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Regional State Capacity and the Optimal Degree of Fiscal Decentralization*

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Abstract

We study the optimal degree of fiscal decentralization in a federation. Regional governments are characterized by their abilities to deliver public goods (administrative capacity) and to raise tax revenues (fiscal capacity). Two regimes are compared on efficiency grounds. Under partial decentralization, regional governments rely on central bailouts to complete local projects in financing needs. Under full decentralization, marginal financing is achieved via local capital taxes. We show that the presence of sufficiently low levels of administrative capacity is a necessary condition for full decentralization dominance. This condition may also be sufficient, depending on the projects' characteristics. Some extensions are presented.

Keywords: Fiscal federalism - State capacity - Partial and full fiscal decentralization - Bailouts - Hard budget constraints. **JEL Codes**: H77.

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1 Introduction

In many developed and developing countries, it is common that tax and expenditure assignments to subnational or regional governments be unbalanced. In particular, regional governments are often in charge of delivering local public services, but cannot raise the required revenues to finance these expenditures. These so called "vertical fiscal imbalances" should either be covered by centrally provided transfers, or just bypassed by decentralizing tax powers to regional governments (see, e.g., Boadway and Shah (2007)).

The first alternative is widely used in practice and gives rise to an institutional setting defined as *partial decentralization* (see Brueckner (2009)). Under this scenario, regional governments may face "soft budget constraints,"[1] which can create negative externalities across regions and induce excessive spending or borrowing.[2] To cope with this problem, a vast literature has put forward different institutional mechanisms so that local authorities face "hard budget constraints" (see, e.g., Rodden et al. (2003)). One mechanism that has attracted significant attention is the complete decentralization of tax powers to subnational governments, or *full decentralization*. In a seminal contribution, Qian and Roland (1998) argue that such a system gives rise to interregional tax competition, which in turn raises the perceived marginal costs of public funds at the regional level. The benefits from full decentralization have also been promoted by a number of international organizations, including the International Monetary Fund, the United Nations, and the World Bank (see Gadenne and Singhal (2014) for a review).

But this conventional view on the advantages of decentralization has been challenged on, at least, two grounds. First, hard budget constraints might generate inefficiencies leading to underprovision of local projects (see Besfamille and Lockwood (2008)). Second, pro-decentralization arguments usually ignore key institutional features molding regional *state capacity*, defined as the state's ability to execute policy[3] (see Prud'homme (1995), Bardhan (2002), and Bardhan and Mookherjee (2006)). The goal of this paper is to

[1] According to Kornai et al. (2003), "A budget-constrained organization faces a hard budget constraint as long as it does not receive support from other organizations to cover its deficit and is obliged to reduce or cease its activity if the deficit persists. The soft budget constraint phenomenon occurs if one or more supporting organizations are ready to cover all or part of the deficit" (page 1097).

[2] See Wildasin (1997) and Goodspeed (2002). On the empirical side, Pettersson-Lidbom (2010) finds that by going from hard to soft budget constraints, local governments in Sweden increased their debt levels by more than 20 percent on average between 1979 and 1992.

[3] This definition is in line with Besley and Persson (2010), who refer to state capacity as the "state's ability to implement a range of policies." Within the political science literature, Mann (1984) defines state capacity as the infrastructural power of the state to enforce policy within its territory. Snyder (2001) and Ziblatt (2004, 2008) apply this concept to regional governments.

integrate these elements into the normative comparison of partial and full decentralization.

We consider an environment in which regional governments decide whether or not to provide a discrete local public good or project. If the project is initiated, it is carried out by regional bureaucracies, and may or may not require an additional round of refinancing to be completed. Initiated projects which do not require refinancing are said to be completed *early* and generate a positive social benefit at the end of the initiation period. Refinanced projects yield the same social benefit but at the end of the following period. These projects are said to be completed *late*. Projects which remain incomplete produce no social benefit in either period. Regional governments have just enough resources to fund initiation costs, but need additional funds for refinancing projects. In the partially decentralized regime, no regional government has tax powers to refinance its incomplete project but the central government can bail out regions. Bailouts are financed via a uniform national tax on capital, which is imperfectly mobile. Under full decentralization, on the other hand, regional governments have to refinance incomplete projects through a tax on capital invested in their jurisdiction, in a context of tax competition. Equilibrium outcomes under partial and full decentralization can be inefficient. In particular, the former can generate overprovision of projects, while the later can produce underprovision, refinancing distortions, or other deadweight losses associated to tax competition. The optimal institutional regime is the one that generates less inefficiencies in equilibrium.

Crucially, we distinguish between two dimensions of local state capacity: *administrative* and *fiscal* (see Section 1.1). Administrative capacity measures the ability of subnational governments to produce and deliver public goods and services, and it is proxied by the probability that a project is finished early. Fiscal capacity gauges the ability to raise revenues through local taxes, and it is modeled as the fraction of the potential tax base that ends up as fiscal revenues of the subnational governments. The model is symmetric *ex ante*, in the sense that all regional governments share the same level of state capacities, and all costs and benefits are identical across regions. However, outcomes can be different *ex post* because some projects might be completed earlier than others.

Our main results indicate how the optimal degree of decentralization hinges on the relative magnitudes of each dimension of state ability. First, we show that when the level of regional fiscal capacity that prevails in the federation is sufficiently low, partial decentralization typically dominates.[4] Basically, when fiscal ability is low, refinancing

[4]As explained in the body of the paper, this is *always* the case whenever expected refinancing costs are

incomplete projects under full decentralization is too costly regardless of the level of regional administrative capacity. Second, and more surprisingly, we find that the presence of sufficiently low levels of administrative ability is a necessary condition for full decentralization dominance. Moreover, when expected refinancing costs are high enough, such a condition is also sufficient. The intuition for this second result is less clear cut, because *both* institutional regimes generate inefficiencies when local governments lack high administrative capacity. Nevertheless, we can still show that, in this case, the magnitude of the distortions under full decentralization tends to be smaller than under partial decentralization. The key mechanism is that tax competition distortions under full decentralization can only emerge if at least one region needs no refinancing (so that equilibrium capital flows are positive), but the likelihood of this event is small when the level of administrative ability prevailing in the federation is low. This finding contradicts the views of certain policy proposals suggesting that high levels of administrative capacity are necessary for successful decentralization reforms (see, among others, Bird (1995) and Loayza et al. (2014)).

We close by analyzing two extensions. The first extension incorporates imperfect fiscal capacity at the central level. We find that, somewhat counterintuitively, lower levels of national fiscal ability might favor partial over full decentralization. While reducing national fiscal capacity would lead costlier bailouts and underinvestment in partial decentralization, the number of inefficiently initiated projects would also decrease under this system. Hence, for a given profile of regional state abilities, the overall effect on the optimal regime choice is, in principle, ambiguous.

In the second extension, we relax the assumption by which the central government can perfectly commit to full decentralization, i.e., we allow for the possibility of bailouts under that system. We draw two major findings. First, perfect commitment is not a necessary condition for our main results to go through. In particular, even in the presence of uncertainty about the commitment capacity of the central government, full decentralization dominates in a parametric area for administrative and fiscal capacities which is analogous to the one in our base model. Second, we find that small deviations from perfect commitment of the center actually make full decentralization more attractive. This is because lower commitment capacity at the central level also leads to smaller refinancing inefficiencies under full decentralization.

also sufficiently low.

1.1 Administrative vs. Fiscal Capacities: Background

Disaggregating state capacity into multiple dimensions is common place among political scientists (see Hanson and Sigman (2013) or Cingolani et al. (2015) for surveys). Sckocpol (1985), for example, argues that "(...) one of the most important facts about the power of a state may be its *unevenness* across policy areas" (page 17). More recently, Soifer (2012) also casts doubt on the validity of unidimensional measures of state capacity. In this paper, we focus on two particular dimensions of regional state capacity, administrative and fiscal, which shape the spending and taxing abilities of regional governments (authors within political science usually isolate the *coercive* ability of the state as well, which we abstract from).

The distinction between administrative and fiscal capacities relies either on case studies or on empirical work. Hanson (2015) provides an example of the first approach and asserts that "(...) the coercive and extractive capacities of the Moroccan state are more developed than its administrative professionalism" (page 327). The author mentions that while Moroccan's capacities to control its territory and to extract tax revenues unfolded during the French colonial rule, its administrative ability still falls behind, as evidenced by its high rates of infant mortality. On the empirical side, Gingerich (2013) argues that national-level capacity measures do not properly approximate the capacity of state agencies executing different functions. He uses survey data for Bolivia, Brazil, and Chile between 2003-2005.

The works just mentioned do not justify the disaggregation of state capacities at the *regional* level. We partially address this issue in Appendix A. There we present an illustrative example for the U.S. States where the correlation between different measures of regional administrative and fiscal capacities is weak.

1.2 Related Literature

This paper is related to various strands of literature. First, other contributions have compared partially and fully decentralized regimes in different contexts. For example, Brueckner (2009) uses a Tiebout-type model, while Peralta (2011) analyzes a political economy setting in which local politicians can be either benevolent or rent-seekers. In the former, full decentralization always dominates (where feasible) as it provides better preference matching. In the latter, full decentralization is the preferred regime as long as the proportion of rent seekers is low.[5] The main difference between our paper and these contributions is that we study a different trade-off between partial and full decentralization. That is, we identify the appropriate balance between inefficient bailouts and project overprovision vs. capital tax competition and project underprovision. Moreover, neither of the previous articles incorporate regional state capacity into the analysis.

The paper is also related to a set of contributions that analyze the advantages and disadvantages of different types of regional budget constraints in federations. The optimality of hard budget constraints has been studied by Qian and Roland (1998) and Inman (2003); whereas the possibility that they may be inefficient has been raised by Besfamille and Lockwood (2008). Our framework differs from the one in this last paper in, at least, three important ways. First, our main focus is to study to what extent is fiscal decentralization more/less desirable in the face of limited regional state capacity, which we break down into two types. Besfamille and Lockwood (2008), on the other hand, do not analyze how the optimal regime changes across different dimensions of regional state ability. Second, unlike in that paper, we do not compare the performances of soft and hard budget constraints, but of two fiscal decentralization regimes with well-defined allocations of tax powers across central and regional governments. Finally, we compare regimes from an *ex ante* perspective (i.e., before the uncertainty on the characteristics of local projects is revealed), and not from an *interim* viewpoint, as that contribution does.

Wildasin (1997), Goodspeed (2002), Akai and Sato (2008) and Crivelli and Staal (2013) describe how bailouts in federations distort, via a common-pool fiscal externality, decisions at the regional level. Silva and Caplan (1997), Caplan et al. (2000), and Köthenbürger (2004) claim that a regime with decentralized leadership, where the central government sets intergovernmental transfers after regional governments have adopted their own policy, may give a more efficient outcome than a regime with hard budget constraints. This result relies on a second best argument, and thus needs some pre-existing distortion in the form of public goods or tax spillovers to hold. Sanguinetti and Tommasi (2004) analyze the trade-off between hard and soft budget constraints, although in the "rules vs. discretion" tradition.

[5]Other authors have considered environments where partial decentralization is the optimal regime, but they adopt different definitions for partial decentralization. Janeba and Wilson (2011), and Hatfield and Padró i Miquel (2012), for example, define partial decentralization as a regime in which a subset of public goods are exclusively funded and provided by local governments. Joanis (2014), on the other hand, defines partial decentralization as "shared responsibility," that is, an institutional regime where both the central and the regional government participate in the funding of a given public good.

The layout of the remainder of the paper is as follows. Section 2 presents the model. Section 3 analyzes the regime of partial decentralization. In Section 4 we study the equilibrium under full decentralization. Section 5 analyzes the sources of inefficiencies under each regime. Section 6 discusses the optimal regime and comparative statics. Section 7 presents the extensions with imperfect national fiscal capacity and imperfect commitment, and Section 8 concludes. The main proofs are contained in the Appendix. Additional proofs and derivations are relegated to the Online Appendix.

2 The Model

The economy lasts for three periods, $t = \{1, 2, 3\}$, and is composed of $L \geq 2$ regions indexed by $\ell \in \{1, ..., L\}$. Each region has a continuum (measure one) of risk-neutral, immobile residents, each of whom has an endowment κ of capital. We consider a federation with two levels of benevolent governments, central and regional, which choose policies to maximize the sum of utilities of their residents over the three periods. Residents do not discount future payoffs and derive utility from consumption of a numéraire good in the last period. The numéraire is produced in every region by competitive firms that operate a constant returns technology. Capital is the only input and units are chosen so that one unit of capital produces one unit of output. Following Persson and Tabellini (1992), we assume that capital can move between regions, but at a cost. Specifically, a resident of a region that invests f units of capital in other region(s) incurs a mobility cost $f^2/2$.

Residents also derive utility from discrete local public goods, or projects, which are provided by the regional governments. Projects require an initiation cost c_0, and may or may not require a second round of financing to be completed. The determination of the refinancing round will be explained below.

Initiated projects which do not require additional funds to be finished yield a social benefit $b > 0$ within a region at the end of the initiation period. Otherwise, projects generate no benefit in the initiation period and require an additional refinancing cost c to be completed. This refinancing cost not only incorporates the technical cost of completion, but also other costs on the population associated with the delay of the project (e.g., an incomplete park may affect pedestrian movement).[6] We assume that c is distributed according to the probability density function $h(c)$ with full support on $[0, b]$. If refinanced,

[6]Delays in local public works are prevalent both in developed and in developing countries. See Guccio et al. (2014).

the project generates social benefit b at the end of the following period; if not, the project remains incomplete and produces no social benefit. It is worth emphasizing that, by construction, $c \leq b$; otherwise, continuation would never be optimal. Henceforth, we say that a project is completed *early* (*late*) if it has been finished at the end of the initiation (following) period. Project outcomes (i.e., whether projects are completed or not at the end of the initiation period) are independent and observable across regions. For technical reasons, we also assume that projects' benefits are sufficiently large:

Assumption 1. $b \geq 2c_0$.

In words, we assume that the benefit-cost ratio is larger than two. This condition considerably simplifies the analysis in the following sections.[7]

While all regional governments have just enough resources to pay for the initiation cost c_0, they need additional revenue to fund the continuation cost c. We consider *two* institutional regimes, depending on which level of government makes the continuation decision for projects which need to be refinanced. Under *partial decentralization* (PD), the central government decides on refinancing incomplete projects through a uniform tax τ on the national stock of capital. Under *full decentralization* (FD), continuation decisions are made by regional governments. To refinance, local authorities use a per unit tax levied on capital invested in their regions at the rate τ_ℓ.

2.1 Regional State Capacities

Regional governments are characterized by two dimensions of state capacity: *administrative* and *fiscal*. The former measures the ability of regional bureaucracies to deliver public goods, and is encapsulated by the probability of completing a project early $\pi \in [0, 1]$.[8] In contrast, fiscal capacity gauges the ability to collect tax revenues. This is summarized by the fraction of the potential tax base which can actually be collected via regional taxes,

[7] Under Assumption 1, the equilibrium expected welfare curve under partial decentralization becomes linear and increasing in administrative capacity π. This feature simplifies the characterization of the optimal regimes across (π, θ), and it is the main reason why Assumption 1 is made (see Section 2 in the Online Appendix for a discussion). Nevertheless, it is worth pointing out that a benefit-cost ratio larger than two is a fairly plausible figure. For example, according to the "Construction Performance Guidelines," the U.S. Army Corps of Engineers only funds projects which economic return displays a benefit-cost ratio of 2.5-to-1 or higher (calculated at a 7-percent discount rate). See `http://cdm16021.contentdm.oclc.org`.

[8] Loayza et al. (2014) quantitatively evaluate how local capacity affects municipal budget execution rates in Peru, among other things. Patil et al. (2013) document that public projects' delays in Indian states are mainly caused by administrative problems that arise during the land acquisition process.

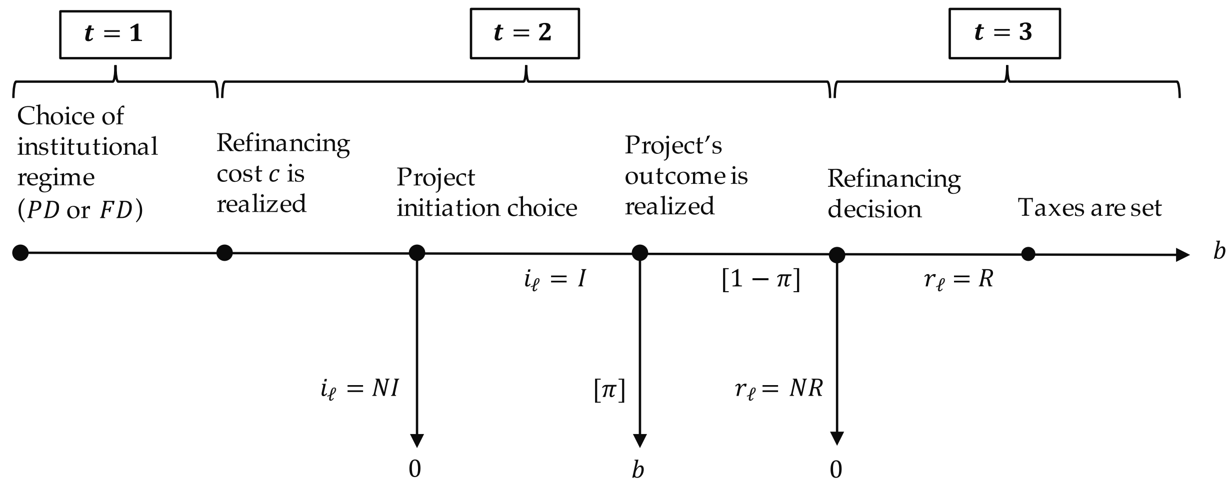


Figure 1: Timing in the model. Values in terminal nodes represent the benefit of the project. $i_\ell = I$ $(= NI)$ if region ℓ initiates (does not initiate the project). $r_\ell = R$ $(= NR)$ if region ℓ refinances (does not refinance the project).

henceforth denoted $\theta \in [0, 1]$. All regional governments share the same exogenous levels of state capacities π and θ.[9]

2.2 Timing

The order of events is as follows. At $t = 1$, a political body (e.g., the Congress) chooses the type of tax decentralization, i.e., PD or FD. At the beginning of $t = 2$, the refinancing cost c (common across regions) is realized, and regional governments decide whether or not to initiate projects. Projects are completed early with probability π and generate payoff b at the end of this period.

At the beginning of $t = 3$, central or regional governments (depending on the institutional regime in place) decide whether to shut down or continue projects in financing needs. Once taxes are set, capital owners invest in the region(s) with the highest net return(s), central or regional governments raise their taxes, production takes place, and private consumption (net of mobility costs) occurs.[10] Projects which are completed late yield social benefit b at the end of period $t = 3$. We summarize the timing in Figure 1.

[9] Our model focuses on the role of initial conditions regarding state capacity in the choice of the optimal decentralization regime. We leave aside the question of how different decentralization regimes influence state capacity formation.

[10] Such a timing is also common in the literature on tax competition. See Wilson (1999) for a survey.

2.3 Discussion

Before putting the model to work, we discuss some of its features.

Local Capital Taxes. Our focus on capital taxes at the local level is in line with Qian and Roland (1998) and with the bulk of the literature on tax competition, following Zodrow and Mieszkowski (1986) and Wilson (1986). Subnational capital taxes are also widespread in practice. One reason is that property tax codes (e.g., in the US) do not commonly distinguish between the values of capital and land when assessing the tax base (see Wilson (1999)). Other local fiscal instruments beyond property taxes are sometimes regarded as taxes on mobile capital as well. This interpretation applies to the local business tax (*Gewerbesteuer*) in Germany, which is the main source of tax revenue for German municipalities.

Central Government Features. Certain characteristics of the central authority in our model deserve further comment. First, along the lines of the seminal contribution of Oates (1972), we assume that national taxation under partial decentralization is uniform across regions. As common in the literature following Oates (1972), if one allowed national taxes to be non-uniform (for example, if taxes were contingent on the regions requiring additional funds), the central government would be able to replicate the first best outcome. But if that was the case, it would certainly be pointless to compare partial and full decentralization, which is one of the main goals of this paper. The assumption of uniform national taxation has a counterpart in many federal countries where, due to constitutional reasons, national taxes (like the income tax or the VAT) are required to be set uniformly across subnational governments.[11]

Second, the central government cannot deliver local public projects. Put differently, expenditure powers are *fully* decentralized. This assumption is motivated by the empirical fact that tax autonomy is much less decentralized than expenditure authority. Across OECD countries, for example, the sub-central share of consolidated government expenditure averaged around 33% in 2014, while the sub-central share in total own revenue was only about 19% for that year (these shares were relatively stable over the last two decades; see OECD/KIPF (2016)).

Third, in our baseline model we assume that the central authority is fully efficient along its fiscal ability, and that it can perfectly commit not to bailout regions under FD.

[11] Among developed countries, U.S., Australia, and Switzerland incorporate uniformity of national taxation explicitly in their constitutions. Analogous examples among developing countries include Argentina, Brazil, and South Africa.

These two assumptions are relaxed in Sections 7.1 and 7.2, respectively.

Nature of Public Projects. We consider a discrete, regional public project, instead of a continuous public good as it is common in most of the literature on tax competition.[12] Examples of discrete public goods abound in reality. In fact, many infrastructure projects, such as bridges, tunnels, roads, airports, or stations, can be considered discrete. From a technical standpoint, indivisibility fixes the type of competition between regions. As in Wildasin (1988), regions compete in refinancing decisions first, and then taxes are set accordingly in a context of imperfect capital mobility.[13] Moreover, this assumption combined with our specification of administrative competence is a simple way to analyze, via refinancing decisions, the interaction between levels of regional state capacity and different intergovernmental fiscal arrangements.

It is also worth stressing that the realization of the refinancing cost c is unknown in the first period. We make this assumption to introduce uncertainty around the characteristics of the projects when the institutional regime is chosen. We believe this is a realistic feature, since decentralization regimes are not typically project-based. Moreover, in a repeated version of the model, changing the institutional regime after each realization of c would be too costly.

Finally, even though projects in the model are *ex ante* and *interim* identical, they are *ex post* heterogeneous. Ex ante (i.e., in period 1), projects share the same social benefit b, investment cost c_0, and probability density function $h(c)$. Interim (i.e., at the beginning of period 2), the cost c is realized and applies to *all* projects in *all* regions alike. Ex post, though, heterogeneity is possible since project outcomes can be different across regions.

3 Partial Decentralization

This section studies the partially decentralized regime. Given that $c \leq b$ by construction, incomplete projects are always refinanced by the central government under this regime. Consequently, project initiation decisions of any given region may ultimately impact other regions. This gives rise to a simultaneous game between regions in the second period (i.e., when the initial investment decision is made).

[12] Cremer et al. (1997), Lockwood (2002), and Besfamille and Lockwood (2008) are other contributions to the local public finance literature which deal with discrete projects.

[13] Akai and Sato (2008) and Köthenbürger (2011) also analyze models with this timing, but they consider income or wage taxation instead.

Let $i_\ell \in \{I, NI\}$ denote region ℓ's initiation decision, where I (NI) denotes initiation (no initiation). Region ℓ's expected welfare at the beginning of the second period is given by

$$\mathbb{E}W_\ell^{PD}(i_\ell, \boldsymbol{i_m}) = \kappa(1-\tau^e) + \mathbb{1}_{\{i_\ell = I\}}[b - c_0], \tag{1}$$

where $\boldsymbol{i_m}$ is the vector of investment decisions adopted by all other regions $m \neq \ell$, $\mathbb{1}_{\{i_\ell = I\}}$ is equal to 1 if region ℓ has initiated the project and to 0 otherwise, and τ^e is the expected tax, which satisfies:

$$\tau^e L\kappa = \left[\sum_\ell \mathbb{1}_{\{i_\ell = I\}}(1-\pi)\right] c, \tag{2}$$

where the term in square brackets gives the expected number of bailouts.[14]

Substituting (2) into (1) and rearranging, we obtain

$$\mathbb{E}W_\ell^{PD}(i_\ell, \boldsymbol{i_m}) = \kappa + \mathbb{1}_{\{i_\ell = I\}}\left[b - c_0 - (1-\pi)\frac{c}{L}\right] - (1-\pi)\frac{c}{L}\sum_{m\neq\ell}\mathbb{1}_{\{i_m = I\}}. \tag{3}$$

By inspection of (3), the effect of i_ℓ on $\mathbb{E}W_\ell^{PD}$ (captured by the term in square brackets) is independent of $\boldsymbol{i_m}$. Hence, we can analyze the choice of i_ℓ by focusing on a representative region ℓ. Additionally, it is worth noting that each region only pays $1/L$ of the cost of refinancing its incomplete project, as this cost is shared through national taxation. In this sense, the central government's budget constraint generates a *common-pool fiscal externality*: any resident of ℓ is negatively affected by the possibility of an incomplete project in region $m \neq \ell$.

The next proposition characterizes project initiation decisions under partial decentralization.

Proposition 1. *Consider the project initiation game under PD. The unique equilibrium in dominant strategies is such that all regions initiate projects.*

[14] The expected tax τ^e is obtained as follows. Let ω be a profile of project outcomes at the end of $t = 2$, and denote by n_ω the corresponding number of completed projects. For a given profile ω, at the beginning of $t = 3$ the central government sets a tax τ_ω to cover the cost of refinancing $\sum_\ell \mathbb{1}_{\{i_\ell = I\}} - n_\omega$ incomplete projects. As this tax is uniform and exporting capital is costly, every household will invest in its own region. This implies that the tax base is $L\kappa$ and that national taxation is non-distortionary, since the aggregate capital stock is fixed. Hence, under profile ω, the central government's budget constraint is

$$\tau_\omega L\kappa = \left[\sum_\ell \mathbb{1}_{\{i_\ell = I\}} - n_\omega\right] c,$$

and the expected tax is given by $\tau^e = \mathbb{E}_\omega \tau_\omega$.

Proof. See Appendix B.1. □

The proof relies on the fact that, as long as $b \geq 2c_0$ and $L \geq 2$, initiating the project is a dominant strategy regardless of the value of c.

4 Full Decentralization

Having described partial decentralization, we now turn to analyze the fully decentralized regime. In this case, a three-stage simultaneous game between regions emerges. First, regional governments take the initial investment decision. Second, the continuation decision is made. Finally, refinancing is achieved by levying regional capital taxes, in a context of tax competition. We solve this game by backwards induction.

4.1 Tax Competition

Before characterizing the equilibrium in tax rates, it will be convenient to describe how capital is allocated based on a tax profile $\boldsymbol{\tau} = \{\tau_1, ..., \tau_L\}$. The household's investment decision can be summarized as follows:

Lemma 1. *Let $f_{\ell m}$ denote the amount of capital that residents of region ℓ invest in region $m \neq \ell$, and let $\widetilde{\tau}_\ell \equiv \min\{\tau_m\}_{m \neq \ell}$ be the minimum tax rate across all regions excluding ℓ.*

1. *If region ℓ sets its capital tax above the minimum tax rate, $\tau_\ell \geq \widetilde{\tau}_\ell$, region ℓ experiences capital outflows in the amount $\sum_{m \neq \ell} f_{\ell m} = \tau_\ell - \widetilde{\tau}_\ell \geq 0$. Moreover, capital only flows from ℓ towards the regions setting the minimum tax rate, so that $f_{\ell m} = 0$ if $\tau_m \neq \widetilde{\tau}_\ell$.*

2. *If region ℓ sets its capital tax strictly below the minimum tax rate, $\tau_\ell < \widetilde{\tau}_\ell$, region ℓ experiences no capital outflows, so that $f_{\ell m} = 0$ for all $m \neq \ell$.*

Proof. See Appendix B.2. □

According to Lemma 1, the household's portfolio decision is fully determined by comparing τ_ℓ only against $\widetilde{\tau}_\ell$, and not against the whole profile of tax rates chosen by regions $m \neq \ell$. In particular, the size of the total capital outflow from a given region is independent of the number of regions with zero capital tax rates.[15] It should also be noted that

[15] Two assumptions underlie this result: constant marginal productivity of capital, and the fact that mobility costs are independent of the distribution of capital flows. Relaxing either of these assumptions could lead to capital outflows being linked to the number of regions with zero taxes. This would substantially increase the complexity of the characterization of the *FD* regime.

capital inflows to region ℓ do not benefit residents of ℓ directly. This is because the returns from these investments are consumed abroad, and there is no immobile production factor. The following proposition characterizes the equilibria of the tax competition subgame:

Proposition 2. *Consider the tax competition subgame under FD. Nash equilibria are as follows:*

1. *If all regions refinance incomplete projects, then the unique symmetric Nash equilibrium in pure strategies is such that all regions set the tax rate $\tau_\ell = c/(\theta\kappa) \equiv \tau_\ell^{sym}$.*

2. *Otherwise, all ℓ-regions that refinance set the tax rate*

$$\tau_\ell^{asym} \equiv \frac{1}{2}\left[\kappa - \sqrt{\kappa^2 - (4c/\theta)}\right].$$

Proof. See Appendix B.3. □

Consider the tax competition subgame that emerges when all regions have decided to refinance their incomplete projects. In this case, all regions set $\tau_\ell^{sym} = c/(\theta\kappa)$ in equilibrium, which corresponds to the rate that regional governments would choose in autarky. By Lemma 1, this implies that there are no capital flows in equilibrium. Moreover, imperfect fiscal capacity (i.e., $\theta < 1$) implies that regions do not only have to cover the technical cost of completing the project c, but a higher effective refinancing cost c/θ.

The proposition also shows that, when at least one region does not refinance, asymmetric taxation emerges in equilibrium, as in Bucovetsky (1991) and Wilson (1991).[16] Just like τ_ℓ^{sym}, the tax rate τ_ℓ^{asym} decreases with θ, but it is strictly greater than τ_ℓ^{sym},[17] and it leads to a capital outflow in the amount $\sum_{m\neq\ell} f_{\ell m} = \tau_\ell^{asym}$. Regional welfare in equilibrium if the region refinances is thus

$$W_\ell^{FD} = \kappa - c_0 + b - \underbrace{\left[\frac{c}{\theta} + \frac{(\tau_\ell^{asym})^2}{2}\right]}_{\equiv T(c,\theta)},$$

[16] The main difference with their result is that variations in tax rates across regions are not originated from ex ante regional asymmetries. Instead, asymmetric taxation emerges here because some regions may end up with incomplete projects ex post.

[17] The intuition behind $\tau_\ell^{asym} > \tau_\ell^{sym}$ is that if the tax base erodes due to capital outflows, refinancing regions can only increase their tax rates to meet the refinancing cost c.

where $T(c, \theta)$ measures the total refinancing cost. This cost incorporates the effective refinancing cost c/θ *and* the deadweight loss $(\tau_\ell^{asym})^2/2$, which arises due to capital mobility. Importantly, the likelihood of having positive capital flows in equilibrium depends upon the level of regional administrative capacity π.

4.2 Refinancing Decision

Next we analyze the Nash equilibria which emerges at the beginning of $t = 3$. At that stage, regional governments play a refinancing subgame in which each region decides whether to shut down or continue incomplete projects.

To proceed, we need to define the cutoff costs $c_1(\theta)$ and $c_2(\theta)$, which are linked to the level of fiscal capacity θ. The threshold $c_1(\theta)$ equalizes the project's benefit b and the total refinancing cost $T(c, \theta)$ faced when *at least one* region does not refinance. $c_2(\theta)$, on the other hand, is the break-even cost that balances b and the total refinancing cost c/θ faced when *all* regions refinance. Clearly, $c_2(\theta) > c_1(\theta)$ because, when some region does not refinance, capital flight adds a deadweight loss. Proposition 3 characterizes equilibria of the refinancing game.

Proposition 3. *Consider the refinancing subgame under FD. Depending on the realization of the refinancing cost c, Nash equilibria are as follows:*

1. *If $c < c_1(\theta)$, regions facing incomplete projects refinance.*

2. *If $c > c_2(\theta)$, regions facing incomplete projects do not refinance.*

3. *Otherwise, regions facing incomplete projects refinance if and only if all regions face incomplete projects.*

Proof. See Appendix B.4. □

In the first and second cases, refinancing and not refinancing, respectively, are dominant strategies. This follows from the definitions of $c_1(\theta)$ and $c_2(\theta)$.

Now consider the third case, under which $c_1(\theta) \leq c \leq c_2(\theta)$. When at least one region has completed a project early, no region refinances. This is because $c \geq c_1(\theta)$, so that the benefit would not cover the total refinancing cost including deadweight losses. When all regions face incomplete projects, on the other hand, a coordination game with two possible Nash equilibria emerges: either all regions refinance, or no region does. In the first equilibrium, there are no capital flows and, hence, no deadweight losses due to distortionary taxation. However, if at least one region decided not to refinance, the other regions would also shut down their projects since $c \geq c_1(\theta)$, which leads to the second equilibrium. We select the Nash equilibrium in which all regions refinance because it is the only one which is *strong* in the sense of Aumann (1959).

A key difference with the PD regime is that not all incomplete projects are being refinanced under FD. The reason is that, in contrast to national taxation, regional taxation is distortionary. Particularly, regional taxation gives rise to deadweight losses due to two assumptions: factor mobility and imperfect fiscal capacity. To clarify this point, it is helpful to see how departing from either of those assumptions would impact the cost thresholds featured in Proposition 3. If the taxable factor was immobile, the local tax base would be fixed at the capital endowment κ, and refinancing regions would set the autarky tax $\tau_\ell = c/(\theta\kappa)$. Hence, the cost threshold $c_1(\theta)$ would coincide with $c_2(\theta)$. On the other hand, if local fiscal capacity was perfect (i.e., if $\theta = 1$) we would have $c_2(\theta) = b$. Altogether, capital immobility coupled with $\theta = 1$ would yield $c_1(\theta) = c_2(\theta) = b$. In that case, all incomplete projects would be refinanced, as regional governments would have access to non-distortionary taxation.

4.3 Project Initiation

We close this section by discussing the project initiation decision under FD.

Proposition 4. *Consider the project initiation game under FD. Given administrative and fiscal capacities (π, θ), there exists a threshold $c^{FD}(\pi, \theta)$ such that initial investment takes place in all regions if and only if the refinancing cost satisfies $c \leq c^{FD}(\pi, \theta)$. Otherwise, no region invests in equilibrium.*

Proof. See Appendix B.5. □

For a given level of the refinancing cost, the initiation decision under FD is shaped by the configuration of fiscal and administrative capacities. This establishes a key difference between PD and FD regimes: while under the former all projects are initiated (see Proposition 1), only some of them receive initial funding under the latter.

To conclude this section, Figure 2 summarizes the content of Proposition 3 and Proposition 4, i.e., refinancing and initiation decisions under FD. To draw this picture, we assume that sufficient conditions for $c^{FD}(\pi, \theta)$ to be increasing in π hold, and that the intercept of this cost threshold is below $c_1(\theta)$.[18] We should also note that when $\pi \geq c_0/b$,

[18]See Appendix B.5 for details. Neither of these assumptions are essential to our results.

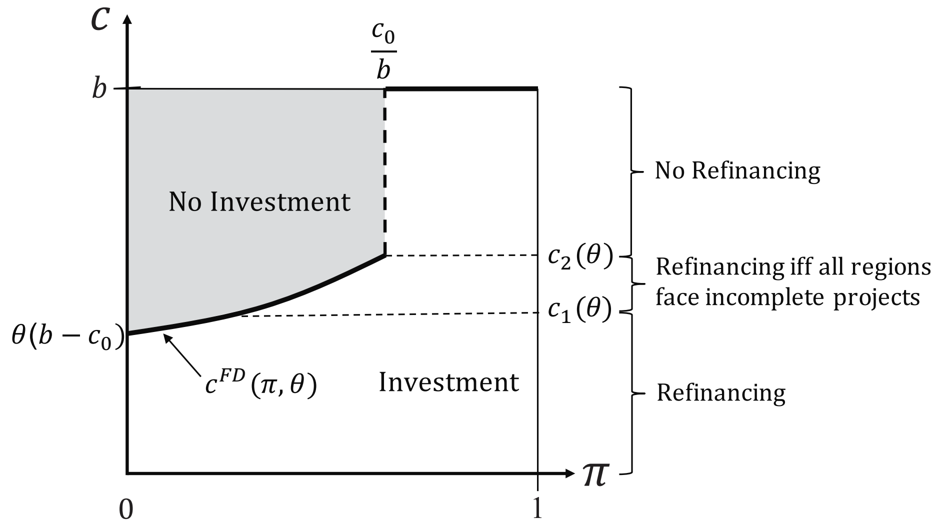


Figure 2: Investment and refinancing decisions under full decentralization as a function of state capacities (π, θ), the refinancing cost c, and other parameters.

the initial investment cost is smaller than the expected return from initiating a project and shutting it down if it needs refinancing. In that case, investment at $t = 2$ is optimal regardless of the realization of c.

5 Interim Inefficiencies

The ultimate goal of this paper is to provide a normative comparison between partial and full decentralization from an *ex ante* perspective, i.e., *before* the refinancing cost c is realized. As pointed out previously, we adopt such a criterion to introduce uncertainty around the characteristics of the projects at the constitutional stage (see Section 2.3). In this section, we take a preliminary step towards understanding the ex ante comparison between regimes. Specifically, for each regime, we isolate the sources of *interim* inefficiencies emerging for a *given* realization of c. This exercise allows us to build intuition, which we carry over to the remainder of the paper.

5.1 First Best

We begin by analyzing the first best benchmark. Consider a social planner who maximizes the sum of utilities of the residents in the federation. The planner makes all decisions, but cannot anticipate whether a project will be completed at the end of $t = 2$ (she has to carry out projects through the regional bureaucracies).

Due to risk neutrality and the fact that the planner maximizes the sum of utilities, optimal refinancing decisions are independent across regions. Hence, continuing incomplete projects is always optimal because $c \leq b$. Moving back to the initial investment decision, the planner initiates projects provided their expected benefit is higher than their expected cost (which includes a possible second round of financing). Let

$$c^*(\pi) \equiv \frac{b - c_0}{1 - \pi}$$

denote the refinancing cost that makes the net expected regional payoff from initiating a project equal to zero. The efficient investment rule follows immediately from the definition of $c^*(\pi)$:

Lemma 2. *For any given region, initial investment is efficient if and only if the refinancing cost satisfies $c \leq c^*(\pi)$.*

5.2 Partial Decentralization

Proposition 1 and Lemma 2 imply the following:

Corollary 1. *Under PD, regions may invest in equilibrium when it is inefficient to do so.*

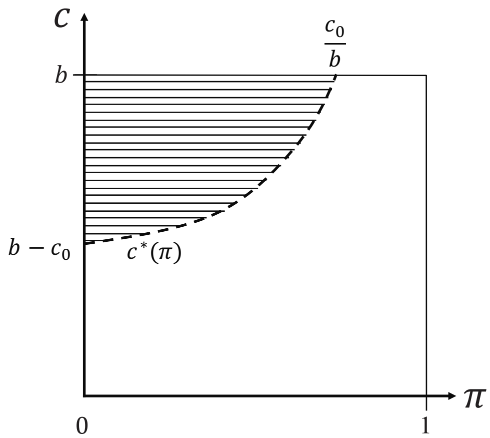
Inefficiencies under *PD* involve *overinvestment*. This result is driven by the well known common-pool fiscal externality (see Wildasin (1997) and Goodspeed (2002)). The horizontally striped area in Figure 3a depicts overinvestment inefficiencies under *PD*. For $\pi \geq c_0/b$, *PD* replicates first best initiation decisions for all c. When $\pi < c_0/b$ initiation decisions are optimal provided $c \leq c^*(\pi)$. Otherwise, projects are initiated under *PD* despite of generating negative expected payoff in equilibrium.

5.3 Full Decentralization

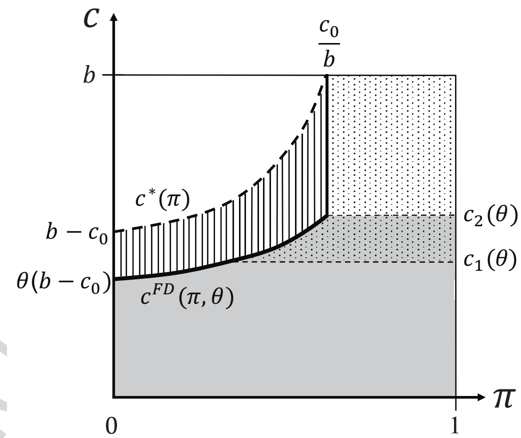
It can be shown that the cost threshold $c^{FD}(\pi, \theta)$ defined in Proposition 4 is below $c^*(\pi)$. As a consequence, the *FD* regime displays the following types of inefficiencies:

Corollary 2. *Under FD, equilibrium outcomes can be inefficient for three reasons:*

1. *Regions do not make initial investments in equilibrium when it is efficient to do so.*



(a) Partial Decentralization.



(b) Full Decentralization.

Figure 3: Interim inefficiencies under each regime: overinvestment (horizontally striped area), underinvestment (vertically striped area), no refinancing (dotted area), and distortionary refinancing (grey area).

2. *Incomplete projects are not refinanced in equilibrium when it is efficient to do so.*

3. *Refinancing incomplete projects generates deadweight losses.*

Proof. See Appendix B.6. □

Figure 3b illustrates the types of interim inefficiencies under the FD regime.[19] The striped area corresponds to the underinvestment inefficiency, as per case 1 in Corollary 2. Cases 2 and 3 are represented with a dotted pattern and with a grey background, respectively. Notably, when $c_1(\theta) \leq c \leq c_2(\theta)$, either case 2 or case 3 can emerge, depending on the profile of project outcomes at the end of $t = 2$ (see Proposition 3).

The third type of inefficiency in Corollary 2 deserves further comment. As explained in Section 4.2, deadweight losses from regional taxation can emerge for two reasons. First, since local tax authorities have imperfect fiscal capacity, they need to collect at least $c/\theta > c$ to refinance a project. Second, interregional capital mobility may render local capital taxes distortionary too. When $c < c_1(\theta)$, both of these channels can operate. When $c_1(\theta) \leq c \leq c_2(\theta)$ and all regions refinance, only the first channel is at work.

[19]The first and second types of inefficiencies resemble analogous results in Zodrow and Mieszkowski (1986) and Besfamille and Lockwood (2008), respectively. It is also worth noting that FD would replicate the first best if capital was immobile and fiscal capacity was perfect. In that case, regional taxation would be non-distortionary, as discussed in Section 4.2. As a consequence, all incomplete projects would be refinanced and regions would only initiate projects which yield positive net expected payoffs (so that the relevant cost threshold would be $c^*(\pi)$, as in the first best).

6 Optimal Institutional Regime

The institutional choice between partial and full decentralization takes place in the initial period, before the realization of the refinancing cost c. Knowing the values of all other parameters in the model, the Congress at this stage chooses the regime that maximizes expected welfare in equilibrium. Next we evaluate how the optimal regime choice is affected by the levels of regional state capacity (π, θ).

Let $\mathbb{E}\widehat{W}^{\mathcal{R}}(\pi, \theta)$ denote the equilibrium level of expected welfare at time $t = 1$ under regime $\mathcal{R} \in \{PD, FD\}$, given state capacities (π, θ).[20] The comparison between $\mathbb{E}\widehat{W}^{FD}$ and $\mathbb{E}\widehat{W}^{PD}$ across (π, θ) is not a priori evident. On the one hand, higher values of θ would push for FD dominance since $\mathbb{E}\widehat{W}^{FD}$ increases and $\mathbb{E}\widehat{W}^{PD}$ remains constant when θ grows. On the other hand, expected welfare under *both* regimes can increase with π.[21] The next proposition characterizes the optimal regime.

Proposition 5. *There exists a unique frontier $\widehat{\pi}(\theta) \in [0, c_0/b)$ which increases with fiscal capacity θ, such that FD dominates if and only if administrative and fiscal capacities (π, θ) satisfy $\pi \leq \widehat{\pi}(\theta)$. Moreover, if the expected refinancing cost $\bar{c} \equiv \int c\, h(c)dc$ is higher than $(b - c_0)$, then $\widehat{\pi}(0) > 0$ and, hence, FD dominates for all θ if π is sufficiently low.*

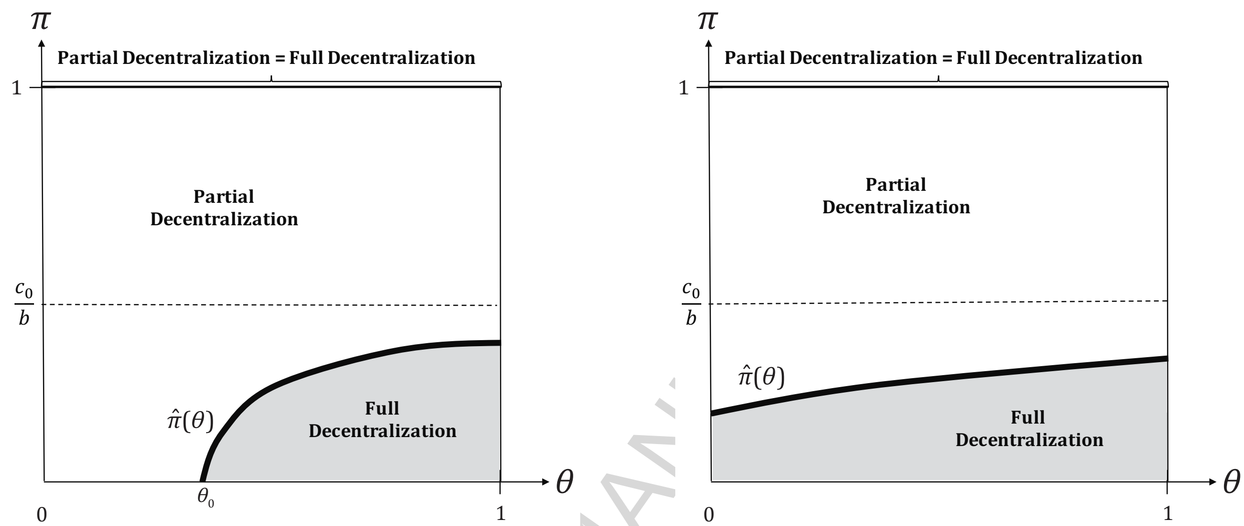
Proof. See Appendix B.7. □

Figure 4 illustrates these results. In either panel, a point in the (θ, π) plane represents a particular configuration of regional state capacities in the federation. FD is the preferred regime below the frontier $\widehat{\pi}(\theta)$. PD dominates elsewhere except at $\pi = 1$, where both regimes replicate the first best and, hence, are equivalent. By Proposition 5, we can isolate two scenarios depending on whether the expected refinancing cost $\bar{c}$ is above or below $(b - c_0)$. In particular, if $\bar{c} < b - c_0$ the locus $\widehat{\pi}(\theta)$ crosses the horizontal axis at $\theta_0 > 0$, as in the left panel. We also include the threshold $\pi = c_0/b$ in the figures to facilitate intuition in the next discussion.

Consider Figure 4a and assume that $\pi < c_0/b$. As expected, FD is optimal only when regional fiscal capacity is relatively high: when $\theta < \theta_0$, refinancing incomplete projects under FD is too costly, so PD dominates. More surprisingly, FD dominance also requires

[20] It is clear that $\mathbb{E}\widehat{W}^{PD}(\pi, \theta) = \mathbb{E}\widehat{W}^{PD}(\pi)$ for all θ. We only leave a latent dependency on θ under PD to reduce notation.

[21] The function $\mathbb{E}\widehat{W}^{FD}(\pi, \theta)$ is continuous, almost everywhere differentiable, and convex in π. For relatively low values of π, $\mathbb{E}\widehat{W}^{FD}(\pi, \theta)$ can increase or decrease with this parameter, but when administrative capacity is high enough, $\mathbb{E}\widehat{W}^{FD}(\pi, \theta)$ always increases with π. Regarding $\mathbb{E}\widehat{W}^{PD}(\pi)$, this is a continuous, linear, and increasing function of π. See Appendix B.7 and the Online Appendix for details.



(a) Assuming $\bar{c} < b - c_0$. **(b)** Assuming $\bar{c} \geq b - c_0$.

Figure 4: Optimal regime choice as a function of state capacities (π, θ). Full decentralization dominates to the southwest of the frontier $\widehat{\pi}(\theta)$. When $\pi = 1$, both regimes replicate the first best.

that regional administrative capacity be sufficiently *low*, i.e., $\pi \leq \widehat{\pi}(\theta)$. The intuition can be grasped by comparing the inefficiencies in Corollaries 1 and 2 over this parametric region. First, when π is low and θ is sufficiently high, it is more likely that *PD* generates overinvestment inefficiencies, than that *FD* generates underinvestment distortions (see Figure 3). Second, for low π the likelihood of creating refinancing and tax distortion inefficiencies under *FD* is low. Essentially, those distortions can only emerge if at least one region needs no refinancing. But that is a low probability event when π is small.

When π is above c_0/b, the model is biased towards project initiation. In this case, *PD* outcomes are efficient (see Figure 3a), while under *FD* the probability of facing capital mobility costs or not refinancing projects is positive. Thus, *PD* dominates. In the limit, when π is equal to one, no project needs to be refinanced and both regimes yield optimal outcomes.

In Figure 4b, we consider the case in which the expected value of the refinancing cost $\bar{c}$ is larger than $b - c_0$. Unlike in the previous scenario, *FD* now dominates *for all* θ provided π is low enough. Put differently, the presence of low enough levels of administrative capacity is a sufficient condition for full decentralization dominance. The underlying mechanism is transparent when $\pi = 0$ and $\theta > 0$. In that case, all projects are initiated and refinanced under *PD*, despite of generating negative expected payoffs (i.e., $b - c_0 - \bar{c} <$

0). In contrast, only some projects are initiated under FD, so this regime dominates. Continuity implies that FD is optimal for relatively low values of π.

Summing up, these results clarify how the different dimensions of regional state capacity shape the trade-off between PD and FD. In particular, contrary to the view held by some authors,[22] high levels of administrative and fiscal capacity do not necessarily imply that FD is optimal. Instead, the presence of relatively low levels of administrative capacity stands out as a necessary condition for FD dominance.

6.1 Comparative Statics

In this subsection we analyze how changes in the key parameters of the model affect the comparison between partial and full decentralization. These results are summarized in Figure 5. Proofs corresponding to this section are contained in the Online Appendix.

Changing the capital endowment κ. A decrease in κ always favors PD, in the sense that this regime would dominate in a larger area of the plane (θ, π). The intuition for this result hinges on two facts. First, the cost of distortions generated under PD does not depend upon the value of κ. Second, a decrease in κ increases τ_ℓ^{asym} and the capital mobility costs under FD.

Changing the project's benefit b. When b increases, overinvestment inefficiencies under PD increase less than the corresponding inefficiencies due to underinvestment with FD. Hence, an increase in b pushes for PD dominance.

Changing the number of regions L. Two opposing effects are triggered when increasing L. First, under PD, the common-pool fiscal externality gets larger, which leads to more projects being inefficiently initiated. Second, the likelihood of bearing deadweight losses under FD (either due to capital mobility or due to shutting down projects) also increases. It can be shown that the latter outweighs the former, so that an increase in L favors PD.

[22] See, among others, Bird (1995) and Loayza et al. (2014).

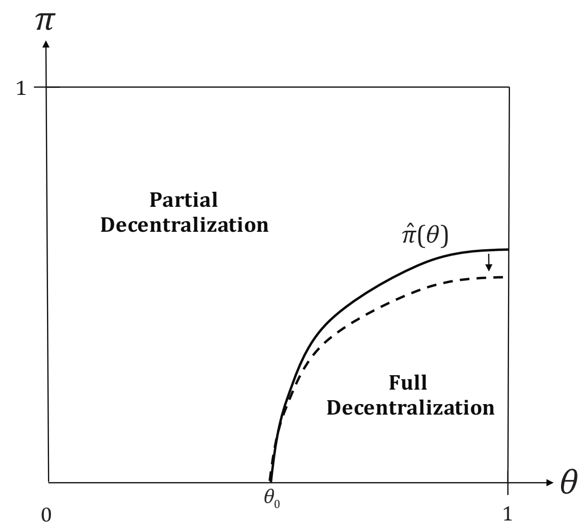


Figure 5: Effect of decreasing the capital endowment κ, increasing the project's benefit b, or increasing the number of regions L on the frontier $\widehat{\pi}(\theta)$.

7 Extensions

7.1 Imperfect National Fiscal Capacity

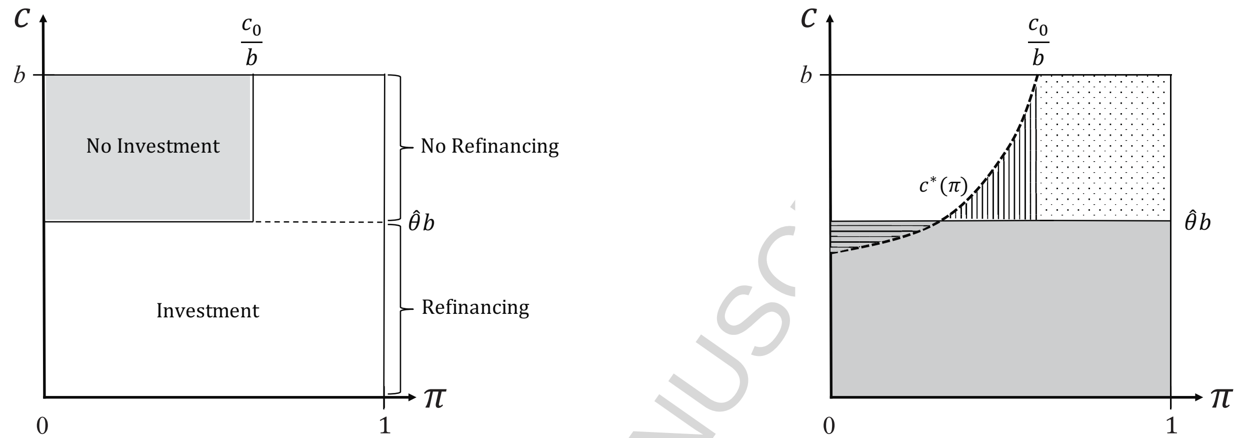
In this section we drop the assumption by which the central government has perfect fiscal capacity. Specifically, we now assume that the central government can only collect a fraction $\widehat{\theta} < 1$ of its potential tax base. While this change does not affect the FD regime, it does change the outcomes and interim inefficiencies under PD, as depicted in Figure 6.[23]

Figure 6a shows that two differences with the benchmark model emerge. First, not all projects are initiated anymore (see upper left corner). Second, not all incomplete projects are refinanced (upper right corner). Indeed, incomplete projects are only bailed out whenever $c \leq \widehat{\theta} b$. As a consequence of those novel outcomes, the inefficiency spectrum is now much richer and contains four types of distortions, as shown in Figure 6b: overinvestment (horizontally striped area), underinvestment (vertically striped area), no refinancing (dotted area), and refinancing by incurring deadweight losses (grey background).[24]

In the Online Appendix we prove that our main result is robust to the presence of im-

[23]The figures are drawn assuming that $\widehat{\theta} \geq 1 - c_0/b$, which allows one to consider all possible cases of distortions. Refer to the Online Appendix for a formal characterization of the project initiation and refinancing decisions as depicted in Figure 6a.

[24]The last region emerges because the central government needs to collect $c/\widehat{\theta} > c$ to refinance incomplete projects.



(a) Investment and Refinancing Decisions. **(b)** Interim Inefficiencies.

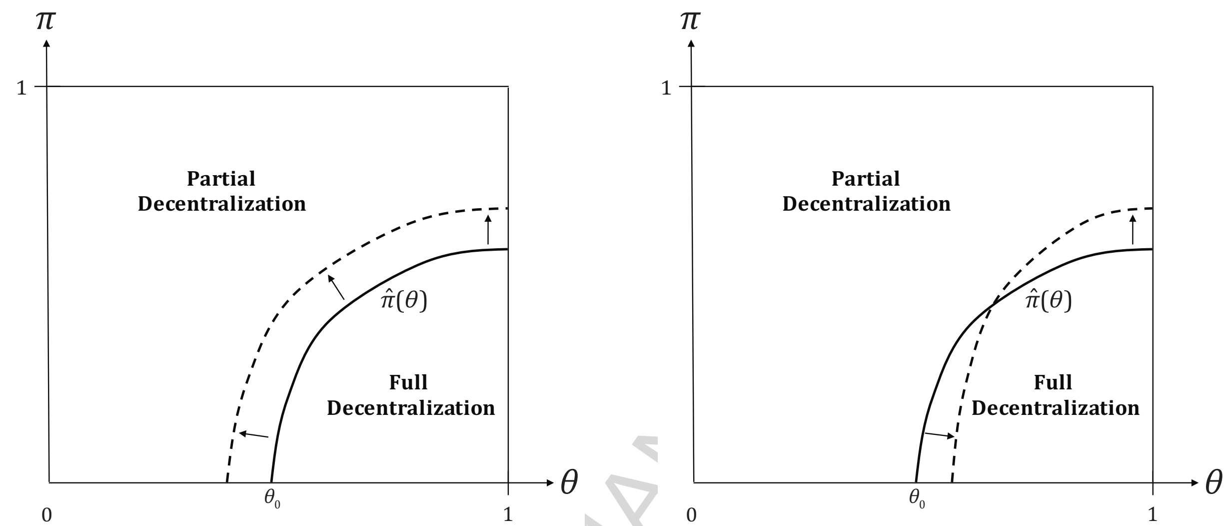
Figure 6: Partial decentralization under imperfect national fiscal capacity $\widehat{\theta} < 1$. Interim inefficiencies in the right panel are: overinvestment (horizontally striped area), underinvestment (vertically striped area), no refinancing (dotted area), and distortionary refinancing (grey area).

perfect national fiscal capacity. Specifically, even for $\widehat{\theta} < 1$, a combination of low levels of administrative capacity and high levels of regional fiscal capacity calls for fully decentralizing tax powers. Notwithstanding, changes to the level of national fiscal capacity affect the optimal regime in a non-trivial way. The next proposition illustrates this result.

Proposition 6. *If regional administrative capacity π is close to zero and national fiscal capacity $\widehat{\theta}$ is close to one, a small reduction in $\widehat{\theta}$ can benefit PD over FD.*

Proof. See Appendix B.8. □

The content of Proposition 6 is illustrated in Figure 7. Suppose $\widehat{\theta}$ decreases. On the one hand, this should favor *FD* since *PD* would lead to costlier bailouts, and larger distortions from underinvestment and from not refinancing incomplete projects. However, for low values of π, the number of projects which are inefficiently initiated in *PD* also decreases as $\widehat{\theta}$ drops (the horizontally striped area in Figure 6b shrinks). As this latter favors *PD*, the overall effect of lowering the level of national fiscal capacity is, in principle, ambiguous. Panel 7a displays a case in which the channels favoring *FD* dominate unambiguously. Panel 7b shows the converse. As shown in Appendix B.8, this last case can occur if, among other things, the density $h(c)$ concentrates sufficient mass on the highest value of its domain, which is b.



(a) Scenario I. **(b)** Scenario II.

Figure 7: Decreasing national fiscal capacity $\widehat{\theta}$. In Scenario I, decreasing $\widehat{\theta}$ below one unambiguously favors full decentralization. In Scenario II, such a reduction in $\widehat{\theta}$ favors partial decentralization when regional administrative capacity π is low.

7.2 Imperfect Commitment Capacity

In the baseline model we assume that the central government can perfectly commit not to bailout regions under FD. As this need not be the case for some countries (see Rodden et al. (2003)), in this section we analyze the consequences of relaxing that assumption.

7.2.1 Extended Environment

We start by introducing bailout uncertainty into our baseline framework along the lines of Inman (2003) or Dovis and Kirpalani (2017). As a first step, we reinterpret the full and partial decentralization regimes in the following way: Assume that the central government keeps its tax powers under either regime but, differently from PD, the FD system gives tax powers to the regions and incorporates a "no bailout" clause in the Constitution. Such a clause prevents the central government from transferring resources across regions to refinance incomplete projects. While this reinterpretation does not change the outcomes of our benchmark model, it allows us to formalize the notion of imperfect commitment next.[25]

[25] In Section 7.2.4 we enrich the analysis by allowing the Congress to choose over tax decentralization and over incorporating or not a "no bailout" clause in the Constitution.

Suppose that there are two possible types of central government: a *committed* type, and an *uncommitted* type. The former abides by the "no bailout" clause in the Constitution (if any), while the latter does not. Only the central government can observe its type, which is not revealed until the refinancing stage. Bailouts, therefore, are uncertain when regions make investment decisions. We let $\eta \in [0, 1]$ denote the probability that the central government is a committed type.

We modify the timing in Section 2.2 as follows. Now we add a new period, $t = 0$, in which the central government learns its type. Then the sequence of events is the same as before, until the refinancing stage ($t = 3$). At the beginning of that period, the commitment type of the center is revealed. Subsequently, central or regional authorities are in charge of refinancing, depending on the decentralization system at hand. If the center is uncommitted, refinancing decisions under *FD* are made in sequence: regions move first, and then the central government follows.[26] The equilibrium of the refinancing stage is discussed below.

In this environment, η can be interpreted as the *commitment capacity* of the central government, as perceived by the Congress and by the regional authorities. Importantly, such commitment capacity is independent of the federal system (*FD* or *PD*) chosen by the Congress. Our benchmark formulation is nested for $\eta = 1$.

7.2.2 Equilibria under *PD* and *FD*

Under *PD*, the underlying type of the central government is irrelevant because the Constitution does not incorporate a "no bailout" clause. Therefore, the corresponding equilibrium is the same as in the baseline model: all projects are initiated and bailed out, if necessary. In what follows, we focus on how imperfect commitment capacity changes the equilibrium outcomes of the *FD* regime.

Consider period $t = 3$. Under *FD*, there are two possibilities. If the center is uncommitted, regions with incomplete projects would not refinance, anticipating that the central government would always bail them out. The reason is that regions only bear a part of the refinancing cost and central bailouts are ex post optimal (because $c \leq b$ and central taxes generate no distortions due to the inelastic supply of capital at the national level). If the center is committed, on the other hand, regions should decide upon refinancing via local capital taxes. In this case, the results of Proposition 3 hold. That is, the same cost thresholds $c_1(\theta)$ and $c_2(\theta)$ stratify the range of c into refinancing and non-refinancing areas, as

[26] This timing resembles the one in Köthenbürger (2004).

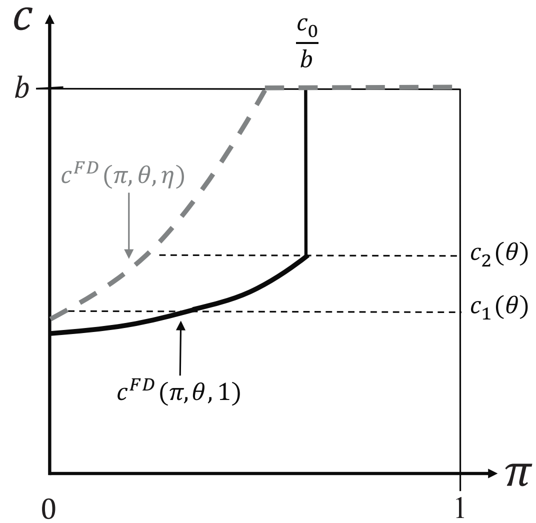


Figure 8: Project initiation threshold under full decentralization given commitment capacity $\eta \in [0,1]$. The investment area below the threshold $c^{FD}(\pi,\theta,\eta)$ increases as η is reduced.

a function of the profile of incomplete projects across regions.

The main difference with the FD system in our baseline framework occurs at the project initiation stage, $t = 2$. In Appendix B.9 we show that given (π,θ,η), there exists a threshold $c^{FD}(\pi,\theta,\eta)$ such that initial investment takes place in all regions if and only if $c \leq c^{FD}(\pi,\theta,\eta)$. Otherwise, no region invests in equilibrium. This result is the analogue of Proposition 4, with the added feature that the relevant cost threshold now depends on η. In the Appendix we also show that $c^{FD}(\pi,\theta,\eta)$ actually decreases with η, as illustrated in Figure 8. That is, the investment area expands as η is reduced. Intuitively, lower values of η imply that there is a higher probability that incomplete projects will be refinanced by the center without distortion. This provides more incentives for the regions to invest.

7.2.3 Optimal Institutional Regime

We divide the analysis of the optimal regime into two parts: small deviations and large deviations from perfect commitment ($\eta = 1$). While we can provide analytical results for the first part, we can only rely on numerical simulations for the last one.

Small Deviations from Perfect Commitment. The next proposition establishes how the choice of the optimal regime changes as η decreases slightly from the benchmark case with $\eta = 1$.

Proposition 7. *Suppose that the central government commits not to bailout regions under FD with probability η.*

1. *In a neighborhood of $\eta = 1$, there exists a frontier $\widehat{\pi}(\theta, \eta)$ such that FD dominates if and only if administrative and fiscal capacities (π, θ) satisfy $\pi \leq \widehat{\pi}(\theta, \eta)$. The frontier $\widehat{\pi}(\theta, \eta)$ is unique, it increases with θ, and is such that $\widehat{\pi}(0, \eta) > 0$ when the expected refinancing cost $\overline{c}$ is sufficiently high.*

2. *Small deviations from perfect commitment capacity favor FD dominance, in the sense that the frontier $\widehat{\pi}(\theta, \eta)$ satisfies $\lim_{\eta \to 1} \partial \widehat{\pi}(\theta, \eta) / \partial \eta \leq 0$.*

Proof. See Appendix B.9. □

Part 1 extends Proposition 5. It shows that perfect commitment is *not* a necessary condition for our main results to go through: even when $\eta = 1 - \varepsilon$ with ε small, *FD* dominates in a parametric area for (θ, π) which is analogous to the one in our base model. Particularly, *FD* is still preferred when π is sufficiently low and, under certain conditions, this result is unrelated to the value of θ.

By Part 2, small deviations from perfect commitment of the central government actually make the *FD* regime *more attractive.* A second best mechanism underlies this result. Basically, decreasing the commitment capacity of the central government can also decrease existing inefficiencies of *FD* under perfect commitment. The key effect is that inefficiencies due to distortionary refinancing under *FD* are reduced: when η is slightly below one, there is a small probability that refinancing is handled by the center in a fully efficient way.

Large Deviations from Perfect Commitment. As η decreases significantly below one, the reduction in *FD* distortions described previously can be potentially offset by overinvestment inefficiencies (as η converges to zero the *FD* regime converges towards *PD*, in which too many projects are initiated). Unfortunately, it is not possible to show analytically how the threshold $\widehat{\pi}(\theta, \eta)$ is affected by a large decrease in η with respect to $\eta = 1$.[27] So to gain some insight into this case, we appeal to numerical simulations.

In Figure 9, we show the frontier $\widehat{\pi}(\theta, \eta)$ within a particular parameterization. We normalize κ to 1, set $c_0 = 0.04$, $b = 0.1$, $L = 3$, and assume that the cost c is distributed

[27] The main complication is that, in general, the sign of $\frac{\partial \mathbb{E}\widehat{W}^{FD}(\pi,\theta,\eta)}{\partial \eta}$ depends on the values of (π, θ, η).

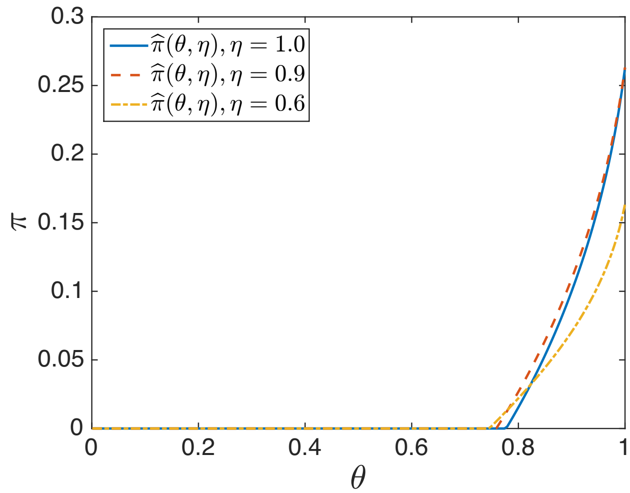


Figure 9: Numerical simulation of the frontier $\widehat{\pi}(\theta,\eta)$. κ is normalized to 1, $c_0 = 0.04$, $b = 0.1$, $L = 3$, and c is distributed according to a $Beta(2,2)$. Full decentralization dominates to the southwest of the frontier $\widehat{\pi}(\theta,\eta)$.

according to the symmetric distribution $Beta(2,2)$. We use $\eta = \{1, 0.9, 0.6\}$. This parameterization is chosen to illustrate our main points in a clear way, but such conclusions have been confirmed for other parameter values. Figure 9 illustrates two main facts. First, even for values of η significantly below one, the areas of FD and PD dominance are analogous to those in the baseline model. Second, changing η has an ambiguous effect on $\widehat{\pi}(\theta,\eta)$, depending on the configuration of (θ,η). In particular, when η decreases from 1 to 0.9, the frontier $\widehat{\pi}(\theta,\eta)$ shifts up, which is consistent with our analysis in the previous section. As η decreases further to 0.6, $\widehat{\pi}(\theta,\eta)$ rotates clockwise. As η converges to zero (not shown), FD nests the PD regime, so that $\widehat{\pi}(\theta,\eta)$ collapses to zero.

7.2.4 Tax Decentralization vs. "No Bailout" Clauses

In this section, we generalize the previous analysis by allowing the Congress to choose over tax decentralization (PD or FD) *and* over incorporating or not a "no bailout" clause (henceforth NBC) in the Constitution. This allows us to isolate the effects of reassigning tax instruments from the effects of banning bailouts in an environment of imperfect commitment. We show that our previous results regarding the optimal regime are robust to this extension.

As before, the central government moves after the regions at the refinancing stage, unless there is a NBC and the center abides by it (the latter occurring with probability

η). Notably, once the inclusion of a NBC becomes a choice variable to the Congress, *four* possible combinations of decentralization and existence of NBCs arise. We've already discussed two of those configurations in the previous analysis, namely, FD with a NBC and PD without a NBC. In what follows, we examine the two remaining systems and show how they affect the regime comparison.

First, consider a FD regime *without* a NBC. This system is identical to a FD regime which does incorporate the NBC, but that has a center with no commitment capacity, or $\eta = 0$. As discussed previously, the outcomes of such an institutional arrangement boil down to PD without a NBC (i.e., all projects are initiated and refinanced if incomplete). We thus refer to the resulting system in the absence of a clause banning bailouts as a "de facto" PD regime.

Now we look at the outcomes of PD *with* a NBC. It is easy to see that if there is a constitutional ban on bailouts, PD is equivalent to a FD regime in which regions entirely lack fiscal capacity, i.e., with $\theta = 0$. The logic is simple. Suppose that the Congress incorporates a NBC. When $\theta = 0$, refinancing under FD is too costly for the regions. Thus, incomplete projects are only refinanced by the central government with probability $(1 - \eta)$. But, by construction, this is the same refinancing equilibrium as under PD. In turn, regions make the same investment decisions under either tax decentralization scheme (more precisely, given (π, η), local governments initiate projects if and only if $c \leq c^{FD}(\pi, 0, \eta)$). The key implication from this result is that PD will *always* be dominated by FD in the presence of a NBC (since welfare under FD increases with θ).

We conclude by analyzing the choice of the optimal regime when the Congress can choose whether or not to constitutionally ban bailouts. As per the above arguments, finding the optimal regime in this richer environment reduces to comparing the performances of only two institutional schemes: "de facto" PD (if bailouts are not banned) vs. FD with a NBC. Actually, these are the same regimes that we contrasted in Section 7.2.3. Hence, our previous results go through.

8 Conclusion

This paper presents a model featuring a central government and regional authorities. The latter are characterized by their levels of administrative and fiscal capacities. We analyze two fiscal regimes. Under partial decentralization, regional governments rely on central bailouts to refinance previously started projects. Hence, regions face soft budget constraints and can overinvest in local public projects. Under full decentralization, regional governments cannot rely on central bailouts, capital tax competition increases the marginal cost of public funds, and regional governments may underinvest.

The main goal of the paper is to conduct a normative comparison between these regimes and determine how different levels of regional state capacity affect this comparison. Contrary to what an aprioristic view could indicate, we show that the presence of sufficiently low levels of administrative capacity is a necessary condition for full decentralization dominance. Moreover, this condition may also be sufficient depending on the projects' characteristics.

We abstract from a number of realistic features to focus on a particular trade-off. Three assumptions in these regards are worth mentioning here: capital being the only input in production, the immobility of residents across regions, and the ex ante symmetry of regions. First, the presence of tax competition distortions under full decentralization requires that at least one taxable factor be mobile across regions. In the paper, capital plays the role of such mobile factor, but our results would still hold if we replaced capital by a different input (such as labor) which could move across regions and be taxed. Incorporating additional productive factors, mobile or immobile, could give rise to more complex forms of tax competition. In principle, that might either hinder or favor full vis-à-vis partial decentralization optimality.[28]

Second, the possibility of regional migration could increase the level of expected welfare under full decentralization, all else equal. The reason is that, unlike under the partial decentralization regime, this system can generate regional differences in the provision of public goods (as projects are not always refinanced). Allowing individuals to exploit such differentials could increase expected welfare from a utilitarian perspective.

Finally, an interesting route for further research is to incorporate ex ante asymmetries between regions (either in capital endowments or in state capacities), and analyze whether regional asymmetry is more or less conducive to decentralization dominance. This would also yield a more suitable framework to deliver quantitative assessments.

[28] We also abstract from local commodity taxation. This would lead to a number of issues on cross-border shopping, and destination vs. origin principles, which are outside of the scope of the paper. See Wilson (1999) for a review on this matter.

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Appendix

A Administrative vs. Fiscal Capacity Across U.S. States

This section presents an illustrative example where the correlation between regional administrative and fiscal capacities is weak. We use data on the U.S. States for 2002-2003. Data on fiscal capacity is taken from Yilmaz et al. (2006), who measure fiscal disparities across the U.S. States for fiscal year 2002. We use two variables which roughly map to the index of fiscal capacity θ in this paper. The first variable is *tax effort*, which is the ratio of actual tax collections to potential tax revenues. The second variable, *revenue effort,* is the ratio of actual revenues to potential revenues. The difference between these measures is that "revenue" in the latter include actual tax collections plus other revenue from nontax sources, such as user charges or lotteries (see Yilmaz et al. (2006) for details). To approximate administrative capacity we follow La Porta et al. (1999) who proxy the quality of public good provision through output measures of essential public goods, such as infant mortality, literacy, or infrastructure quality. We focus on infant mortality and illiteracy, given that these series are widely available at the regional level for the U.S..[29]

Figure A.1 shows the scatter plots involving the four variables described previously (two proxies for fiscal capacity and two proxies for administrative capacity).[30] Clearly, the correlation between the measures of fiscal and administrative capacity is extremely low. In fact, in all cases one cannot reject the absence of correlation at reasonable levels of significance. For example, the Spearman correlation coefficient between infant mortality and tax effort is 0.025, with a p-value of 0.86.

B Proofs

B.1 Proof of Proposition 1

Consider an arbitrary region ℓ. By (3), initiating the project is a dominant strategy if $c \leq L\frac{b-c_0}{1-\pi} \equiv c^{PD}(\pi)$. As $b \geq 2c_0$ (by Assumption 1) and $L \geq 2$, it follows that $c^{PD}(\pi) \geq b$, so that all projects are initiated. $\square$

B.2 Proof of Lemma 1

Given a profile of tax rates $\boldsymbol{\tau} = \{\tau_1, ..., \tau_L\}$, a resident of region ℓ decides where to invest its capital endowment by solving the following problem:

$$\max_{h_\ell, \{f_{\ell m}\}_{m \neq \ell}} h_\ell \left(1 - \tau_\ell\right) + \sum_{m \neq \ell} f_{\ell m} \left(1 - \tau_m\right) - \frac{1}{2}\left(\sum_{m \neq \ell} f_{\ell m}\right)^2$$

[29] Infant mortality for 2002 is taken from the National Vital Statistics Reports elaborated by the Centers for Disease Control and Prevention. Illiteracy is measured by the percent of individuals over 16 years old lacking basic prose literacy skills for 2003, as estimated by the National Center for Education Statistics.

[30] We exclude New York (Alaska) from the first (second) column for being an outlier in tax effort (revenue effort).

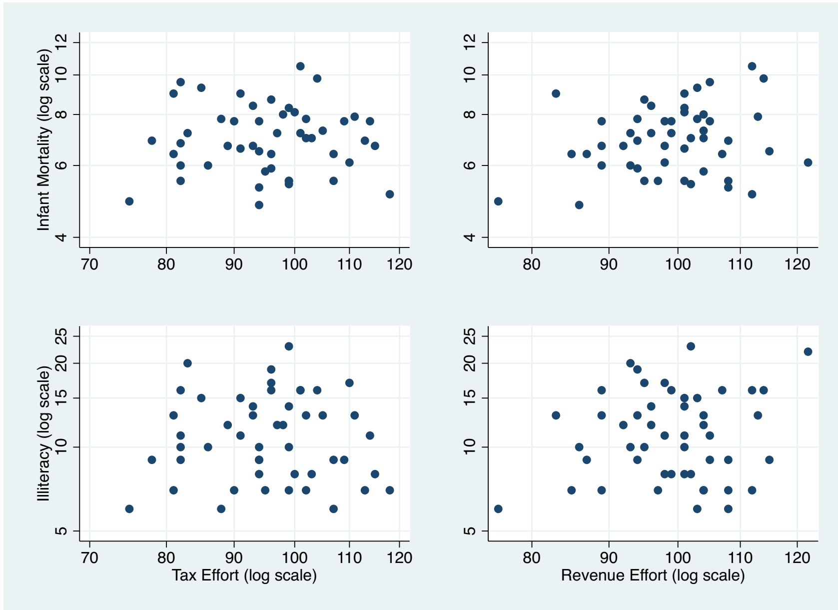

Figure A.1: Fiscal vs. administrative capacities across U.S. states for 2002-2003. Fiscal capacity is proxied via tax effort and revenue effort. Administrative capacity is proxied via infant mortality and illiteracy.

subject to

$$h_\ell + \sum_{m \neq \ell} f_{\ell m} = \kappa, \qquad \text{and} \qquad f_{\ell m} \geq 0 \quad \forall m \neq \ell,$$

where h_ℓ is the level of capital invested in region ℓ. Letting $\lambda_{\ell n}$ be the multipliers associated with the non-negativity constraints, first-order conditions $\forall n \neq \ell$ yield

$$\tau_\ell - \tau_n + \lambda_{\ell n} = \sum_{m \neq \ell} f_{\ell m}, \tag{B.1}$$

along with the complementary slackness condition: $\lambda_{\ell n} f_{\ell n} = 0$, $\lambda_{\ell n} \geq 0$. We prove the lemma by means of two claims.

Claim 1. *Assume there exist two regions $m, n \neq \ell$, with $\tau_m > \tau_n$. Then $f_{\ell m} = 0$.*

Proof. Subtracting m's first-order condition from n's first-order condition, we obtain $\tau_m - \tau_n + \lambda_{\ell n} = \lambda_{\ell m}$. As $\tau_m > \tau_n$ and $\lambda_{\ell n} \geq 0$, we get $\lambda_{\ell m} > 0$. Hence, complementary slackness yields $f_{\ell m} = 0$. □

Let $\widetilde{M}$ be the set of regions $\widetilde{m} \neq \ell$ that have chosen the minimum tax rate $\widetilde{\tau}_\ell = \min\{\tau_m\}_{m \neq \ell}$. An immediate consequence of the previous claim is that $f_{\ell m} = 0$ for all regions $m \neq \ell, \widetilde{m}$. Next we characterize capital flows to the set $\widetilde{M}$.

Claim 2. Assume that $\tau_\ell \geq \widetilde{\tau}_\ell$. Then $\sum_{\widetilde{m}\in\widetilde{M}} f_{\ell\widetilde{m}} = \tau_\ell - \widetilde{\tau}_\ell$.

Proof. For all ℓ, first-order conditions that characterize flows $f_{\ell\widetilde{m}}$ are: $\tau_\ell - \widetilde{\tau}_\ell + \lambda_{\ell\widetilde{m}} = \sum_{\widetilde{m}\in\widetilde{M}} f_{\ell\widetilde{m}}$. To satisfy these conditions, all multipliers $\lambda_{\ell\widetilde{m}}$ should be equal across $\widetilde{m}$. If they were all strictly positive, then all outflows $f_{\ell\widetilde{m}}$ should be equal to 0, implying that $\sum_{\widetilde{m}\in\widetilde{M}} f_{\ell\widetilde{m}} = 0$. But as $\tau_\ell \geq \widetilde{\tau}_\ell$, this would yield a contradiction, so all multipliers should be zero. Using $\lambda_{\ell\widetilde{m}} = 0$ for all $\widetilde{m}$ into (B.1) yields $\sum_{\widetilde{m}\in\widetilde{M}} f_{\ell\widetilde{m}} = \tau_\ell - \widetilde{\tau}_\ell$, as was to be shown. □

B.3 Proof of Proposition 2

Let $\boldsymbol{\tau_m}$ be the profile of tax rates chosen by regions $m \neq \ell$. Given $\boldsymbol{\tau_m}$, the regional government of ℓ can follow three types of strategies: set τ_ℓ above, below, or equal to $\widetilde{\tau}_\ell \equiv \min\{\tau_m\}_{m\neq\ell}$. Let $\overline{\tau}_\ell(\boldsymbol{\tau_m})$ and $\underline{\tau}_\ell(\boldsymbol{\tau_m})$ be the optimal tax rates conditional on setting τ_ℓ above or below $\widetilde{\tau}_\ell$, respectively. We start by characterizing those tax rates:[31]

1. If the regional government of ℓ set its tax rate strictly above $\widetilde{\tau}_\ell$, there would be capital outflows to regions $\widetilde{m} \in \widetilde{M}$. Hence, regional welfare would be

$$W_\ell^{FD} = (\kappa - \sum_{\widetilde{m}\in\widetilde{M}} f_{\ell\widetilde{m}})\,(1-\tau_\ell) + \sum_{\widetilde{m}\in\widetilde{M}} f_{\ell\widetilde{m}}\,(1-\widetilde{\tau}_\ell) - \frac{1}{2}(\sum_{\widetilde{m}\in\widetilde{M}} f_{\ell\widetilde{m}})^2 + b.$$

   By the Envelope Theorem, $\partial W_\ell^{FD}/\partial\tau_\ell = -(\kappa - \sum_{\widetilde{m}\in\widetilde{M}} f_{\ell\widetilde{m}}) < 0$. So the regional government of ℓ should set the lowest tax rate that satisfies its budget constraint

$$\theta\tau_\ell(\kappa - \sum_{\widetilde{m}\in\widetilde{M}} f_{\ell\widetilde{m}}) = c. \tag{B.2}$$

   Using Lemma 1, the smallest root of (B.2) is given by

$$\overline{\tau}_\ell(\boldsymbol{\tau_m}) \equiv \frac{1}{2}\left[\kappa + \widetilde{\tau}_\ell - \sqrt{(\kappa+\widetilde{\tau}_\ell)^2 - \frac{4c}{\theta}}\right]. \tag{B.3}$$

   Throughout the paper we assume that κ is large enough so that the square root on the right hand side exists.[32]

2. If the regional government of ℓ set its tax rate strictly below $\widetilde{\tau}_\ell$, region ℓ would experience no capital outflows, but positive capital inflows (which do not affect regional welfare). The

[31] Due to specific features of this model, we cannot apply the methodology in Wildasin (1988) to derive the equilibrium tax rates.

[32] Specifically, it is assumed that $\kappa > \max\{\sqrt{4b(L-1)/\theta}, b/\theta\}$. This not only ensures the existence of $\overline{\tau}_\ell$, but also of $\underline{\tau}_\ell$ defined in (B.6). Additionally, the condition guarantees that equilibrium tax rates satisfy $\tau_\ell^{sym} < 1$ for all ℓ.

regional government of ℓ would then choose the lowest tax rate that satisfies its budget constraint

$$\theta\tau_\ell(\kappa + \sum_{m\neq\ell} f_{m\ell}) = c, \tag{B.4}$$

where

$$\sum_{m\neq\ell} f_{m\ell} = \sum_{m\neq\ell} \tau_m - (L-1)\tau_\ell \tag{B.5}$$

are the total capital inflows to region ℓ. Using (B.5), the smallest root of (B.4) is

$$\underline{\tau}_\ell(\boldsymbol{\tau_m}) \equiv \frac{1}{2}\left[\frac{1}{L-1}\left(\kappa + \sum_{m\neq\ell}\tau_m\right) - \sqrt{\left(\frac{\kappa + \sum_{m\neq\ell}\tau_m}{L-1}\right)^2 - \frac{4c}{\theta(L-1)}}\right]. \tag{B.6}$$

By definition, $\underline{\tau}_\ell$ is only consistent with $\widetilde{\tau}_\ell > 0$.

Next we characterize the equilibria of the tax competition game, depending on whether all regions refinance their incomplete projects, or at least one region does not refinance. It is worth noting that $\overline{\tau}_\ell$ and $\underline{\tau}_\ell$ are decreasing functions of the taxes set by all other regions. This implies that tax rates are strategic substitutes.

Scenario 1: All regions decided to refinance their incomplete projects

We focus on symmetric Nash equilibria in pure strategies where $\tau_\ell = \tau_m$ for all ℓ, m. We begin by establishing that $\tau_\ell = c/(\theta\kappa) \equiv \tau_\ell^{sym}$ for all ℓ, is a Nash equilibrium. In fact, suppose that $\tau_m = c/(\theta\kappa)$ for $m \neq \ell$, and denote this profile using the shorthand notation $\boldsymbol{\tau_m} = \boldsymbol{c/(\theta\kappa)}$. Plugging into (B.3) and (B.6) gives:

$$\overline{\tau}_\ell(\boldsymbol{c/(\theta\kappa)}) = c/(\theta\kappa) = \underline{\tau}_\ell(\boldsymbol{c/(\theta\kappa)}).$$

This contradicts the definitions of $\overline{\tau}_\ell$ and $\underline{\tau}_\ell$, and implies that the best response of ℓ is $\tau_\ell = c/(\theta\kappa)$.

Now we show that when all regions decided to refinance, the equilibrium with $\tau_\ell = \tau_\ell^{sym}$ for all ℓ is actually the unique symmetric Nash equilibrium. First, suppose $\tau_m = c/(\theta\kappa) + \epsilon$ for all $m \neq \ell$, with $\epsilon > 0$. Using this profile into (B.3) and (B.6) we obtain

$$\overline{\tau}_\ell(\boldsymbol{c/(\theta\kappa) + \epsilon}) < c/(\theta\kappa) + \epsilon, \quad \text{and} \quad \underline{\tau}_\ell(\boldsymbol{c/(\theta\kappa) + \epsilon}) < c/(\theta\kappa) + \epsilon, \tag{B.7}$$

which implies that only downward deviations from $c/(\theta\kappa) + \epsilon$ are feasible (as the first expression contradicts the definition of $\overline{\tau}_\ell$). Regional welfare from downward deviating is

$$W_\ell^{FD}\big(\underline{\tau}_\ell(\boldsymbol{c/(\theta\kappa) + \epsilon})\big) = \kappa\big(1 - \underline{\tau}_\ell(\boldsymbol{c/(\theta\kappa) + \epsilon})\big) + b,$$

while welfare from replicating $c/(\theta\kappa)+\epsilon$ is

$$W_\ell^{FD}\big(c/(\theta\kappa)+\epsilon\big)=\kappa\big(1-(c/(\theta\kappa)+\epsilon)\big)+b.$$

It follows from (B.7) that $W_\ell^{FD}\big(\underline{\tau}_\ell(\boldsymbol{c/(\theta\kappa)+\epsilon})\big)>W_\ell^{FD}\big(c/(\theta\kappa)+\epsilon\big)$, so that downward deviating is profitable. Hence, we rule out symmetric equilibria with $\tau_\ell=c/(\theta\kappa)+\epsilon$ for all ℓ.

Finally, assume by contradiction that $\tau_\ell=c/(\theta\kappa)-\epsilon$ for all ℓ is a symmetric equilibrium, with $\epsilon>0$. In this case, tax revenues for each region ℓ are given by $\theta\kappa\big(c/(\theta\kappa)-\epsilon\big)<c$, so that projects cannot be refinanced. We conclude that $c/(\theta\kappa)-\epsilon$ cannot be a symmetric equilibrium of the subgame emerging when all regions refinance.

Scenario 2: At least one region has decided not to refinance

Under this scenario, $\widetilde{\tau}_\ell=0$. Plugging into (B.3) gives τ_ℓ^{asym}. □

B.4 Proof of Proposition 3

First we prove existence of $c_1(\theta)$ and $c_2(\theta)$. When there is at least one region that does not refinance, the total cost from completing a project in any region $T(c,\theta)$ is a strictly increasing and convex function of c with $\lim_{c\to 0}T(c,\theta)=0$ and $\lim_{c\to b}T(c,\theta)>b$. Hence, Bolzano's Theorem implies that there exists a threshold $c_1(\theta)\in(0,b)$ such that, when $c\le c_1(\theta)$, $b-T(c,\theta)\ge 0$. Also, as $c/\theta\in[c,T(c,\theta)]$, there exists another threshold $c_2(\theta)>c_1(\theta)$ such that $c_2(\theta)/\theta=b$.

Suppose $c<c_1(\theta)$. In this case, refinancing is a dominant strategy. This is because the marginal payoffs from refinancing are positive, regardless of what other regions do, i.e., $b-c/\theta>b-T(c,\theta)>0$. On the other hand, if $c>c_2(\theta)$, not refinancing is a dominant strategy as $b-T(c,\theta)<b-c/\theta<0$. Now assume $c\in[c_1(\theta),c_2(\theta)]$. If at least one region does not refinance, not refinancing is the best response because $b-T(c,\theta)<0$. However, if all regions face incomplete projects we have:

$$W_\ell^{FD}(R,\boldsymbol{R})\equiv\kappa-c_0+b-c/\theta\ge\kappa-c_0\equiv W_\ell^{FD}(NR,\boldsymbol{R}),\tag{B.8}$$

and

$$W_\ell^{FD}(R,\boldsymbol{NR})\equiv\kappa-c_0+b-T(c,\theta)\le\kappa-c_0\equiv W_\ell^{FD}(NR,\boldsymbol{NR}),\tag{B.9}$$

where $W_\ell^{FD}(r_\ell,\boldsymbol{r_m})$ is the payoff of region ℓ in the refinancing game, $r_\ell\in\{R,NR\}$ is the refinancing strategy for region ℓ, R (NR) denotes "refinancing" ("not refinancing"), $\boldsymbol{r_m}$ is the profile of refinancing decisions in regions $m\neq\ell$, and $\boldsymbol{R}$ and $\boldsymbol{NR}$ denote the profiles where all $m\neq\ell$ regions play R and NR, respectively.

The payoffs in (B.8)-(B.9) give rise to a coordination game between regions, with two Nash equilibria: either all regions refinance in equilibrium, or no region does. We choose the first equilibrium because it is the only one which is strong (Aumann (1959)), i.e., taking as given the strategies of the others, no coalition of players can jointly deviate and thus increase the payoffs of each of its members. More specifically, by definition of Nash equilibria, no region can do better by unilaterally changing its equilibrium strategy. Coalitions of $\mathcal{L}-$regions, with $1 < \mathcal{L} < L$, can do no better by deviating either: if the other regions refinance (not refinance), the $\mathcal{L}$ regions do not want to deviate because $b - c/\theta \geq 0$ ($b - T(c,\theta) \leq 0$). Finally, take the L-regions coalition. If all regions refinance, they do not want to deviate since $b - c/\theta \geq 0$. But, when no region refinances, they all wish to deviate because the refinancing equilibrium is Pareto optimal. □

B.5 Proof of Proposition 4

Henceforth, $i_\ell \in \{I, NI\}$ denotes the investment strategy for region ℓ, with I (NI) being "investment" ("no investment"). Similarly, let $\boldsymbol{i_m} \equiv \{i_m\}_{m \neq \ell}$, and define $\mathbb{E}W_\ell^{FD}(i_\ell, \boldsymbol{i_m})$ as the expected welfare of the project initiation game for region ℓ. We also use $\boldsymbol{i_m} = \boldsymbol{I}$ ($\boldsymbol{i_m} = \boldsymbol{NI}$) to denote the profile under which all regions $m \neq \ell$ initiate (do not initiate) the project, and $\boldsymbol{i_m} = \boldsymbol{I^c}$ to represent the complement of $\boldsymbol{I}$. We first characterize the project initiation equilibria as a function of the realization of c. As per Proposition 3, we consider three cases depending on the type of equilibrium in the refinancing subgame. (We assume throughout that sufficient conditions for the existence of the thresholds defined below hold; this only allows us to consider the most general case to characterize equilibria.)

Case 1: $c < c_1(\theta)$. Refinancing is a dominant strategy in this scenario. Hence, welfare of region ℓ from initiating a project can either be given by

$$\mathbb{E}W_\ell^{FD}(I, \boldsymbol{I}) = \kappa - c_0 + b - (1-\pi)^L \frac{c}{\theta} - (1-\pi)(1-(1-\pi)^{L-1})T(c,\theta), \tag{B.10}$$

when all other regions initiate, or by

$$\mathbb{E}W_\ell^{FD}(I, \boldsymbol{I^c}) = \kappa - c_0 + b - (1-\pi)T(c,\theta), \tag{B.11}$$

if some region does not invest. As we focus on symmetric Nash equilibria in pure strategies, we need to consider two possible equilibria: all regions initiate projects, or no region does. The first equilibrium occurs if and only if $\mathbb{E}W_\ell^{FD}(I, \boldsymbol{I}) \geq \mathbb{E}W_\ell^{FD}(NI, \boldsymbol{I}) = \kappa$. Using (B.10), this condition boils down to $c \leq c_{R_1}(\pi, \theta)$, where $c_{R_1}(\pi, \theta)$ is implicitly defined by

$$(1-\pi)\left[(1-\pi)^{L-1}\frac{c_{R_1}(\pi,\theta)}{\theta} + (1-(1-\pi)^{L-1})T(c_{R_1}(\pi,\theta),\theta)\right] = b - c_0. \tag{B.12}$$

Analogously, a symmetric equilibrium with no region initiating projects emerges if and only if $\kappa \geq \mathbb{E}W_\ell^{FD}(I, \boldsymbol{NI})$. This is equivalent to $c \geq c_{R_2}(\pi,\theta)$, with $c_{R_2}(\pi,\theta)$ satisfying $(1-\pi)T(c_{R_2}(\pi,\theta),\theta) = b - c_0$, which follows from (B.11). Since $T(c,\theta) > c/\theta$ and $T(c,\theta)$ is increasing in c, we have that $c_{R_1}(\pi,\theta) \geq c_{R_2}(\pi,\theta)$ for all (π,θ). Therefore, both $(I, \boldsymbol{I})$ and $(NI, \boldsymbol{NI})$ are Nash equilibria when $c \in [c_{R_2}(\pi,\theta), c_{R_1}(\pi,\theta)]$. We select the former equilibrium as this is the only one which is strong. From now on, we denote the relevant frontier by $c_R(\pi,\theta) \equiv c_{R_1}(\pi,\theta)$.

Case 2: $c \in [c_1(\theta), c_2(\theta)]$. In this case, all regions refinance if and only if all regions face incomplete projects. Welfare functions then satisfy:

$$\mathbb{E}W_\ell^{FD}(I, \boldsymbol{I}) = \kappa - c_0 + \pi b + (1-\pi)^L\left(b - \frac{c}{\theta}\right), \qquad \text{and} \qquad \mathbb{E}W_\ell^{FD}(I, \boldsymbol{I^c}) = \kappa - c_0 + \pi b.$$

These expressions imply that: (i) there is a threshold $c_{NAR}(\pi,\theta)$ defined by

$$(1-\pi)\left[(1-\pi)^{L-1}\frac{c_{NAR}(\pi,\theta)}{\theta} + (1-(1-\pi)^{L-1})b\right] = b - c_0, \tag{B.13}$$

such that $(I, \boldsymbol{I})$ is a symmetric Nash equilibrium whenever $c \leq c_{NAR}(\pi,\theta)$, and (ii) the condition for $(NI, \boldsymbol{NI})$ to be a symmetric equilibrium reduces to $\pi \leq c_0/b$. Consequently, when (c,π,θ) is such that $c \leq c_{NAR}(\pi,\theta)$ and $\pi \leq c_0/b$, multiple symmetric equilibria emerge. But, as in Case 1, only the equilibrium with investment is strong, so we keep that outcome when multiple equilibria occurs.

Case 3: $c > c_2(\theta)$. Here regions do not refinance incomplete projects. It is then straightforward to show that investing is a dominant strategy if and only if $\pi > c_0/b$. Otherwise, no region invests in equilibrium.

We conclude by constructing the frontier separating investment from no investment outcomes for any (c,π,θ). Take any θ and let $\pi_1(\theta)$ be implicitly defined by $c_R(\pi_1(\theta),\theta) = c_1(\theta)$. One can easily verify that

$$c_R(\pi_1(\theta),\theta) = c_{NAR}(\pi_1(\theta),\theta) \quad \text{and} \quad c_{NAR}(c_0/b,\theta) = c_2(\theta).$$

We assume that sufficient conditions for $c_R(\pi,\theta)$ and $c_{NAR}(\pi,\theta)$ to be increasing in π hold, and that $c_R(0,\theta) < c_1(\theta)$.[33] This ensures that $c_R(\pi,\theta)$ and $c_{NAR}(\pi,\theta)$ cross $c_1(\theta)$ and $c_2(\theta)$, respec-

[33] A sufficient condition for $c_R(\pi,\theta)$ and $c_{NAR}(\pi,\theta)$ to be increasing in π is that $L \leq \widehat{L} \equiv b(b-c_1(1))^{-1}$.

tively, at most once, and that $\pi_1(\theta) < c_0/b$. Other configurations can be accommodated as special cases. We can then define a frontier $c^{FD}(\pi,\theta)$ as

$$c^{FD}(\pi,\theta) = \begin{cases} c_R(\pi,\theta) & \text{if} \quad \pi \in [0, \pi_1(\theta)], \\ c_{NAR}(\pi,\theta) & \text{if} \quad \pi \in (\pi_1(\theta), c_0/b], \\ b & \text{if} \quad \pi \in (c_0/b, 1]. \end{cases}$$

Using the previous results, it follows that given (π,θ), all regions invest when $c \leq c^{FD}(\pi,\theta)$. Otherwise, no region invests in equilibrium. The threshold $c^{FD}(\pi,\theta)$ is illustrated in Figure 2.

□

B.6 Proof of Corollary 2

We only need to show that $c_R(\pi,\theta)$ and $c_{NAR}(\pi,\theta)$ are below $c^*(\pi)$ for all (π,θ). This simply follows from the definition of $c^*(\pi)$, and by inspecting (B.12) and (B.13). □

B.7 Proof of Proposition 5

Under partial decentralization, any project is initiated and refinanced if needed. Hence, equilibrium expected welfare under this regime is given by

$$\mathbb{E}\widehat{W}^{PD}(\pi) = \kappa + b - c_0 - (1-\pi)\bar{c}. \tag{B.14}$$

Using the thresholds defined in the proof of Proposition 4, we can write equilibrium expected welfare under full decentralization as

$$\mathbb{E}\widehat{W}^{FD}(\pi,\theta) = \begin{cases} \kappa + \int_0^{c_R(\pi,\theta)} \big[b - c_0 - (1-\pi)^L c/\theta \\ \qquad -(1-\pi)\big(1-(1-\pi)^{L-1}\big)T(c,\theta)\big]h(c)dc & \text{if} \quad \pi \in [0, \pi_1(\theta)], \\ \\ \kappa + \int_0^{c_{NAR}(\pi,\theta)} \big[\pi b - c_0 + (1-\pi)^L\,(b - c/\theta)\,\big]h(c)dc \\ \qquad +(1-\pi)\,\big(1-(1-\pi)^{L-1}\big)\int_0^{c_1(\theta)} \big[b - T(c,\theta)\big]h(c)dc & \text{if} \quad \pi \in (\pi_1(\theta), c_0/b], \\ \\ \kappa + (1-\pi)\big(1-(1-\pi)^{L-1}\big)\int_0^{c_1(\theta)}[b - T(c,\theta)]\,h(c)dc \\ \qquad +(1-\pi)^L \int_0^{c_2(\theta)}[b - c/\theta]\,h(c)dc + \pi b - c_0 & \text{if} \quad \pi \in (c_0/b, 1]. \end{cases} \tag{B.15}$$

The intercept of $c_R(0,\theta)$ is guaranteed to be below $c_1(\theta)$ as long as $b - c_0 < c_1(1)$.

By (B.14), expected welfare under partial decentralization is a continuous, increasing and linear function of π. On the other hand, the expected welfare function under full decentralization in (B.15) is continuous and convex in π, and continuous and increasing in θ (see Online Appendix for details).

To characterize the optimal regime across (π, θ), we proceed in four steps. First, suppose $\pi \in [c_0/b, 1)$. Here we can show that $\mathbb{E}\widehat{W}^{FD}(\pi, \theta) < \mathbb{E}\widehat{W}^{PD}(\pi) = \mathbb{E}\widehat{W}^{*}(\pi)$, where $\mathbb{E}\widehat{W}^{*}(\pi)$ is the equilibrium expected welfare at the first best. Hence, in this case partial decentralization always dominates. Second, suppose $\pi = 1$. We can prove that $\mathbb{E}\widehat{W}^{FD}(\pi, \theta)$ converges from below to $\mathbb{E}\widehat{W}^{*}(\pi)$ as $\pi \to 1$. And since $\mathbb{E}\widehat{W}^{PD}(1) = \mathbb{E}\widehat{W}^{*}(1)$, it follows that partial and full decentralization are equivalent when $\pi = 1$. Third, assume that $\pi = 0$. The next lemma characterizes the regime comparison for this case.

Lemma 3. *Assume that $\pi = 0$. Two scenarios can emerge:*

1. *Suppose $\bar{c} < b - c_0$, then there exists a threshold θ_0 such that: $\mathbb{E}\widehat{W}^{FD}(0, \theta_0) = \mathbb{E}\widehat{W}^{PD}(0)$, $\mathbb{E}\widehat{W}^{FD}(0, \theta) \geq \mathbb{E}\widehat{W}^{PD}(0)$ if $\theta \geq \theta_0$, and $\mathbb{E}\widehat{W}^{FD}(0, \theta) < \mathbb{E}\widehat{W}^{PD}(0)$ otherwise.*

2. *Suppose $\bar{c} \geq b - c_0$, then $\mathbb{E}\widehat{W}^{FD}(0, \theta) \geq \mathbb{E}\widehat{W}^{PD}(0)$ for all θ.*

Proof. By (B.14) and (B.15),

$$\mathbb{E}\widehat{W}^{PD}(0) = \kappa + b - c_0 - \bar{c}, \quad \text{and} \quad \mathbb{E}\widehat{W}^{FD}(0, \theta) = \kappa + \int_{0}^{\theta(b-c_0)} \left[b - c_0 - \frac{c}{\theta}\right] h(c) dc. \tag{B.16}$$

The last expression implies that

$$\mathbb{E}\widehat{W}^{FD}(0, 0) = \kappa, \quad \text{and} \quad \mathbb{E}\widehat{W}^{FD}(0, 1) = \kappa + b - c_0 - \bar{c} - \int_{b-c_0}^{b} [b - c_0 - c]\, h(c) dc. \tag{B.17}$$

Suppose $\bar{c} < b - c_0$. Then (B.16) and (B.17) imply that $\mathbb{E}\widehat{W}^{FD}(0, 0) < \mathbb{E}\widehat{W}^{PD}(0)$ and $\mathbb{E}\widehat{W}^{FD}(0, 1) > \mathbb{E}\widehat{W}^{PD}(0)$. Since $\mathbb{E}\widehat{W}^{FD}(0, \theta)$ monotonically increases with θ, it follows that there exists a unique θ_0 such that $\mathbb{E}\widehat{W}^{FD}(0, \theta) \geq \mathbb{E}\widehat{W}^{PD}(0)$ for $\theta \geq \theta_0$, and $\mathbb{E}\widehat{W}^{FD}(0, \theta) \leq \mathbb{E}\widehat{W}^{PD}(0)$ for $\theta \leq \theta_0$. Now suppose $\bar{c} \geq b - c_0$. Then $\mathbb{E}\widehat{W}^{FD}(0, 0) \geq \mathbb{E}\widehat{W}^{PD}(0)$, so that $\mathbb{E}\widehat{W}^{FD}(0, \theta) \geq \mathbb{E}\widehat{W}^{PD}(0)$ for all θ. $\square$

Fourth, suppose $\pi \in (0, c_0/b)$. In the lines of Lemma 3, we consider two cases:

1. If $\bar{c} < b - c_0$, $\lim_{\pi \to 0}[\mathbb{E}\widehat{W}^{FD}(\pi, \theta) - \mathbb{E}\widehat{W}^{PD}(\pi)] \geq 0$ provided $\theta \geq \theta_0$. Hence, as $\mathbb{E}\widehat{W}^{FD}(\pi, \theta)$ converges to $\mathbb{E}\widehat{W}^{PD}(\pi)$ from below when $\pi \to 1$, $\mathbb{E}\widehat{W}^{FD}(\pi, \theta)$ crosses $\mathbb{E}\widehat{W}^{PD}(\pi)$ from above on the interval $(0, c_0/b)$. Denote the value of π where such intersection occurs by $\widehat{\pi}(\theta)$. Similar arguments yield that $\mathbb{E}\widehat{W}^{FD}(\pi, \theta) < \mathbb{E}\widehat{W}^{PD}(\pi)$ if $\theta < \theta_0$.

2. If $\bar{c} \geq b - c_0$, $\lim_{\pi \to 0}[\mathbb{E}\widehat{W}^{FD}(\pi, \theta) - \mathbb{E}\widehat{W}^{PD}(\pi)] \geq 0$ for all θ. We can then show that, as π increases, there exists a threshold $\widehat{\pi}(\theta)$ such that full decentralization dominates when $\pi \leq \widehat{\pi}(\theta)$. The logic is analogous to the one applied for case 1.

Using a geometric argument, it follows that $\widehat{\pi}(\theta)$ identified in cases 1 and 2 above is unique. If there was another intersection, then $\mathbb{E}\widehat{W}^{FD}(\pi, \theta)$ would cross $\mathbb{E}\widehat{W}^{PD}(\pi)$ from below. But that would be inconsistent with the facts that $\mathbb{E}\widehat{W}^{FD}(\pi, \theta)$ is convex, $\mathbb{E}\widehat{W}^{PD}(\pi)$ is linear, and that the former converges to the latter from below as $\pi \to 1$. To show that $\widehat{\pi}(\theta)$ is increasing in θ, we apply the Implicit Function Theorem to the expression defining $\widehat{\pi}(\theta)$. This yields

$$\frac{\partial \widehat{\pi}(\theta)}{\partial \theta} = -\frac{\partial \mathbb{E}\widehat{W}^{FD}(\widehat{\pi}(\theta), \theta)/\partial \theta}{\partial \mathbb{E}\widehat{W}^{FD}(\widehat{\pi}(\theta), \theta)/\partial \pi - \partial \mathbb{E}\widehat{W}^{PD}(\widehat{\pi}(\theta))/\partial \pi} > 0,$$

which follows from the fact that $\mathbb{E}\widehat{W}^{FD}(\pi, \theta)$ crosses $\mathbb{E}\widehat{W}^{PD}(\pi)$ from above at $\widehat{\pi}(\theta)$. □

B.8 Proof of Proposition 6

By inspection of Figure 6a (see Online Appendix for a derivation), equilibrium expected welfare when national fiscal capacity is indexed by $\widehat{\theta}$ is given by

$$\mathbb{E}\widehat{W}^{PD}(\pi, \widehat{\theta}) = \begin{cases} \kappa + \int_0^{\widehat{\theta}b} \left[b - c_0 - (1-\pi)\frac{c}{\widehat{\theta}} \right] h(c)dc & \text{if } \pi \leq c_0/b, \\ \\ \kappa + \pi b - c_0 + (1-\pi) \int_0^{\widehat{\theta}b} \left[b - \frac{c}{\widehat{\theta}} \right] h(c)dc & \text{otherwise.} \end{cases}$$

To assess the impact of a decrease in $\widehat{\theta}$ on the expected regional welfare, we compute

$$\frac{\partial \mathbb{E}\widehat{W}^{PD}(\pi, \widehat{\theta})}{\partial \widehat{\theta}} = \begin{cases} \int_0^{\widehat{\theta}b} \frac{(1-\pi)c}{\widehat{\theta}^2} h(c)dc + (\pi b - c_0) h(\widehat{\theta}b)b & \text{if } \pi \leq c_0/b, \\ \\ \int_0^{\widehat{\theta}b} \frac{(1-\pi)c}{\widehat{\theta}^2} h(c)dc & \text{otherwise.} \end{cases}$$

Note that $\lim_{\widehat{\theta} \to 1} \left. \frac{\partial \mathbb{E}\widehat{W}^{PD}(\pi, \widehat{\theta})}{\partial \widehat{\theta}} \right|_{\pi=0} = \bar{c} - c_0 h(b) b$. This expression can be positive or negative. The last case can occur if, among other things, the density $h(c)$ concentrates sufficient mass on the highest value of its domain, i.e., on b.

B.9 Proofs of Section 7.2

B.9.1 Project Initiation under FD

First we provide a sketch of the proof of the existence of $c^{FD}(\pi, \theta, \eta)$ (further details are contained in the Online Appendix). The argument goes along the lines of the proof of Proposition 4, and we apply a similar notation here. Suppose that $c < c_1(\theta)$. Then all regions initiate projects in equilibrium if and only if $c \leq c_{R_I}(\pi, \theta, \eta)$, where $c_{R_I}(\pi, \theta, \eta)$ is the cost that equalizes $\mathbb{E}W_\ell^{FD}(I, \boldsymbol{I})$ and $\mathbb{E}W_\ell^{FD}(NI, \boldsymbol{I})$, or

$$\eta(1-\pi)\left[(1-\pi)^{L-1}\frac{c_{R_I}}{\theta} + (1-(1-\pi)^{L-1})T(c_{R_I}, \theta)\right] + (1-\eta)(1-\pi)\frac{c_{R_I}}{L} = b - c_0.$$

Similarly, no region initiates if and only if $c \geq c_{R_{NI}}(\pi, \theta, \eta)$, where the latter equalizes $\mathbb{E}W_\ell^{FD}(NI, \boldsymbol{NI})$ and $\mathbb{E}W_\ell^{FD}(I, \boldsymbol{NI})$, so that

$$\eta(1-\pi)T(c_{R_{NI}}, \theta) + (1-\eta)(1-\pi)\frac{c_{R_{NI}}}{L} = b - c_0.$$

It is straightforward to prove that $c_{R_I} \geq c_{R_{NI}}$, which implies that there is multiple equilibria for $c \in [c_{R_{NI}}, c_{R_I}]$. As before, we apply a refinement requiring that the equilibrium be strong. It can be shown that all regions investing is the unique strong equilibrium if and only if $c \leq c_{R_L}(\pi, \theta, \eta)$, with $c_{R_L}(\pi, \theta, \eta)$ satisfying

$$\eta(1-\pi)\left[(1-\pi)^{L-1}\frac{c_{R_L}}{\theta} + (1-(1-\pi)^{L-1})T(c_{R_L}, \theta)\right] + (1-\eta)(1-\pi)c_{R_L} = b - c_0.$$

Otherwise, no region investing is the unique strong equilibrium. Given this result, we define the threshold $c_R(\pi, \theta, \eta) \equiv \max\{c_{R_L}(\pi, \theta, \eta), c_{R_{NI}}(\pi, \theta, \eta)\}$, such that all regions invest if and only if $c \leq c_R(\pi, \theta, \eta)$.

Now assume that $c \in [c_1(\theta), c_2(\theta)]$. This case is analogous to the previous scenario. In particular, we can define a threshold $c_{NAR}(\pi, \theta, \eta) \equiv \max\{c_{NAR_L}(\pi, \theta, \eta), c_{NAR_{NI}}(\pi, \theta, \eta)\}$, such that all regions invest if and only if $c \leq c_{NAR}(\pi, \theta, \eta)$, where $c_{NAR_L}(\pi, \theta, \eta)$ and $c_{NAR_{NI}}(\pi, \theta, \eta)$ are defined by

$$\eta(1-\pi)\left[(1-\pi)^{L-1}\frac{c_{NAR_L}}{\theta} + (1-(1-\pi)^{L-1})b\right] + (1-\eta)(1-\pi)c_{NAR_L} = b - c_0,$$

and

$$\eta(1-\pi)b + (1-\eta)(1-\pi)\frac{c_{NAR_{NI}}}{L} = b - c_0,$$

respectively. This construction ensures that the initiation equilibrium is strong.

Finally, suppose that $c > c_2(\theta)$. We can show that in this case all regions initiate projects if and only if

$$c < c_{NR}(\pi,\eta) \equiv \frac{L}{(1-\eta)(1-\pi)}\left[\eta\pi b + (1-\eta)b - c_0\right].$$

To construct the frontier $c^{FD}(\pi,\theta,\eta)$, we define the π-cutoffs $\pi_1(\theta,\eta)$, $\pi_2(\theta,\eta)$ and $\pi_3(\theta,\eta)$ as

$$c_R(\pi_1(\theta,\eta),\theta,\eta) = c_1(\theta), \quad c_{NAR}(\pi_2(\theta,\eta),\theta,\eta) = c_2(\theta), \quad \text{and} \quad c_{NR}(\pi_3(\theta,\eta),\theta,\eta) = b.$$

Using that $c_{NAR}(\pi_1(\theta,\eta),\theta,\eta) = c_1(\theta)$, $c_{NR}(\pi_2(\theta,\eta),\theta,\eta) = c_2(\theta)$, and assuming that c_R and c_{NAR} are increasing in π (other configurations can be contemplated) we can define $c^{FD}(\pi,\theta,\eta)$ as

$$c^{FD}(\pi,\theta,\eta) = \begin{cases} c_R(\pi,\theta,\eta) & \text{if} \quad \pi \in [0,\pi_1(\theta,\eta)], \\ c_{NAR}(\pi,\theta,\eta) & \text{if} \quad \pi \in (\pi_1(\theta,\eta),\pi_2(\theta,\eta)], \\ c_{NR}(\pi,\theta,\eta) & \text{if} \quad \pi \in (\pi_2(\theta,\eta),\pi_3(\theta,\eta)], \\ b & \text{if} \quad \pi \in (\pi_3(\theta,\eta),1]. \end{cases}$$

To conclude, based on the expressions defining c_R, c_{NAR} and c_{NR} above, it is simple to verify that $\frac{\partial c_i(\pi,\theta,\eta)}{\partial\eta} \leq 0$ for $i = \{R, NAR, NR\}$. This proves that $c^{FD}(\pi,\theta,\eta)$ decreases with η. $\square$

B.9.2 Proposition 7

Part 1. Using the π-cutoffs defined previously, equilibrium expected welfare under FD is:

$$\mathbb{E}\widehat{W}^{FD}(\pi,\theta,\eta) = \begin{cases} \kappa + \int_0^{c_R(\pi,\theta,\eta)} \Big\{ b - c_0 - \eta(1-\pi)\big[(1-\pi)^{L-1}\frac{c}{\theta} \\ \quad +(1-(1-\pi)^{L-1})T(c,\theta)\big] - (1-\eta)(1-\pi)c \Big\} h(c)dc & \text{if } \pi \in [0,\pi_1(\theta,\eta)], \\ \\ \kappa + \int_0^{c_{NAR}(\pi,\theta,\eta)} \Big\{ - c_0 + \eta\big[\pi b + (1-\pi)^L\left(b - \frac{c}{\theta}\right)\big] \\ \quad +(1-\eta)(b-(1-\pi)c) \Big\} h(c)dc \\ \quad +\eta(1-\pi)(1-(1-\pi)^{L-1}) \int_0^{c_1(\theta)} [b - T(c,\theta)]h(c)dc & \text{if } \pi \in (\pi_1(\theta,\eta),\pi_2(\theta,\eta)], \\ \\ \kappa + \int_0^{c_{NR}(\pi,\theta,\eta)} \Big\{ - c_0 + \eta\pi b + (1-\eta)(b-(1-\pi)c) \Big\} h(c)dc \\ \quad +\eta(1-\pi)^L \int_0^{c_2(\theta)} \left[b - \frac{c}{\theta}\right] h(c)dc \\ \quad +\eta(1-\pi)(1-(1-\pi)^{L-1}) \int_0^{c_1(\theta)} [b - T(c,\theta)]h(c)dc & \text{if } \pi \in (\pi_2(\theta,\eta),\pi_3(\theta,\eta)], \\ \\ \kappa - c_0 + \eta\pi b + (1-\eta)b - (1-\eta)(1-\pi)\bar{c} \\ \quad +\eta(1-\pi)^L \int_0^{c_2(\theta)} \left[b - \frac{c}{\theta}\right] h(c)dc \\ \quad +\eta(1-\pi)(1-(1-\pi)^{L-1}) \int_0^{c_1(\theta)} [b - T(c,\theta)]h(c)dc & \text{if } \pi \in (\pi_3(\theta,\eta),1]. \end{cases} \tag{B.18}$$

This function is continuous and, in a neighborhood of $\eta = 1$, it is also convex in π and increasing in θ. Since $\mathbb{E}\widehat{W}^{PD}(\pi)$ is linear and increasing, and $\mathbb{E}\widehat{W}^{FD}(1,\theta,\eta) = \kappa - c_0 + b = \mathbb{E}\widehat{W}^{PD}(1)$, it follows that for η close to one, $\mathbb{E}\widehat{W}^{FD}(\pi,\theta,\eta)$ and $\mathbb{E}\widehat{W}^{PD}(\pi)$ cross at most once at $\pi \in [0,1)$. This crossing defines the frontier $\widehat{\pi}(\theta,\eta)$, whose properties can be derived using the arguments in the proof of Proposition 5.

Part 2. Since $\mathbb{E}\widehat{W}^{PD}(\pi)$ is independent of η, we only need to show that for all (π,θ):

$$\lim_{\eta\to 1} \frac{\partial \mathbb{E}\widehat{W}^{FD}(\pi,\theta,\eta)}{\partial \eta} \leq 0. \tag{B.19}$$

Using that $c_R \to c_{R_L}$ and $c_{NAR} \to c_{NAR_L}$ as $\eta \to 1$, it can be shown that (B.19) holds for the first two segments in (B.18) (see Online Appendix). The third segment vanishes as $\eta \to 1$, since we can prove that $\pi_2(\theta,\eta) = 1 - \frac{b-c_0}{\eta b + (1-\eta)\frac{c_2(\theta)}{L}}$, and $\pi_3(\theta,\eta) = 1 - \frac{b-c_0}{\eta b+(1-\eta)\frac{b}{L}}$, so that $(\pi_2(\theta,\eta),\pi_3(\theta,\eta)) \to (c_0/b, c_0/b)$. In the fourth segment of (B.18), $\partial\mathbb{E}\widehat{W}^{FD}(\pi,\theta,\eta)/\partial\eta \leq 0$ for all (π,θ,η). $\square$

Highlights

- We study the optimal degree of tax decentralization under imperfect state capacity
- Local administrative (fiscal) ability affects public good delivery (tax collection)
- Full tax decentralization is optimal only if administrative capacity is low enough
- Such a condition can be sufficient, depending on local projects' characteristics
- Some extensions are presented