FISCAL DECENTRALIZATION, POLITICAL HETEROGENEITY AND WELFARE

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Abstract

This paper contributes to the literature on fiscal decentralization by presenting a formal model of the interaction between the central and local governments (CG and LGs, respectively) where LGs may differ in their degree of political alignment with CG. The non-cooperative optimal behaviour of the agents reveals that optimal tax increases with the extent of fiscal decentralization (FD), political unison and spillovers across localities, while LGs' optimal tax collection effort is negatively associated with all of these parameters. The first novel finding of our study is that both welfare peaks and income distribution are more equitable at a lower level of FD in the case of spillovers than in the case of no spillovers, which supports the decentralization theorem. The second novel finding is that both the amount of redistributable income and central government utility increase with the degree of political unison.

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JEL Classification: E62, H71, H72

1. Introduction

Heterogeneity in resources, preferences and political alignment is an essential feature of complex economies. Understanding how heterogeneity affects policy-making is vital for determining policies that are effective in promoting general welfare. In this paper, we contribute to the literature on fiscal decentralization (FD) by formally investigating the welfare effects of the interaction between local and central fiscal administrations that portray political heterogeneity.

The literature on the welfare effects of FD has been expanding since the seminal works of Buchanan (1950) and Tiebout (1956). Oates (1972) stated that FD is welfare-improving if the central government provides public goods uniformly, faces the same

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cost structure as the sub-national or local governments, and if there are no spillovers or externalities across localities. Coined as the *decentralization theorem*, the postulate of the first-generation theory of FD is that local governments (LG)[1] are better positioned to know and respond to local preferences and, hence, they are likely to be more efficient in public good provision than the central government (CG). The theorem is complemented by the argument that decentralization of fiscal activities may reduce transaction costs since LGs can be more transparent in their actions and more accountable for their decisions than CGs.[2] As an institutional mechanism to achieve fiscal efficiency, FD is more justified the more heterogeneous the society is and the greater the diversity of socioeconomic preferences or priorities across localities.

On the down side, local administrative and financial capacity constraints are likely to mitigate the potential welfare gains from FD.[3] In addition, CG's transfer decision tends to be strategic, given one or a combination of the objectives of maximizing its re-electability, favouring own constituency or serving certain special interests, and supporting a particular ideology.[4] Hence, some LGs may receive more transfers than others depending solely on their political or ideological alignment with, or proximity to, the CG. This leads to local transfer allocations becoming economically inefficient and thus reduces welfare. Indeed, there is ample empirical evidence showing that redistribution decisions tend to be systematically related to electoral incentives (see, inter alia, Dellmuth and Stoffel, 2012; Solé-Ollé and Sorribas-Navarro, 2008; Arulampalam *et al*., 2009; Brollo and Nannicini, 2012; Herwartz and Theilen, 2014; Bracco *et al*., 2015; Neyapti and Oluk, 2021). For a broader discussion of the political economy of intergovernmental transfers, see also Inman and Rubinfeld (1996), Khemani (2007) and Sato (2007).

The second-generation FD literature addresses the question of whether the decentralization theorem survives after relaxing the assumptions of a benevolent CG, local heterogeneity, no externalities and uniform public good provision under centralization. Both

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1   The term "local government" is mainly used in the context of federal states, while for unitary states it is appropriate to refer to it as *local administration* rather than local government. Nonetheless, for purposes of simplicity, we refer to all sub-national governments or administrative jurisdictions as *local governments* (LGs) or *localities* throughout the paper.

2   See Ligthart and van Oudheusden (2015) for empirical evidence on the positive relationship between trust in the government and FD.

3   Based on the World Bank Fiscal Decentralization Indicators, it is clear that central transfers constitute a sizable share of local government resources even in developed countries.

4   Well-designed and transparent transfer mechanisms are therefore crucial for eliminating discretionary or politically-oriented redistributive policies and to achieve efficient and equitable outcomes. Ma (1997) discussed the types of fiscal transfer rules. In a cross-sectional study, Neyapti (2013) showed that fiscal rules have significant effects on the fiscal disciplining impact of FD. Bulut-Cevik and Neyapti (2014) and Akin *et al*. (2016) also investigated the welfare effects of transfer rules.

empirical and theoretical studies indicate that various structural and political factors, such as governance, democracy, bargaining for delegation and tax competition, affect macroeconomic outcomes of FD.[5] Thus, besides fiscal rules, political structure and institutions, such as electoral systems and political party typology, are factors that play a role in the effectiveness of FD in delivering fiscal efficiency.[6] These factors also help define the socio-political environment within which the level of FD is determined.[7] Hence, as a departure from the first-generation theory of FD, the second generation of FD literature is concerned with the role of political motives in understanding the welfare effects of FD.

We contribute to the second-generation decentralization literature by investigating the welfare implications of the strategic interaction between the central and local administrations, the latter being heterogeneous with respect to both income level and political orientation. In doing this, we also depart from the earlier studies in two important aspects. Firstly, we consider that the CG takes into account LGs' degree of alignment with its own socio-political preferences, priorities or ideological position (which we refer to as *political proximity* between CG and LG) to solve its optimization problem. We explore the implications of this parameter for the CG's strategic choice of the tax rate. Secondly, rather than comparing the outcomes of centralized versus decentralized fiscal regimes, we consider that FD is a continuous parameter that can be treated as an index number, which ranges between zero and one. Since the revenues collected are the only source of LGs' spending, FD stands for both revenue and expenditure decentralization.

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5   Enikolopov and Zhuravskaya (2007), for example, showed empirically that the outcomes of FD improve with the strength of national political government, but deteriorate with the extent to which local administration is subordinated to CG. Likewise, Ponce-Rodríguez *et al.* (2016) argued that democratic decentralization combined with a strong CG contribute to FD effectiveness even when regional spillovers exist. Eaton (2001), however, reported no significant relationship between such political factors and the outcomes of FD. Besley and Coate (2003) argued that, when regional and central governments bargain for delegation, centralization does not necessarily imply uniformity of public good provision; they showed that centralization can welfare-dominate FD even when regions are heterogeneous and there are no spillovers across regions. Lockwood (2008) argued that the decentralization theorem fails only when the benevolence assumption is replaced with direct democracy or majority voting; decentralization can be welfare-dominating even when regions are homogeneous and there are positive externalities. Gonzalez *et al.* (2006) argued that welfare effects (measured by the extent of political business cycles) of FD, vis-à-vis centralization, depend on the extent of the political rents of the central government in a majority voting model. Janeba and Wilson (2011) argued that optimal fiscal decentralization is affected by tax competition and spillovers.

6   See, for example, Inman and Rubinfeld (1997), Besley and Coate (2003) and Neyapti (2013). Weingast (2007) also argued that these factors explain why fiscal federalism does not work well in all countries.

7   See for example, North and Weingast (1989), O'Neill (2003) and Dreher *et al.* (2017).

We present a static partial equilibrium model whose main institutional characteristics are the exogenously given degree of FD and the political proximity parameters of LGs.[8] The remaining features of the model are as follows. Facing an exogenous level of FD[9], the CG chooses a uniform tax rate optimally and redistributes the pool of tax revenue based on its political preferences, whereas LGs choose their tax collection effort optimally.[10] The non-cooperative solution of the two agents' optimization problems implies that the tax rate is positively related to the ex-ante level of FD, while it is negatively related to the local tax collection effort as in Aslim and Neyapti (2017). These optimal choices together determine the effective tax rate.

The novel findings of the present study help explain the relationships among FD, welfare, income distribution, *political polarization* (measured by the squared distances between localities' political proximity to the CG), and *political unison* (measured as the sum of the LGs' political proximity to the CG). Firstly, the model's solution reveals that both the optimal tax rate and the tax revenue increase in political unison, which supports the discussion in the literature on the impact of social or political homogeneity on macroeconomic outcomes.[11] Secondly, LG's tax collection efficiency is found to be uniform across localities and decreasing in FD; this effect is also observed to increase in both FD and political unison. Thirdly, simulations show that both tax revenue and the CG's utility peak at an intermediate level of FD. The finding that tax revenue declines at the extreme values of FD conforms to the *decentralization-Laffer curve*, as has also been noted in Aslim and Neyapti (2017). Simulation results also demonstrate that the CG's utility increases in political unison.

As an extension, we introduce spillovers into the model. The model yields a solution in a leader-follower framework, where the leader is the LG and the solution necessitates symmetric spillovers across localities. This extension is motivated by the literature on spatial interdependencies showing that local public spending may be affected by the level of spending in neighbouring localities (see, *e.g.*, Baicker, 2005). We observe that the optimal tax collection effort declines in spillovers while the optimal tax rate increases in them, resulting

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8   The endogenous solution of FD was investigated in Aslim and Neyapti (2017). In this setup, the optimal choice of FD by CG is trivial since it would be optimal to centralize all the public good provision when CG is politically oriented.

9   FD is considered exogenous due to the assumptions that LGs have uniform ability to collect revenues and also face a legal local budget balance constraint, regardless of the local income level. The local tax collection ability is related to local capacity constraints, such as zero borrowing and personnel quality, which we assume to be constant across localities in the current model.

10   As in Besley and Coate (2003) and Lockwood (2008), the centrally determined tax rate is uniform across the economy.

11   See, for example, the empirical studies of Knack and Keefer (1997), Knack and Zak (2003) and the theoretical study of Neyapti (2017). A casual look at the relationship between the tax rates and political stability indicators, as a proxy of political unison, across countries also supports this finding.

in an ambiguous net effect of spillovers on tax revenue. The reduction in the tax collection effort is consistent with the recent empirical findings that spillovers from neighbouring localities may incentivize free-riding behaviour (see, *e.g.*, De Siano and D'Uva, 2017). The roles played by political unison and spillovers are similar in this regard. In addition, we observe that the level of FD that corresponds to maximum central government utility is lower in the case of spillovers than otherwise, which provides support for the decentralization theorem.

Another notable observation is that the level of FD corresponding to the optimal choice of the tax rate that maximizes CG's utility is 0.3, which happens to coincide with the observed OECD average of fiscal decentralization.[12] The observations that political unison and tax revenues are associated positively, while the relationship of polarization with LGs' utility and income distribution is ambiguous, point at the need for adopting institutional mechanisms, such as transparent fiscal rules, in order to reduce the political biases in transfer allocations.

In what follows, we introduce the model and provide its solution in Section 2. In Section 3, comparative statics and simulation results are presented. In Section 4, we present an extension of the benchmark model by introducing spillovers across localities, and provide a comparative analysis of the two models' results. The conclusion and discussion of the possible extensions of the paper is provided in Section 5.

2. Model

We explore the welfare implications of fiscal decentralization in an economy where local fiscal authorities may differ from the central authority in their socio-political and/or ideological preferences as well as resources. To this end, we consider a closed--economy partial-equilibrium model that is comprised of utility-maximizing central and local governments (denoted by CG and LGs, respectively). We assume, for simplicity, that there is no resource mobility or tax competition across the LGs that have identical utility functions but diverse resources and political inclinations. The model is static, where the degree of FD, as well as each locality's income (Y_i) and political position (p_i) *vis-à-vis* the CG are given exogenously, where p_i represents the degree of proximity between the preferences of the local and the central governments and $i = 1, \ldots, n$ is the number of localities. The assumption that FD, as a vertical revenue-sharing mechanism, is exogenous is justified based on the observation that the rates of both expenditure and revenue decentralization can also be considered structural features that change very slowly over time (see, *e.g.*, Neyapti, 2010). Political and social views and priorities of localities are also considered to be highly persistent over time.

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12   Based on the World Bank database of Fiscal Decentralization Indicators for 1997.

The model is then solved both without spillovers (the benchmark model) and with spillovers across localities. The following describes the key variables of the model. Total spending in region i, which is denoted by $\tilde{Y}_i$,[13] is assumed to be equal to the sum of the private (C_i) and public sector spending. For simplicity, each locality is assumed to be homogeneous and (C_i) represents the total consumption in locality i. Public sector spending consists of spending by CG and LGs, denoted by G_i^C and G_i^L, respectively, which are considered as the levels of centrally and locally provided public goods. Hence, income and its components in locality i are given by Equations (1) to (4):

$$\tilde{Y}_i = C_i + G_i^L + G_i^C, \tag{1}$$

where

$$C_i = (1 - \left[a_i\phi + (1 - \phi)\right]t)Y_i\ ; \tag{2}$$

$$G_i^L = \phi a_i t Y_i\ ; \tag{3}$$

$$G_i^C = (1 - \phi)t\hat{p}_i \sum_i Y_i \tag{4}$$

for all i. In Equations (2)–(4), $\phi \in [0, 1]$ stands for the exogenously given degree of FD, based on the assumption that LGs' tax collection capacity per unit of income, relative to that of the CG, is uniform across LGs. As we assume away the possibility of differential ability and revenue collection costs across LGs, $a_i\,(0 < a_i < 1)$ indicates LG$_i$'s tax collection effort or its *willingness* to collect tax in its jurisdiction.[14] Hence, given an exogenous (*ex-ante*) level of ϕ, $a_i\phi$ expresses the *ex-post*, or "effective" level of FD, in the locality i.

Equation (2) stands for private consumption, which is equal to the after-tax income, where $t \in (0, 1)$ is the flat tax rate set by the central government. Tax revenue in each locality is either collected by the local government (by the amount of $a_i\phi tY_i$) or by CG (by the amount of $(1 - \phi)tY_i$) Hence, the effective tax rate for the region i ($\hat{t}_i$) is given by:

$$\hat{t}_i = \left[a_i\phi + (1 - \phi)\right]t\ , \tag{5}$$

which is constrained by the unit interval ($\hat{t}_i \in (0, 1)$) for feasibility.[15]

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13 The initial level of local income (Y_i) is exogenously given and differs from total local spending, denoted by $(\tilde{Y}_i)$, by the amount of transfers made by the central government. However, for the economy, total income is equal to total expenditures (*i.e.*, $\Sigma_i\tilde{Y}_i = \Sigma_i Y_i$).

14 Differential local capacity constraints and transaction costs may also affect the value of ai, which we do not take into consideration in the current model for the sake of simplicity. For an empirical analysis of these issues, see, for example, De Mello (2000), Treisman (2006) and Freinkman and Plekhanov (2009).

15 Note that for $\hat{t}_i \in (0, 1)$, given $a_i > 0$, $\phi \in [0, 1]$ and $t \in (0, 1)$, it must be that $a_i < 1 + (1/\phi t)(1 - t)$.

Equations (3) and (4) imply that both LGs and CG are assumed to follow a balanced budget rule. LGs' spending (denoted by G_i^L) is thus a fraction of the total local tax revenue; in the extreme case of $\phi = 1$, all the tax revenue is collected and spent by LGs. When $\phi = 0$, on the other hand, the CG becomes the agent that collects all the revenues and does all the public spending in the locality i.

While the above features of the model follow Aslim and Neyapti (2017), we depart from that model in the way we define G_i^C. Specifically, G_i^C did not depend on the proximity of LGs to the CG's political position in Aslim and Neyapti (2017). In Equation (4), $\hat{p}_i$ is defined as $\hat{p}_i = p_i / \Sigma_i p_i$, where $\{\hat{p}_i, p_i\} \in [0, 1]$ and represents the *relative* proximity of LG_i to the CG's political position or ideology in relation to that of the remaining LGs.[16] Because it is unlikely that $\Sigma_i p_i = 1$ holds, the locality i's share of the central pool of revenues, in the form of G_i^C, is determined based on the share of p_i in $\Sigma_i p_i$. Then, $\Sigma_i \hat{p}_i = 1$ ensures that the CG's budget balance holds. Hence, redistribution is assumed to be merely politically driven.[17] For instance, G_i^C is zero when p_i is zero. Summing G_i^C's in Equation (4) for all i's (given $\Sigma_i \hat{p}_i = 1$), we obtain total central government spending:

$$G^C = \sum_i G_i^C = (1 - \phi) t \sum_i Y_i . \tag{6}$$

Based on Equation (4), it can easily be shown that when LGs' political positions are identical, the CG acts as a benevolent government and spends the same amount in each region: $G_i^C = (1 - \phi)\frac{t}{n} \Sigma_i Y_i$.[18]

Given that local incomes constitute the only tax base to be shared between LGs and the CG, the total tax revenue is given by the following:

$$T = t\sum_i (a_i \phi + (1 - \phi)) Y_i . \tag{7}$$

T is also equivalent to total government spending, G, where $G = \Sigma_i G_i^L + G^C$. Hence, the overall government budget constraint holds, as do the central and the local 'governments'. In the absence of a transfer rule, the CG reallocates its tax revenues to LG_i based on the political proximity parameter p_i, as shown in Equation (4). Hence, the difference between local incomes before and after transfers represents the "net transfers" to the region i:

16   Consider for $n = 2$, for example, that the CG's political position is closer to locality 1 (0.8) than locality 2 (0.6). Hence, the relative proximity to locality 1 is 0.8/1.4 = 4/7 = 0.57 and to locality 2 is 0.6/1.4 = 3/7 = 0.43. This would imply that the CG's spending is greater in locality 1 due to its political position. To ensure that CG's budget balance holds, we also have 0.57 + 0.43 = 1.

17   Consider that there are n localities and all but one of them have $p_i = 0$. In this case, the CG spends in only one region that has at least some level of political association with itself. We rule out the case that $\Sigma_i p_i = 0$ as unrealistic.

18   Note that differently from Aslim and Neyapti (2017), in this paper we consider that the CG delivers local, rather than pure, public goods; hence $G^C \neq G_i^C$; that is, the CG's spending is rivalrous.

$$\left(\tilde{Y}_i - Y_i\right) = \left(1-\phi\right)t(\hat{p}_i \sum_1 Y_i - Y_i) .$$ (8)

In what follows, we describe the optimization problems of LGs and the CG. The non-cooperative game, defined by the joint solution of a_i' s and t that are chosen optimally by LGs and the CG respectively, yields a Nash equilibrium.[19]

2.1 Representative local government's problem

We define the LG optimization problem, following Aslim and Neyapti (2017), where a representative LG chooses its tax collection effort in order to maximize its utility. Local utility depends on public (local and central government) and private spending in a given locality. We consider that LGs do not distinguish between local and central spending on public goods, G_i^L and G_i^C; hence, they are substitutes. This is justified if G_i^C is in the form of open-ended or unconditional central transfers to local governments. Assume that a representative LG's utility is log-linear, where α ($\alpha \in (0, 1)$) stands for the utility weight on private local spending and $(1 - \alpha)$ is the utility weight on public spending[20]:

$$U_i^{LG} = \alpha\ln C_i + \left(1-\alpha\right)\left(\ln G_i^L + \ln G_i^C\right).$$ (9)

Equation (9) is maximized subject to the constraints given in Equations (2) to (4). Restating that each locality may differ in the level of income and political alignment with the CG, the unconstrained problem of a representative LG becomes:

$$\max_{a_i} U_i^{LG} = \alpha\ln\left(\left(1-\hat{t}_i\right)Y_i\right)+\left(1-\alpha\right)\ln\left(\phi a_i tY_i\right)+\left(1-\alpha\right)\ln\left(\left(1-\phi\right)t\hat{p}_i \sum_i Y_i\right)$$ (10)

where $\hat{t}$ is the effective tax rate given by Equation (5). The first-order condition for the above problem is:

$$a_i = a = \left(1-\alpha\right)\frac{1 - t + \phi t}{\phi t} .$$ (11)

Proof: *Appendix A*

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19   The solution to a non-cooperative game between the three agents, local governments, the central government and a social planner (SP), is also explored, where, differently from the CG, the SP maximizes the sum of the LGs' utilities. This is a problem similar to that of the central government given above, except with $p_i = 1/2$. This scenario is based on the joint solution of the local and central government problems, which, however, fails to yield a solution. That is, there is no common set of parameters that satisfies the set of optimal solutions for the general tax rate, the level of fiscal decentralization and the level of local public good provision (or local tax collection effort). The problem of SP and LG, on the other hand, is separately analyzed in Aslim and Neyapti (2017).

20   Note that G_i^L and G_i^C are not perfect substitutes, which essentially implies that corner solutions are not feasible, as a departure from the existing literature. We believe this is a more realistic representation of reality.

In Equation (11), we take $a_i = a$ since the solution does not depend on the locality index i. Put differently, despite the fact that LGs differ with respect to their political alignment, their optimal choice is uniform. Hence, regardless of their tax base and political position, LGs exert the same tax collection effort given a flat tax rate determined by the CG. This follows from the asymmetry between the static non-cooperative game between LGs and the CG in that LGs' political position matters only for the CG's strategic decision making. We observe that a and t are negatively related due to perfect substitutability between C_i and G_i in the utility function of LGs.

2.2 Central government's problem

The CG chooses t non-cooperatively in order to maximize the aggregate utility, given exogenous ϕ. The objective function of the CG differs from the sum of LGs' objective functions by the relative utility weights that the CG attributes to G_i^L's, which are p_i's.[21] Having defined p_i as LG_i's degree of political alignment with the CG, here we consider that this parameter also represents the utility weight that the CG assigns to G_i^L. As such, p_i indicates the degree of substitutability between G_i^L and G_i^C for the CG. Hence, the CG's optimization problem is:

$$\max_t U^{CG} = \sum_i (\alpha \ln C_i + p_i (1-\alpha) \ln G_i^L + (1-\alpha) \ln G_i^C) \tag{12}$$

which indicates that the CG gets higher utility from G_i^L the more the locality i is politically aligned with it. The CG's optimization problem is solved after substituting the constraints given in Equations (2) to (4):

$$\max_t U^{CG} = \sum_i \left(\alpha \ln \left((1-\hat{t}_i) Y_i \right) + p_i (1-\alpha) \ln \left(\phi a_i t Y_i \right) + (1-\alpha) \ln \left((1-\phi) t \hat{p}_i \sum_i Y_i \right) \right). \tag{13}$$

Let us consider that $n = 2$, and define define $P = p_1 + p_2$ as political unison, where $P \in [0, 2]$. This simplification enables us to keep the model tractable while also providing sufficient room to differentiate localities with respect to their political positions so as to investigate the implications of political polarization or unison. Given that LGs are symmetric in their optimizing behaviour [see Equation (9)] and, hence, $a = a_1 + a_2$ the first order condition of the CG problem yields:

$$t = \frac{(1-\alpha)(P+2)}{(1-\phi(1-a))(2\alpha + (1-\alpha)(P+2))}. \tag{14}$$

Proof: *Appendix A*

Equations (11) and (14) stand for the best responses of the LG and the CG, respectively, to the other player's action. Thus, given Equations (1) to (4), the Nash equilibrium of the model is defined as the set of $\{t, a\}$ that satisfies Equations (11) and (14).

Lemma 1. The joint solution of Equations (11) and (14) for $i \in \{1, 2\}$ yields the following solutions:

$$t^* = \frac{(1-\alpha)P}{(1-\phi)(2\alpha+(1-\alpha)(P+2))} \text{ and } a^* = \frac{2(1-\phi)}{\phi P}. \qquad (15)$$

Proof: *Appendix A*

Substituting the optimal a and t in Equation (5), we obtain the effective tax rate as $\hat{t}^* = (1-\alpha)(P+2)/(2+(1-\alpha)P)$. Note that the equilibrium effective tax rate is identical across LGs as are a_i^* s. This result nonetheless takes into account that P is composed of the different levels of LG_is' political alignment with the CG. Hence, society-wide political alignment with the CG matters for the equilibrium levels of t and a, whose direction of relationship is explored next.

For the uniqueness of the Nash equilibrium, corresponding to each exogenous parameter in the set $\{\alpha, \phi, P\}$, there should exist a unique corresponding pair of endogenous variables $\{t^*, a^*\}$. As both reaction functions [Equations (11) and (14)] are negatively sloped, the uniqueness of the optimal solution hinges on the absence of corner solutions. Equation (11) rules out the possibility that $t = 0$, for which a is undefined. It is also clear from Equation (15) that $a^* = 0$ when $\phi = 1$, which is the case of full decentralization; this is also not feasible since it implies that $t = T = 0$ see Equation (7)], which means zero tax collection and thus zero public good provision. Hence, corner solutions are not feasible.[22] Therefore, the joint solution of the problem shown by Lemma 1 exists and is unique. The comparative statics, the income distribution and welfare, measured by the sum of local utilities, and implications of the model are presented below.

3. Comparative Statics

In this section, we investigate how the underlying model parameters $\{\alpha, \phi, \text{ and } P \text{ (or } p_i)\}$ affect the optimal choices of the central and local governments. Table 1 presents the signs of the partial derivatives of the optimal solutions given in Equation (15).

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22   The lack of corner solutions implies, however, that our results are not directly comparable to that of the existing studies in the related literature that focus on the polar cases of full decentralization and full centralization.

Table 1: Signs of partial derivatives, benchmark case

	t^*	a^*
ϕ	$+$	$-$
p_i	$+$	$-$
α	$-$	0

Table 1 shows that ϕ affects t^* positively, but a^* negatively. The first of these arises as the CG compensates for its declining revenues when ϕ increases. The second effect is due to the LG's effort to compensate for the loss in its utility as disposable income and C_i decrease when t^* increases.

Proposition 1. An increase in ϕ leads to a decrease in a^* and an increase in t^*.

Proof: *Appendix A*

Corollary 1. The negative response of a^* to ϕ increases in both ϕ and P.

Proof: *Appendix A*

In view of these opposing effects, the net impact of ϕ on the tax revenue, when evaluated based on the optimal values of t and a, is ambiguous. The effect of the rest of the model parameters on the sign of this effect is further investigated via simulations in the next section.

Table 1 also indicates that p_i has a negative effect on a^*, and a positive effect on t^* (the same results hold for P). These opposing effects can be explained as follows. *Ceteris paribus*, the CG derives higher utility from G_i^L the higher p_i is [see Equation (10)], which compensates for the utility loss arising from a decrease in C_i that arises in response to an increase in t^*. C_i also falls in a^* that is reduced by the LG's response to an increase in transfers as p_i increases [see Equation (8)]. Intuitively, this also means that the CG accepts a greater degree of crowding-out the greater p_i is. The net effect of p_i on the effective tax rate ($\hat{t}_i$) and total tax revenue, however, is ambiguous and will be explored via simulation analysis.

Proposition 2. The greater is P, the higher is t^*

Proof: *Appendix A*

It is also observed that increasing p_i increases the negative relationship between ϕ and a^*.

Corollary 2. A negative response of a^* to P increases in P.

Proof: *Appendix A*

Thus, it is optimal for the CG to tax more the greater the degree of political unison. Given p_i's negative effect on a^* however, the net effect of p_i on the effective tax rate ($\hat{t}^*$) or the tax revenue (T) is ambiguous. Hence, we also resort to a simulation analysis to explore this effect further.

Table 1 also shows that the optimal tax rate is negatively related to the utility share of the private good (α) and thus positively with that of the public good ($1 - \alpha$). The explanation for this is straightforward from the utility of the central government (U^{CG} which increases in t^* the higher the utility share of the public spending and the lower the share of private spending. The results are the same in nature when t^* is replaced with T; the higher the utility share of the public good, the higher the tax revenue.

3.1 Simulations

The above comparative statics leave the effects of the model parameters on the effective tax rate ($\hat{t}^*$), tax revenue (T) and the rest of the model aggregates ambiguous. In this section, we investigate how $\{\tilde{Y}_1 / \tilde{Y}_2, t, T, U^{LG}, U^{CG}\}$ respond to changes in the model parameters: $\{\phi, p_i, \alpha\}$, where $\tilde{Y}_1 / \tilde{Y}_2$, denotes ex-post income distribution and U^{LG} denotes the utility of the local government. To obtain simulation data on income distribution, Y_1 is fixed arbitrarily and Y_2 is defined as a multiple (x) of it, where $x \in [0.1, 5]$. Hence, we set locality 1's income such that it can be as small as one-tenth, or as large as five times the income of locality 2.

Table 2: Calibration of parameters

Parameter	Range	Increment
x	[0.1, 5]	0.5
ϕ	[0.1, 1]	0.1
α	[0.1, 1]	0.1
p_1	[0.1, 1]	0.1
p_2	[0.1, 1]	0.1

Source: Authors' calculations

The simulations we perform are based on the feasible ranges of the underlying model parameters: $\{\phi, p_i, \alpha\} \in [0, 1]$; $\{a^*, t^*, \hat{t}^*\} \in (0, 1)$; and for the remaining endogenous variables: $\{C_i, G, G_i^L, G_i^C, \tilde{Y}_i\} \in \mathbf{R}_+$, for $i = 1, 2$. Given the increments we select, as reported in Table 2, the data set obtained using the Matlab software is composed of 410,310 observations. In the following, we report only the cases of definite relations that are revealed from the boxplot analysis of the simulated data.

Based on the simulation data, we observe that tax revenue (T) is positively related with t^* since the optimal tax rate is utility-maximizing, only the rising portion of the traditional Laffer curve is observed (see Figure A1).

Remark 1. T increases in t^*.

We also observe that the maximum level of T depicts an inverse-U relationship with ϕ, supporting the *decentralization-Laffer curve* relationship proposed in Aslim and Neyapti (2017). To clarify, t^* increases in ϕ up to $\phi \lesssim 0.5$ so as to overcompensate for the reduction in the tax collection effort (see Figure A2). For $\phi \gtrsim 0.5$, however, the reduction in a^* dominates the increase in t^*. The relationship between T and ϕ has been called the *decentralization-Laffer curve* by Aslim and Neyapti (2017). This observation conforms to the consensus in the recent fiscal decentralization literature that provides discussions regarding both the pros and cons of decentralization: the extreme values of ϕ do not contribute to fiscal efficiency and welfare.[23] Figure A3 also demonstrates that U^{LG} (also U^{CG}, not shown)[24] and ($\tilde{Y}_1 / \tilde{Y}_2$) depict a relationship with ϕ that is similar to the relationship of T with ϕ (see Figure A4).

Next, we investigate the relationship between the political variables and the endogenous variables of the model. We define political unison, denoted by P, as the sum of p_i's; and political polarization, denoted by σ_P, where $\sigma_P = (p_1 - p_2)^2$.[25] P can be viewed as the degree to which the society's political choices are in accord with those of the CG, while σ_P measures the degree to which LGs diverge from each other with respect to their ideological or political positions. Simulations reveal that T increases in P monotonously (see Figure A5). This is consistent with the findings of Herwartz and Theilen (2014) in the case of Germany. The interpretation of this finding is that homogeneity in political inclinations induces agents to increase their contribution to pure public good provision, which is viewed similar to local public goods or local spending. This is certainly driven by the fact that local tax collection effort is at most 1.

Remark 2. T increases with P.

On the other hand, neither a^* or t^* depicts a definitive relationship with the political variables. The relationships of both t^* and T with σ_P are also ambiguous. Likewise, income distribution does not depict a clear relationship with our political variables. The effects of P and σ_P on the LG's and CG's utilities are also examined, as these relations are not

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23   See, *e.g.*, Nguyen Viet Hanh *et al*. (2014) and Treisman (2006).

24   We consider that welfare is represented by U^{LG}, rather than by the politically weighted U^{CG}.

25   There is a double-peaked hump-shaped relationship between σ_P and P. Thus, note that for $p_1 = p_2 = 0.5$; P is 1 but σ_P is 0; for $p_1 = p_2 = 0.7$, P is 1.4 but is still 0. The upper bounds of σ_P and P are equal to 1 and 2, respectively, in the simulations for $i = 1, 2$.

clear at the onset. Simulations show that while U^{CG} clearly increases in P, its relation with σ_P is ambiguous; U^{LG} shows no clear relationship with the political variables, however.

4. Extension: Introducing Spillovers Across Localities

In this section, we investigate how spillovers of local public goods affect our benchmark results reported in the foregoing sections. We consider that spillovers are in the form of either positive or negative externalities that may arise from the central or local governments' spending in the neighbouring localities. Positive externalities may arise due to increasing incomes and mutually beneficial cultural and trade relations across localities, while negative externalities may arise from socio-political instability or economic activities that harm the environment. By incorporating spillover effects into our model, we investigate the validity of the decentralization theorem that postulates that spillovers reduce the potential benefits of fiscal decentralization.[26] Hence, we also explore the robustness of our benchmark findings on the relationships between welfare, political polarization and FD.

Given the possibility of informational asymmetries between LGs and the CG regarding spillovers, two cases are considered for the joint solution of the LG and CG problems. In the first, we assume that only LGs are fully informed about the extent of the spillovers they receive from other localities (s_i) and, given lack of information, the CG assumes $s_i = 0$. We find out that in this case the solution of the non-cooperative strategic game between LGs and the CG remains the same as in the benchmark model. In the case of full information assumption, however, no feasible solution for t could be obtained from a simultaneous-move game.

We obtain the solution for the case of full information about spillovers by assuming that the LG is the leader and the CG is the follower, where a representative LG makes its decision by taking the reaction function of the CG into account. Given that the LG's objective functions are symmetric for $n = 2$, we write the objective function for the LG_i with the spillover effect from the other locality as:

$$\max_{a_i} U^{LG}_{i,\, spillover} = \alpha \ln C_i + (1+\alpha)\left(\left[\ln G_i^L + \ln G_i^C\right] + s_i\left[\ln G_j^L + \ln G_j^C\right]\right) \tag{16}$$

where the spillover $s_i \in [-1, 1]$ stands for the extent to which total public spending in the locality j affects the locality i. Note that since $\{i, j\} \in \{1, 2\}$ denote the two locations, Equation (16) can also be written for LG_j with $s_j \in [-1, 1]$ instead of s_i.

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26 By contrast, Koethenbuerger (2008) argued that welfare gains of FD may increase under spillovers.

Assuming full information about spillovers across localities, the CG's problem becomes[27]:

$$\max_t U^{CG}_{spillover} = \sum_{\substack{(i,j)\in\{1,2\}, \\ i\neq j}} \left(\alpha\ln C_i + p_i\left(1-\alpha\right)\left(\ln G_i^L + s_i\ln G_j^L\right) + \left(1-\alpha\right)\ln G_i^C \right) \tag{17}$$

where the CG derives utility from LGs' expenditures by the extent of their proximity to its own political values, but benefits fully from its own spending in each region. As in the benchmark model, both of the above problems are subject to the constraints given by Equations (2) to (4), and $n = 2$ is assumed from here onward to obtain an explicit solution. The solution of the CG's problem necessitates a_i's to be identical for $i \in \{1, 2\}$[28], leading to the following expression:

$$t_{spillover} = \frac{\left(1-\alpha\right)\sum_{i\in\{1,2\}}\left(p_i\left(1+s_i\right)+1\right)}{\left(1+\phi\left(a-1\right)\right)\left(2\alpha+\left(1-\alpha\right)\sum_{i\in\{1,2\}}\left(p_i\left(1+s_i\right)+1\right)\right)}. \tag{18}$$

Proof: *Appendix B*

Lemma 2. Substituting Equation (18) into Equation (16), the solution of the LG's problem is obtained as: $a^*_{i,\,spillover} = \dfrac{1-\phi}{\phi\left(1+2s_i\right)}$. Given that $a = a_i$ is assumed for the solution of the CG's problem in Equation (18), The LG's optimal solution implies that s_i's are also identical across localities $i \in \{1, 2\}$. Therefore,

$$a^*_{i,\,spillover} = \frac{1-\phi}{\phi\left(1+2s_i\right)}. \tag{19}$$

Hence, substituting $a^*_{i,\,spillover}$ back in Equation (18) yields:

$$t^*_{spillover} = \frac{\left(1-\alpha\right)\left(1+\sum_{i\in\{1,2\}}\left(p_i\left(1+s\right)+1\right)\right.}{2\left(1-\phi\right)\left(1+s\right)\left(2\alpha+\left(1-\alpha\right)\sum_{i\in\{1,2\}}\left(p_i\left(1+s\right)+1\right)\right)}. \tag{20}$$

Proof: *Appendix B*

Given the above solution to the sequential problem, for identical spillovers across localities s, the CG takes the weighted average of p_1 and p_2 in the determination of the tax rate.

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27   Not taking into account the spillovers from G^C across localities does not alter the optimal solutions.

28   Without assuming the identity of a_i's for $i \in \{1, 2\}$, an explicit solution for t cannot be obtained.

The comparative statics of the new equilibrium variables are reported in Appendix B and summarized in Table 3. These findings match with the signs reported in Table 1, with the exception that p_i now has no effect on $a^*_{spillover}$. This means that, unlike in the benchmark case of no spillovers (see Equation 15), $a^*_{spillover}$ is not affected by the political parameters, political unison ($P = \Sigma_i p_i$) in particular. This is because spillovers and P both have the effect of reducing the local tax collection effort via incentivizing free-riding. Equation (19) also indicates that the range of spillovers is $(-0.5, 0.5]$ for $a^*_{spillover}$ to be economically feasible.

Proposition 3. In the case of spillovers, p_i (or P) does not affect a^*, but affects t^* positively.

Proof: The proof is trivial for a^* as Equation (18) does not contain p_i.

See *Appendix B*.

Two observations additional to those reported in Table 1 pertain to the effect of spillovers; while $a^*_{spillover}$ responds positively to s_i, the sign of the effect is the opposite for $a^*_{spillover}$. The interpretation of this observation is similar to the opposing effects of ϕ on a^* and t^* in the benchmark case: an increase in spillovers induces the CG to increase the optimal tax rate in reaction to the reduced incentives for LGs to exert effort to collect local taxes. This implies that, *ceteris paribus*, the effects of spillovers on the effective tax rate, tax revenue, and thus income distribution, are not certain. We find that both of these effects increase in ϕ; that is the higher ϕ, the greater the effects of s on $a^*_{spillover}$ and $t^*_{spillover}$.

We next resort to the simulation analysis to compare the rest of the model implications with those of the benchmark case.[29] As implied by the opposite signs for $t^*_{spillover}$ and $a^*_{spillover}$ in Table 3, the simulations show no direct relationship between s's and the variables $\{T, U^{CG}, U^{LG}\}$. We also observe, however, that each of these variables is maximized and $\tilde{Y}_1 / \tilde{Y}_2$ is minimized at $s = 0.8$.

The relationships between the model endogenous variables with the parameters $\{\phi, P\}$ are reported in Table B1 to enable a comparison with the benchmark case (see *Appendix B*).[30] A notable point is that the value of ϕ at which T reaches its maximum is smaller than in the benchmark case. Specifically, this indicates that for levels of ϕ higher than 0.3, the response of $a^*_{spillover}$ to ϕ dominates that of $t^*_{spillover}$ such that T decreases in ϕ. We also observe that income distribution improves at a lower level of ϕ in the case of spillovers ($\tilde{Y}_1 / \tilde{Y}_2 = 1.5$ at $\phi = 0.3$) as compared to the benchmark case ($\tilde{Y}_1 / \tilde{Y}_2 = 1.85$ at $\phi = 0.6$).

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29   The size of the data set obtained from the simulations is 609,376, which results from the addition of two spillover effects: $s \in (-0.5, 0.5]$, with the increments of 0.1, to the parameters reported in Table 2; in order to economize on the run time, we increase the increments of α and $(1 - \alpha)$ to 0.2.

30   The table does not contain σ_p since no clear relationship is observed between the model variables with this parameter.

Table 3: Signs of partial derivatives, spillovers case

	$t^*_{spillover}$	$a^*_{spillover}$
ϕ	+	−
p_i (or P)	+	0
α	−	0
s	+	−

Source: Authors' calculations

Proposition 4. The higher s, the higher $a^*_{spillover}$ and the lower $t^*_{spillover}$.
Proof: *Appendix B*

We further observe, based on simulations, a U-shaped relationship between ϕ and both U^{CG} and U^{LG}, where both utilities peak at $\phi \approx 0.3$. This finding implies that CG, as the agent who chooses institutions, would have an incentive to set $\phi \approx 0.3$. This optimal value happens to match with the OECD average of expenditure decentralization, which can be interpreted as that fiscal decentralization in the OECD countries has, on average, been optimal.[31]

Remark 3. In a model with spillovers, both the welfare and the utility of a politically--oriented CG reach their maximums and income distribution reaches its most equitable point at $\phi \approx 0.3$.

Taking stock, the current framework reveals that the welfare effects of FD vary greatly with both political orientation and spillover effects. We particularly make the following observations. Firstly, both spillovers and FD are associated negatively with tax collection efficiency and positively with the tax rate. Secondly, while welfare and income distribution do not portray a clear relationship with FD, the central government's utility is observed to improve up to an intermediate value of FD that is consistent with the observed level of FD in developed countries. Thirdly, while the effect of political polarization on welfare, income distribution and efficiency are ambiguous, it is clear that political unison (P) leads to unambiguous improvements in the level of redistributable resources and central government utility.

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31 Authors' calculations, based on the World Bank Fiscal Decentralization Indicators. Source: http://www1.worldbank.org/publicsector/decentralization/fiscalindicators.htm

Conclusions

According to the decentralization theorem, fiscal decentralization (FD) is more effective the greater the heterogeneity and the smaller the spillover effects of public spending across localities. This study presents a formal model in order to examine the validity of this theorem by way of exploring explicitly the welfare implications of these features.

Our partial equilibrium model involves a central government that determines a flat tax rate and local governments that determine their tax collection effort optimally. Local governments are assumed to be heterogeneous in both their income levels and political alignment with the central government, where this last feature is the main novelty of this study. We solve the model both with and without spillover effects, where the latter necessitates a different game structure than the former in the case of full information about spillovers. We then investigate the connections of welfare and income distribution with the degrees of FD, political unison and polarization.

In the case of no spillovers, the solution of the non-cooperative game between the local and central governments reveals that optimal tax collection effort and optimal tax rate are negatively related. Both of these variables also depict a negative association with FD. The model reveals that tax revenue has a non-monotonic (inverted-U type) relationship with FD, indicating that the effect of FD on optimal tax rate dominates its effect on localities' tax collection effort up to an intermediate level of FD, beyond which point the second effect dominates the first. This non-linear relationship, termed the decentralization-Laffer curve, is also supported by the model simulations (and by empirical evidence), which depict a non-linear relationship of FD with both tax revenues and central government utility. Simulations also reveal that while the model outcomes are not associated with polarization, the degree of political unison is positively associated with both central government utility and tax revenue.

The extension of the model reveals that optimal tax rate increases in spillovers but optimal tax collection efficiency decreases in spillovers. In addition, both the central and local governments' utilities are observed to peak at a lower level of FD in the case of spillovers than in the benchmark case, supporting the decentralization theorem. Income distribution is also observed to be the most equitable at a lower level of FD in the case of spillovers than in the benchmark case.

In summary, we demonstrate that when the central and local governments act strategically, increasing FD does not monotonically lead to efficiency and welfare gains. Moreover, spillover effects reduce the welfare-maximizing level of FD. Although welfare, measured by aggregate local government utility here, is not related to either political unison or heterogeneity, it is related to FD in the same way as the central government

utility. Given that political unison is revealed to improve redistributable resources and the central government utility, but not income distribution or welfare, our findings point at the need for rule-based redistributive mechanisms, even if a society is not politically polarized, to improve the welfare outcomes under FD.[32] Finally, we concede that a possible weakness of the current study is that, given the structure of the preferences modelled here, this study does not nest some of the former models that also addressed heterogeneity under polar cases of decentralization.
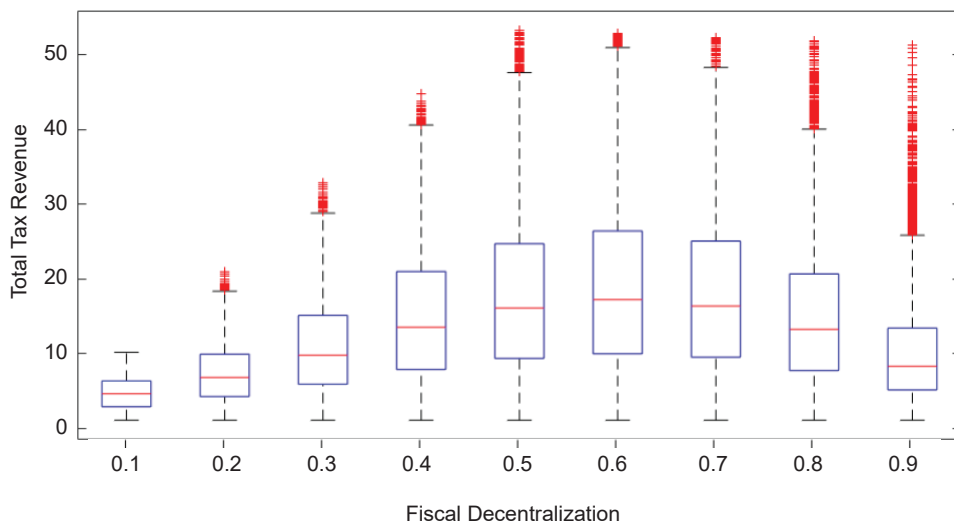
Figures

A: Simulations

Figure A1: Optimal tax rate and total tax revenue
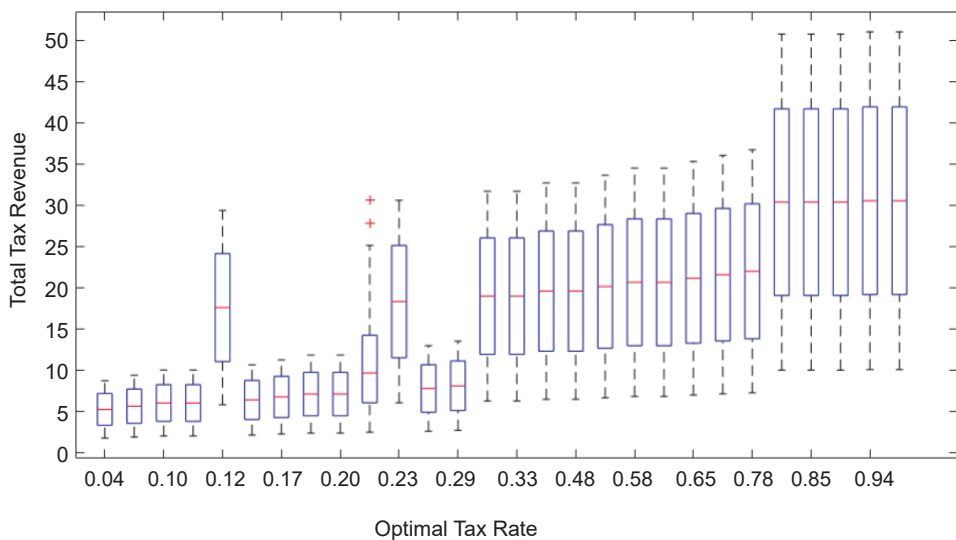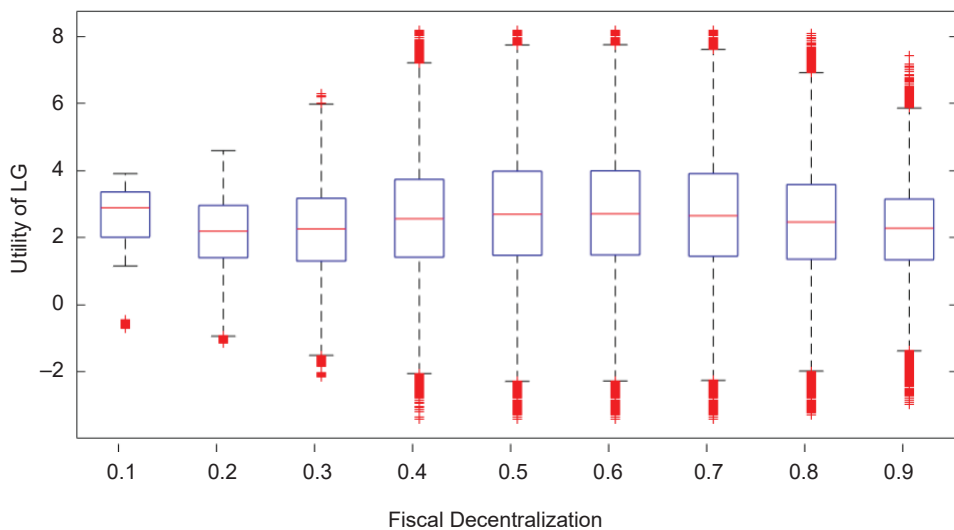

Source: Own elaboration

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32   See, for example, Akin *et al.* (2016), and Bulut-Cevik and Neyapti (2014) for the role of transfer rules and equalization target on the efficiency effects of FD. Shah (2006), Budina *et al.* (2012) and Neyapti (2013) are examples of studies that emphasize the role of fiscal rules.

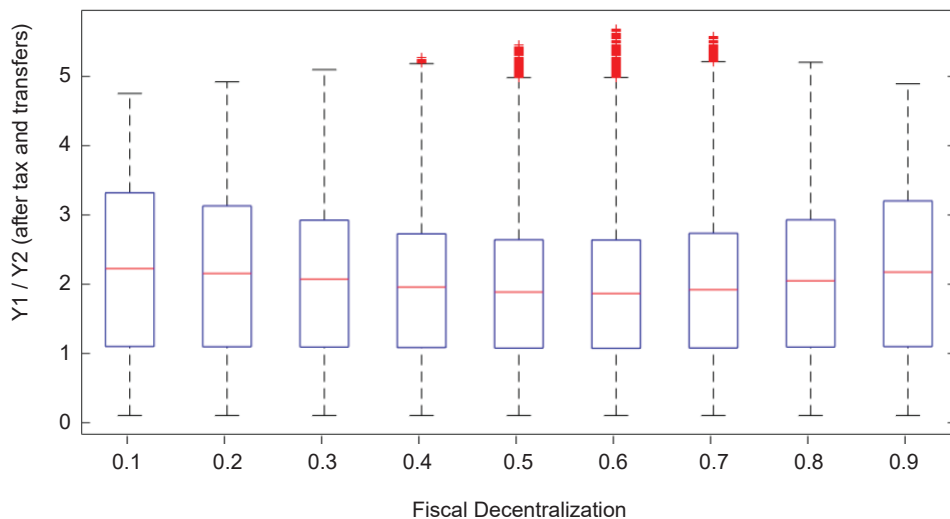**Figure A2: Fiscal decentralization and total tax revenue**

Source: Own elaboration

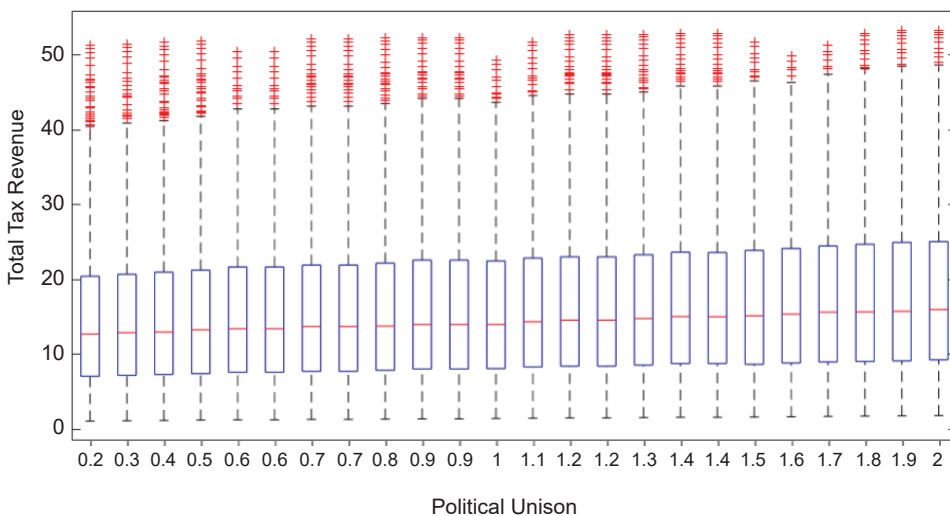**Figure A3: Fiscal decentralization and LG utility**

Source: Own elaboration

Figure A4: Fiscal decentralization and income distribution

Source: Own elaboration

Figure A5: Political unison and total tax revenue

Source: Own elaboration

Appendix

Appendix A: The Benchmark Case

Proof of the LG's reaction function. The first-order condition of Equation (10) with respect to a_i is

$$\frac{(1-\alpha)}{a_i} - \frac{\alpha\phi t Y_i}{Y_i - \phi a_i t Y_i - (1-\phi) t Y_i} = 0 .$$

Rearranging terms yields

$$\alpha\phi a_i t Y_i = (1-\alpha)\big(1 - \phi a_i t - (1-\phi) t\big) Y_i .$$

Simplifying the equation above and solving for a_i yields

$$a_i = (1-\alpha)\frac{1 - t + \phi t}{\phi t}$$

where $a = a_i$ is implied by the above expression.

Proof of the CG's reaction function. The following first-order condition of Equation (13) with respect to t is obtained for each i, assuming $i \in \{1, 2\}$ without loss of generality[33]:

$$\alpha\left(\frac{\phi(1-a_1)-1}{(1-t\phi a_1)-t(1-\phi)} + \frac{\phi(1-a_2)-1}{(1-t\phi a_2)-t(1-\phi)}\right) + (1-\alpha)\left(\frac{p_1 + p_2 + 2}{t}\right) = 0 .$$

Let $P = p_1 + p_2$. Considering the symmetric first order conditions for LGs such that $a = a_1 = a_2$ for $i = 1, 2$, we can simplify the CG's first-order condition as

$$\frac{2\alpha\big(\phi(1-a)-1\big)t}{1 + \big(\phi(1-a)-1\big)t} = -(1-a)(P+2).$$

Now let $A = \phi(1-a) - 1$. The first-order condition above becomes

$$t\big(2\alpha A + (1-\alpha)PA + 2(1-\alpha)A\big) = -(1-\alpha)(P+2) \rightarrow t = \frac{-(1-\alpha)(P+2)}{A\big(2\alpha + (1-\alpha)(P+2)\big)} .$$

Finally, we substitute in the equation for A

$$t = \frac{(1-\alpha)(P+2)}{\big(1 - \phi(1-a)\big)\big(2\alpha + (1-\alpha)(P+2)\big)} .$$

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33 The findings remain robust to the extension of the analysis to the case of "n" localities except that the number "2" in the joint solution would be replaced with "n" and P would be $\{p_1 + p_2 + \ldots + p_n\}$.

Proof of Lemma 1. In order to obtain the Nash equilibrium, we solve the LGs' and CG's reaction functions simultaneously.

Substituting t into the LGs' reaction function yields

$$a = (1-\alpha)\left(\frac{(1-\phi(1-a))(2\alpha+(1-\alpha)(P+2))}{\phi(1-\alpha)(P+2)} - \frac{1}{\phi} + 1\right).$$

To simplify the equation above, let $A = \phi(1-a) - 1$. Then, we have

$$a = \frac{2A\alpha + A(1-\alpha)(P+2) - (1-\alpha)(P+2) + \phi(1-\alpha)(P+2)}{\phi(P+2)}.$$

Cross-multiplying the terms and dividing both sides by $(P + 2)$ yield

$$a\phi = \frac{2A\alpha}{P+2} + A(1-\alpha) + (1-\alpha)(\phi-1).$$

Replacing the equation for A and rearranging the terms yield

$$a\phi - \left(\frac{2\alpha}{P+2} + (1-\alpha)\right)(1-\phi+\phi a) = (1-\alpha)(\phi-1).$$

Further simplification yields

$$a\left(\frac{\alpha(P+2)-2\alpha}{P+2}\right) = \left(\frac{\phi-1}{\phi}\right)\left(\frac{2\alpha}{P+2}\right).$$

Multiplying both sides of the above expression by $(P + 2)$ and solving for a yields a^*

$$a^* = \frac{2(1-\phi)}{\phi P}.$$

Now we substitute a into the CG's reaction function

$$t = \frac{(1-\alpha)(P+2)}{\left(1-\phi\left(\alpha\left(\frac{1}{\phi t}-\frac{1}{\phi}+1\right)\right)\right)(2\alpha+(1-\alpha)(P+2))}.$$

To simplify the equation above, let $R = (1 - \alpha)$ and $C = 2\alpha + (1 - \alpha)(P + 2)$. Then,

$$t = \frac{(1-\alpha)(P+2)}{\left(1+\frac{R}{t}-R+(R-1)\phi\right)C}.$$

Cross-multiplying and rearranging the terms yield

$$t(R-1)(\phi-1) + R = \frac{(1-\alpha)(P+2)}{C}.$$

By replacing the equation for R and further simplifying the equation above, we obtain

$$t(\phi-1) = \frac{(1-\alpha)}{\alpha}\left(1 - \frac{(P+2)}{C}\right).$$

Substituting for the equation for C, we solve for t:

$$t^* = \frac{(1-\alpha)P}{(1-\phi)(2\alpha+(1-\alpha)(P+2))}.$$

Proof of Proposition 1. For $\phi \in (0, 1)$, the partial derivatives of t^* and a^* with respect to ϕ are

$$\frac{\partial t^*}{\partial \phi} = \frac{(1-\alpha)P}{(\phi-1)^2(2\alpha+(1-\alpha)(P+2))} > 0 \; and \; \frac{\partial a^*}{\partial \phi} = -\frac{2}{\phi^2 P} < 0.$$

Proof of Corollary 1. For $\phi \in (0, 1)$, the second derivative of a^* with respect to ϕ is

$$\frac{\partial^2 a^*}{\partial \phi^2} = \frac{4}{\phi^3 P} > 0.$$

Additionally, the cross partial derivative of $\partial a^*/\partial \phi$ with respect to P is

$$\frac{\partial^2 a^*}{\partial \phi \partial P} = \frac{2}{\phi^2 P^2} > 0.$$

Proof of Proposition 2. For $\phi \in (0, 1)$, taking the partial derivative of t^* with respect to P yield

$$\frac{\partial t^*}{\partial P} = \frac{-2(1-\alpha)}{(\phi-1)(2\alpha+(1-\alpha)(P+2))^2} > 0.$$

Proof of Corollary 2. For $\varphi \in (0, 1)$, the second partial derivative of a^* with respect to P is

$$\frac{\partial^2 a^*}{\partial P^2} = \frac{4(1-\phi)}{\phi P^3} > 0.$$

Appendix B: The Spillovers Case

Proof of the CG's reaction function. Assuming $n = 2$ without loss of generality, the CG maximizes the following utility function:

$$U_{spillover}^{CG} = \sum_{\substack{(i,j)\{1,2\}, \\ i \neq j}} \left(\alpha \ln\left((1-\hat{t}_i)Y_i\right) + p_i(1-\alpha)\left(\ln\left(\phi a_i t Y_i\right) + s_i \ln\left(\phi a_j t Y_i\right)\right)\right) +$$

$$+ (1-\alpha)ln((1-\phi)t\hat{p}_i \textstyle\sum Y_i).$$

We obtain the following first-order condition with respect to t:

$$a\left(\frac{\phi(1-a_1)-1}{(1-t\phi a_1)-t(1-\phi)}+\frac{\phi(1-a_2)-1}{(1-t\phi a_2)-t(1-\phi)}\right)+\frac{(1-\alpha)}{t}\left(p_1(1+s_1)+p_2(1+s_2)+2\right)=0.$$

Considering symmetry in LGs' tax collection efforts ($a = a_1 = a_2$) across localities given Equation (16), the CG's reaction function becomes

$$t = \frac{(1-\alpha)\sum_i(p_i(1+s_i)+1)}{(1+\phi(a+1))(2\alpha+(1-\alpha)\sum_i(p_i(1+s_i)+1))} \text{ for } i \in \{1,2\}.$$

Proof of Lemma 2. To obtain the Nash equilibrium in a leader-follower framework, we solve LGs' utility maximization problem by taking into account the CG's reaction function. Hence, the first-order condition from LGs' problem is:

$$\underbrace{\frac{-\alpha\left(\phi t+(a\phi+(1-\phi))\frac{\partial t}{\partial a}\right)}{1-a\phi t-(1-\phi)t}}_{LHS}+\underbrace{\frac{2(1-\alpha)}{t}\frac{\partial t}{\partial a}(1+s_i)+\frac{(1-\alpha)}{a_i}}_{RHS}=0.$$

Let $D = (1 - \alpha) \sum_i (p_i(1+s_i)+1$ Then, the partial derivative of t with respect to a is:

$$\frac{\partial a}{\partial t}=\frac{-\phi D}{(2\alpha+D)(a\phi+(1-\phi))^2}.$$

Substituting $\partial a/\partial t$ and t into LHS and RHS yields

$$\underbrace{\frac{\alpha\left(\frac{\phi D}{(2\alpha+D)(a\phi+(1-\phi))}-\frac{\phi D}{(2\alpha+D)(a\phi+(1-\phi))}\right)}{1-\frac{D}{2\alpha+D}}}_{LHS=0}-\underbrace{\frac{2(1-\alpha)\phi(1+s_i)}{a\phi+(1-\phi)}+\frac{(1-\alpha)}{a}}_{RHS}=0.$$

Rearranging the terms yield

$$a^*_{spillover}=\frac{1-\phi}{\phi(1+2s_i)}.$$

Assuming $a = a_i$ also implies that s_i's are identical across localities $i \in \{1, 2\}$. Therefore,

$$a^*_{spillover}=\frac{1-\phi}{\phi(1+2s)}.$$

We now substitute $a^*_{spillover}$ into the CG's reaction function

$$t = \frac{(1-\alpha)\sum_i\left(p_i\left(1+s\right)+1\right)}{(1-\phi)\left(1+\dfrac{1}{1+2s}\right)\left(2\alpha+(1-\alpha)\sum_i\left(p_i\left(1+s\right)+1\right)\right)}.$$

Simplifying the equation above yields

$$t^*_{spillover} = \frac{(1-\alpha)(1+2s)\sum_i\left(p_i\left(1+s\right)+1\right)}{2(1+\phi)(1+s)\left(2\alpha+(1-\alpha)\sum_i\left(p_i\left(1+s\right)+1\right)\right)} \text{ for } i \in \{1,2\}.$$

Proof of Proposition 3. For $\in (0, 1)$, the partial derivative of $t^*_{spillover}$ with respect to p_i is

$$\frac{\partial t^*_{spillover}}{\partial p_i} = \frac{-\alpha(1-\alpha)(2s+1)}{(\phi-1)(2\alpha+(1-\alpha)\sum_i\left(p_i\left(1+s\right)+1\right))^2} > 0.$$

Proof of Proposition 4. For $\phi \in (0, 1)$, taking the partial derivatives of $t^*_{spillover}$ and $a^*_{i,spillover}$ with respect to s yield

$$\frac{\partial a^*_{spillover}}{\partial s} = \frac{2(\phi-1)}{\phi(1+2s)^2} < 0 \text{ and}$$

$$\frac{\partial t^*_{spillover}}{\partial s} = \underbrace{\frac{(2s+1)(1-\alpha)\sum_i\left(p_i\left(1+s\right)+1\right)}{2(\phi-1)(s+1)^2\left(2\alpha+(1-\alpha)\sum_i\left(p_i\left(1+s\right)+1\right)\right)}}_{F} -$$

$$\underbrace{\frac{(1-\alpha)p_j\left(2s+1\right)+2(1-\alpha)\sum_i\left(p_i\left(1+s\right)+1\right)}{2(\phi-1)(s+1)\left(2\alpha+(1-\alpha)\sum_i\left(p_i\left(1+s\right)+1\right)\right)}}_{G} +$$

$$\underbrace{\frac{p_j\left(2s+1\right)(1-\ )\sum\left(p_i\left(1+s\right)+1\right)}{2(\phi-1)(s+1)(2\alpha+(1-\alpha)\sum\left(p\left(1+s\right)+1\right))}}_{H} > 0, \text{ where } i \neq j.$$

We want to show that $F + H < G$. Again, let $D = (1 - \alpha) \sum_i (p_i (1 + s_i) + 1)$, and also let $E = (1 - \alpha) p_j (2s + 1) (s + 1)$. Thus,

$$F + H < G \Leftrightarrow DE + 2(s + 1/2) (2\alpha + D) D < (2\alpha + D) E + 2(s + 1) (2\alpha + D) D.$$

Since $\alpha \in [0, 1]$, $F + H < G$ holds true.

Table B1: Comparing the benchmark case with the case of spillovers

	a^*		t^*		$\widehat{t}^{\,*}$		T		U^{CG}		U^{LG}		$\tilde{Y}_1 / \tilde{Y}_2$	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
P	−	0	+	+	?	+	+	+	+	+	?	?	?	?
ϕ	−	−	+	+	?	Max: 0.3–0.4	Max: 0.6	Max: 0.3	Max: 0.5	Max: 0.3	Max: 0.6	Max: 0.3	Max: 0.6	Max: 0.3

Note: (1) denotes the benchmark case. (2) denotes the spillover case.

Source: Authors' calculations

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