Asymmetric Regions and the Optimal Degree of Fiscal Decentralization*

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Abstract

We study the optimal degree of fiscal decentralization in a federation under imperfect regional state capacity. Regional governments are characterized by their capital endowment. Two regimes are compared on efficiency grounds: partial and full decentralization. Under partial decentralization, regional governments have no tax powers and rely on central bailouts to refinance incomplete projects. Under full decentralization, regional governments refinance incomplete projects through capital taxes, in a context of tax competition. We show that when the difference in capital endowments is low, the higher the capital in the rich region the more often full decentralization dominates. This result is overturned for higher levels of capital endowment's difference.

Keywords: Fiscal federalism - Asymmetric regions - Capital endowments - Partial and full fiscal decentralization - Bailouts - Hard budget constraints.

JEL Codes: H77.

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1 Introduction

This paper tries to provide a first answer to the following question: Should an unequal, partially decentralized country become more fiscally decentralized?

Partial decentralization is an institutional regime where tax and expenditure assignments to regional governments are not balanced. In practice, these vertical fiscal imbalances are often solved by centrally provided transfers to regional governments. But this often generates problems: because of a common-pool fiscal externality, regional governments may face soft budget constraints, and thus they have incentives to over-expend, and/or pay insufficient attention to the quality of their investments.

In the economic and policy literature, it is widely accepted that regional governments have to face *hard budget constraints*. One of the mechanisms that have been put forward to implement hard budget constraints at the regional level is full fiscal decentralization. Indeed, according to Qian and Roland (1998), tax competition hardens regional governments' budget constraints and promotes efficient behavior at the regional level. However, this conventional view has been challenged on two grounds. First, according to Besfamille and Lockwood (2008), hard budget constraints may also be inefficient. This implies that a normative comparison between partial and full decentralization along the abovementioned trade-off is necessary. This normative comparison has been analyzed by Bellofatto and Besfamille (2015), in the context of symmetric regions. But, as it has been emphasized by Cai and Treisman (2005) (or, in a different context, by Janeba and Todtenhaupt (2016)), the existence of asymmetries between regions may undermine the disciplinary benefits of full fiscal decentralization. Therefore, an analysis of how differences in regions affect this trade-off is worthwhile.

This paper builds a model that enables us to answer the initial question because it incorporates all these trade-offs, provides a clear normative comparison between partial and full decentralization, and evaluates how this comparison is affected by exogenous regional asymmetries in capital endowments. Our main result is that when the difference in capital endowments is small, an increase in this difference makes full decentralization to dominate "more often". But for larger differences, this result is reversed. This result cautions previous findings, regarding the negative effects of even tiny regional asymmetries on tax competition settings.

1.1 Related literature

This paper is related to various strands of literature. First, other contributions have compared partially and fully decentralized regimes. Brueckner (2009) presents a Tiebout-type model, where local governments provide a local public good, private developers build houses, and then heterogeneous consumers decide on their location. He shows that when local governments are benevolent, full decentralization always dominates because uniform transfers under partial decentralization generate less variety of local public goods, and thus a worse preference matching. Peralta (2011) presents a political economy model, with both benevolent and rent-seeking local politicians. In her environment, voters cannot observe neither the politician's type nor the cost of the public good being provided. She finds that partial decentralization improves politician's selection (i.e., voting out rent-seekers) whereas full decentralization fosters discipline (i.e., giving rent seekers incentives to behave benevolently), and that this last regime dominates when the proportion of rent seekers is low.[1] The main differences between our paper and these contributions is that we study a different trade-off between partial and full decentralization, namely, the right balance between inefficient bailouts and project overprovision vs. capital tax competition and project underprovision. Moreover, neither of the previous articles incorporate regional asymmetries into the analysis. Bellofatto and Besfamille (2015) is the closest paper to this one. In our previous analysis, we analyze how the trade-off between partial and full decentralization is affected by different levels of regional state capacities, but in a context of symmetric regions.

The paper is also related to an important 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). The main differences between Besfamille and Lockwood (2008) and our paper are the following. These authors compare, from a normative point of view, soft and hard budget constraints at the *interim* stage (i.e., project by project), whereas we take an *ex ante* perspective, more suitable for an institutional comparison. Moreover, they do not consider how different levels of regional capital endowments affect the trade-off between partial and full decentralization, which is one of our main objectives. On the other hand, 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, but in the "rules vs. discretion" tradition.

Finally, the paper is related to the literature on asymmetries of regions in tax competition models: Wilson (1991), Bucovetsky (1991), Peralta and van

[1] 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.

Ypersele (2005), Cai and Treisman (2005) and Janeba and Todtenhaupt (2016).

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. Section 7 concludes. The main proofs are contained in the Appendix. Additional proofs and derivations are relegated to the Online Appendix.

2 Model

2.1 Preliminaries

The economy lasts for three periods $t = \{1, 2, 3\}$ and is composed of 2 regions. Each region $\ell \in \{p, r\}$ has a continuum (of measure one) of risk-neutral, immobile residents, each of whom has an endowment κ_ℓ of capital. We assume that $0 < \kappa_p \leq \kappa_r$. Let $\kappa = \kappa_p + \kappa_r$ be the national stock of capital.

In the last period, each resident derives utility from consumption of a numéraire good, 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 is mobile between regions, but at a cost. Specifically, a resident of a region that invests f units of capital in the other region incurs a mobility cost $f^2/2$. As we explain below, residents may also benefit from a discrete local public good, or project.

There are two levels of government: central and regional. Throughout the paper, we assume that both levels of government are benevolent and choose policies so as to maximize the sum of utilities of their residents. For simplicity, there is no discounting of future payoffs.

2.2 Timing

The order of events is as follows. At $t = 1$, a political body (e.g., a Congress) chooses between partial (PD) and full decentralization (FD). These institutional regimes rule all fiscal interactions between the central and regional governments, in a way specified below.

At the beginning of $t = 2$, each regional government faces a project in their region. For the sake of simplicity, we assume that projects' initial investment cost is c_0 in every region, and that Nature draws c (i.e., the refinancing cost of the projects, see below), according to a strictly positive probability density function $h(c)$ on $[0, b]$. Based on this, regional governments choose whether to initiate the project. This decision is denoted by $i_\ell \in \{I, NI\}$, where I (NI) stands for initiation (not initiation). Regional governments have just enough resources to fund the initial investment c_0.

If initiated, a project is carried out by the regional bureaucracy. With an exogenous probability $\pi \in [0, 1]$, a project generates a social benefit $b > 0$ for all residents of the region at the end of the current period.[2] With probability $(1-\pi)$, the project remains incomplete and yields no benefit during this period.[3] Projects' outcomes are the result of independent draws from the probability distribution $(\pi, 1-\pi)$, and are observable.

At $t = 3$, central or regional governments, depending on the institutional regime in place, decide whether to shut down or continue incomplete projects. In the last case, a project requires an additional input of c of the consumption good to be completed. It is worth emphasizing that, by construction, $c \leq b$; otherwise, continuation would never be optimal.

Under partial decentralization, the central government decides on refinancing incomplete projects through a uniform tax τ on the national stock of capital κ, collected by the national tax authority. Under full decentralization, each regional government decides whether or not to refinance its incomplete project, using a per unit tax levied on capital invested in its region at the rate τ_ℓ.[4]

Once taxes are set, capital owners invest in the region with the highest net return, central or regional governments raise their taxes, production takes place, and private consumption (net of mobility costs) occurs.[5] When the project is completed, it generates the social benefit b for all residents of the region.

In our environment, each regional government is characterized by the *administrative* dimension of state capacity.[6] It measures the ability of regional bureaucracies to carry out projects in due time, and it is encapsulated by the probability π.[7] We assume that both regional governments share the same exogenous level of state capacity π.

We summarize the timing in Figure 1. Values in terminal nodes represent the benefit of the project.

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[2]To focus on the trade off between soft and hard budget constraints, we rule out spillovers across regions.

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

[4]Regions do not have access to credit markets to refinance their incomplete projects. But, in any case, if regions could issue debt they would ultimately have to raise taxes to pay back their obligations.

[5]Such a timing is also adopted in the bulk of the literature on tax competition. See Wilson (1999) for a survey.

[6]Mann (1984) provides a general definition of state capacity as the infrastructural power of the state to enforce policy within its territory. Snyder (2001) and Ziblatt (2008) apply this concept to regional governments.

[7]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.

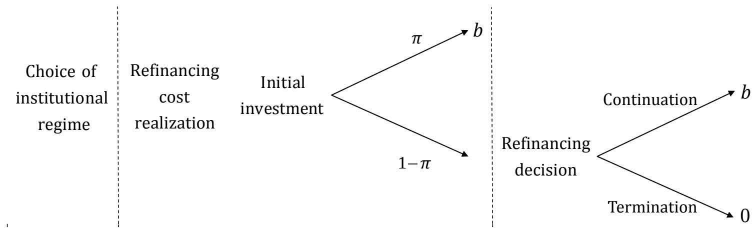


Figure 1: Timing

2.3 Discussion

Before putting the model to work, we comment on certain of its features.

Central Government Features. Certain characteristics of the central authority in our model deserve further comment. First, we assume that national taxation under partial decentralization is uniform across regions. This assumption has a counterpart in many federal countries, where national taxes (like the income tax or the VAT) are required to be set uniformly across subnational governments due to constitutional reasons.[8] In our model, it is straightforward to show that if one allowed national taxes to be non-uniform (for example, if they were contingent on which region requires 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.

Second, we suppose that the central government can commit not to bailout regions under full decentralization. If that wasn't the case, we would need to consider a "hybrid" regime, as in Köthenbürger (2004), where the central government keeps the option to bailout regions that have decided to refinance a fraction of their incomplete project. However, it can be shown that the equilibrium of such a regime would actually replicate the partial decentralization system. Indeed, anticipating a bailout from the central government (which is, by assumption, ex post optimal) and in order to avoid the use of distortionary taxation, each region would decide not to refinance its incomplete project. In the end, the central government would bailout all regions.

Third, we do not incorporate considerations of administrative capacity at the central level. The reason is that, in order to focus on bailouts under par-

[8]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.

tial decentralization, we suppose that the central government cannot intervene regions to avoid that projects be delayed.

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.[9] 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.[10] 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.

For technical reasons, we also assume that projects' benefits are sufficiently large: $b > 2c_0$. In other words, it is required that the benefit-cost ratio be larger than two. This condition considerably simplifies the analysis in the following sections.[11]

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, projects in the model are *ex ante* and *interim* identical, but *ex post* heterogeneous. Ex ante (i.e., in period 1), projects are all characterized by the same configuration of exogenous social benefits b, investment cost c_0, and by the same probability density function $h(c)$. Interim (i.e., at the beginning of period 2), the cost c is realized and applies for all projects in all regions. However, we still introduce ex post heterogeneity given that projects' outcomes can be different across regions.[12]

3 Partial Decentralization

This section studies the partially decentralized regime. Given that $c \leq b$, under this regime incomplete projects are always refinanced by the central government using a uniform tax on capital. This implies that project initiation decisions of

[9] 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.

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

[11] If the abovementioned assumption was violated, our main results would still hold but at the cost of extensive algebraic derivations. Nevertheless, 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`.

[12] An important feature of the model is risk neutrality. If individuals were risk averse, this could imply an insurance motive for bailouts under partial decentralization.

any given region may ultimately impact welfare of others, thus giving rise to a simultaneous game between regions in the second period (i.e., when the initial investment decision is made).

Region ℓ's expected welfare at the beginning of the second period is given by

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

where i_m is the investment decision chosen by region $m \neq \ell$, $\mathbb{I}_{\{i_\ell=I\}}$ is equal to 1 if region ℓ has initiated the project and to 0 otherwise, and τ^e is the expected tax.

The expected tax τ^e is obtained as follows. At the end of the second period, all projects' outcomes are realized. Let ω be a profile of outcomes, and denote by $n(\omega)$ the number of completed projects in this particular realization of outcomes. For any profile ω, the central government mechanically sets a tax τ_ω to cover, at the beginning of the third period, the cost of refinancing $\sum_\ell \mathbb{I}_{\{i_\ell=I\}} - n(\omega)$ 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 κ, and taxation is non distortionary. Hence, under the profile ω, the central government's budget constraint is

$$\tau_\omega.\kappa = \left[\sum_\ell \mathbb{I}_{\{i_\ell=I\}} - n(\omega)\right] c.$$

Therefore, when deciding on initial investment before the outcome of projects are realized, each region faces the expected tax $\tau^e \equiv \mathbb{E}_\omega \tau_\omega$, which satisfies

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

where the term in square brackets gives the expected number of bailouts. Substituting (2) into (1) and rearranging, we obtain

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

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 i_m. So, we can analyze the choice of i_ℓ just for a representative region ℓ.

Notice that each region only pays a fraction κ_ℓ/κ of the cost of refinancing its incomplete project, as this cost is shared through national taxation. Therefore, 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 a region $m \neq \ell$. But, as regions differ in their tax base, the impact of this externality is not symmetric. Let

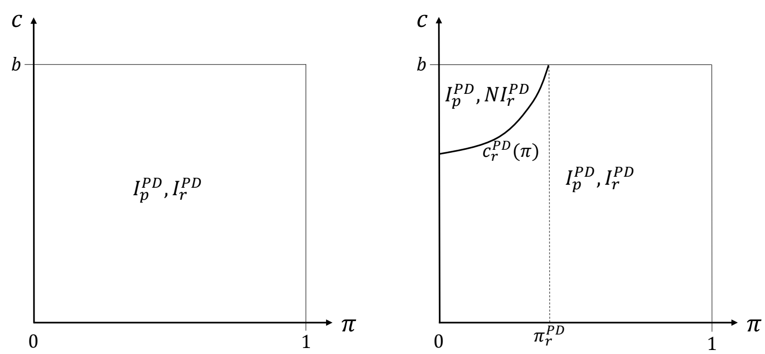
$$c_\ell^{PD}(\pi) \equiv \frac{\kappa}{\kappa_\ell}\frac{b-c_0}{1-\pi}$$

be the cost that makes region ℓ's net expected welfare from initiating the project under partial decentralization equal to zero. The next proposition completely characterizes regional project initiation decisions under this institutional regime.

Proposition 1. *Consider the project initiation game under PD.*
When $\kappa_p \leq \kappa_r < \left(\frac{b}{c_0} - 1\right)\kappa_p$, $b < c_r^{PD}(\pi) < c_p^{PD}(\pi)$. Hence, both regions invest in equilibrium.
When $\left(\frac{b}{c_0} - 1\right)\kappa_p \leq \kappa_r$, $c_r^{PD}(\pi) \leq b$ provided $\pi \leq \pi_r^{PD} \equiv \frac{c_0}{b} - \frac{\kappa_p}{\kappa_r}(1 - \frac{c_0}{b})$. Hence, if $c \leq c_r^{PD}(\pi)$, both regions invest in equilibrium. Otherwise, when $c \in \left[c_r^{PD}(\pi), b\right]$ only region p initiates the project.

Proof. see the Appendix. □

When the difference between κ_p and κ_r is not large, both regions pay a relatively similar share of any bailout. Thus, as $b > 2c_0$, initiating the project is a dominant strategy for any value of the refinancing cost c. But when κ_r is sufficiently larger than κ_p, region r pays a higher share of a bailout. Thus, for high values of the refinancing cost c, it is a dominant strategy for this region to not initiate its project. Due to the common-pool fiscal externality, this is not the case for region p. The following figures depict the initiation decisions under partial decentralization.



(a) $\kappa_r < \left(\frac{b}{c_0} - 1\right)\kappa_p$ (b) $\kappa_r \geq \left(\frac{b}{c_0} - 1\right)\kappa_p$

Figures 1: Initiation decisions under PD

4 Full Decentralization

In this section we 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 taxes on capital employed in the region, in a context of tax competition.

4.1 Equilibrium in Tax Rates

Before characterizing equilibrium tax rates, it will be convenient to describe how capital reacts to different tax profiles. Given a profile of tax rates $\tau = \{\tau_p, \tau_r\}$ set by both regions, a household resident in region ℓ decides where to invest its capital endowment. Let τ_m denote the tax rate chosen by the other region $m \neq \ell$ and $f_{\ell m}$, the amount of capital that this household invests in the other region $m \neq \ell$. The following proposition characterizes the household's investment decision.

Lemma 1. *If* $\tau_\ell \geq \tau_m$, $f_{\ell m} = \tau_\ell - \tau_m \geq 0$. *Otherwise,* $f_{\ell m} = 0$.

Proof. see the Appendix. □

As a household in region ℓ seeks to maximize net returns from its investments and the marginal productivity of capital is constant everywhere, its portfolio decision only depends upon the comparison between τ_ℓ and τ_m. As expected, a household in region ℓ invests "abroad" in the other region m provided $\tau_\ell > \tau_m$. The intuition behind the expression in the proposition is straightforward, as capital leaves region ℓ until the marginal tax savings equal the marginal mobility cost. As expected, this flow increases with the difference $\tau_\ell - \tau_m$.

When the regional tax rate τ_ℓ is lower than τ_m, there is no capital outflow from region ℓ and its residents invest all their endowment "at home." Moreover, in this case, region ℓ receives a capital inflow from the other region. But this does not benefit directly its residents because returns from these investments are consumed abroad, by residents in the other region $m \neq \ell$. Despite this fact, this capital inflow has an important role in the determination of the equilibrium tax rates.

In the remainder of the section, we solve the game between both regions backwards. We start with the last stage, where regional governments set tax rates to refinance incomplete projects.

To obtain the equilibrium tax rates, in the Appendix we derive region ℓ's reaction function $\tau_\ell(\tau_m)$. We have previously discussed that, depending upon the profile of tax rates, capital may leave (or enter) region ℓ to (from) the other region. Despite these different possibilities, region ℓ's after-tax consumption monotonically decreases with τ_ℓ, and so does regional welfare. Hence, for any τ_m, the tax rate chosen in region ℓ should be the lowest tax rate that enables the regional government to raise c.

The reaction function $\tau_\ell(\tau_m)$ is built around the value c/κ_ℓ, which is the tax rate that a regional government would choose in Starkey, and is decreasing. When $\tau_m < c/\kappa_\ell$, region ℓ's optimal response is to tax strictly above τ_m. Despite the fact that this decision will trigger a capital outflow, this is the only way to ensure the project's refinancing. When $\tau_m = c/\kappa_\ell$, region ℓ's optimal response is to replicate this level. Due to the way we model imperfect capital mobility, the tax collection's elasticity with respect to τ_ℓ is lower than one. This, combined with the fact that region ℓ needs to collect enough revenues to refinance its incomplete project, makes tax undercutting not a profitable deviation.

Finally, when $\tau_m > c/\kappa_\ell$, region ℓ's optimal response is to tax strictly below τ_m. This decision generates an inflow of capital that allows the government to raise sufficient revenues to pursue its incomplete project, thus moderating the tax burden on its residents.

As region ℓ's reaction function is continuous, we can characterize the Nash equilibria of this subgame as follows.

Proposition 2. *Consider the tax competition subgame under FD. Nash equilibria are as follows.*
If both regions have decided to refinance their incomplete project, there exists a unique Nash equilibrium in pure strategies characterized by $\widehat{\tau}_r < \widehat{\tau}_p$.
If there is a region which does not refinance, then the region that refinances sets

$$\widehat{\tau}_\ell\,(0) \equiv \frac{1}{2}\left[\kappa_\ell - \sqrt{\kappa_\ell^2 - 4c}\right].$$

Proof. see the Appendix. □

Consider the tax competition subgame that emerges when both regions have decided to refinance their incomplete project. The equilibrium tax rate $\widehat{\tau}_p$ and $\widehat{\tau}_r$ increase with the cost of the project c. Moreover, for a given value of κ_p, when κ_r increases, the difference $\widehat{\tau}_p - \widehat{\tau}_r$ also increases. The higher the capital endowment κ_r, the larger the tax base in region r and thus the lower the tax rate needed to refinance its incomplete project, *ceteris paribus*. On the other hand, due to the increasing capital outflow that it faces, region p has to increase its own tax rate. Asymmetric taxation emerges as the unique equilibrium, as in Bucovetsky (1991) and Wilson (1991). In this case, the regions' welfare (net of the initial cost c_0) are

$$W_p^{FD} = \kappa_p + b - TC_p^2(\kappa_p, \kappa_r, c)$$

and

$$W_r^{FD} = \kappa_r + b - TC_r^2(\kappa_p, \kappa_r, c),$$

where $TC_p^2(\kappa_p, \kappa_r, c) \equiv c + \frac{1}{2}\left[(\widehat{\tau}_p)^2 - (\widehat{\tau}_r)^2\right]$ and $TC_r^2(\kappa_p, \kappa_r, c) \equiv c - \widehat{\tau}_r\left[\widehat{\tau}_p - \widehat{\tau}_r\right]$. These expressions correspond to the total refinancing cost of an incomplete project in regions p and r, when both refinance. The total refinancing cost that region p faces comprises the effective refinancing cost c, plus the deadweight loss $\frac{1}{2}\left[(\widehat{\tau}_p)^2 - (\widehat{\tau}_r)^2\right]$ of financing the continuation of the project through a distortionary tax. This distortion is due to mobility costs incurred by owners of capital seeking to avoid the higher taxation in region p. On the other hand, in region r, the total refinancing cost of an incomplete project is, thanks to the capital inflow that comes from the other region, lower than c. Indeed, part of the refinancing cost is passed to the incoming capital.

The proposition also shows that, when region m does not refinance (in which case it does not need to tax its population), region ℓ has to set the tax rate $\widehat{\tau}_\ell\,(0)$ to pursue its incomplete project. Again, asymmetric taxation emerges as a possible equilibrium. The difference with the previous result is that differences in tax rates across regions are not originated from an ex ante regional asymmetry, but rather from the possibility that some regions may end up with incomplete projects ex post. The tax rate $\widehat{\tau}_\ell(0)$ also decreases with the capital endowment κ_ℓ. With this tax rate, the resulting capital outflow is $f_{\ell m} = \widehat{\tau}_\ell(0)$ and the equilibrium regional welfare (net of the initial cost c_0) is

$$W_\ell^{FD} = \kappa_\ell + b - TC_\ell^1(\kappa_\ell, c)$$

where

$$TC_\ell^1(\kappa_\ell, c) = c + \frac{[\widehat{\tau}_\ell(0)]^2}{2}$$

measures the total refinancing cost when only one region refinances. It comprises the effective refinancing cost c, plus the deadweight loss $[\widehat{\tau}_\ell(0)]^2/2$ of financing the continuation of the project through a distortionary tax. Again, this distortion is due to mobility costs incurred by owners of capital seeking to avoid taxation in region ℓ. Therefore, distortionary taxation emerges, in a way or in another, in all final nodes of the tax competition subgame. More importantly, the likelihood of these final nodes depends upon the level of regional administrative capacity π.

4.2 Refinancing

At the beginning of $t = 3$, regional governments decide whether to shut down or continue incomplete projects. We analyze Nash equilibria of the refinancing subgame next.

Proposition 3. *Consider the refinancing subgame under FD. Let $c_\ell^1(\kappa_\ell)$ denote the value of c that makes the total refinancing cost $TC_\ell^1(\kappa_\ell, c)$ equal to the benefit b, and let $c_p^2(\kappa_p, \kappa_r)$ be the cost that makes the total refinancing cost $TC_p^2(\kappa_p, \kappa_r, c)$ equal to the benefit b. There exists a threshold $\widehat{\kappa}_r$ such that Nash equilibria are as follows:*

1. *Suppose that both regions face incomplete projects.*

   (a) *When $\kappa_r \leq \widehat{\kappa}_r$, both regions refinance if and only if $c \leq c_p^2(\kappa_p, \kappa_r)$, and do not refinance otherwise.*

   (b) *When $\kappa_r > \widehat{\kappa}_r$, both regions refinance if and only if $c \leq c_p^2(\kappa_p, \kappa_r)$. Then, if $c_p^2(\kappa_p, \kappa_r) < c \leq c_r^1(\kappa_r)$, only region r refinances. Finally, when $c_r^1(\kappa_r) < c \leq b$, no region refinances.*

2. *If region $m \neq \ell$ does not need refinancing, the other region with an incomplete project refinances it if and only if $c \leq c_\ell^1(\kappa_\ell)$.*

Proof. See the Appendix. □

For a given value of the capital endowment κ_p, Nash equilibria of the refinancing subgame depend upon the capital endowment κ_r and the refinancing cost c. Suppose that both regions face incomplete projects. When $\kappa_r \leq \widehat{\kappa}_r$, as the difference in capital endowments is relatively small, both regions refinance their incomplete project with fairly similar tax rates if it were the case. Thus the Nash equilibria of this subgame are symmetric. Either both regions refinance their incomplete project when c is relatively low; otherwise no region refinances. In this last case, local governments face an endogenous hard budget constraint due distortionary taxation, as in Qian and Roland (1998). But when $\kappa_r > \widehat{\kappa}_r$, region r has an large tax base, which enables its local government to tax capital invested there at a relatively low rate. Therefore, under some circumstances, Nash equilibria are asymmetric. Indeed, when $c_p^2(\kappa_p, \kappa_r) < c \leq c_r^1(\kappa_r)$, not refinancing is a dominant strategy for region p, while the opposite holds for region r.

In all other subgames, when one region does not need refinancing, region ℓ continues its incomplete project provided $c \leq c_\ell^1(\kappa_\ell)$. Otherwise, the total cost from refinancing is higher than the benefit b, pushing region ℓ to shutdown its incomplete project. This is again an endogenous hard budget constraint.

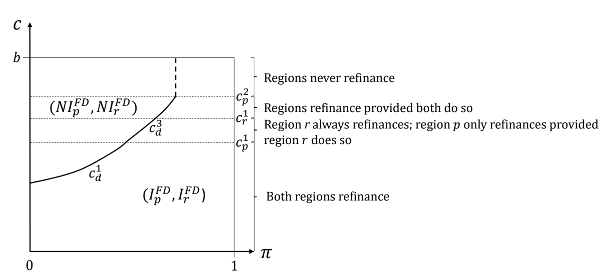
4.3 Project Initiation

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

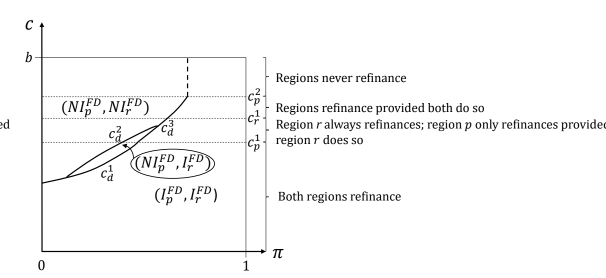
Proposition 4. *Consider the project initiation game under FD. There exists thresholds c_d^1, c_d^2, c_d^3 and $\overline{\kappa}_r$ such that the Nash equilibria are as follows.*
When $\kappa_r \leq \overline{\kappa}_r$, both regions initiate their project provided $c \leq c_d^1, c_d^3$. Otherwise, no region invests.
When $\kappa_r > \overline{\kappa}_r$, both regions initiate their project provided $c \leq c_d^1, c_d^3$. When $c_d^1, c_d^3 < c \leq c_d^2$, only region r initiates its project. Otherwise, no region invests.

Proof. See the Appendix. □

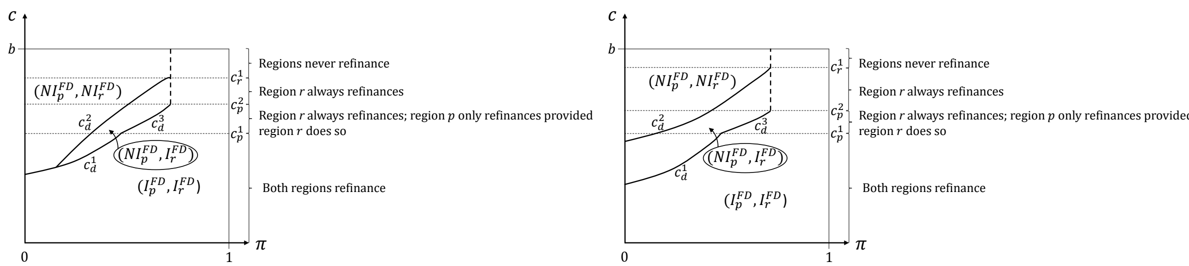
The following figures depict the initiation decisions and equilibrium outcomes that emerge under full decentralization.



(a) $\kappa_r < \overline{\kappa}_r$



(b) $\overline{\kappa}_r \leq \kappa_r < \widehat{\kappa}_r$



(c) $\widehat{\kappa}_r \leq \kappa_r < \widetilde{\kappa}_r$

(d) $\widetilde{\kappa}_r \leq \kappa_r < \infty$

Figures 2: Initiation and refinancing decisions under FD

5 Inefficiencies

In this section we analyze the sources of inefficiencies for each regime. We begin by analyzing the first best benchmark.

5.1 First Best

Consider a social planner who makes all decisions, but cannot anticipate whether a project will be completed at the end of $t = 2$ (i.e., he 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 welfare from initiating a project equal to zero. The efficient investment rule follows immediately from the definition of $c^*(\pi)$:

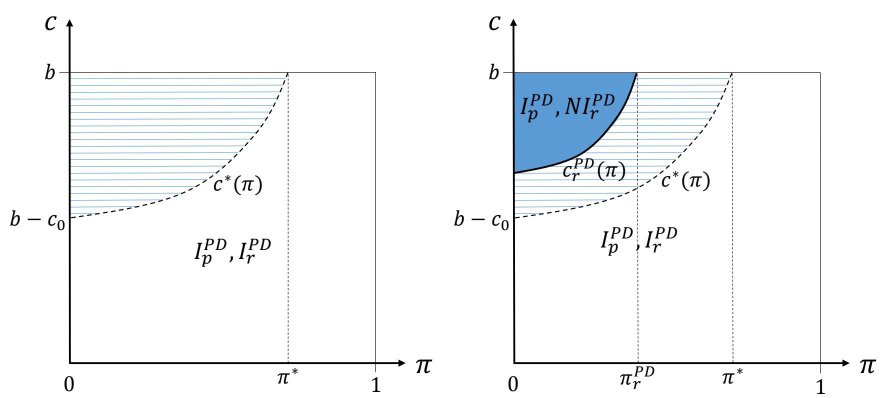
Lemma 2. *For any given region, initial investment is optimal if and only if* $c \leq c^*(\pi)$.

5.2 Partial Decentralization

Proposition 1 and Lemma 2 directly imply the following:

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

Inefficiencies under PD involve *over investment*. This result is driven by the well known common-pool fiscal externality (see Wildasin (1997) and Goodspeed (2002)). It is worth emphasizing that the equilibrium under PD is such that each region ℓ is expected to contribute an amount equal to the cost of refinancing by itself the share κ_ℓ/κ of its incomplete project. Despite this fact, as utilities are linear, interim expected national welfare under PD coincides with its counterpart in the first best level. Nevertheless, the PD regime does lead to initiating projects which yield negative expected welfare in equilibrium, while the first best does not. The following figures combine first best allocations and equilibrium outcomes that emerge under partial decentralization.



(a) $\kappa_r < \left(\frac{b}{c_0} - 1\right)\kappa_p$ (b) $\kappa_r \geq \left(\frac{b}{c_0} - 1\right)\kappa_p$

Figures 3: Inefficiencies under PD

In both figures, in the white area, regional investment decisions are optimal. For relatively low values of κ_r, $c_r^{PD}(\pi) > b$. Hence, in Figure 2(a), in the dashed area (i.e., when $c \in [c^*(\pi), b]$), projects are inefficiently initiated in equilibrium in both regions. As κ_r increases, the share of the bailouts cost that region r is expected to pay increases, implying that $c_r^{PD}(\pi)$ decreases. In particular, when $\kappa_r \geq \left(\frac{b}{c_0} - 1\right)\kappa_p$, $c_r^{PD}(\pi)$ can be lower than b. This can be seen in Figure 2(b). Now, in the shaded area (i.e., when $c \in [c_r^{PD}(\pi), b]$), the project is inefficiently initiated in equilibrium only in region p. Indeed, as $\kappa_p < \kappa_r$, region r is more incentivized to not initiate an inefficient project, because it pays a higher fraction of any number of bailouts. As in the previous figure, in the dashed area both regions initiate inefficient projects. Finally, when $\pi^* < \pi \leq 1$, inefficient investments cannot emerge because the model is biased towards project initiation. Under these parameter conditions, partial decentralization replicates the first best outcome.

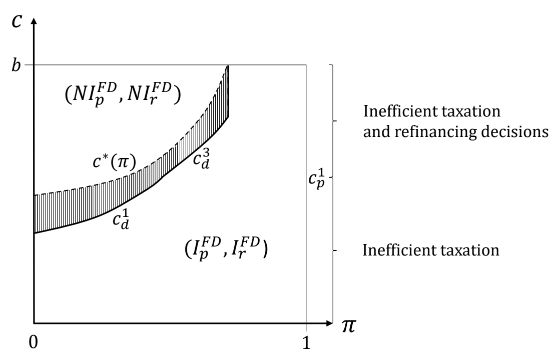
5.3 Full Decentralization

In the Appendix we show that the cost thresholds c_d^1, c_d^2, c_d^3 in Proposition 4 are below than $c^*(\pi)$. Hence, we can establish the types of inefficiencies that emerge under this institutional regime, as follows.

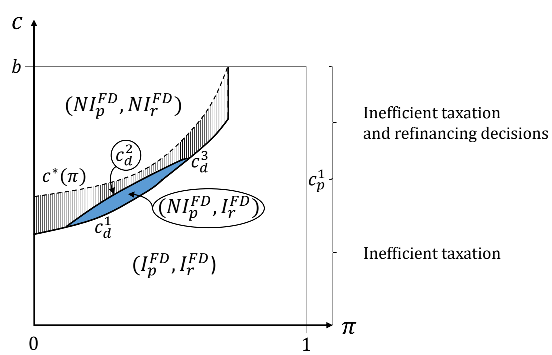
Corollary 2. *Under FD, equilibrium outcomes can be inefficient for three reasons:*

1. *Regions do not make initial investments in equilibrium when it is efficient to do so.*
2. *Incomplete projects are not refinanced in equilibrium when it is efficient to do so.*
3. *Incomplete projects are refinanced using distortionary capital taxes.*

Figures 4a and 4b illustrate these results.



(a) $\kappa_r \leq \overline{\kappa}_r$.



(b) $\kappa_r > \widehat{\kappa}_r$.

Figures 4: Inefficiencies under FD

In Figure 4(a), in the non-empty area (NI_p^{FD}, NI_r^{FD}), delimited from below by the thick curves representing the cost thresholds $c_d^1(\pi, \kappa_p, \kappa_r)$ and $c_d^3(\pi, \kappa_p, \kappa_r)$, projects are not initiated. In the complementary area, denoted by (I_p^{FD}, I_r^{FD}), all projects are initiated.

When $c \in [c^*(\pi), b]$, efficient decisions are adopted. In all other areas, either the projects' initiation and continuation decisions are distorted or regions refinance bearing deadweight losses. For low values of π, two different types of inefficiency emerge. First, when $c \in [0, c_d^1(\pi, \kappa_p, \kappa_r)]$, initiation and continuation decisions are optimal, but refinancing is done bearing deadweight losses generated by distortionary capital taxation. Second, as $c_d^1(\pi, \kappa_p, \kappa_r) < c^*(\pi)$, the condition for project initiation is stricter with full decentralization than for the social planner. Therefore, in the dashed area when $c \in [c_d^1(\pi, \kappa_p, \kappa_r), c^*(\pi)]$, investments are not initiated in equilibrium, despite the fact that they are efficient. Underinvestment is due to i) distortionary refinancing, when $c \in [c_d^1(\pi, \kappa_p, \kappa_r), c_p^1(\kappa_p)]$, and ii) endogenous hard budget constraints for region p combined with distortionary refinancing for region r, when $c \in [c_p^1(\kappa_p), c^*(\pi)]$.

For higher values of π, a new type of inefficiency emerges. When

$$c \in \left[c_p^1(\kappa_p), min\{c_d^3(\pi, \kappa_p, \kappa_r), c_r^1(\kappa_r)\}\right],$$

projects are initiated and always refinanced by region r but only by region p when both regions do so. When $c \in \left[c_r^1(\kappa_r), c_p^2(\kappa_p, \kappa_r)\right]$, projects are initiated and refinanced by both regions, provided both regions refinance. Again, there is underinvestment when $c \in [c_d^3(\pi, \kappa_p, \kappa_r), c^*(\pi)]$.

Finally, when $\pi > \pi^*$, the model is biased towards project initiation. Incomplete projects are either refinanced in a distortionary way, shut down in some terminal nodes of the tax competition subgame, or when $c \in \left[c_p^2(\kappa_p, \kappa_r), b\right]$, they are never finished.

Figure 3(b) depicts the distortions that emerge when $\kappa_r > \widehat{\kappa}_r$. As region r's capital endowment is relatively high, refinancing is easier there than in region p. Therefore, region r can refinance projects with higher costs. This implies that, for intermediate values of π, there exists a parameter region $c \in \left[c_d^1(\pi, \kappa_p, \kappa_r), c_d^2(\pi, \kappa_r)\right]$ where projects are only initiated (and, if necessary, refinanced) by region r.

6 Optimal Institutional Regime

The institutional choice between partial and full decentralization takes place in the initial period. At this stage, the Congress observes projects' initial cost c_0 and benefit b, the regional capital endowments κ_ℓ and the state capacity π, and knows that the refinancing cost c is distributed according to a strictly positive pdf $h(c)$ over $[0, b]$. Let $\mathbb{E}\widehat{W}_\ell^{IR}(c, \pi, \kappa_p, \kappa_r)$ denote the equilibrium level of expected welfare given $(c, \pi, \kappa_p, \kappa_r)$ under the institutional regime $IR \in \{PD, FD\}$ for a representative region ℓ. The Congress chooses the optimal regime by solving

$$\max\left\{\mathbb{E}\widehat{W}_p^{PD}(\pi,\kappa_p,\kappa_r)+\mathbb{E}\widehat{W}_r^{PD}(\pi,\kappa_p,\kappa_r),\mathbb{E}\widehat{W}_p^{FD}(\pi,\kappa_p,\kappa_r)+\mathbb{E}\widehat{W}_r^{FD}(\pi,\kappa_p,\kappa_r)\right\},$$

where $\mathbb{E}\widehat{W}_\ell^{IR}(\pi,\kappa_p,\kappa_r)$ is the expected welfare of a region ℓ in equilibrium given (π,κ_p,κ_r) under regime IR, i.e.

$$\mathbb{E}\widehat{W}_\ell^{IR}(\pi,\kappa_p,\kappa_r)\equiv\int_0^b \mathbb{E}\widehat{W}_\ell^{IR}(c,\pi,\kappa_p,\kappa_r)h(c)dc.$$

Next we evaluate how the optimal regime is affected by the level of the differential in capital endowment. In this endeavor, the comparison between $\mathbb{E}\widehat{W}^{FD}$ and $\mathbb{E}\widehat{W}^{PD}$ across (π,κ_r) is not a priori evident. The following proposition characterizes this comparison.

Proposition 5. *There exists a unique threshold $\widetilde{\pi}(\kappa_r)$ such that, when the regional administrative capacity $\pi\leq\widetilde{\pi}(\kappa_r)$, full decentralization dominates. Otherwise, partial decentralization dominates.*

When the regional administrative capacity equals one, both regimes are efficient.

Proof. See the Appendix

This proposition shows that there exists a unique threshold that separates both regimes. In particular, FD dominates for lower levels of the regional administrative capacity. This result, reminiscent to Bellofatto and Besfamille (2015), implies that FD dominance requires that regional administrative capacity be sufficiently *low*, i.e., $\pi\leq\widehat{\pi}(\kappa_r)$. The intuition can be grasped by comparing the inefficiencies in Corollaries 1 and 2, over this parametric region. First, when π is low, it is more likely to generate overinvestment inefficiencies under PD, than underinvestment inefficiencies under FD. Second, the likelihood of creating refinancing and tax distortion inefficiencies under FD is low when π is low. Essentially, those distortions can only emerge if one region needs no refinancing, but for small π the probability of this event is low. Next we show how this frontier evolves with differential in capital endowments. □

Proposition. *When $\kappa_r\to\kappa_p$, $\widetilde{\pi}(\kappa_r)$ increases with κ_r.*

When $\kappa_r\to\infty$, either $\widetilde{\pi}(\kappa_r)$ decreases with κ_r and converges to a strictly positive value $\widetilde{\pi}_\infty$, or $\widetilde{\pi}(\kappa_r)=0$.

The following (simulated) figure illustrates these results.

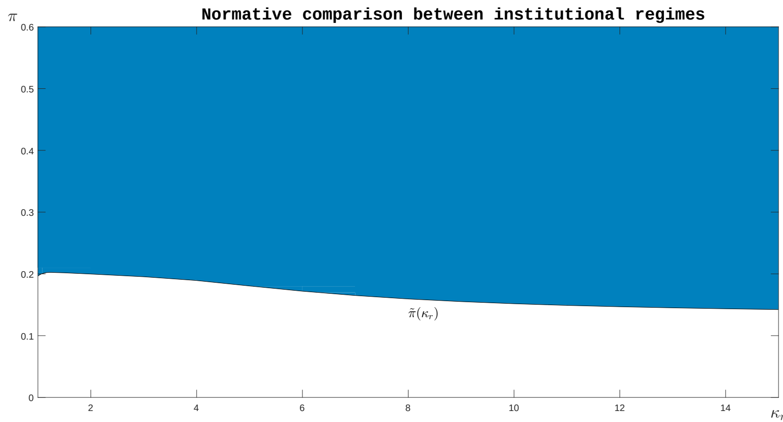


Figure 5: Normative comparison between PD and FD

Figure 5 depicts a frontier $\widehat{\pi}(\kappa_r)$, below which FD dominates; and above which PD dominates. In particular, Figure 5 confirms that $\widehat{\pi}(\kappa_r)$ is not monotone. For low levels of κ_r, FD's dominance increases with this parameter. But, when the difference between capital endowments is sufficiently high, FD dominates in a smaller parameter area. The intuition for this results hinges again on the comparisons between distortions that emerge under both regimes. For low levels of κ_r, an increase in this capital endowment has no impact on expected welfare under PD. But this is not the case in the other regime. Despite the fact that when κ_r increases less projects are undertaken (because $c_d^1(\pi, \kappa_p, \kappa_r)$ decreases), the whole welfare cost of the tax distortions decreases as well. Therefore, for a given value of π, the former effect is of second order wrt the latter, and thus the expected welfare increases. For higher levels of κ_r this observation does not hold any more.

Importantly, this last result cast doubts on the robustness of Cai and Treisman (2005) pessimistic result regarding the benefits of tax competition. In their model, the national expected welfare always decreases when the asymmetries between regions increases. Moreover, as they do not compare the outcome under other institutional regime, they have to be cautious regarding their policy recommendations. Here, at least based in our simulations, we can clearly state when FD should be the preferred regime, and that an increase in region's asymmetry is not always detrimental to the fully decentralized regime.

7 Conclusion

This paper presents a model featuring a central government and regional authorities. The latter are characterized their levels of administrative capacities, and the stock of private capital in their jurisdiction. 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 and face hard budget constraints. In this scenario, 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 capital endowments affect this comparison. Contrary to some previous results, we show that when asymmetries in capital endowments are low, an increase in the capital endowment of the richer region favors full decentralization. But this result is overturned when this differential increases.

An interesting route for further research is to incorporate another ex ante asymmetries between regions, in particular in administrative state capacities. This would yield a more suitable framework to deliver quantitative assessments, and would be an essential feature to endogenize regional state capacity formation under different fiscal regimes.

References

[1] Akai, N. and M. Sato (2008), "Too Big or Too Small? A Synthetic View of the Commitment Problem of Interregional Transfers," *Journal of Urban Economics*, **64**, 551-559.

[2] Bellofatto, A. and M. Besfamille (2015), "Regional State Capacity and the Optimal Degree of Fiscal Decentralization", Documento de Trabajo IE-PUC, N° 460, 2015.

[3] Besfamille, M. and B. Lockwood (2008), "Bailouts in Federations: Is a Hard Budget Constraint Always Best?," *International Economic Review*, **49**, 577-593.

[4] Brueckner, J. (2009), "Partial Fiscal Decentralization," *Regional Science and Urban Economics*, **39**, 23-32.

[5] Bucovetsky, S. (1991), "Asymmetric Tax Competition," *Journal of Urban Economics*, **30**, 167-181.

[6] Caplan, A., R. Cornes and E. Silva (2000), "Pure Public Goods and Income Redistribution in a Federation with Decentralized Leadership and Imperfect Labour Mobility," *Journal of Public Economics*, **77**, 265-284.

[7] Cremer, H., M. Marchand and P. Pestieau (1997), "Investment in Local Public Services: Nash Equilibrium and Social Optimum," *Journal of Public Economics*, **65**, 23-35.

[8] Crivelli, E. and K. Staal (2013), "Size, Spillovers and Soft Budget Constraints," *International Tax and Public Finance*, **20**, 338-356.

[9] Goodspeed, T. (2002), "Bailouts in a Federation," *International Tax and Public Finance*, **9**, 409-421.

[10] Guccio, C., G. Pignataro and I. Rizzo (2014), "Do Local Governments Do it Better? Analysis of Time Performance in the Execution of Public Works," *European Journal of Political Economy*, **34**, 237-252.

[11] Hatfield, J. and G. Padró i Miquel (2012), "A Political Economy Theory of Partial Decentralization," *Journal of the European Economic Association*, **10**, 605-633.

[12] Janeba, E. and J. Wilson (2011), "Optimal Fiscal Federalism in the Presence of Tax Competition," *Journal of Public Economics*, **95**, 1032-1311.

[13] Joanis, M. (2014), "Shared Accountability and Partial Decentralization in Local Public Good Provision," *Journal of Development Economics*, **107**, 28-37.

[14] Köthenbürger, M. (2004), "Tax Competition in a Fiscal Union with Decentralized Leadership," *Journal of Urban Economics*, **55**, 498-513.

[15] Köthenbürger, M. (2011), "How Do Local governments Decide on Public Policy in Fiscal Federalism? Tax Vs. Expenditure Optimization," *Journal of Public Economics*, **95**, 1516-1522.

[16] Lockwood, B. (2002), "Distributive Politics and the Costs of Centralization," *The Review of Economic Studies*, **69**, 313-337.

[17] Mann, M. (1984), "The Autonomous Power of the State: Its Origins, Mechanisms and Results," *Archives Européennes de Sociologie*, **25**, 185-213.

[18] Patil, S., A. Gupta, D. Desai and A. Sajane (2013), "Causes of Delay in Indian Transportation Infrastructure Projects," *International Journal of Research in Engineering and Technology*, **2**, 71-80.

[19] Peralta, S. (2011), "Partial Fiscal Decentralization, Local Elections and Accountability," mimeo, Nova School of Business and Economics.

[20] Persson, T. and G. Tabellini (1992), "The Politics of 1992: Fiscal Policy and European Integration," *Review of Economic Studies*, **59**, 689-701.

[21] Qian, Y. and G. Roland (1998), "Federalism and the Soft-Budget Constraint," *American Economic Review*, **88**, 1146-1162.

[22] Sanguinetti, P. and M. Tommasi (2004) "Intergovernmental Transfers and Fiscal Behavior Insurance Versus Aggregate Discipline," *Journal of International Economics*, **62**, 149-170.

[23] Silva, E. and A. Caplan (1997), "Transboundary Pollution Control in Federal Systems," *Journal of Environmental Economics and Management*, **34**, 173-186.

[24] Snyder, R. (2001), "Scaling Down: the Subnational Comparative Method," *Studies in Comparative International Development*, **36**, 93-110.

[25] Wildasin, D. (1988), "Nash Equilibria in Models of Fiscal Competition," *Journal of Public Economics*, **35**, 229-240.

[26] Wildasin, D. (1997), "Externalities and Bailouts Hard and Soft Budget Constraints in Intergovernmental Fiscal Relations," mimeo, Vanderbilt University.

[27] Wilson, J. (1991), "Tax Competition with Interregional Differences in Factor Endowments," *Regional Science and Urban Economics*, **21**, 423-451.

[28] Wilson, J. (1999), "Theories of Tax Competition," *National Tax Journal*, **52**, 269-304.

[29] Ziblatt, D. (2008), "Why Some Cities Provide More Public Goods than Others: A Subnational Comparison of the Provision of Public Goods in German Cities in 1912," *Studies in Comparative International Development*, **43**, 273-289.

[30] Zodrow, G. and P. Mieszkowski (1986), "Pigou, Tiebout, Property Taxation, and the Underprovision of Local Public Goods," *Journal of Urban Economics*, **19**, 356-370.

8 Appendix

8.1 Proof of Proposition 1

The government of region ℓ anticipates that its net expected welfare from investing in the project is

$$\kappa_\ell + \mathbb{1}_{\{i_\ell = I\}} \left[b - c_0 - (1-\pi)\frac{\kappa_\ell}{\kappa} c \right] - \mathbb{1}_{\{i_m = I\}} (1-\pi) \frac{\kappa_\ell}{\kappa} c, \tag{4}$$

whereas its net expected welfare from not investing is

$$\kappa_\ell - \mathbb{1}_{\{i_m = I\}} (1-\pi) \frac{\kappa_\ell}{\kappa} c \cdot$$

So, for any region ℓ, initiating the project is a dominant strategy if

$$c \le c_\ell^{PD}(\pi) \equiv \frac{\kappa}{\kappa_\ell} c^*(\pi) \cdot$$

Since $\kappa > \kappa_r > \kappa_p$, it follows that $c_p^{PD}(\pi) > c_r^{PD}(\pi) > c^*(\pi)$. Moreover, we can show that

$$\frac{\partial}{\partial \pi} c_\ell^{PD}(\pi) = \frac{\kappa}{\kappa_\ell} \frac{b - c_0}{(1-\pi)^2} > 0,$$

$$\frac{\partial^2 c_\ell^{PD}(\pi)}{\partial \pi^2} = \frac{\kappa}{\kappa_\ell} \frac{2(b - c_0)}{(1-\pi)^3} > 0,$$

and that $c_\ell^{PD} = b$ when $\pi = \pi^* - \frac{\kappa_m}{\kappa_\ell}(1-\pi^*)$.

In order to figure out whether a region initiates its project, we only need to know when $c_\ell^{PD}(0) \geq b$. It is straightforward to show that, as $b > 2c_0$, $c_p^{PD}(0) > b$, while $c_r^{PD}(0) \geq b$ iff $\kappa_r \leq \left(\frac{b}{c_0} - 1\right)\kappa_p$. $\square$

8.2 Proof of Lemma 1

Given a profile of tax rates $\tau = \{\tau_p, \tau_r\}$, a household resident in region ℓ decides where to invest its capital endowment by solving the following problem:

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

subject to its portfolio constraint

$$h_\ell + f_{\ell m} = \kappa_\ell$$

and the non-negativity constraint

$$f_{\ell m} \geq 0,$$

where h_ℓ is capital invested in region ℓ, and $f_{\ell m}$ is capital invested in the other region $m \neq \ell$. Denote by $\lambda_{\ell m}$ the multiplier associated with the non-negativity constraint. Using the portfolio constraint to replace h_ℓ in the maximand of the household's problem, we obtain the first-order condition for $f_{\ell m}$ and the complementary slackness condition

$$\begin{cases} \tau_\ell - \tau_m + \lambda_{\ell m} = f_{\ell m} \\ \lambda_{\ell m} f_{\ell m} = 0 \quad \lambda_{\ell m} \geq 0. \end{cases}$$

If $\tau_\ell > \tau_m$, $f_{\ell m} > 0$ and thus $\lambda_{\ell m} = 0$. If $\tau_\ell = \tau_m$, $\lambda_{\ell m} = f_{\ell m}$. In this case, the unique combination that satisfies the complementary slackness condition is $\lambda_{\ell m} = f_{\ell m} = 0$. Finally, if $\tau_\ell < \tau_m$, $\lambda_{\ell m} > 0$ to ensure that $f_{\ell m} \geq 0$. Hence, by the complementary slackness condition, $f_{\ell m} = 0$. $\square$

8.3 Proof of Proposition 2

To obtain the equilibrium tax rates, first we derive region ℓ's reaction function.[13]

Scenario 1: Both regions have decided to refinance their incomplete project

For any tax rate τ_m, we need to consider three cases.

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

1. If the regional government of ℓ plans to replicate τ_m, $f_{\ell m} = f_{m\ell} = 0$. The unique tax rate τ_m that enables region ℓ to refinance its incomplete project by replicating it is $\tau_m = c/\kappa_\ell$.

2. If the regional government of ℓ plans to set its tax rate strictly above τ_m, there will be a capital outflow to the other region m. Hence, the regional welfare would be

$$W_\ell^{FD} = (\kappa_\ell - f_{\ell m})(1-\tau_\ell) + f_{\ell m}(1-\tau_m) - \frac{1}{2}(f_{\ell m})^2 + b.$$

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

$$\tau_\ell(\kappa_\ell - f_{\ell m}) = c. \tag{5}$$

   As $f_{\ell m} = \tau_\ell - \tau_m$, the smallest root of (5) is given by[14]

$$\overline{\tau}_\ell \equiv \frac{1}{2}\left[\kappa_\ell + \tau_m - \sqrt{(\kappa_\ell + \tau_m)^2 - 4c}\right], \tag{6}$$

   which is a decreasing and convex function of τ_m.

3. If the regional government of ℓ plans to set its tax rate strictly below τ_m, there will be no capital outflow to the other region. Thus, regional welfare would be

$$W_\ell^{FD} = \kappa_\ell(1-\tau_\ell) + b.$$

   Again, by the Envelope Theorem, $\partial W_\ell^{FD}/\partial \tau_\ell = -\kappa_\ell < 0$. So, the regional government of ℓ should choose the lowest tax rate that satisfies its budget constraint

$$\tau_\ell(\kappa_\ell + f_{m\ell}) = c, \tag{7}$$

   where

$$f_{m\ell} = \tau_m - \tau_\ell \tag{8}$$

   represents the capital inflow that leaves region $m \neq \ell$, and enters region ℓ. Rearranging terms, the smallest root of (7) is given by

$$\underline{\tau}_\ell \equiv \frac{1}{2}\left[\kappa_\ell + \tau_m - \sqrt{(\kappa_\ell + \tau_m)^2 - 4c}\right]. \tag{9}$$

As $\lim_{\tau_m \xrightarrow{+} c/\kappa_\ell} \underline{\tau}_\ell = \lim_{\tau_m \xrightarrow{-} c/\kappa_\ell} \overline{\tau} = c/\kappa_\ell$, the reaction function is

$$\tau_\ell(\tau_m) \equiv \frac{1}{2}\left[\kappa_\ell + \tau_m - \sqrt{(\kappa_\ell + \tau_m)^2 - 4c}\right]. \tag{10}$$

[14]Throughout the paper, we assume that $\kappa_\ell \gg 2\sqrt{b}$, so that this square root always exists (see footnote 14).

Let's define the function

$$\Gamma: \quad [0,1]^2 \quad \longrightarrow \quad [0,1]^2 \quad .$$

$$\begin{pmatrix} \tau_p \\ \tau_r \end{pmatrix} \longrightarrow \begin{pmatrix} \tau_p(\tau_r) \\ \tau_r(\tau_p) \end{pmatrix}$$

This function is continuous, and maps a compact set into itself. Hence, by Brower's Theorem, Γ has at least a fixed point $(\widehat{\tau}_p, \widehat{\tau}_r)$, which is a Nash equilibrium of the tax competition game. The couple $(\widehat{\tau}_p, \widehat{\tau}_r)$ satisfies

$$\begin{cases} \widehat{\tau}_p = \frac{1}{2}\left[\kappa_p + \widehat{\tau}_r - \sqrt{(\kappa_p + \widehat{\tau}_r)^2 - 4c}\right] \\ \\ \widehat{\tau}_r = \frac{1}{2}\left[\kappa_r + \widehat{\tau}_p - \sqrt{(\kappa_r + \widehat{\tau}_p)^2 - 4c}\right] \end{cases} . \tag{11}$$

To prove uniqueness, we evaluate

$$\lim_{\tau_p \to 0} \left.\frac{\partial \tau_r}{\partial \tau_p}\right|_{\tau_r(\tau_p)} - \lim_{\tau_r \to 0} \left.\frac{\partial \tau_r}{\partial \tau_p}\right|_{\tau_p(\tau_r)} = \Omega(\kappa_p, \kappa_r) \equiv \frac{1}{2} - \frac{\kappa_r}{2\sqrt{\kappa_r^2 - 4c}} - \frac{2\sqrt{\kappa_p^2 - 4c}}{\sqrt{\kappa_p^2 - 4c} - \kappa_p}.$$

As $\kappa_p \gg 2\sqrt{b}$,

$$\lim_{\kappa_r \to \kappa_p} \Omega(\kappa_p, \kappa_r) = \frac{\left(\kappa_p - 3\sqrt{\kappa_p^2 - 4c}\right)\left(\kappa_p + \sqrt{\kappa_p^2 - 4c}\right)}{-2\sqrt{\kappa_p^2 - 4c}\left(\kappa_p - \sqrt{\kappa_p^2 - 4c}\right)} > 0$$

and

$$\frac{\partial \Omega(\kappa_p, \kappa_r)}{\partial \kappa_r} = \frac{\frac{\kappa_r}{\sqrt{\kappa_r^2 - 4c}} - \sqrt{\kappa_r^2 - 4c}}{2\left(\kappa_r^2 - 4c\right)} > 0.$$

Hence, for any $\kappa_r > \kappa_p$, $\Omega(\kappa_p, \kappa_r)$ is strictly positive. By convexity, this implies that when both reaction functions intersect, the slope of $\tau_r(\tau_p)$ is lower (in absolute value) than the slope of $\tau_p(\tau_r)$. Therefore, the reaction functions crosses each other only once.

Finally, using a similar geometric argument, we can show that $\widehat{\tau}_r < \widehat{\tau}_p$. If this were not the case, by convexity, $\tau_r(\tau_p)$ would cross the 45° line farther from the origin than $\tau_p(\tau_r)$ does. But this contradicts the fact that the unique taxes that replicate the other are $\tau_r = c/\kappa_r < \tau_p = c/\kappa_p$.

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

In this case, the regional government of ℓ has to set the tax rate $\widehat{\tau}_\ell(0)$ to refinance its incomplete project. This tax rate is obtained replacing τ_m by 0 in (10).[15] □

[15] A sufficient condition for the existence of the square roots in (10), and to ensure that $\widehat{\tau}_\ell < 1$ is $\kappa_p \geq \max\{2\sqrt{b}, b\}$.

8.4 Proof of Proposition 3

First, we prove the existence of the thresholds $c_\ell^1(\kappa_\ell)$ and $c_p^2(\kappa_p, \kappa_r)$.

When region m does not need refinancing, the total cost from completing the project in region ℓ, $TC_\ell^1(\kappa_\ell, c) > c$, is a strictly increasing and convex function of c, that satisfies

$$\lim_{c \to 0} TC_\ell^1(\kappa_\ell, c) = 0$$

and

$$\lim_{c \to b} TC_\ell^1(\kappa_\ell, c) > b.$$

Hence, Bolzano's Theorem implies that there exists a threshold $c_\ell^1(\kappa_\ell) \in (0, b)$ such that, when $c \leq c_\ell^1(\kappa_\ell)$, $b - TC_\ell^1(\kappa_\ell, c) \geq 0$. Moreover, as $\kappa_p < \kappa_r$, it is straightforward to show that $c < TC_r^1(\kappa_r, c) < TC_p^1(\kappa_p, c)$, implying that $c_p^1(\kappa_p) < c_r^1(\kappa_r)$.

When both regions refinance, $TC_p^2(\kappa_p, \kappa_r, c) > c > TC_r^2(\kappa_p, \kappa_r, c)$. In order to characterize how $TC_p^2(\kappa_p, \kappa_r, c)$ evolves with c, we compute

$$\frac{\partial TC_p^2(\kappa_p, \kappa_r, c)}{\partial c} = 1 + \widehat{\tau}_p \frac{\partial \widehat{\tau}_p}{\partial c} - \widehat{\tau}_r \frac{\partial \widehat{\tau}_r}{\partial c}.$$

Differentiating completely (11), we obtain

$$\begin{aligned} \frac{\partial TC_p^2(\kappa_p,\kappa_r,c)}{\partial c} = \quad & 1 + \widehat{\tau}_p \frac{2\sqrt{(\kappa_r+\widehat{\tau}_p)^2-4c}-2\widehat{\tau}_p}{2\sqrt{(\kappa_p+\widehat{\tau}_r)^2-4c}\sqrt{(\kappa_r+\widehat{\tau}_p)^2-4c}-2\widehat{\tau}_p\widehat{\tau}_r} \\ & -\widehat{\tau}_r \frac{2\sqrt{(\kappa_p+\widehat{\tau}_r)^2-4c}-2\widehat{\tau}_r}{2\sqrt{(\kappa_p+\widehat{\tau}_r)^2-4c}\sqrt{(\kappa_p+\widehat{\tau}_r)^2-4c}-2\widehat{\tau}_p\widehat{\tau}_r}. \end{aligned}$$

Using the fact that $\sqrt{(\kappa_p + \widehat{\tau}_r)^2 - 4c} = \kappa_p + \widehat{\tau}_r - 2\widehat{\tau}_p$ and $\sqrt{(\kappa_r + \widehat{\tau}_p)^2 - 4c} = \kappa_r + \widehat{\tau}_p - 2\widehat{\tau}_r$, and rearranging, we obtain

$$\frac{\partial TC_p^2(\kappa_p, \kappa_r, c)}{\partial c} = 1 + \frac{\widehat{\tau}_p\kappa_r - \widehat{\tau}_r\kappa_p}{\sqrt{(\kappa_p + \widehat{\tau}_r)^2 - 4c}\sqrt{(\kappa_p + \widehat{\tau}_r)^2 - 4c} - \widehat{\tau}_p\widehat{\tau}_r}.$$

As $\widehat{\tau}_p > \widehat{\tau}_r$, $\kappa_r > \kappa_p$ and the fact that both κ_p, κ_r are sufficiently large,

$$\frac{\partial TC_p^2(\kappa_p, \kappa_r, c)}{\partial c} > 0.$$

Hence, as $\lim_{c \to 0} TC_p^2(\kappa_p, \kappa_r, c) = 0$ and $\lim_{c \to b} TC_p^2(\kappa_p, \kappa_r, c) > b$, Boltzmann's Theorem implies that there exists a threshold $c_p^2(\kappa_p, \kappa_r) \in (0, b)$ such that, when $c \leq c_p^2(\kappa_p, \kappa_r)$, $b - TC_p^2(\kappa_p, \kappa_r, c) \geq 0$.

In what follows it will be important to compare $TC_r^1(\kappa_r, c)$ and $TC_p^2(\kappa_p, \kappa_r, c)$ (or similarly $c_r^1(\kappa_r)$ with $c_p^2(\kappa_p, \kappa_r)$). As $\tau_r(0)$ decreases with κ_r, $TC_r^1(\kappa_r, c)$ decreases with κ_r as well, and thus $c_r^1(\kappa_r)$ increases with κ_r. Moreover, as $\lim_{\kappa_r \to \infty} TC_r^1(\kappa_r, c) = c$, $\lim_{\kappa_r \to \infty} c_r^1(\kappa_r) = b$.

Then, we study how $TC_p^2(\kappa_p, \kappa_r, c)$ evolves with κ_r. First, observe that

$$\lim_{\kappa_r \to \kappa_p} TC_p^2(\kappa_p, \kappa_r, c) = c$$

because, when regions are symmetric, the Nash equilibrium is symmetric. Then, we compute

$$\frac{\partial TC_p^2(\kappa_p, \kappa_r, c)}{\partial \kappa_r} = 1 + \widehat{\tau}_p \frac{\partial \widehat{\tau}_p}{\partial \kappa_r} - \widehat{\tau}_r \frac{\partial \widehat{\tau}_r}{\partial \kappa_r}.$$

Differentiating completely (11), we obtain

$$\frac{\partial \widehat{\tau}_p}{\partial \kappa_r} = \frac{\widehat{\tau}_p \widehat{\tau}_r}{\sqrt{(\kappa_p + \widehat{\tau}_r)^2 - 4c}\sqrt{(\kappa_p + \widehat{\tau}_r)^2 - 4c} - \widehat{\tau}_p \widehat{\tau}_r} > 0$$

and

$$\frac{\partial \widehat{\tau}_r}{\partial \kappa_r} = \frac{-\widehat{\tau}_r \sqrt{(\kappa_p + \widehat{\tau}_r)^2 - 4c}}{\sqrt{(\kappa_p + \widehat{\tau}_r)^2 - 4c}\sqrt{(\kappa_p + \widehat{\tau}_r)^2 - 4c} - \widehat{\tau}_p \widehat{\tau}_r} < 0.$$

Hence,

$$\frac{\partial TC_p^2(\kappa_p, \kappa_r, c)}{\partial \kappa_r} > 0.$$

Finally, when $\kappa_r \to \infty$, the Nash equilibrium $(\widehat{\tau}_p, \widehat{\tau}_r) \to (\widehat{\tau}_p(0), 0)$. Hence,

$$\lim_{\kappa_r \to \infty} TC_p^2(\kappa_p, \kappa_r, c) = TC_p^1(\kappa_p, c).$$

Thus, $c_p^2(\kappa_p, \kappa_r)$ decreases with κ_r and converges to $c_p^1(\kappa_p)$. Therefore, there exists a unique value of κ_r, denoted by $\widehat{\kappa}_r$, such that, when $\kappa_r \leq \widehat{\kappa}_r$, $c_r^1(\kappa_r) \leq c_p^2(\kappa_p, \kappa_r)$; otherwise, $c_p^2(\kappa_p, \kappa_r) < c_r^1(\kappa_r)$.

Define $r_\ell \in \{R, NR\}$ as the refinancing strategy for region ℓ, where R (NR) denotes "refinancing" ("not refinancing"). Let r_m denote the refinancing decision in the other region $m \neq \ell$. Additionally, define $W_p^{FD}(r_p, r_r)$ $\left(W_r^{FD}(r_p, r_r)\right)$ as the payoff of region p (r) in the refinancing game, given (r_p, r_r).

Consider the case in which all regions face an incomplete project, and $\kappa_r \leq \widehat{\kappa}_r$. If $0 \leq c \leq c_p^1(\kappa_p)$, refinancing is a dominant strategy for both regions. This is because:

$$W_p^{FD}(R, R) = \kappa_p + b - TC_p^2(\kappa_p, \kappa_r, c) - c_0$$

$$> W_p^{FD}(R, NR) = \kappa_p + b - TC_p^1(\kappa_p, c) - c_0$$

$$\geq W_p^{FD}(NR, r_r) = \kappa_p - c_0$$

and

$$W_r^{FD}(R, R) = \kappa_r + b - TC_r^2(\kappa_p, \kappa_r, c) - c_0$$

$$> W_r^{FD}(NR, R) = \kappa_r + b - TC_r^1(\kappa_r, c) - c_0$$

$$\geq W_r^{FD}(r_p, NR) = \kappa_r - c_0.$$

When $c_p^1(\kappa_p) < c \leq c_r^1(\kappa_r)$, refinancing is a dominant strategy for region r while, for region p,

$$W_p^{FD}(R,R) = \kappa_p + b - TC_p^2(\kappa_p, \kappa_r, c) - c_0 \geq W_p^{FD}(NR,R) = \kappa_p - c_0$$

and

$$W_p^{FD}(R,NR) = \kappa_p + b - TC_p^1(\kappa_p, c) - c_0 \leq W_p^{FD}(NR,NR) \equiv \kappa_p - c_0.$$

Hence, both regions refinance at the Nash equilibrium.

Now assume that $c_r^1(\kappa_r) < c \leq c_p^2(\kappa_p, \kappa_r)$. Notice that:

$$W_p^{FD}(R,R) = \kappa_p + b - TC_p^2(\kappa_p, \kappa_r, c) - c_0 \geq W_p^{FD}(NR,R) = \kappa_p - c_0$$

but

$$W_p^{FD}(R,NR) = \kappa_p + b - TC_p^1(\kappa_p, c) - c_0 < W_p^{FD}(NR,NR) = \kappa_p - c_0.$$

The same conditions hold for region r. These payoffs give rise to a coordination (sub)game between regions, with two Nash equilibria: either both regions refinance in equilibrium, or no region refinances. We choose the first equilibrium because it is the only which is strong (Aumann, 1959). Indeed, by definition of the Nash equilibrium, no region can do better by unilaterally changing its equilibrium strategy. Now consider the 2-regions coalition. If both regions refinance, they do not want to deviate since $b - TC_\ell^2(\kappa_\ell, \kappa_m, c) \geq 0$. But, when no region refinances, they all wish to deviate because both regions obtain a higher payoff in the first Nash equilibrium. This implies that only the equilibrium in which both regions refinance is immune to joint deviations of all subset of players.

Last suppose that $c_p^2(\kappa_p, \kappa_r) < c \leq b$. Clearly, not refinancing is a dominant strategy for region p while, for region r,

$$W_r^{FD}(R,R) = \kappa_r + b - TC_r^2(\kappa_p, \kappa_r, c) - c_0 \geq W_r^{FD}(R,NR) = \kappa_r - c_0$$

and

$$W_r^{FD}(NR,R) = \kappa_r + b - TC_r^1(\kappa_r, c) - c_0 \leq W_r^{FD}(NR,NR) = \kappa_r - c_0.$$

Hence, no region refinances at the Nash equilibrium.

Now assume that $\kappa_r > \widehat{\kappa}_r$. If $0 \leq c \leq c_p^1(\kappa_p)$, refinancing is a dominant strategy for both regions.

When $c_p^1(\kappa_p) < c \leq c_p^2(\kappa_p, \kappa_r)$, refinancing is a dominant strategy for region r while, for region p,

$$W_p^{FD}(R,R) = \kappa_p + b - TC_p^2(\kappa_p, \kappa_r, c) - c_0 \geq W_p^{FD}(NR,R) = \kappa_p - c_0$$

and

$$W_p^{FD}(R,NR) = \kappa_p + b - TC_p^1(\kappa_p, c) - c_0 \leq W_p^{FD}(NR,NR) = \kappa_p - c_0.$$

Hence, both regions refinance at the Nash equilibrium.

Now assume that $c_p^2(\kappa_p, \kappa_r) < c \leq c_r^1(\kappa_r)$. Notice that not refinancing is a dominant strategy for region p, while the opposite holds for region r.

Last suppose that $c_r^1(\kappa_r) < c \leq b$. Clearly, not refinancing is a dominant strategy for region p while, for region r,

$$W_r^{FD}(R, R) = \kappa_r + b - TC_r^2(\kappa_p, \kappa_r, c) - c_0 \geq W_r^{FD}(R, NR) = \kappa_r - c_0$$

and

$$W_r^{FD}(NR, R) = \kappa_r + b - TC_r^1(\kappa_r, c) - c_0 \leq W_r^{FD}(NR, NR) = \kappa_r - c_0.$$

Hence, no region refinances at the Nash equilibrium.

The proof of the second part of the proposition is immediate and thus omitted.□

8.5 Proof of Proposition 4

First, we evaluate net regional expected welfares under different parameter conditions. Define $\mathbb{E}W_\ell^{FD}(i_p, i_r)$ as the expected welfare of region ℓ in the initial investment game, given (i_p, i_r).

Consider that $\kappa_r \leq \widehat{\kappa}_r$.[16] If $0 \leq c \leq c_p^1(\kappa_p)$, region p's net expected welfare is:

$$\begin{aligned}
\mathbb{E}W_p^{FD}(I, I) &= \kappa_p + b - c_0 - (1-\pi)\left[(1-\pi)TC_p^2(\kappa_p, \kappa_r, c) + \pi TC_p^1(\kappa_p, c)\right], \\
\mathbb{E}W_p^{FD}(I, NI) &= \kappa_p + b - c_0 - (1-\pi)TC_p^1(\kappa_p, c), \\
\mathbb{E}W_p^{FD}(NI, i_r) &= \kappa_p
\end{aligned}$$

where i_r denotes the initiation decision for region r. The expressions for region r are analogous.

If $c_p^1(\kappa_p) < c \leq c_r^1(\kappa_r)$, region p's net expected welfare is:

$$\begin{aligned}
\mathbb{E}W_p^{FD}(I, I) &= \kappa_p + b - c_0 - (1-\pi)\left[(1-\pi)TC_p^2(\kappa_p, \kappa_r, c) + \pi b\right], \\
\mathbb{E}W_p^{FD}(I, NI) &= \kappa_p + b - c_0 - (1-\pi)b, \\
\mathbb{E}W_p^{FD}(NI, i_r) &= \kappa_p.
\end{aligned}$$

Region r's net expected welfare is:

$$\begin{aligned}
\mathbb{E}W_r^{FD}(I, I) &= \kappa_r + b - c_0 - (1-\pi)\left[(1-\pi)TC_r^2(\kappa_p, \kappa_r, c) + \pi TC_r^1(\kappa_r, c)\right], \\
\mathbb{E}W_r^{FD}(NI, I) &= \kappa_r + b - c_0 - (1-\pi)TC_r^1(\kappa_r, c), \\
\mathbb{E}W_r^{FD}(i_p, NI) &= \kappa_p.
\end{aligned}$$

[16]When $\kappa_r > \widehat{\kappa}_r$ the expressions of the expected welfares are identical.

When $c_r^1(\kappa_r) < c \leq c_p^2(\kappa_p, \kappa_r)$, region p's net expected welfare is:

$$\mathbb{E}W_p^{FD}(I, I) = \kappa_p + b - c_0 - (1-\pi)\left[(1-\pi)TC_p^2(\kappa_p, \kappa_r, c) + \pi b\right],$$
$$\mathbb{E}W_p^{FD}(I, NI) = \kappa_p + b - c_0 - (1-\pi)b,$$
$$\mathbb{E}W_p^{FD}(NI, i_r) = \kappa_p.$$

The expressions for region r are analogous.
Finally, when $c_p^2(\kappa_p, \kappa_r) < c \leq b$, region p's net expected welfare is:

$$\mathbb{E}W_p^{FD}(I, i_r) = \kappa_p + b - c_0 - (1-\pi)b,$$
$$\mathbb{E}W_p^{FD}(NI, i_r) = \kappa_p.$$

The expressions for region r are analogous.

In order to characterize the Nash equilibria of the initial investment game, we need to compare these different levels of regional welfare. To proceed, we adopt a geometrical devise that simplifies these comparisons. First, let's define

$$\Delta^*(c) \equiv (1-\pi)c,$$

which is an increasing, linear function of c that satisfies

$$\lim_{c\to 0} \Delta^*(c) = 0$$

and

$$\lim_{c\to b} \Delta^*(c) = (1-\pi)b.$$

When $0 \leq c \leq c_p^1(\kappa_p)$, we define two functions

$$\Delta_\ell^1(c, \pi, \kappa_p, \kappa_r) \equiv (1-\pi)\left[(1-\pi)TC_\ell^2(\kappa_\ell, \kappa_m, c) + \pi TC_\ell^1(\kappa_\ell, c)\right],$$

which are continuous, increasing functions of c that satisfy

$$\lim_{c\to 0}\Delta_\ell^1(c, \pi, \kappa_p, \kappa_r) = \Delta_\ell^1(0, \pi, \kappa_p, \kappa_r) = 0,\ \Delta_R^{FD}(c) > \Delta^*(c),$$

$$\lim_{c\to c_p^1(\kappa_p)} \Delta_p^1(c, \pi, \kappa_p, \kappa_r) = \Delta_p^1(c_p^1(\kappa_p), \pi, \kappa_p, \kappa_r) = (1-\pi)\left[(1-\pi)TC_p^2(\kappa_p, \kappa_r, c_p^1(\kappa_p)) + \pi b\right]$$

and

$$\lim_{c\to c_p^1(\kappa_p)} \Delta_r^1(c, \pi, \kappa_p, \kappa_r) = \Delta_r^1(c_p^1(\kappa_p), \pi, \kappa_p, \kappa_r)$$
$$= (1-\pi)\left[(1-\pi)TC_r^2(\kappa_p, \kappa_r, c_p^1(\kappa_p)) + \pi TC_r^1(\kappa_r, c_p^1(\kappa_p))\right].$$

We also define two other functions $\Delta_\ell^2(c, \pi, \kappa_\ell) \equiv (1-\pi)TC_\ell^1(\kappa_\ell, c)$. These two functions are also continuous, increasing and convex functions of c, that satisfy

$$\lim_{c\to 0}\Delta_\ell^2(c, \pi, \kappa_\ell) = \Delta_\ell^2(0, \pi, \kappa_\ell) = 0,\ \Delta_\ell^2(c, \pi, \kappa_\ell) > \Delta^*(c),$$
$$\lim_{c\to c_p^1(\kappa_p)} \Delta_p^2(c, \pi, \kappa_p) = \Delta_p^2(c_p^1(\kappa_p), \pi, \kappa_p) = (1-\pi)b$$

and

$$\lim_{c\to c_p^1(\kappa_p)} \Delta_r^2(c, \pi, \kappa_r) = \Delta_r^2(c_p^1(\kappa_p), \pi, \kappa_r) = (1-\pi)TC_r^1(\kappa_r, c_p^1(\kappa_p)).$$

When $c_p^1(\kappa_p) < c \leq c_r^1(\kappa_r)$, we define

$$\Delta_p^3(c, \pi, \kappa_p, \kappa_r) \equiv (1-\pi)\left[(1-\pi)TC_p^2(\kappa_p, \kappa_r, c) + \pi b\right],$$

which is a continuous, increasing function of c that satisfies

$$\lim_{c \to c_p^1(\kappa_p)} \Delta_p^3(c, \pi, \kappa_p, \kappa_r) = \Delta_p^1(c_p^1(\kappa_p), \pi, \kappa_p, \kappa_r), \;\; \Delta_p^3(c, \pi, \kappa_p, \kappa_r) > \Delta^*(c),$$

and

$$\lim_{c \to c_r^1(\kappa_r)} \Delta_p^3(c, \pi, \kappa_p, \kappa_r) = \Delta_p^1(c_r^1(\kappa_r), \pi, \kappa_p, \kappa_r) = (1-\pi)\left[(1-\pi)TC_p^2(\kappa_p, \kappa_r, c_r^1(\kappa_r)) + \pi b\right].$$

When $c_r^1(\kappa_r) < c \leq c_p^2(\kappa_p, \kappa_r)$, we define

$$\Delta_r^3(c, \pi, \kappa_p, \kappa\Delta_r^3(c, \pi, \kappa_p, \kappa_r) > \Delta^*(c)_r) \equiv (1-\pi)\left[(1-\pi)TC_r^2(\kappa_p, \kappa_r, c) + \pi b\right],$$

which is a continuous function of c that satisfies

$$\lim_{c \to c_r^1(\kappa_r)} \Delta_r^3(c, \pi, \kappa_p, \kappa_r) = \Delta_r^1(c_r^1(\kappa_r), \pi, \kappa_p, \kappa_r), \;\; \Delta_r^3(c, \pi, \kappa_p, \kappa_r) > \Delta^*(c)$$

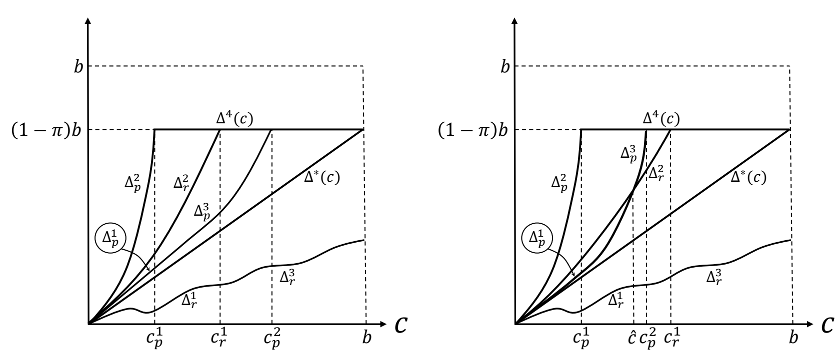
and

$$\begin{aligned}\lim_{c \to c_p^2(\kappa_p, \kappa_r)} \Delta_r^3(c, \pi, \kappa_p, \kappa_r) &= \Delta_r^3(c_p^2(\kappa_p, \kappa_r), \pi, \kappa_p, \kappa_r) \\ &= (1-\pi)\left[(1-\pi)TC_r^2(\kappa_p, \kappa_r, c_p^2(\kappa_p, \kappa_r)) + \pi b\right].\end{aligned}$$

Finally, when $c_p^2(\kappa_p, \kappa_r) < c \leq b$, we also define $\Delta^4(c) \equiv (1-\pi)b$, which satisfies

$$\Delta^4(c) = \Delta_p^2(c_p^1(\kappa_p), \pi, \kappa_p) = \Delta_r^2(c_r^1(\kappa_r), \pi, \kappa_r) = \Delta_p^3(c_p^2(\kappa_p, \kappa_r), \pi, \kappa_p, \kappa_r) \geq \Delta^*(c).$$

For an arbitrary pair (κ_r, π), we plot the "Δ-functions" just defined in Figures 6(a) and 6(b).



(a) $\kappa_r \leq \widehat{\kappa}_r$ (b) $\kappa_r > \widehat{\kappa}_r$

Figures 6: $\Delta-$functions.

The Δ-functions (weakly) increase with c.[17] The unique difference between these figures is the following. When $\kappa_r > \widehat{\kappa}_r$, the functions $\Delta_r^2(c, \pi, \kappa_r)$ and $\Delta_p^3(c, \pi, \kappa_p, \kappa_r)$ (or $\Delta_p^1(c, \pi, \kappa_p, \kappa_r)$) crosses each other, at a unique value $\widehat{c}$. We can show that $\widehat{c}$ decreases with κ_r and π.

For a given value of the refinancing cost c, these figures facilitate the comparison of the values adopted by the Δ-functions against $b - c_0$, and so the comparisons between region's expected welfares. We thus easily obtain the Nash equilibria of this subgame, for any value of the administrative capacity π. From now on, we assume that $b - c_0 < c_p^1(\kappa_p)$, as this parametric configuration allows us to consider all possible cases of equilibria.

First, assume that $\kappa_r \leq \widehat{\kappa}_r$.

1. $0 \leq \pi \leq \pi_1^{FD}$.

   Let π_1^{FD} be implicitly defined by $\Delta_p^1(c_p^1(\kappa_p), \pi_1^{FD}, \kappa_p, \kappa_r) = b - c_0$. The intersection between $\Delta_p^2(c, \pi, \kappa_p)$ and $b - c_0$ defines a threshold $c_a(\pi, \kappa_p)$. The intersection between $\Delta_r^2(c, \pi, \kappa_r)$ and $b - c_0$ defines another threshold $c_b(\pi, \kappa_r)$. Finally, the intersection between $\Delta_p^1(c, \pi, \kappa_p, \kappa_r)$ and $b - c_0$ defines another threshold $c_c(\pi, \kappa_p, \kappa_r)$. As

   $$\Delta_p^2(c, \pi, \kappa_p) > \Delta_r^2(c, \pi, \kappa_r) > \Delta_p^1(c, \pi, \kappa_p, \kappa_r) > \Delta^*(c),$$

   $c_a(\pi, \kappa_p) \leq c_b(\pi, \kappa_r) \leq c_c(\pi, \kappa_p, \kappa_r) < c^*(\pi)$. Clearly, $c_a(\pi, \kappa_p)$ and $c_b(\pi, \kappa_r)$ increase with π. The behavior of $c_c(\pi, \kappa_p, \kappa_r)$ is ambiguous: it may increase or decrease with π. But as $\Delta_r^2(c, \pi, \kappa_r) > \Delta_p^1(c, \pi, \kappa_p, \kappa_r)$ eventually $c_c(\pi, \kappa_p, \kappa_r)$ has to increase with π. The Nash equilibria are the following:[18]

   (a) When $0 \leq c \leq c_a(\pi, \kappa_p)$,

   $$\Delta_r^1(c, \pi, \kappa_p, \kappa_r) < c < \Delta_p^1(c, \pi, \kappa_p, \kappa_r) < \Delta_r^2(c, \pi, \kappa_r) \leq \Delta_p^2(c, \pi, \kappa_p) \leq b - c_0,$$

   which implies that

   $$\mathbb{E}W_p^{FD}(I, I) > \mathbb{E}W_p^{FD}(NI, I)$$

   and

   $$\mathbb{E}W_p^{FD}(I, NI) \geq \mathbb{E}W_p^{FD}(NI, NI).$$

   Similar expressions hold for region r. Hence, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

   (b) When $c_a(\pi, \kappa_p) < c \leq c_b(\pi, \kappa_r)$,

   $$\Delta_r^1(c, \pi, \kappa_p, \kappa_r) < c < \Delta_p^1(c, \pi, \kappa_p, \kappa_r) < \Delta_r^2(c, \pi, \kappa_r) \leq b - c_0 < \Delta_p^2(c, \pi, \kappa_p),$$

[17] We were not able to completely characterize how the functions Δ_r^1 and Δ_r^3 evolve with c. As we will see below, this is is without any loss of generality.

[18] We only present the complete proof for this case. The proofs of the remaining cases are analogous.

which implies that

$$\mathbb{E}W_p^{FD}(I,I) > \mathbb{E}W_p^{FD}(NI,I),$$

$$\mathbb{E}W_p^{FD}(I,NI) < \mathbb{E}W_p^{FD}(NI,NI),$$

and

$$\mathbb{E}W_r^{FD}(i_p,I) \geq \mathbb{E}W_r^{FD}(i_p,NI).$$

Hence, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

(c) When $c_b(\pi,\kappa_r) < c \leq c_c(\pi,\kappa_p,\kappa_r)$,

$$\Delta_r^1(c,\pi,\kappa_p,\kappa_r) < c < \Delta_p^1(c,\pi,\kappa_p,\kappa_r) \leq b - c_0 < \Delta_r^2(c,\pi,\kappa_r) < \Delta_p^2(c,\pi,\kappa_p),$$

which implies that

$$\mathbb{E}W_p^{FD}(I,I) \geq \mathbb{E}W_p^{FD}(NI,I) \text{ and } \mathbb{E}W_r^{FD}(I,I) \geq \mathbb{E}W_r^{FD}(I,NI)$$

but

$$\mathbb{E}W_p^{FD}(I,NI) < \mathbb{E}W_p^{FD}(NI,NI) \text{and } \mathbb{E}W_r^{FD}(NI,I) < \mathbb{E}W_r^{FD}(NI,NI).$$

Two Nash equilibria emerge: i) both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$, or ii) no region invests. We choose the first equilibrium because, as $\Delta_p^1(c,\pi,\kappa_p,\kappa_r)$ and $\Delta_r^1(c,\pi,\kappa_p,\kappa_r)$ are lower than $b - c_0$, this equilibrium is strong.

(d) When $c_c(\pi,\kappa_p,\kappa_r) < c \leq c_r^1(\kappa_r)$,

$$\Delta_r^1(c,\pi,\kappa_p,\kappa_r) \lesseqgtr b - c_0 < \Delta_p^1(c,\pi,\kappa_p,\kappa_r) \leq \Delta_r^2(c,\pi,\kappa_r) < \Delta_p^2(c,\pi,\kappa_p) < \Delta^4(c),$$

which implies that

$$\mathbb{E}W_p^{FD}(I,i_r) < \mathbb{E}W_p^{FD}(NI,i_r),$$

$$\mathbb{E}W_r^{FD}(I,I) \lesseqgtr \mathbb{E}W_r^{FD}(I,NI)$$

and

$$\mathbb{E}W_r^{FD}(NI,I) < \mathbb{E}W_r^{FD}(NI,NI).$$

Hence, no region initiates its project.

(e) When $c_r^1(\kappa_r) < c \leq c_p^2(\kappa_p,\kappa_r)$,

$$\Delta_r^3(c,\pi,\kappa_p,\kappa_r) \lesseqgtr b - c_0 < \Delta_p^1(c,\pi,\kappa_p,\kappa_r) \leq \Delta_r^2(c,\pi,\kappa_r) < \Delta_p^2(c,\pi,\kappa_p) < \Delta^4(c),$$

which implies that

$$\mathbb{E}W_p^{FD}(I,i_r) < \mathbb{E}W_p^{FD}(NI,i_r),$$

$$\mathbb{E}W_r^{FD}(I,I) \lesseqgtr \mathbb{E}W_r^{FD}(I,NI)$$

and

$$\mathbb{E}W_r^{FD}(NI,I) < \mathbb{E}W_r^{FD}(NI,NI).$$

Hence, no region initiates its project.

(f) When $c_p^2(\kappa_p, \kappa_r) < c \leq b$, $b - c_0 < \Delta^4(c)$. This implies that

$$\mathbb{E}W_p^{FD}(I, i_r) < \mathbb{E}W_p^{FD}(NI, i_r)$$

and

$$\mathbb{E}W_r^{FD}(i_p, I) < \mathbb{E}W_r^{FD}(i_p, NI).$$

Hence, no region initiates its project.

2. $\pi_1^{FD} < \pi \leq \pi_2^{FD}$.

Let π_2^{FD} be implicitly defined by $\Delta_r^2(c_p^1(\kappa_p), \pi_2^{FD}, \kappa_r) = b - c_0$. The intersection between $\Delta_p^3(c, \pi, \kappa_p, \kappa_r)$ and $b - c_0$ defines another threshold $c_d(\pi, \kappa_p, \kappa_r)$ that increases with π and satisfies $c_p^1(\kappa_p) \leq c_d(\pi, \kappa_p, \kappa_r) \leq c_r^1(\kappa_r)$. As $\Delta_p^3(c, \pi, \kappa_p, \kappa_r) > \Delta^*(c)$, $c_d(\pi, \kappa_p, \kappa_r) \leq c^*(\pi)$. The Nash equilibria are the following:

(a) When $0 \leq c \leq c_b(\pi, \kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

(b) When $c_b(\pi, \kappa_r) < c \leq c_p^1(\kappa_p)$, two Nash equilibria emerge: i) both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$; or ii) no region invests. Again, as $\Delta_p^3(c, \pi, \kappa_p, \kappa_r)$ and $\Delta_r^1(c, \pi, \kappa_p, \kappa_r)$ are lower than $b - c_0$, we select the first equilibrium because it is strong.

(c) When $c_p^1(\kappa_p) < c \leq c_d(\pi, \kappa_p, \kappa_r)$, two Nash equilibria emerge: i) both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so; or ii) no region invests. Again, as $\Delta_p^3(c, \pi, \kappa_p, \kappa_r)$ and $\Delta_r^1(c, \pi, \kappa_p, \kappa_r)$ are lower than $b - c_0$, we select the first equilibrium because it is strong.

(d) When $c_d(\pi, \kappa_p, \kappa_r) < c \leq b$, no region initiates its project.

3. $\pi_2^{FD} < \pi \leq \pi_3^{FD}$.

Let π_3^{FD} be implicitly defined by $\Delta_p^3(c_r^1(\kappa_r), \pi_3^{FD}, \kappa_r) = b - c_0$. The Nash equilibria are the following:

(a) When $0 \leq c \leq c_p^1(\kappa_p)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

(b) When $c_p^1(\kappa_p) < c \leq c_b(\pi, \kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so.

(c) When $c_b(\pi, \kappa_r) < c \leq c_d(\pi, \kappa_p, \kappa_r)$, two Nash equilibria emerge: i) both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so; or ii) no region invests. Again, as $\Delta_p^3(c, \pi, \kappa_p, \kappa_r)$ and $\Delta_r^1(c, \pi, \kappa_p, \kappa_r)$ are lower than $b - c_0$, we select the first equilibrium because it is strong.

(d) When $c_d(\pi, \kappa_p, \kappa_r) < c \leq b$, no region initiates its project.

4. $\pi_3^{FD} < \pi < \pi_4^{FD} \equiv c_0/b$.

   π_4^{FD} satisfies

   $$\Delta_p^2(c_p^1(\kappa_p), \pi_4^{FD}, \kappa_p) = \Delta_r^2(c_r^1(\kappa_r), \pi_4^{FD}, \kappa_r) = \Delta_p^3(c_p^2(\kappa_p, \kappa_r), \pi_4^{FD}, \kappa_p, \kappa_r) = b - c_0.$$

   The Nash equilibria are the following:

   (a) When $0 \leq c \leq c_p^1(\kappa_p)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

   (b) When $c_p^1(\kappa_p) < c \leq c_b(\pi, \kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so.

   (c) When $c_b(\pi, \kappa_r) < c \leq c_r^1(\kappa_r)$, two Nash equilibria emerge: i) both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so; or ii) no region invests. Again, as $\Delta_p^3(c, \pi, \kappa_p, \kappa_r)$ and $\Delta_r^1(c, \pi, \kappa_p, \kappa_r)$ are lower than $b - c_0$, we select the first equilibrium because it is strong.

   (d) $c_r^1(\kappa_r) < c \leq c_d(\pi, \kappa_p, \kappa_r)$, again two Nash equilibria emerge: i) both regions initiate their project and if they remain incomplete at the end of $t = 2$, they refinance them in $t = 3$ provided both regions do so; or ii) no region invests. Again, as $\Delta_p^3(c, \pi, \kappa_p, \kappa_r)$ and $\Delta_r^1(c, \pi, \kappa_p, \kappa_r)$ are lower than $b - c_0$, we select the first equilibrium because it is strong.

   (e) When $c_d(\pi, \kappa_p, \kappa_r) < c \leq b$, no region initiates its project.

5. $\pi = \pi_4^{FD}$.

   When $\pi = \pi_4^{FD}$, $c_a(\pi, \kappa_p) = c_p^1(\kappa_p)$, $c_b(\pi, \kappa_r) = c_r^1(\kappa_r)$ and $c_d(\pi, \kappa_p, \kappa_r) = c_p^2(\kappa_p, \kappa_r)$. The Nash equilibria are the following:

   (a) When $0 \leq c < c_p^1(\kappa_p)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

   (b) When $c_p^1(\kappa_p) < c \leq c_r^1(\kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so.

   (c) When $c_r^1(\kappa_r) < c \leq c_p^2(\kappa_p, \kappa_r)$, two Nash equilibria emerge: i) both regions initiate their project and if they remain incomplete at the end of $t = 2$, they refinance them in $t = 3$ provided both regions do so; or ii) no region invests. Again, as $\Delta_p^3(c, \pi, \kappa_p, \kappa_r)$ and $\Delta_r^1(c, \pi, \kappa_p, \kappa_r)$ are lower than $b - c_0$, we select the first equilibrium because it is strong.

(d) When $c_p^2(\kappa_p, \kappa_r) < c \leq b$, all pairs of strategies form an equilibrium, because the payoffs are equivalent. Therefore, adopting a continuity argument with the previous cases, we select the equilibrium where no region initiates the project as the one to consider.

6. $\pi_4^{FD} < \pi \leq 1$.

   The Nash equilibria are the following:

   (a) When $0 \leq c < c_p^1(\kappa_p)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

   (b) When $c_p^1(\kappa_p) < c \leq c_r^1(\kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so.

   (c) When $c_r^1(\kappa_r) < c \leq c_p^2(\kappa_p, \kappa_r)$, both regions initiate their project and if they remain incomplete at the end of $t = 2$, they refinance them in $t = 3$ provided both regions do so.

   (d) When $c_p^2(\kappa_p, \kappa_r) < c \leq b$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they do not refinance them.

When $\kappa_r > \widehat{\kappa}_r$, the analysis is identical: in order to characterize the Nash equilibria we compare $b - c_0$ and the Δ functions already defined.

1. $0 \leq \pi \leq \pi_1^{FD}$.

   (a) When $0 \leq c \leq c_c(\pi, \kappa_p, \kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

   (b) When $c_c(\pi, \kappa_p, \kappa_r) < c \leq b$, no region initiates its project.

2. $\pi_1^{FD} < \pi \leq \pi_2^{FD}$.

   (a) When $0 \leq c \leq c_p^1(\kappa_p)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

   (b) When $c_p^1(\kappa_r) < c \leq c_d(\pi, \kappa_p, \kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so.

   (c) When $c_d(\pi, \kappa_p, \kappa_r) < c \leq b$, no region initiates its project.

3. $\pi_2^{FD} < \pi \leq \widehat{\pi}$.

   Let $\widehat{\pi}$ be implicitly defined by $\Delta_r^1(\widehat{c}(\widehat{\pi}, \kappa_r), \widehat{\pi}, \kappa_r) = b - c_0$. The Nash equilibria are the following:

   (a) When $0 \leq c \leq c_p^1(\kappa_p)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

   (b) When $c_p^1(\kappa_p) < c \leq c_d(\pi, \kappa_p, \kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so.

(c) When $c_d(\pi, \kappa_p, \kappa_r) < c \leq b$, no region initiates its project.

4. $\widehat{\pi} < \pi \leq \pi_3^{FD}$.

   The Nash equilibria are the following:

   (a) When $0 \leq c \leq c_p^1(\kappa_p)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

   (b) When $c_p^1(\kappa_p) < c \leq c_d(\pi, \kappa_p, \kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so.

   (c) When $c_d(\pi, \kappa_p, \kappa_r) < c \leq c_b(\pi, \kappa_r)$, an asymmetric Nash equilibrium emerges. As $\Delta_p^3(c, \pi, \kappa_p, \kappa_r) > b - c_0 > \Delta_r^2(c, \pi, \kappa_p, \kappa_r)$, region p does not initiate its project, while the opposite holds for region r. Moreover, if the project remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$.

   (d) When $c_b(\pi, \kappa_r) < c \leq b$, no region initiates its project.

5. $\pi_3^{FD} < \pi \leq \pi_4^{FD}$.

   The Nash equilibria are the following:

   (a) When $0 \leq c \leq c_p^1(\kappa_p)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

   (b) When $0 \leq c \leq c_d(\pi, \kappa_p, \kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so.

   (c) When $c_d(\pi, \kappa_p, \kappa_r) < c \leq c_b(\pi, \kappa_r)$, region p does not initiate its project, while the opposite holds for region r. Moreover, if the project remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$.

   (d) When $c_b(\pi, \kappa_r) < c \leq b$, no region initiates its project.

6. $\pi_4^{FD} < \pi \leq 1$.

   The Nash equilibria are the following:

   (a) When $0 \leq c \leq c_p^1(\kappa_p)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they refinance it in $t = 3$.

   (b) When $c_p^1(\kappa_p) \leq c \leq c_p^2(\kappa_p, \kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, while region p only refinances when both regions do so.

   (c) When $c_p^2(\kappa_p, \kappa_r) < c \leq c_r^1(\kappa_r)$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, region r refinances it in $t = 3$, but region p does not refinance.

   (d) When $c_b(\pi, \kappa_p, \kappa_r) < c \leq b$, both regions initiate their project and, if it remains incomplete at the end of $t = 2$, they do not refinance them.

When κ_r is sufficiently large, $\widehat{c} < c_c(\pi, \kappa_p, \kappa_r) < c_b(\pi, \kappa_r) < c_p^1(\kappa_p)$. Therefore, no matter the value of π, there will always exist a parameter region when $c_c(\pi, \kappa_p, \kappa_r) \leq c \leq c_b(\pi, \kappa_r)$ (or when $c_d(\pi, \kappa_p, \kappa_r) \leq c \leq c_b(\pi, \kappa_r)$) with the asymmetric Nash equilibrium.

8.6 Proof of Proposition 5 and 6

TO COMPLETE