of the two-tier governments. Furthermore, it is suggested that decentralized fiscal systems are generally superior to the centralized system because the efficiency loss overweighs the agency cost. The model is then applied to analyzing different growth experiences in the West and China by institutional and cultural differences.

JEL classification: E61; E62; H1; H5; O41; R5

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Highlights

- Centralized and decentralized fiscal federal systems are compared.
- Conflicts of interest exists between central and local governments.
- Decentralized fiscal systems are generally superior due to agency cost.
- The optimal fiscal federalism should impose restrictions based on output.
- There are cultural reasons for institutional differences of fiscal federalism.

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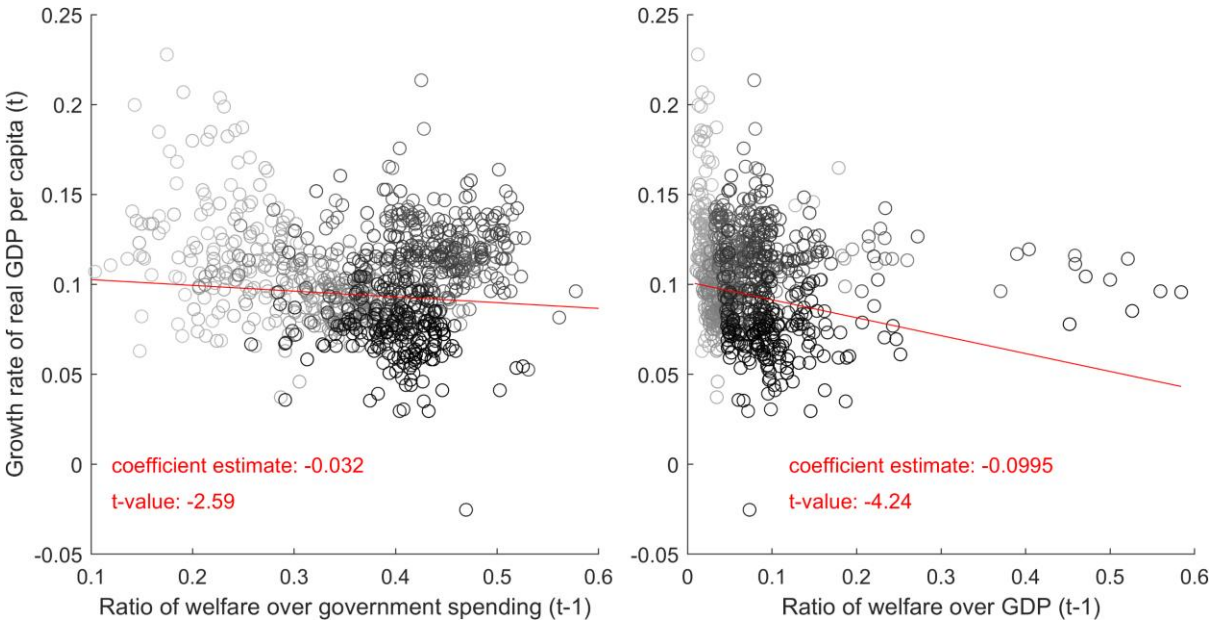
1 Introduction

Since 1950s, there has been a trend in many countries to devolve fiscal powers to subnational governments (Martinez-Vazquez, 2017). This reform is supported by the First-Generation Fiscal Federalism based on two fundamental assumptions. One is preference heterogeneity (Samuelson, 1954, 1955; Musgrave, 1959; Arrow, 1969)—each level of government seeks to maximize the social welfare of its respective constituency (Oates, 2005). The other is information advantage of local governments over the central government on local demand, since residents either vote for or "foot vote" for preferred mixes of public services and taxation (Hayek, 1945; Tiebout, 1956). Therefore, the First-Generation Fiscal Federalism argues that devolution of tax and expenditure can increase social welfare (Musgrave, 1959; Oates, 1972).

However, empirical evidence does not always support this claim (Thornton, 2007; Bjørnskov, 2008; Li et al., 2016; Carniti et al., 2018). Specifically, a more decentralized government structure does not necessarily lead to better economic performance (measured by economic growth) or social welfare in many developing countries (Zou, 1998; Li et al., 2016). In addition to measurement errors and endogeneity problems raised in these empirical studies, many theoretical omissions also attract academic attention to explain First-Generation Fiscal Federalism's failure, such as soft budget constraints (Kornai, 1986), predatory state (Frye & Shleifer, 1997; Shleifer & Vishny, 1998; Dixit, 2004), factor immobility (Foreman-Peck & Zhou, 2020), and adaptive efficiency (Hayek, 1960; North, 1990). These studies form the basis of the Second-Generation Fiscal Federalism. A common feature of Second-Generation Fiscal Federalism is to model a principal-agent problem where public officials are self-interested with their own objective functions that often diverge from benevolent public officials (Qian & Weingast, 1997; Oates, 2005; Weingast, 2009). For a "benevolent" central government (as termed by Dovis & Kirpalani, 2020), the primary objective is to maximize the social welfare, while local governments usually engage in the so-called "growth tournament" to compete for political promotion especially in political systems like China (Li et al., 2019). Nevertheless, the two objectives are contradictory within a limited budget—growth maximization requires infrastructure investment, but welfare maximization necessitates public consumption. As shown in Figure 1, there is a negative relationship between growth rate and welfare ratios as the welfare expenditure expands over time.

Figure 1 The trade-off between provincial growth and welfare spending in China



Note: A darker shade of the circles indicates more recent observations. The coefficient estimates are based on the fixed effects regression model. The key parameters reported in the figure are the coefficients of welfare ratios on growth rate. They are all negative and significant. Data source: China Statistical Yearbook (1990-2019).

To address this trade-off, two key fundamental issues are to be answered in the Second-Generation Fiscal Federalism: (i) Whether a decentralization fiscal system is preferred to a centralized one? (ii) If so, what is the optimal decentralized fiscal federalism? This paper aims to answer the two research questions with an endogenous growth model. Our model extends Barro (1990), Turnovsky & Fisher (1995), and Davoodi & Zou (1998) by distinguishing two types of public goods synchronously provided by central and local government. The objective of the central government is to maximize citizen welfare ("benevolent government"), while local governments aim to maximize local economic growth (GDP tournament). Specifically, the central government in China started to emphasize high-quality development rather than high-speed growth since 2012. A series of notions, e.g., targeted poverty alleviation and common prosperity, came into effect in recent years to strengthen the assumption of a benevolent government. However, the objective for local officials is still maximization of GDP growth in their jurisdictions because GDP is the only quantifiable and feasible indictor in terms of political promotion (Maskin et al., 2000; Li & Zhou, 2005; Li et al., 2019).

Based on the model, we numerically evaluate a centralized fiscal system and three variants of decentralized fiscal systems. Admittedly, it is impracticable to prescribe a universal optimal fiscal system for all countries because any effective policy recipe must account for the vested interests of stakeholders in existing institutions, which vary from country to country and from context to context. Given the rich variations of China's fiscal policies, this paper uses China as

the calibration basis to discuss decentralization, growth, and welfare. Generalization of our quantitative conclusions should be carefully reassessed under different calibrations and setups, but there are three robust findings which seem to be generalizable to other developing and developed economies. First, regarding how to impose limited fiscal autonomy, it is found that setting the expenditure-GDP ratio leads to higher growth and welfare than setting expenditure-budget ratio or central-local expenditure ratio. The spirit of the optimal fiscal decentralization (expenditure-GDP ratio) is to ensure incentive compatibility. The restrictions should be based on GDP rather than other macroeconomic variables because GDP growth is the objective of local governments. Hence, this optimal decentralized system can give rise to stability and "self-enforcement" of fiscal federalism (Weingast, 2014). Second, we find that, under complete and perfect information, the centralized fiscal system yields higher social welfare than decentralized federal system, while the growth rate of the former is lower than the latter. The efficiency loss of the central government reinforces the support for fiscal federalism which can generate both faster growth and higher welfare compared to the centralized system. Third, the cultural differences in time preference and intergenerational altruism form the institutional differences between China and the West. The growth miracle of China can partly be attributed to welfare sacrifices of current generations for future generations.

The rest of the paper is organized as follows. Section 2 critically reviews the relevant literature. Section 3 develops an endogenous growth model with decentralized fiscal systems and discusses the optimal decentralized fiscal system. In section 4, we extend the models with efficiency loss under fiscal centralization and compare the economic outcomes with decentralized systems. Section 5 applies the model to discuss different growth experiences in the West and China based on the cultural and institutional differences. Section 6 concludes the paper.

2 Literature Review

Second-Generation Fiscal Federalism has been developed to account for the divergence that some federal systems promote macroeconomic performance while others do just the opposite. The essence is that appropriate institutional arrangements in decentralized fiscal systems can mitigate the agency costs by aligning the interests of central and local governments. The theory puts forward an ideal type of decentralization institution called *market-preserving federalism*, which is said to be conducive to a thriving private sector and vigorous economic development (Weingast, 1995; Qian & Weingast, 1997; Qian & Roland et al., 1998).

China's fiscal federalism provides a positive example. The so-called Fiscal Contracting System operating from 1980 to 1993 was regarded as a crucial contributor to the rapid economic growth in the early stage of the "reform and opening-up" in China (Qian & Weingast, 1997; Lin & Liu, 2000; Jin et al., 2005). This system is characterized by credible commitment between the

central and provincial governments, hard budget constraints, jurisdictional competition, and a large marginal retention rate of the provincial government in its revenue. As a result, local governments are motivated to promote tax revenue and play a "helping hand" role to the market, which leads to provincial economic prosperity and environmental sustainability (Khan et al., 2021; Shan et al., 2021; Zhan et al., 2022). In contrast, other emerging economies, for example, Argentina, Brazil, Mexico, India, and Russia, have been entrapped in pathological forms of decentralization which reduce economic efficiency by distorting resources allocation (Jin et al., 2005; Weingast, 2009). In addition, Blanchard & Shleifer (2001) argue that fiscal federalism with political centralization tends to receive greater economic benefits than those without political centralization. Therefore, the national government needs to be strong and disciplined to induce subnational governments to favor growth.

Unlike the mixed findings in forementioned developing economies, developed countries with mature democratic and legal systems enjoy a mature federal structure that subnational governments are granted the fiscal power to reduce inefficiencies of market economies (Weingast, 2009; Foreman-Peck & Zhou, 2020a). The sophisticated market-supporting federalism adopted in modern developed economies was not created overnight. Instead, it co-evolved and co-integrated with the native market economy, so simply copying these "best practices" to developing countries will not work (Xu, 2011). As a result, it is worthwhile exploring whether decentralization is a good choice for developing countries and how to construct the optimal fiscal federalism to yield desirable economic performance in line with their own features.

In addition to the cross-sectional differences, the answers to the same questions may vary over time as well. Returning to the example of China's fiscal federalism, most literature analyzes the Fiscal Contracting System up to 1993. Nevertheless, the fiscal system in China was then substantially re-centralized after 1994 in a series of reforms (Xu, 2011; Shen, 2012). The new system is called Tax Sharing System. Empirical evidence offers controversial conclusions under the new system Tax Sharing System in comparison to the old system Fiscal Contracting System. Ding et al. (2019) find that the fiscal re-centralization of revenues under the Tax Sharing System corrects for the overshooting behavior in decentralized Fiscal Contracting System. The flattening structure makes it difficult for upper-level governments to coordinate with and monitor lower-level governments, which hampers local economic performance (Li et al., 2016). However, many policies of Tax Sharing System centralize public revenue, such as adjustment of income tax sharing, rural tax-for-fee reform, and replacing business tax with VAT, which exacerbates vertical fiscal imbalances and increases local expenditure burdens. It results in biased public spending, deficient public services, and slow local economic growth (Shen, 2012; Jia et al., 2014; Zhou & Chen, 2015; Sun et al., 2017). Furthermore, the negative trade-off between local growth and welfare spending (Figure 1) renders local officials in favor of

infrastructure investment (to have higher local growth and so better promotion prospect) rather than welfare spending.

Methodology wise, only a few studies discuss optimal fiscal federalism using a general equilibrium model. Among others, Gong & Zou (2002) construct a general equilibrium analytical framework with multiple levels of government to understand optimal taxation and intergovernmental transfer, but the expenditure financed by different taxes with the central and local government is inconsistent with the current fiscal practice (e.g., Tax Sharing System). Siggelkow (2018) studies tax competition and policy coordination in the presence of fiscal federalism with two-tier jurisdictions but no attention is paid to economic outcome. Additionally, it is at odds with the reality that each level of government of developing countries is assumed to be benevolent to maximize the consumers' utility. Thus, it is not a Second-Generation Fiscal Federalism theoretical framework. Our paper aims to fill this methodological gap in the literature by developing an endogenous growth model with public consumption and infrastructure services provided by two-tier governments in line with fiscal practice and accounting for the principal-agent problem (conflicts of interest and asymmetric information).

3 Decentralized Systems

Following Barro (1990), Turnovsky & Fisher (1995), and Davoodi & Zou (1998), the supply side of the endogenous growth model is characterized by a production function with two factor inputs: private capital and public capital (infrastructure). On the demand side, individuals derive utility through two utility inputs: private goods and public goods (welfare). We extend previous models by allowing both central and local governments to provide both types of public spending (infrastructure and welfare).

Let k be private capital stock and g_A^I be the aggregate government infrastructure spending, which is equal to the sum of g_C^I (central government infrastructure spending) and g_L^I (local government infrastructure spending). The production function is assumed to have constant returns to scale (Cobb-Douglass):

$$y = Ak^{\alpha}(g_C^I)^{\beta}(g_L^I)^{\omega} \tag{1}$$

where y is per capita output, $A > 0$ is total factor productivity, and $\alpha + \beta + \omega = 1$. Therefore, the dynamic budget constraint of the representative agent is:

$$\dot{k} + c = (1-\tau)Ak^{\alpha}(g_C^I)^{\beta}(g_L^I)^{\omega}, \text{ for given } k_0. \tag{2}$$

Let c be private consumption and g_A^W be the aggregate government welfare spending (or public consumption, used interchangeably hereinafter), which is equal to the sum of g_C^W (central government welfare spending) and g_L^W (local government welfare spending). The representative agent's objective function can be written as:

$$U = \int_0^\infty e^{-\rho t}\, u(c, g_C^W, g_L^W)dt, \tag{3}$$

where ρ is the subjective discount rate. The utility function $u(.)$ is increasing and concave. For simplicity, we adopt an additively separable function:

$$u(c, g_C^W, g_L^W) \equiv \nu \ln c + (1-\nu)[\theta \ln g_C^W + (1-\theta) \ln g_L^W]$$

where the parameter $0 < \nu < 1$ is the utility weight of private consumption relative to public consumption, and $0 < \theta < 1$ is the utility weight of central government welfare spending relative to local welfare spending.

The consolidated government spending g is financed by a flat output tax at rate τ_A. For simplicity, we assume a balanced budget of the government. In the case of Ricardian Equivalence, this assumption makes no essential difference.

$$g \equiv g_A^W + g_A^I \equiv g_C^W + g_L^W + g_C^I + g_L^I = \tau_A y \tag{4}$$

The aggregate tax rate, τ_A, is the sum of the central government rate τ_C and the local government rate τ_L.

The budget constraints of central and local governments take the following form:

$$g_C \equiv g_C^W + g_C^I = \tau_C y \tag{5}$$

$$g_L \equiv g_L^W + g_L^I = \tau_L y \tag{6}$$

where g_C is total central government spending and consists of g_C^I and g_C^W, g_L is total local government spending and consists of g_L^I and g_L^W. Therefore, we have:

$$g_C^W = b_C \tau_C y,\ g_C^I = (1-b_C)\tau_C y \tag{7}$$

$$g_L^W = b_L \tau_L y,\ g_L^I = (1-b_L)\tau_L y \tag{8}$$

where $0 \le b_C \le 1$, $0 \le b_L \le 1$ are the fractions of tax revenues of central and local governments used to finance g_C^W and g_L^W. So $0 \le 1-b_C \le 1$ and $0 \le 1-b_L \le 1$ are the fractions to finance g_C^I and g_L^I.

3.1 Representative Agent

The representative agent takes fiscal policy parameters, i.e., τ_A, g_C^I, g_L^I, g_C^W, and g_L^W, as given when choosing the optimal consumption path and capital path $\{c(t), k(t): t \geq 0\}$. Maximize the objective function (3) subject to (2) and (4):

$$\frac{\nu}{c} = \lambda_k \tag{9}$$

$$\dot{\lambda}_k = \lambda_k \left[\rho - (1 - \tau_A) A\alpha \left(\frac{g_C^I}{k}\right)^{\beta} \left(\frac{g_L^I}{k}\right)^{\omega} \right] \tag{10}$$

where the Hamilton multiplier λ_k is the co-state variable, corresponding to the state variable k. The Euler equation is given by:

$$\dot{c} = c \left[(1 - \tau_A) A\alpha \left(\frac{g_C^I}{k}\right)^{\beta} \left(\frac{g_L^I}{k}\right)^{\omega} - \rho \right] \tag{11}$$

The transversality condition is:

$$\lim_{t \to \infty} \lambda_k k e^{-\rho t} = 0 \tag{12}$$

Equations (9)-(12) together with the production function (1) and the allocation rules of government spending (5)-(8) determine the representative individual's optimal policy functions and the balanced growth path. Thus, the balanced growth path rate of the economy (γ) can be expressed by the government fiscal policyτ_C, τ_L, b_C, b_L, and exogenous parameters:

$$\gamma = \alpha(1 - \tau_A) A^{\frac{1}{\alpha}} [\tau_C (1 - b_C)]^{\frac{\beta}{\alpha}} [\tau_L (1 - b_L)]^{\frac{\omega}{\alpha}} - \rho \tag{13}$$

3.2 Governments

In this subsection, we develop and evaluate three decentralized fiscal systems. In a decentralized fiscal system, local governments have certain autonomy to set their own fiscal policies under some restrictions imposed by the central government (Kassouri, 2022). Different fiscal federal systems are shaped by how these restrictions are imposed (Burret et al., 2022).

As argued earlier, local governments can have a different objective (growth maximizer) from the central government (welfare maximizer) due to divergent political incentives (Lyu et al., 2022). As a result, local officials are motivated to spend only the basic amount on welfare spending and maximize infrastructure spending to boost local GDP growth. To ensure adequate welfare expenditure, the central government must formulate some budgeting rules on local

government spending. Three popular rules are adopted in fiscal practice to impose such restrictions.

(1) Restrict the fraction of tax revenue for local welfare spending ($b_L = g_L^W/\tau_L y$).
(2) Restrict the fraction of output used for local welfare spending (g_L^W/y).
(3) Restrict the fraction of local welfare spending (g_L^W/g_A^W).

The restrictions of b_L and g_L^W/y in the first two rules are broadly used in the theoretical and empirical literature (Devarajan et al., 1996; Economides et al., 2011; Luintel et al., 2020). The third restriction is based on the fiscal policy practice in many countries. For example, the central government follows some fiscal formulae to transfer a pro rata block grant to the local government for welfare expenditure (e.g., "Barnett formula" in the UK, "*peitao buokuan*" in China). Namely, the central government bears a fixed proportion of the funding responsibility of public services, but the rest is borne by local governments.

The three decentralized fiscal systems differ by denominators in the restrictions, so we respectively term them as (1) tax-based, (2) output-based, and (3) expenditure-based. To facilitate subsequent comparisons of these three fiscal federal systems, we denote x_{Ci}, x_{Li}, x_{Ai} as the endogenous variables of interest for the central government, local governments and aggregate government, where $i = 1,2,3$ indicates one of the three decentralized fiscal systems. We will discuss the implications of the three fiscal systems respectively.

3.2.1 Tax-Based Restriction

We rewrite equations (7) and (8) by adding a subscript "1" to capture the tax-based restriction:

$$g_{C1}^W = b_{C1}g_{C1} = b_{C1}\tau_{C1}y_1,\ g_{C1}^I = (1-b_{C1})g_{C1} = (1-b_{C1})\tau_{C1}y_1 \qquad (14)$$

$$g_{L1}^W = b_{L1}g_{L1} = b_{L1}\tau_{L1}y_1,\ g_{L1}^I = (1-b_{L1})g_{L1} = (1-b_{L1})\tau_{L1}y_1 \qquad (15)$$

There are three agents in a decentralized fiscal system: agent/citizen, local government, and central government following Dovis & Kirpalani (2020). Their decisions compose a dynamic game in sequence where the central government moves first, followed by the local government and then the citizen. Using backward induction, the citizen's optimal behavior should be solved first given all the governments' policies. The balanced growth path rate γ_1 under this decentralized system is:

$$\gamma_1 = \alpha(1-\tau_{A1})A^{\frac{1}{\alpha}}[\tau_{C1}(1-b_{C1})]^{\frac{\beta}{\alpha}}[\tau_{L1}(1-b_{L1})]^{\frac{\omega}{\alpha}} - \rho \qquad (16)$$

Then, given the central government's announced fiscal policies (τ_{C1}, b_{C1}, b_{L1}), the local government chooses the optimal τ_{L1} to maximize the growth rate γ_1, subject to $\tau_{A1} = \tau_{C1} + \tau_{L1}$. The best response function of the local government is solved as:

$$\tau_{L1} = \frac{\omega}{\alpha+\omega}(1 - \tau_{C1}) \tag{17}$$

This condition indicates that there is a negative relationship between optimal tax rates of central and local governments, because the two taxes are substitutes to finance the expenditure.

Finally, the central government chooses τ_{C1}, b_{C1}, and b_{L1} to maximize the social welfare U_1 as a benevolent government. The objective function can be written as:

$$\max_{\{\tau_{C1}, b_{C1}, b_{L1}\}} U_1 = \frac{\gamma_1}{\rho^2} + \frac{1}{\rho}\begin{Bmatrix} \ln k_0 - (2-\nu)\ln\alpha + (1-\nu)[\theta\ln(\alpha+\omega) + (1-\theta)\ln\omega] \\ +\nu\ln[\rho + (1-\alpha)\gamma_1] + (1-\nu)\ln(\gamma_1+\rho) \\ +(1-\nu)[\theta(\ln b_{C1} + \ln\tau_{C1} - \ln(1-\tau_{C1})) + (1-\theta)\ln b_{L1}] \end{Bmatrix} \tag{18}$$

A nonlinear equation system of $\tilde{\tau}_{C1}$, $\tilde{b}_{C1}$, $\tilde{b}_{L1}$ is:

$$\frac{\partial\tilde{\gamma}_1}{\partial\tilde{\tau}_{C1}}\frac{1}{\rho}\left[\frac{1}{\rho} + \frac{\nu(1-\alpha)}{\rho+(1-\alpha)\tilde{\gamma}_1} + \frac{1-\nu}{\tilde{\gamma}_1+\rho}\right] + \frac{(1-\nu)\theta}{\rho\tilde{\tau}_{C1}(1-\tilde{\tau}_{C1})} = 0, \tag{19}$$

$$\frac{\partial\tilde{\gamma}_1}{\partial\tilde{b}_{C1}}\frac{1}{\rho}\left[\frac{1}{\rho} + \frac{\nu(1-\alpha)}{\rho+(1-\alpha)\tilde{\gamma}_1} + \frac{1-\nu}{\tilde{\gamma}_1+\rho}\right] + \frac{(1-\nu)\theta}{\rho\tilde{b}_{C1}} = 0, \tag{20}$$

$$\frac{\partial\tilde{\gamma}_1}{\partial\tilde{b}_{L1}}\frac{1}{\rho}\left[\frac{1}{\rho} + \frac{\nu(1-\alpha)}{\rho+(1-\alpha)\tilde{\gamma}_1} + \frac{1-\nu}{\tilde{\gamma}_1+\rho}\right] + \frac{(1-\nu)(1-\theta)}{\rho\tilde{b}_{L1}} = 0. \tag{21}$$

The above optimality conditions are standard, but the nonlinearity of the equation system prevents us to obtain closed-form solutions. Instead, we calibrate the model and obtain the numerical solutions of optimal decisions and optimal policies. The calibration follows the existing literature on economic growth, e.g., Barro (1990), Eicher & Turnovsky (2000), Ghosh & Roy (2004), and Hashimzade & Myles (2010).

For ease of calculation and always get a positive value for the utility level, we set $k_0 = e^3$. We set the total factor productivity as $A = 0.5$ according to Barro (1990) and Hashimzade (2010), the output share of private capital as $\alpha = 0.75$ followed by Barro (1990). There are few references closely related to our model by which we can calibrate the parameters for the output share of central government infrastructure (β), the output share of local government infrastructure (ω), the utility weight of private consumption (ν), and the utility of central/local government consumption (θ). However, these parameters can be simple to calibration by calculating the fraction of centra/local government investment in the aggregate government investment, the fraction of household/government consumption expenditure in the total consumption

expenditure, and the fraction of centra/local government consumption in the aggregate government consumption. According to the recent data from China Statistical Yearbook (2019), we set $\beta = 0.05$, $\omega = 0.20$, $\nu = 0.7$, and $\theta = 0.25$ as our baseline calibration. The conclusions do not qualitatively vary for other values.

Table 1 The simulated equilibrium of the tax-based fiscal system

ρ	$\tilde{b}_{C1}$	$\tilde{b}_{L1}$	$\tilde{\tau}_{C1}$	$\tilde{\tau}_{L1}$	$\tilde{\tau}_{A1}$	$\tilde{g}^W_{C1}/y_1$	$\tilde{g}^W_{L1}/y_1$	$\tilde{g}^W_{A1}/y_1$	$\tilde{\gamma}_1$	$\widetilde{U}_1$
0.02	17.31%	10.88%	6.05%	19.78%	25.83%	1.05%	2.15%	3.20%	9.38%	200.21
0.03	23.45%	15.16%	6.53%	19.68%	26.21%	1.53%	2.98%	4.51%	8.16%	74.52
0.04	**28.58%**	**18.93%**	**7.00%**	**19.58%**	**26.58%**	**2.00%**	**3.71%**	**5.71%**	**6.95%**	**35.28**
0.05	32.96%	22.29%	7.46%	19.48%	26.94%	2.46%	4.34%	6.80%	5.76%	19.08
0.06	36.75%	25.31%	7.91%	19.39%	27.29%	2.91%	4.91%	7.81%	4.59%	11.26

Note 1: ρ measures the time preference rate. The numerical simulations are based on the baseline calibration of $\rho = 0.04$ according to Ghosh (2004) and Hashimzade (2010). The baseline results are in bold font.

Note 2: In the first decentralized system, $\tilde{b}_{C1}$ and $\tilde{b}_{L1}$ respectively denote the fractions of central and local government tax revenue to finance their own public consumption, $\tilde{\tau}_{C1}$ and $\tilde{\tau}_{L1}$ are central and local government tax rates, $\tilde{\tau}_{A1} = \tilde{\tau}_{C1} + \tilde{\tau}_{L1}$ is aggregate government tax rate, $\tilde{\gamma}_1$is growth rate, and $\widetilde{U}_1$ is social welfare.$\tilde{g}^W_{C1}/y_1 = \tilde{b}_{C1}\tilde{\tau}_{C1}$, $\tilde{g}^W_{L1}/y_1 = \tilde{b}_{L1}\tilde{\tau}_{L1}$, $\tilde{g}^W_{A1}/y_1 = (\tilde{g}^W_{C1} + \tilde{g}^W_{L1})/y_1$ denote output shares of central, local and aggregate government consumption spending, $\tilde{g}^I_{A1}/y_1 = (\tilde{g}^I_{C1} + \tilde{g}^I_{L1})/y_1$ denotes the output share of aggregate infrastructure spending.

The numerical solution of the general equilibrium is reported in Table 1 for a wide range of values of subjective discount rate (ρ). We choose ρ as the key parameter to vary because it captures the cultural difference in time preferences, which contribute to disparate institutional arrangements in the West and China. There are two key findings. A higher patience (lower ρ) results in lower tax fractions ($\tilde{b}_{C1}$, $\tilde{b}_{L1}$) and government size ($\tilde{\tau}_{C1}$, $\tilde{\tau}_{A1}$), but higher growth ($\tilde{\gamma}_1$) and welfare ($\widetilde{U}_1$). Different from the centralized system, a lower ρ leads to a higher local government size ($\tilde{\tau}_{L1}$) because local and central tax rates are negatively related as derived in (17).

3.2.2 Output Based Restriction

If the restriction on welfare spending imposed by the central government is based on output, the fiscal structure is modified as:

$$g^W_{C2} = \tau^W_{C2} y_2,\ g^I_{C2} = \tau^I_{C2} y_2 \tag{22}$$

$$g^W_{L2} = \tau^W_{L2} y_2,\ g^I_{L2} = \tau^I_{L2} y_2 \tag{23}$$

where τ^W_{C2}, τ^I_{C2} are the tax rates of the central government to finance welfare spending and infrastructure spending and τ^W_{L2}, τ^I_{L2} are the counterparts of the local government. It is easy to see that $\tau^W_{C2} = b_{C2}\tau_{C2}$, $\tau^I_{C2} = (1 - b_{C2})\tau_{C2}$, $\tau^W_{L2} = b_{L2}\tau_{L2}$, and $\tau^I_{L2} = (1 - b_{L2})\tau_{L2}$. Instead of regulating b_L as in the tax-based restriction, the central government effectively places a limit on τ^W_{C2} because output y is endogenous. At the aggregate level, the tax rate is:

$$\tau_{C2}^{W} + \tau_{C2}^{I} + \tau_{L2}^{W} + \tau_{L2}^{I} = \tau_{C2} + \tau_{L2} = \tau_{A2} \tag{24}$$

Again, start with the citizen's optimization problem following the backward induction. Based on the best response function, the balanced growth path under this system can be derived as:

$$\gamma_2 = \alpha(1-\tau_{A2})A^{\frac{1}{\alpha}}(\tau_{C2}^{I})^{\frac{\beta}{\alpha}}(\tau_{L2}^{I})^{\frac{\omega}{\alpha}} - \rho \tag{25}$$

The maximization problem for the local government is to maximize the economic growth (25) subject to (23) and (24). The best response function for the local government can be written as:

$$\tau_{L2}^{I} = \frac{\omega}{\alpha+\omega}(1-\tau_{C2}^{I}-\tau_{C2}^{W}-\tau_{L2}^{W}) \tag{26}$$

Equation (26) indicates that the optimal tax rate for the local government to finance infrastructure expenditure (τ_{L2}^{I}) is not only negatively correlated to the tax rates of the central government (τ_{C2}^{I}, τ_{C2}^{W}) but also the tax rate with which the local government must comply for welfare expenditure (τ_{L2}^{W}). Combining these conditions results in the equilibrium growth rate:

$$\gamma_2 = \frac{\alpha^2}{\alpha+\omega}\left(\frac{\omega}{\alpha+\omega}\right)^{\frac{\omega}{\alpha}} A^{\frac{1}{\alpha}}(1-\tau_{C2}^{I}-\tau_{C2}^{W}-\tau_{L2}^{W})^{\frac{\alpha+\omega}{\alpha}}(\tau_{C2}^{I})^{\frac{\beta}{\alpha}} - \rho \tag{27}$$

Subject to (26) and (27), the central government's optimization problem is:

$$\max_{\{\tau_{C2}^{I},\tau_{C2}^{W},\tau_{L2}^{W}\}} U_2 = \frac{\gamma_2}{\rho^2} + \frac{1}{\rho}\begin{Bmatrix} \ln k_0 - (2-\nu)\ln\alpha + (1-\nu)\ln(\alpha+\omega) \\ +\nu\ln[\rho+(1-\alpha)\gamma_2] + (1-\nu)\ln(\gamma_2+\rho) \\ +(1-\nu)[\theta\ln\tau_{C2}^{W} + (1-\theta)\ln\tau_{L2}^{W} - \ln(1-\tau_{C2}^{I}-\tau_{C2}^{W}-\tau_{L2}^{W})] \end{Bmatrix} \tag{28}$$

The interior solutions of the welfare-maximizing tax rate, $\tilde{\tau}_{C2}^{I}$, $\tilde{\tau}_{C2}^{W}$, and $\tilde{\tau}_{L2}^{W}$, are:

$$\frac{\partial\tilde{\gamma}_2}{\partial\tilde{\tau}_{C2}^{I}}\frac{1}{\rho}\left[\frac{1}{\rho} + \frac{\nu(1-\alpha)}{\rho+(1-\alpha)\tilde{\gamma}_2} + \frac{1-\nu}{\tilde{\gamma}_2+\rho}\right] + \frac{1-\nu}{\rho(1-\tilde{\tau}_{C2}^{I}-\tilde{\tau}_{C2}^{c}-\tilde{\tau}_{L2}^{c})} = 0, \tag{29}$$

$$\frac{\partial\tilde{\gamma}_2}{\partial\tilde{\tau}_{C2}^{W}}\frac{1}{\rho}\left[\frac{1}{\rho} + \frac{\nu(1-\alpha)}{\rho+(1-\alpha)\tilde{\gamma}_2} + \frac{1-\nu}{\tilde{\gamma}_2+\rho}\right] + \frac{1-\nu}{\rho}\left(\frac{\theta}{\tilde{\tau}_{C2}^{W}} + \frac{1}{1-\tilde{\tau}_{C2}^{I}-\tilde{\tau}_{C2}^{c}-\tilde{\tau}_{L2}^{c}}\right) = 0, \tag{30}$$

$$\frac{\partial\tilde{\gamma}_2}{\partial\tilde{\tau}_{L2}^{W}}\frac{1}{\rho}\left[\frac{1}{\rho} + \frac{\nu(1-\alpha)}{\rho+(1-\alpha)\tilde{\gamma}_2} + \frac{1-\nu}{\tilde{\gamma}_2+\rho}\right] + \frac{1-\nu}{\rho}\left(\frac{1-\theta}{\tilde{\tau}_{L2}^{W}} + \frac{1}{\tilde{\tau}_{C2}^{I}-\tilde{\tau}_{C2}^{W}-\tilde{\tau}_{L2}^{W}}\right) = 0. \tag{31}$$

where $\tilde{\gamma}_2$ is determined by combining with (27). Solve the above nonlinear system numerically and the equilibrium is exhibited in Table 2.

Table 2 The simulated equilibrium of the output-based fiscal system

ρ	$\tilde{b}_{C2}$	$\tilde{b}_{L2}$	$\tilde{\tau}_{C2}$	$\tilde{\tau}_{L2}$	$\tilde{\tau}_{A2}$	$\tilde{g}_{C2}^{W}/y_2$	$\tilde{g}_{L2}^{W}/y_2$	$\tilde{g}_{A2}^{W}/y_2$	$\tilde{\gamma}_2$	$\widetilde{U}_2$
0.02	17.35%	11.28%	6.05%	21.71%	27.76%	1.05%	2.45%	3.50%	9.350%	201.08
0.03	23.54%	15.96%	6.54%	22.51%	29.05%	1.54%	3.59%	5.13%	8.094%	75.37
0.04	**28.76%**	**20.22%**	**7.02%**	**23.29%**	**30.31%**	**2.02%**	**4.71%**	**6.73%**	**6.844%**	**36.10**
0.05	33.25%	24.15%	7.49%	24.06%	31.55%	2.49%	5.81%	8.30%	5.600%	19.88
0.06	37.17%	27.80%	7.96%	24.83%	32.78%	2.96%	6.90%	9.86%	4.360%	12.04

The positive relationship between ρ and fiscal policy parameters are maintained. Besides, compared with the first decentralized fiscal system (the tax-based restriction), this decentralized system leads to a larger fraction of tax revenue for the central government to finance public consumption ($\tilde{b}_{C2} > \tilde{b}_{C1}$) and a larger fraction for the local government to spend in welfare ($\tilde{b}_{L2} > \tilde{b}_{L1}$). The overall aggregate government size is larger ($\tilde{\tau}_{A2} > \tilde{\tau}_{A1}$) since both central and local government sizes are larger ($\tilde{\tau}_{C2} > \tilde{\tau}_{C1}$, $\tilde{\tau}_{L2} > \tilde{\tau}_{L1}$). The growth rate under this decentralized system is lower than that under the first decentralized system ($\tilde{\gamma}_1 > \tilde{\gamma}_2$), while the ranking of social welfare is reversed ($\widetilde{U}_1 < \widetilde{U}_2$). It is because the output-based restriction implies a proportionate change in welfare spending with economic growth. A higher growth is both the objective of the local government and the basis of the welfare budget. This institutional arrangement substantially reduces the agency cost by partly aligning the central and local government's objectives. Our finding is in line with Chi et al. (2021) who find a positive effect of fiscal decentralization and economic performance. They identify the mechanism of innovation, while our model emphasizes the mechanism of infrastructure.

3.2.3 Expenditure-Based Restriction

We finally inspect the third way of restriction by the ratio of local government welfare spending over the aggregate government welfare spending (the sum of both local and central government spending). Under this federal system, the limited-autonomy local government must undertake a pre-defined proportion of public consumption. Thus, the ratio of local government consumption expenditure(τ_{L3}^{W}) to central government consumption expenditure (τ_{C3}^{W}) is a constant set by the central government. Let $\tau_{L3}^{W}/\tau_{C3}^{W} \equiv a$, then we can easily derive $\tau_{L3}^{W} = a\tau_{C3}^{W}$ and $\tau_{L3}^{W}/(\tau_{C3}^{W} + \tau_{L3}^{W}) = a/(1+a)$.

Based on the above assumptions, we re-calculate the balanced growth path rate as:

$$\gamma_3 = \frac{\alpha^2}{\alpha+\omega}\left(\frac{\omega}{\alpha+\omega}\right)^{\frac{\omega}{\alpha}} A^{\frac{1}{\alpha}}[1-\tau_{C3}^{I}-(1+a)\tau_{C3}^{W}]^{\frac{\alpha+\omega}{\alpha}}(\tau_{C3}^{I})^{\frac{\beta}{\alpha}} - \rho \qquad (32)$$

and the maximization problem for the central government is revised as:

$$\max_{\{\tau_{C3}^{I},\tau_{C3}^{W},a\}} U_3 = \frac{\gamma_3}{\rho^2} + \frac{1}{\rho}\begin{Bmatrix} \ln k_0 - (2-\nu)\ln\alpha + (1-\nu)\ln(\alpha+\omega) \\ +\nu\ln[\rho + (1-\alpha)\gamma_3] + (1-\nu)\ln(\gamma_3+\rho) \\ +(1-\nu)\left[\theta\ln\tau_{C3}^{W} + (1-\theta)\ln\left(a\tau_{C3}^{W}\right) - \ln\left(1-\tau_{C3}^{I}-(1+a)\tau_{C3}^{W}\right)\right] \end{Bmatrix} \quad (33)$$

The interior solutions for the welfare-maximizing policy $\tilde{\tau}_{C3}^{I}$, $\tilde{\tau}_{C3}^{W}$, and $\tilde{a}$ are:

$$\frac{\partial\tilde{\gamma}_3}{\partial\tilde{\tau}_{C3}^{I}}\frac{1}{\rho}\left[\frac{1}{\rho} + \frac{\nu(1-\alpha)}{\rho+(1-\alpha)\tilde{\gamma}_3} + \frac{1-\nu}{\tilde{\gamma}_3+\rho}\right] + \frac{1-\nu}{\rho\left[1-\tilde{\tau}_{C3}^{I}-(1+a)\tilde{\tau}_{C3}^{W}\right]} = 0, \quad (34)$$

$$\frac{\partial\tilde{\gamma}_3}{\partial\tilde{\tau}_{C3}^{W}}\frac{1}{\rho}\left[\frac{1}{\rho} + \frac{\nu(1-\alpha)}{\rho+(1-\alpha)\tilde{\gamma}_3} + \frac{1-\nu}{\tilde{\gamma}_3+\rho}\right] + \frac{1-\nu}{\rho}\left[\frac{1}{\tilde{\tau}_{C3}^{W}} + \frac{1+a}{1-\tilde{\tau}_{C3}^{I}-(1+a)\tilde{\tau}_{C3}^{W}}\right] = 0, \quad (35)$$

$$\frac{\partial\tilde{\gamma}_3}{\partial\tilde{a}}\frac{1}{\rho}\left[\frac{1}{\rho} + \frac{\nu(1-\alpha)}{\rho+(1-\alpha)\tilde{\gamma}_3} + \frac{1-\nu}{\tilde{\gamma}_3+\rho}\right] + \frac{1-\nu}{\rho}\left[\frac{1-\theta}{a} + \frac{\tilde{\tau}_{C3}^{W}}{1-\tilde{\tau}_{C3}^{I}-(1+\tilde{a})\tilde{\tau}_{C3}^{W}}\right] = 0. \quad (36)$$

where $\tilde{\gamma}_3$ is determined by (32). The nonlinear system is solved numerically and reported in Table 3. Compared with previous results, we find that the third decentralized fiscal system leads to the largest fraction of tax revenue for the central government to finance welfare spending among the three different decentralized systems ($\tilde{b}_{C3} > \tilde{b}_{C2} > \tilde{b}_{C1}$), the smallest fraction for the local government ($\tilde{b}_{L3} < \tilde{b}_{L1} < \tilde{b}_{L2}$), the largest central government size ($\tilde{\tau}_{C3} > \tilde{\tau}_{C2} > \tilde{\tau}_{C1}$), but a medium local government size ($\tilde{\tau}_{L1} < \tilde{\tau}_{L3} < \tilde{\tau}_{L2}$) and aggregate government size ($\tilde{\tau}_{A1} < \tilde{\tau}_{A3} < \tilde{\tau}_{A2}$). The resulting growth rate is the lowest among the three decentralized systems ($\tilde{\gamma}_3 < \tilde{\gamma}_2 < \tilde{\gamma}_1$), while the social welfare is larger than that under the first decentralized system but lower than that under the second system ($\widetilde{U}_1 < \widetilde{U}_3 < \widetilde{U}_2$).

Table 3 The simulated equilibrium of the expenditure-based fiscal system

ρ	$\tilde{b}_{C3}$	$\tilde{b}_{L3}$	$\tilde{\tau}_{C3}$	$\tilde{\tau}_{L3}$	$\tilde{\tau}_{A3}$	$\tilde{g}_{C3}^{W}/y_3$	$\tilde{g}_{L3}^{W}/y_3$	$\tilde{g}_{A3}^{W}/y_3$	$\tilde{\gamma}_3$	$\widetilde{U}_3$
0.02	25.91%	8.32%	6.75%	21.01%	27.76%	1.75%	1.75%	3.50%	9.350%	199.85
0.03	33.91%	11.94%	7.57%	21.49%	29.05%	2.57%	2.57%	5.13%	8.094%	74.54
0.04	**40.23%**	**15.33%**	**8.36%**	**21.95%**	**30.31%**	**3.36%**	**3.36%**	**6.73%**	**6.844%**	**35.48**
0.05	45.36%	18.53%	9.15%	22.40%	31.55%	4.15%	4.15%	8.30%	5.600%	19.39
0.06	49.64%	21.57%	9.93%	22.85%	32.78%	4.93%	4.93%	9.86%	4.360%	11.63

3.3 The Optimal Decentralized Fiscal System

To facilitate comparison, we summarize in Table 4 the rankings of key variables under decentralized fiscal systems. In particular, the second decentralized system (i.e., output-based restriction) returns the largest fraction of tax revenue for the local government to finance welfare spending, the largest output share of local government welfare spending, the largest local government size, and the highest social welfare. As analyzed earlier, the output-based restriction can partially align the interests between the two-tier governments—output is both the objective of the local government and the basis of welfare spending (Lyu et al., 2022). As a result, it is the optimal decentralized fiscal system to generate a similar level of social welfare without

losing much of efficiency. The agency costs of the principal-agent problem between the central and local government are minimized under the output-based restriction.

Table 4 The summary of the balanced growth path equilibria of decentralized fiscal systems

	Central government	Local government	Aggregate government
Welfare/G	$\tilde{b}_{C1} < \tilde{b}_{C2} < \tilde{b}_{C3}$	$\tilde{b}_{L3} < \tilde{b}_{L1} < \tilde{b}_{L2}$	$\tilde{b}_{A1} < \tilde{b}_{A3} < \tilde{b}_{A2}$
Welfare/Output	$\frac{\tilde{g}_{C1}^{W}}{y_1} < \frac{\tilde{g}_{C2}^{W}}{y_2} < \frac{\tilde{g}_{C3}^{W}}{y_3}$	$\frac{\tilde{g}_{L3}^{W}}{y_3} < \frac{\tilde{g}_{L1}^{W}}{y_1} < \frac{\tilde{g}_{L2}^{W}}{y_2}$	$\frac{\tilde{g}_{A1}^{W}}{y_1} < \frac{\tilde{g}_{A3}^{W}}{y_3} < \frac{\tilde{g}_{A2}^{W}}{y_2}$
Infrastructure/Output	$\frac{\tilde{g}_{C2}^{I}}{y_2} < \frac{\tilde{g}_{C1}^{I}}{y_1} < \frac{\tilde{g}_{C3}^{I}}{y_3}$	$\frac{\tilde{g}_{L1}^{I}}{y_1} < \frac{\tilde{g}_{L2}^{I}}{y_2} < \frac{\tilde{g}_{L3}^{I}}{y_3}$	$\frac{\tilde{g}_{A1}^{I}}{y_1} < \frac{\tilde{g}_{A2}^{I}}{y_2} < \frac{\tilde{g}_{A3}^{I}}{y_3}$
Government size	$\tilde{\tau}_{C1} < \tilde{\tau}_{C2} < \tilde{\tau}_{C3}$	$\tilde{\tau}_{L1} < \tilde{\tau}_{L3} < \tilde{\tau}_{L2}$	$\tilde{\tau}_{A1} < \tilde{\tau}_{A3} < \tilde{\tau}_{A2}$
Growth rate		$\tilde{\gamma}_3 < \tilde{\gamma}_2 < \tilde{\gamma}_1$	
Social welfare level		$\widetilde{U}_1 < \widetilde{U}_3 < \widetilde{U}_2$	

Note: The numerical simulations are based on the baseline calibration.

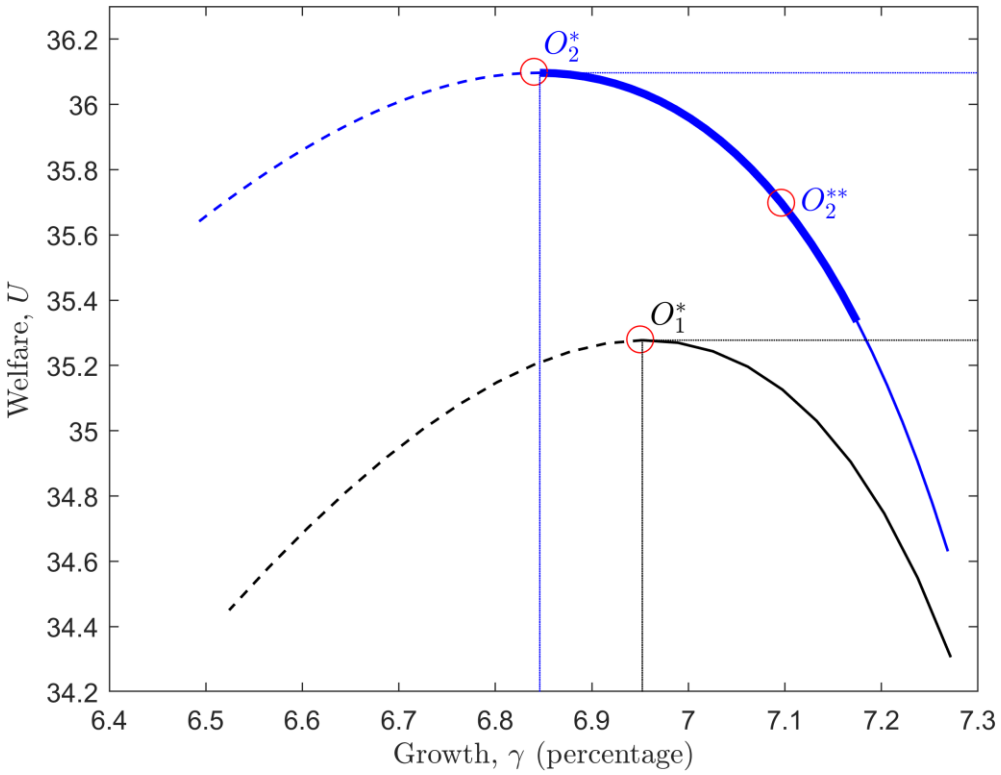
Table 4 shows that the third decentralized system (expenditure-based restriction) always delivers poorer economic growth and social welfare than the second one (output-based restriction). Therefore, the third system is strictly dominated by the second system. The choice of the optimal decentralized fiscal system then boils down to choosing between the first and the second systems.

It is not straightforward, however, to compare between tax-based and output-based systems because they generate mixed results in growth and welfare. Note that the tax-based system cannot further increase welfare because $\widetilde{U}_1$ is already the maximized level under the system which is still lower than $\widetilde{U}_2$. Therefore, it leaves no room for further policy adjustment. In contrast, the output-based system has a higher $\widetilde{U}_2$ under welfare maximization, so the central government can still fine-tune the policy restriction to trade some short-run welfare loss for greater long-run growth. This is demonstrated in Figure 2 by numerical simulations under the baseline calibration, where the second decentralized system always dominates the first decentralized system in terms of welfare under any given growth. Therefore, it is feasible for the second system to trade some welfare for higher growth by moving from the optimum point O_2^* to the right as long as the welfare level is still above O_1^*, for example, point O_2^{**}.

In general, define a strategy set $S \equiv \{b_C, b_L, \tau_C, \tau_L; \mathcal{F}\}$ with a payoff function $f: S \longrightarrow O$, where $O \equiv \{\gamma, U\}$ represents the economic outcomes resulting from S. Specifically, $\mathcal{F}$ stands for the chosen fiscal system. Let $\mathcal{F}_{D1}, \mathcal{F}_{D2}, \mathcal{F}_{D3}$ denote the first, second and third fiscal decentralized system mentioned earlier. The central government can search for a feasible strategy set, $\hat{S}_{D2} = \{\hat{b}_{C2}, \hat{b}_{L2}, \hat{\tau}_{C2}, \hat{\tau}_{L2}; \mathcal{F}_{D2}\}$ under the second decentralized system (output-based) to achieve $\hat{O}_{D2} \equiv \{\hat{\gamma}_2, \widehat{U}_2\}$ such that $\hat{\gamma}_2 > \tilde{\gamma}_1 > \tilde{\gamma}_2$ and $\widetilde{U}_2 > \widehat{U}_2 > \widetilde{U}_1$. That is, the policy restriction

(g_{L2}^{W}/y_2) under the output-based system can be improved to achieve a higher growth rate at the expense of bearable social welfare loss, outperforming the tax-based system in both criteria. In other words, the output-based fiscal system is the best option among the three decentralized fiscal systems because it has greater institutional flexibility and less conflicts of interests.

Figure 2 The comparison of economic outcomes between fiscal decentralized systems



Finally, let us turn to the implications on the political promotion under the three systems. Given that the optimal fiscal policy (the second) aligns the welfare spending with economic growth, it has little impact on local government incentives. Assuming all local authorities are affected uniformly (no greater fiscal autonomy for some), the second decentralized fiscal system does not alter the ranking of local officials in political competition for promotion based on GDP score. Therefore, the reform towards the optimal fiscal policy from other fiscal systems does not disrupt the existing incentive and behavior of local governments. Stability of incentive is important for maintaining stability of politics, since different incentives entail different skill sets of the government team. This is another politically appealing feature of the decentralized fiscal system with output-based restriction.

4 Centralized Fiscal System

In a centralized fiscal system, all the policies are determined by the central government even though the local government is involved in providing the public goods and services. Therefore,

the centralized system is also called the unitary system. In practice, it is not possible for the central government to reach the welfare-maximizing optimum without efficiency loss. The central government is relatively distant from citizens than local governments, so it has an inferior knowledge of the preferences of local residents. Besides, due to incomplete information, management cost, and corruption (Oates, 2005; Weingast, 2009; Martinez-Vazquez, 2017), the central government can be biased in scheduling local government expenditures, which can distort the comparison between different fiscal systems. Thus, in this section, the model is extended by incorporating these disadvantages of the central government.

To take the disadvantages of central government into account, the production function and utility function are revised as:

$$\bar{y} = Ak^{\alpha}(g_C^I)^{\beta}(\kappa g_L^I)^{\omega} \tag{37}$$

$$\bar{u}(c, g_C^W, g_L^W) = \nu \ln c + (1-\nu)[\theta \ln g_C^W + (1-\theta)\ln(\kappa g_L^W)] \tag{38}$$

where the key parameter $0 < \kappa \leq 1$ is the degree of efficiency loss , measured by the proportion of the local public goods and services that should have been supplied locally but were provided by the central government due to the disadvantages of the central government. If $\kappa = 1$, then the central government provides public service as efficiently as local governments, which includes the models in Section 2 as special cases.

Under the centralized system, the total government spending, $\bar{g}$, is allocated between central and local governments:

$$g_C \equiv \phi g = \phi\bar{\tau}\bar{y} \tag{39}$$

$$g_L \equiv (1-\phi)g = (1-\phi)\bar{\tau}\bar{y} \tag{40}$$

Where $\bar{\tau}$ is the overall tax rate, $0 \leq \phi \leq 1$ is the fraction of tax revenue used to finance $\bar{g}_C$, and $0 \leq 1-\phi \leq 1$ is the fraction that finances $\bar{g}_L$. Government spending structure decided by the central government takes the following form:

$$g_C^W = \bar{b}_C\phi\bar{\tau}\bar{y},\ g_C^I = \left(1-\bar{b}_C\right)\phi\bar{\tau}\bar{y} \tag{41}$$

$$g_L^W = \bar{b}_L\phi\bar{\tau}\bar{y},\ g_L^I = \left(1-\bar{b}_L\right)\phi\bar{\tau}\bar{y} \tag{42}$$

The welfare-maximizing growth rate of the central fiscal system now takes a more general form:

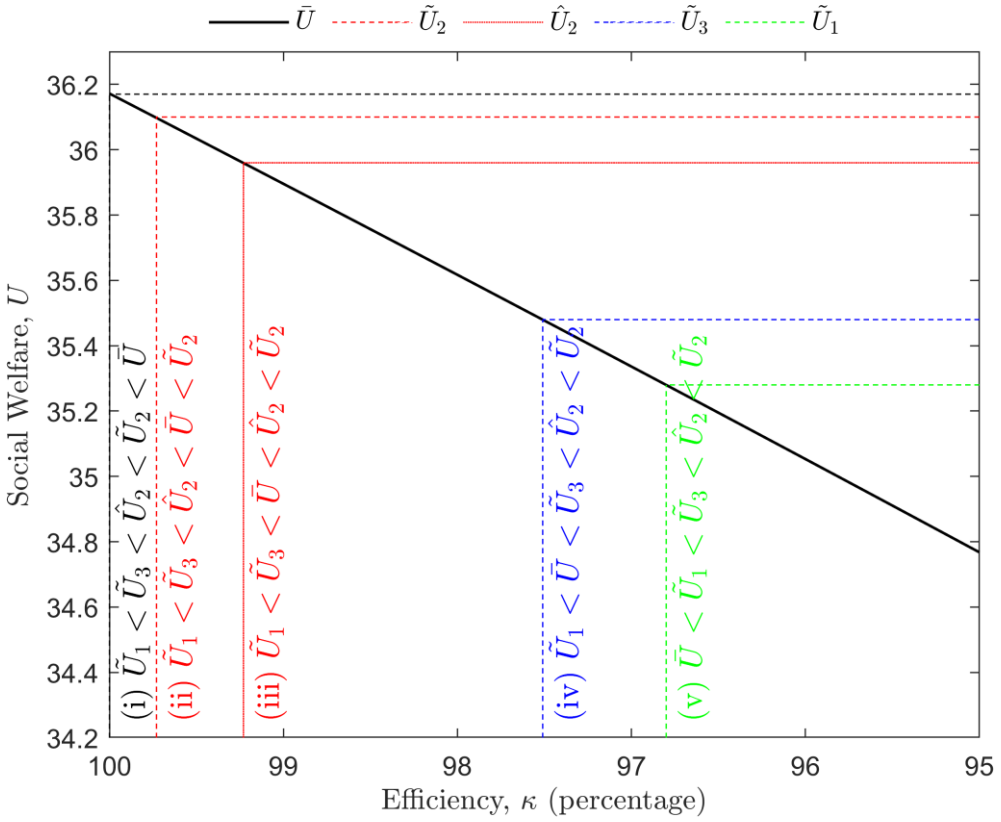
$$\bar{\gamma} = \alpha(1-\bar{\tau})\bar{\tau}^{\frac{1-\alpha}{\alpha}} A^{\frac{1}{\alpha}} \kappa^{\frac{\omega}{\alpha}} \left[\bar{\phi}\left(1-\bar{b}_C\right)\right]^{\frac{\beta}{\alpha}} \left[(1-\bar{\phi})\left(1-\bar{b}_L\right)\right]^{\frac{\omega}{\alpha}} - \rho \qquad (43)$$

and the welfare level becomes:

$$\bar{U} = \frac{\bar{\gamma}}{\rho^2} + \frac{1}{\rho}\left\{\begin{array}{l} \ln k_0 - \ln\alpha + \nu \ln[\rho + (1-\alpha)\bar{\gamma}] \\ +(1-\nu)[\ln(\bar{\gamma}+\rho) + \ln\bar{\tau} - \ln(1-\bar{\tau})] \\ +(1-\nu)\left[\theta\left(\ln\bar{b}_C + \ln\bar{\phi}\right) + (1-\theta)\left(\ln\bar{b}_L + \ln(1-\bar{\phi}) + \ln\kappa\right)\right] \end{array}\right\} \qquad (44)$$

Denote the optimal policy combo as ($\bar{\tau}$, $\bar{\phi}$, $\bar{b}_C$, $\bar{b}_L$). We can infer from the assumption of efficiency disadvantage that the central government with limited information on citizens' preferences can hardly prescribe an adequate fiscal policy combo under the centralized system.

Figure 3 The effect of efficiency loss on social welfare



Note: The numerical simulations are based on the baseline calibration. The horizontal axis is in descending order of efficiency.

From (43) and (44), it is easy to derive that $\partial\bar{\gamma}/\partial\kappa > 0$ and $\partial\bar{U}/\partial\kappa > 0$, which intuitively account for the decrease in growth rate and social welfare resulting from the increase of efficiency loss(a lower κ). Figure 3 presents the effect of efficiency loss on social welfare under the centralized system in comparison to decentralized systems. By numerical simulations over a range of the key parameter κ, we divide the domain of κ into four regions in relation to the three

decentralized systems. From bottom up, the lowest utility level ($\widetilde{U}_1$) is derived from the first system with tax-based restriction, followed by the third system ($\widetilde{U}_3$) with expenditure-based restriction. The second system with output-based restriction generates two utility levels $\widehat{U}_2 < \widetilde{U}_2$, where $\widetilde{U}_2$ is based on the baseline calibration and $\widehat{U}_2$ is based on the improved calibration. As κ drops from 1, the efficiency loss of the central government rises, leading to a descending utility level of the centralized system ($\overline{U}$) relative to the four levels of the three decentralized systems.

(i) If $0.9973 < \kappa \leq 1$, the centralized system can achieve a higher welfare than all decentralized systems thanks to trivial efficiency loss.

(ii) If $0.9923 < \kappa \leq 0.9973$, the welfare of the centralized system ($\overline{U}$) drops below the second decentralized system under the baseline calibration ($\widetilde{U}_2$).

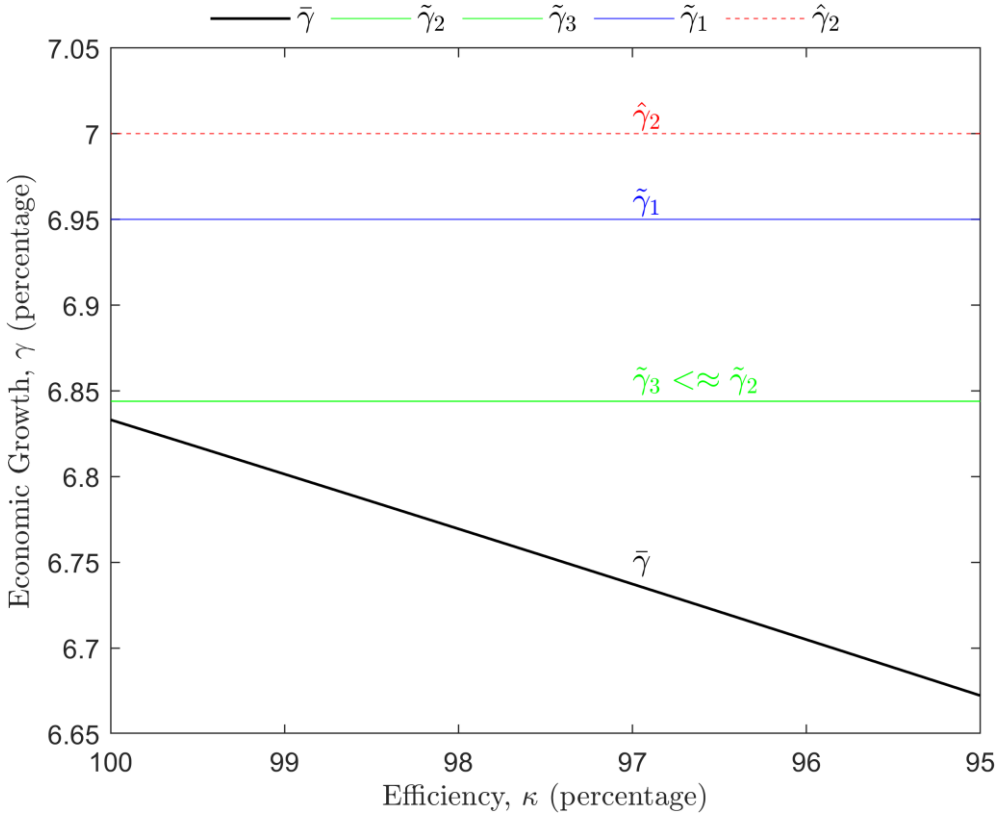
(iii) If $0.9751 < \kappa \leq 0.9923$, the welfare of the centralized system ($\overline{U}$) drops below the second decentralized system under the improved policy ($\widehat{U}_2$).

(iv) If $0.9680 < \kappa \leq 0.9751$, the welfare of the centralized system ($\overline{U}$) drops below the third decentralized system ($\widetilde{U}_3$).

(v) If $\kappa < 0.9680$, the welfare of the centralized system ($\overline{U}$) is inferior to all decentralized systems due to the substantial efficiency loss.

It is obvious that the advantage of welfare under the centralized system is very sensitive to the efficiency loss of the central government. When κ is marginally lower than 1, the consequence on welfare (or on the ranking of welfare) is significant. Therefore, efficiency disadvantage of the central government in the centralized system strengthens our and other Second-Generation Fiscal Federalism's conclusions on the advantage of fiscal federalism. Furthermore, the effect of efficiency loss on growth only reinforces this conclusion because the growth rate under the centralized system is always lower than those under decentralized system even when $\kappa = 1$ (Figure 4). A lower κ simply leads to even lower growth given that $\partial\bar{\gamma}/\partial\kappa > 0$.

Figure 4 The Effect of efficiency loss on growth rate



Note: The numerical simulations are based on the baseline calibration. The horizontal axis is in descending order of efficiency.

5 Discussion: A Contributor to Slower Growth in Western Countries

In the western democratic system, the appointment of mayors and governors is determined by local elections. The national administration usually has little control over political promotion of local political officials. Unlike the GDP tournaments in China among provinces (Li et al., 2019), competition among local governments in the West is rarely based on economic growth. For example, in the US the federal government leaves the states to freely decide the development goals and fiscal policies. Similarly, in the UK the central government devolves substantial fiscal autonomy and legislative power to subnational governments in Scotland, Wales, and Northern Ireland. The competition among local authorities is naturally realized by attracting intranational migrants by distinct mixes of public goods and services in different jurisdictions (Foreman-Peck & Zhou, 2020). Thus, local officials in the western democracy naturally pay more attention to the welfare of local citizens to win more election votes or more "foot votes", rather than the economic growth.

In this case, local governments are also benevolent (welfare maximizer), so there are no conflicts of interest between different tiers of fiscal policymakers. Therefore, without agency cost,

decentralized systems can arrive at the maximized social welfare of $\tilde{\gamma}$ and a growth rate of $\widetilde{U}$, which is equivalent to the centralized system without efficiency loss ($\kappa = 1$). This justifies the choice of fiscal federalism in the most countries in the West.

This appealing feature of democracy to resolve the principal-agent problem is, nevertheless, not costless. We have shown that the growth rate in the decentralized system with benevolent local government cannot exceed that in decentralized system if local governments are growth maximizers ($\tilde{\gamma} < \tilde{\gamma}_3 < \tilde{\gamma}_2 < \tilde{\gamma}_1$). That is one of the institutional reasons why western democratic countries usually have lower growth compared to countries like China.

Again, the comparison is also a dynamic one. Initially, the welfare level under the western democracy is higher than China at the cost of a slower economic growth. However, growth is accumulative and at some point, the welfare level of the West will eventually be overtaken by China if her fiscal system is politically sustainable. To show the difference between the West and China formally, assume time begins at $t = 0$, and let the overtaking time occurs at $t = T$. Under the same parameterization, the maximized welfare level of benevolent local governments (the West) is:

$$\widetilde{U}(T) = \int_0^{\infty} u\left[c(0)e^{\tilde{\gamma}(T+t)}, g_C^W(0)e^{\tilde{\gamma}(T+t)}, g_L^W(0)e^{\tilde{\gamma}(T+t)}\right]$$

and the maximized welfare level with nonbenevolent local government (China) is:

$$\widetilde{U}_i(T) = \int_0^{\infty} u\left[c_i(0)e^{\tilde{\gamma}_i(T+t)}, g_{Ci}^W(0)e^{\tilde{\gamma}_i(T+t)}, g_{Li}^W(0)e^{\tilde{\gamma}_i(T+t)}\right]$$

where $i = 1,2,3$ denotes three variants of decentralized fiscal system. Impose the condition of overtaking $\widetilde{U}(T) = \widetilde{U}_i(T)$, then we have:

$$T = \frac{\rho(\widetilde{U} - \widetilde{U}_i)}{\tilde{\gamma}_i - \tilde{\gamma}}$$

Since $\tilde{\gamma}_i > \tilde{\gamma}$, there always exists a positive T for overtaking. In other words, after T periods, both social welfare and growth rate with nonbenevolent government will exceed those with benevolent government, i.e., $\widetilde{U}_i(T+n) > \widetilde{U}(T+n)$ and $\tilde{\gamma}_i(T+n) > \tilde{\gamma}(T+n)$ for $n > 0$.

Table 5 numerically simulates the discounted sum of utility levels standing at different times. We can interpret each period as a generation. If we compare different systems for all generations from $t = 0$ onwards, then the conclusion ($\widetilde{U} > \widetilde{U}_2 > \widehat{U}_2 > \widetilde{U}_3 > \widetilde{U}_1$) is what we have shown in Section 3. Nevertheless, if we allow for a dynamic comparison and ignore the first several generations, then the welfare ranking can be reversed because a higher growth rate is always more beneficial to future generations at the cost of current generations.

Table 5 Dynamic comparison in terms of welfare ranking

t	Welfare ranking
0	$\boldsymbol{\widetilde{U}} > \widetilde{U}_2 > \widehat{U}_2 > \widetilde{U}_3 > \widetilde{U}_1$
4	$\boldsymbol{\widetilde{U}} > \widehat{U}_2 > \widetilde{U}_2 > \widetilde{U}_3 > \widetilde{U}_1$
6	$\widehat{U}_2 > \boldsymbol{\widetilde{U}} > \widetilde{U}_2 > \widetilde{U}_3 > \widetilde{U}_1$
8	$\widehat{U}_2 > \boldsymbol{\widetilde{U}} > \widetilde{U}_2 > \widetilde{U}_1 > \widetilde{U}_3$
…	$\widehat{U}_2 > \boldsymbol{\widetilde{U}} > \widetilde{U}_2 > \widetilde{U}_1 > \widetilde{U}_3$
28	$\widehat{U}_2 > \widetilde{U}_2 > \boldsymbol{\widetilde{U}} > \widetilde{U}_1 > \widetilde{U}_3$
30	$\widehat{U}_2 > \widetilde{U}_1 > \widetilde{U}_2 > \boldsymbol{\widetilde{U}} > \widetilde{U}_3$
…	$\widehat{U}_2 > \widetilde{U}_1 > \widetilde{U}_2 > \boldsymbol{\widetilde{U}} > \widetilde{U}_3$
247	$\widehat{U}_2 > \widetilde{U}_1 > \widetilde{U}_2 > \widetilde{U}_3 > \boldsymbol{\widetilde{U}}$
∞	$\widehat{U}_2 > \widetilde{U}_1 > \widetilde{U}_2 > \widetilde{U}_3 > \boldsymbol{\widetilde{U}}$

Note: The numerical simulations are based on the baseline calibration. The conclusions do not qualitatively vary for other parameter values.

From Table 5, we can see that the three decentralized fiscal systems ($\widetilde{U}_1$, $\widetilde{U}_2$, and $\widetilde{U}_3$) need 30, 28 and 247 periods respectively to overtake the centralized fiscal system ($\widetilde{U}$) thanks to the higher growth rates ($\tilde{\gamma} < \tilde{\gamma}_3 = \tilde{\gamma}_2 < \tilde{\gamma}_1$). In light of the discussion in Section 3, we know that there exists a strategy set under the second decentralized fiscal system ($\hat{S}_{D2}$) such that the growth rate is higher than all other alternative decentralized systems ($\boldsymbol{\hat{\gamma}_2} > \tilde{\gamma}_1 > \tilde{\gamma}_2 > \tilde{\gamma}_3$) at the cost of a slightly lower current welfare ($\widetilde{U}_2 > \boldsymbol{\widehat{U}_2} > \widetilde{U}_1 > \widetilde{U}_3$). In this case, the overtaking time is $t = 6$.

Institutions and policies are set/voted by current generations, so it is difficult for a democratic system in the West to sacrifice the current generation for future generation. In contrast, many Asian economies like China, Singapore, South Korea, and India (Ding & Slater, 2021) are more capable of enforcing long-term scoped institutions and policies to foster a faster growth at the cost of current generation's welfare. Ultimately, the institutional difference is derived from the cultural difference in intergenerational altruism and time preferences between the West and China. The traditional culture in China emphasizes thrift and savings, which reflect a low subjective discount rate (ρ in our model). This collective time preference supports or "self-enforces" the existence of a powerful government and the accompanying fiscal federalism to trade lower welfare in the short run for higher growth in the long run. The first several decades of development in China since World War 2 was basically a history of sacrifice of current generations for future generations. This system may seem unreasonable and unsustainable to the western culture, but the intergenerational transfer and the sacrificing culture have lasted thousands of years in China. It is found that this old value system contributed to the Chinese growth miracle after the "reform and opening-up" in 1978 (Yao, 2014).

In contrast, the culture and value in the West emphasize freedom and individualism, which is the cornerstone of the western democratic politics. The democratic institutions define a very different incentive system for the central and local governments. It is more important to maximize the welfare of the voters to win election (which is a bottom-up approach to forming the government) than to maximize the growth of the jurisdiction to gain promotion (which is a top-down approach to forming the government). Elections are periodic every four or five years, so the political cycle usually determines the short time scope of policies. The institutional differences in incentive systems partly contribute to the lower growth compared to China.

However, our implication only holds if the differences between China and the West are sustainable in the long run. As some empirical studies suggest, the time preferences of present Chinese people are getting closer to the rest of the world compared to their parent generation decades ago (Burro et al., 2022). At the meantime, many western countries start to put forward long-term development plans intended beyond political cycles (e.g., The Long-Term Strategy of the US, National Long-Term Strategies in the EU, Long-Term Development Statement in the UK). It suggests that preferences and institutions *per se* may evolve endogenously with income level and environmental pressure, so it seems that China and the West may converge as the developmental gap narrows. This is an interesting issue but is beyond this paper's scope.

6 Conclusion

We develop a dynamic general equilibrium model of endogenous growth in which welfare and infrastructure expenditure are co-financed by central and local governments. Due to the possible conflicts of interest between the two-tier governments, the centralized and decentralized fiscal systems can lead to very different economic outcomes. We compare welfare and growth outcomes under the centralized and various decentralized systems. It is found that the optimal decentralized fiscal system is the one with output-based restrictions imposed by the central government. Compared to alternative restrictions based on tax revenue and expenditure budget, output-based restrictions can effectively mitigate the conflicts of interest between the welfare-maximizing central government and the growth-maximizing local government. Moreover, centralized system with efficiency loss generally yields lower growth rate and welfare than decentralized systems. We also find that, despite a lower welfare level at the start, decentralized fiscal systems with nonbenevolent (growth maximizer) local governments can catch up with and eventually overtake the decentralized fiscal system with benevolent local governments (welfare maximizer) thanks to the accumulated faster growth under the assumption of fixed institutions. In addition, in rare disasters such as pandemics and wars, the output-based system has a greater flexibility to juggle among competing objectives (Greer et al., 2023). In such cases, output can be temporarily prioritized by the central government to trade off with moderate welfare loss as shown in Figure 2.

This conclusion sheds light on the difference between different political incentive systems. The vote-based democracy in the West naturally resolves the conflicts of interest between the central and local governments, so it tends to generate higher welfare but lower growth. The power-based politics in China can only partially align the objectives between the two-tier government in a decentralized fiscal system, so it tends to generate lower welfare but higher growth. The institutional difference is attributed to the cultural difference in time preferences. Should the Chinese system be sustainable, the growth benefits can eventually dominate the welfare costs, leading to a higher welfare for future generations.

However, our analysis assumes constant time preferences. In the long run, all parameters can change. The institutional arrangement and cultural value are not exceptions. As income rises, the subjective discount rate can decrease. This is similar to the wealth effect in microeconomic theory—richer individuals tend to value current welfare more than future welfare due to the increasing opportunity cost of foregone welfare. Collectively, the Chinese traditional value of thrift and savings contributed to the fast growth since 1978. We predict that this advantage may not be sustained due to institutional and cultural convergence as China transitions from a growth-oriented state to a welfare-oriented state.

Our conclusions are also informative to fiscal reformation in developed, democratic countries. The competition among subnational jurisdictions is mainly realized by providing better public consumptions or welfare expenditure to win more intra and international migrants (Foreman-Peck & Zhou, 2020b). Nevertheless, the current practice of fiscal federation in the West (e.g., US and UK) focuses on the expenditure side of fiscal policies. Greater autonomy over how funds are spent is devolved to local governments, but responsibility of taxation is less decentralized. For example, the Welsh government receives a block grant from the UK government to fill the gap between local tax revenue and expenditure, mostly on welfare. The block grant is calculated according to the Barnett Formula, which is “need based”, rather than tax based or output based. In this partially decentralized fiscal system, local governments have less incentive to promote growth because of the discrepancy between revenue and expenditure, or indeed between power and responsibility. The fiscal reform should devolve more responsibility (as well as power) to local government, and as suggested by our conclusions, a reasonable direction is to link the block grant with the output. The ultimate principle of the optimal fiscal federalism is to align the incentives of central and local governments.

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