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# Federalism and the Optimal Degree of Centralization of Public Goods

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## Abstract

In this paper we analyze the optimal degree of centralization for the supply of public goods. We identify the reliance on an exclusion mechanism as a central feature of the decentralized provision of public goods. An exclusion mechanism induces a contest between users of the public goods who want to free ride and the providers who want to exclude free riding. This contest explains the costs of decentralization. A centralized contribution does not rely on an exclusion mechanism to finance the public goods but on taxation which induces different types of transaction costs. A comparison of the relevant distortions explains the optimal degree of centralization of the supply of public goods.

*Keywords:* Public Goods, Club Goods, Contests, Fiscal Federalism

*JEL classifications:* D74, H41, H70, K42

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# 1 Introduction

The discussion about the optimal degree of centralization of political responsibilities in an economic union evolves around different arguments.<sup>1</sup> Tiebout-type models (Tiebout 1956) stress that the decentralized provision of (local) public goods may improve upon the centralized provision if the central agency is constrained in the choice of instruments and voter-citizens are sufficiently mobile to vote by feet. Some authors stress that technological reasons or the mobility of goods and factors may cause inter-regional interdependencies which explain the superiority of certain tax principles over others.<sup>2</sup> Part of the literature has focused on asymmetric information and political forces to derive rules for the optimal assignments of rights to supply public goods.<sup>3</sup>

Both, asymmetric information as well as political mechanisms are important factors that add to a theory of the optimal allocation of political responsibilities to provide public goods. What is common to the above-mentioned literature is that it shares a common methodological approach (Janeba and Wilson 2001). It either takes the division of responsibilities between local and central governments as given and analyzes the consequences of such a division.<sup>4</sup> Or it analyzes the properties of ex-ante given institutional structures. In both cases the literature does not explain why the imperfections build in the institutions cannot be overcome by the agents under consideration. For example the classic literature on tax competition focuses on the efficiency of equilibria between decentralized authorities that can only use tax instruments. This restriction can turn out to be crucial if an argument in favor of

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<sup>1</sup>See Oates (1999) for a comprehensive survey of the literature.

<sup>2</sup>A good example is the literature on capital-tax competition. See Oates (1996), Oates and Schwab (1991), Bucovetsky and Wilson (1991), among others.

<sup>3</sup>See for example Alesina and Spolaore (1997) and Besley and Coate (2000) for different public-choice approaches to fiscal federalism, and Bordignon, Manasse and Tabellini (1999), Bucovetsky, Marchand and Pestieau (1999), Cornes and Silva (2000), Lockwood (1999) for the analysis of asymmetric information.

<sup>4</sup>Janeba and Wilson (2001) and Bucovetsky (2001) deviate from this tradition. In both papers, a theory of the optimal degree of centralization is developed that explicitly compares the costs of centralization and decentralization.

centralization is derived from these models and if the character of the equilibrium depends on the restriction of the strategy space. More instruments, for example interjurisdictional transfers, might eliminate the inefficiency (as demonstrated by Myers 1990). Hence, a theory of fiscal federalism whose objective is to explain the optimal division of policies between centralized and decentralized authorities has to explain why Pareto-improving strategies cannot be used at the decentralized level, whereas they can be used by a center, and vice versa.

From a different perspective, Oates (1999) elaborates on an intellectual puzzle very much in the spirit of the Coase theorem that he calls the ‘Decentralization Theorem.’ Broadly speaking this theorem states that in the absence of cost-savings the level of welfare with a decentralized provision of public goods is at least as high as with a centralized provision. By the same token it can be argued that in the absence of transaction costs the level of welfare with a centralized provision of public goods is at least as high as with a decentralized provision. In summary it is the cost differential between centralized and decentralized provision that explains or justifies centralization or decentralization.

In this paper I focus on a specific type of costs inherent to decentralization. A decentralized provision of public goods relies on an *exclusion mechanism* for the financing of the public good:<sup>5</sup> a decentralized provision of public goods implies that the only way for the providing region to finance its supply of the public good is to charge other regions using the public good. In order to charge another region it has to be able to exclude it from the use. If exclusion is possible the region can ideally charge Lindahl prices which implies that it has first-best incentives to supply the public good. In this case a region providing a public good is a special case of a firm supplying a good produced under conditions of increasing returns to scale if perfect price discrimination is possible.

However, the use of the exclusion mechanism is not without a cost. A country has to invest resources to make sure that the user charges are actually paid. A region that finances its roads by, for example, taxes paid by regional residents and tolls paid by nonresident visitors has to employ workers to collect the tolls and security

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<sup>5</sup>See Cornes and Sandler (1996).

forces to control the payment of the toll. On the other hand, the non-resident users of the public good may find it in their interest to invest resources to circumvent the enforcement measures. Hence, the use of the exclusion mechanism induces a contest between defense and free riding. The resource costs of this *free-rider contest* define part of the transaction costs of the decentralized provision of the public good. By applying the idea that law enforcement has the character of a contest we borrow from the growing literature on anarchy and conflict (see for example Bush and Mayer (1974), de Meta and Gould (1992), Grossman (2001), Grossman and Kim (1995), Hirshleifer (1995), Skaperdas (1992), Sutter (1995), Wärneryd (1993)) and extend it to the analysis of public goods.

We can show that with costly exclusion decentralization induces three types of inefficiencies compared to the first best: first, each region takes into account that other regions will free-ride on part of the public good provided by the region. The resulting marginal conditions deviate from the Samuelson condition which characterizes the first best. Second, the exclusion mechanism creates costs that consist of the resources devoted to free riding and exclusion. Third, if the regions cannot commit to long-term access-price contracts, every region has an incentive to use the quantity of the public good strategically in order to influence the equilibrium prices in its favor. This opportunity occurs because access prices are individualized prices resulting in a bilateral monopoly between supply and demand.

With a centralized provision of the public good the union can avoid the costs of using the exclusion mechanism if the center has sufficient coercive power to raise regional taxes to finance the public goods. Hence, centralization is defined as a situation where the public good is provided by a center using taxes. Such a centralized mechanism incurs different types of transaction costs. First, an additional agency incurs resource costs in itself, for example the opportunity costs of the number of employees of the agency.<sup>6</sup> Second, any costs that result from ill-designed incentives for the agency. These agency costs are either the resource costs resulting if the regions cannot use Groves-type mechanisms. And similar to the case of decentralization, if

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<sup>6</sup>See Polinsky and Shavell (2000) for a comprehensive survey about the literature on public law enforcement.

the center cannot commit to prices and taxes in a long-term contract the regions have an incentive to over-provide the public goods anticipating that they will be bailed-out ex post. Third, in the absence of lump-sum taxes the marginal costs of public funds resulting from the larger total tax revenues needed to finance the public goods must be included in the costs of centralization.

The focus of this paper is on an explicit derivation of the costs of decentralization. We will therefore use a reduced-form model to include the costs of centralization. In this model, centralization incurs costs  $C$  that summarize the lump-sum equivalent of all resource costs of creating a centralized agency plus the agency costs if Groves mechanisms are not available. We allow, however, for binding long-term and non-binding long-term contracts between the center and the regions. We analyze two extreme situations in order to see the range of possible results, a center that can perfectly commit to long-term contracts and a center that cannot commit at all.

The optimal degree of centralization depends on a comparison of both types of transaction costs. In the benchmark case with no costs of exclusion and long-term price contracts on the one hand and lump-sum taxes and efficient delegation without costs on the other hand decentralization and centralization are equally efficient.

The paper proceeds as follows. In Section 2 we present the formal model. In Section 3 we characterize the equilibria with a decentralized and centralized provision of public goods. In Section 4 we characterize the transaction-costs of both institutional structures for a functional specification of the model. Section 5 concludes.

## 2 The model

Consider an economy that is divided in  $n$  different regions,  $i = 1, \dots, n$ . Together they form a country. For simplicity we assume that every region  $i$  is populated by a representative agent  $i$ . This agent is endowed with one unit of total time that he can use for the production of a private good,  $x_i$ , and for the production of a public good,  $c_i$ . Production is linear in time and we will therefore use  $x_i$  and  $c_i$  also to indicate time investments. We define the public good by its property to be non-rival

in consumption. Being non-rival in consumption does not imply that individuals cannot be excluded from consumption. Exclusion can be used as a mechanism to implement the optimum, but exclusion may incur costs that differ from good to good.

The public good can be a regional public good, in which case there are no spill-overs to the other regions. An example for this is a specific environmental policy for emissions that does not spill-over to other regions. It can also be a global public good, in which case every region can in principle consume the same quantity of the good. An example is an environmental policy for global emissions that effect all the regions in the same way. Or it can be an impure public good, which means that the utility from this good is largest in the region where it is produced. An example for this is again an environmental policy for an emission that spills over to other regions but whose concentration is highest in the region of origin. Another example is infrastructure like roads if regions are linked by commuters. Roads will be used by all citizens of the country, the intensity of use will be, however, highest for the roads in the region of residence in general.

## 2.1 Decentralization

To consider the most general case we assume that every region produces a different public good. The case that there is only one global public good jointly produced by all regions follows as a special case. By *decentralization* we define that every region produces its own public good and can levy user charges on the other regions. The payment of these user charges is voluntary and the price will be determined in equilibrium. In order to induce payment the user charges have to be enforced. If not enforced the agents of the other regions will (illegally, if one wants to) free-ride. We assume that enforcement incurs an (endogenous) time cost  $d_i$  (defense), for example the patrolling of police cars on the streets. One peculiar feature of the regional enforcement of user charges is that it leads to a contest between the producer of the good and the potential users. As in the case of private goods where it may be rational to invest part of the resources in stealing from other individuals it may be rational

to invest part of the resources to free ride if user charges are not perfectly enforced. Depending on the investments for the enforcement of user charges the agents of the other regions rationally decide how much they want to free ride. Hence, the agents can invest part of their time  $a_i$  (appropriation) to figure out ways to overcome the enforcement measures by the other regions. For example the agents can use part of their time planning how to travel through the other region in order not to be detected, or to figure out ways to avoid being taxed by the other region when, for example, exporting to this region. We denote by

$$x_i + c_i + \sum_{j \neq i} a_i^j + \sum_{j \neq i} d_i^j = 1, \quad i = 1, \dots, n \quad (1)$$

the distribution of time among these different activities.  $a_i^j$  denotes the amount of time invested by region  $i$  to free-ride on the public goods provided by region  $j$  and  $d_i^j$  the amount of time invested by region  $i$  to enforce the user charges levied on citizens of region  $j$ .<sup>7</sup>

Given time investments  $a_i^j$ ,  $d_i^j$  we denote by  $\pi_i^j(d_i^j, a_j^i, \theta) \in [0, 1]$  the fraction of the total amount of public good  $c_i$  that is successfully defended against free riding by region  $j$ . Analogously,  $(1 - \pi_i^j(d_i^j, a_j^i, \theta))$  is the fraction of the public good  $c_i$  for which region  $j$  is successful in free-riding.  $\theta \geq 0$  is a parameter that measures how easy it is to free-ride, where larger values of  $\theta$  imply easier free-riding and  $\pi_i^j(\cdot, \cdot, 0) = 1$  (perfect enforcement is without costs).  $\pi_i^j$  reflects the technology of contest<sup>8</sup> This technology can depend on the nature of the good that is to be excluded because free riding is ceteris paribus easier for some goods than for others. This effect is captured by the parameter  $\theta$ . The functions  $\pi_i^j$  have the following properties:

$$\frac{\partial \pi_i^j}{\partial d_i^j} > 0, \quad \frac{\partial \pi_i^j}{\partial a_j^i} < 0, \quad \frac{\partial^2 \pi_i^j}{\partial (d_i^j)^2} < 0, \quad \frac{\partial^2 \pi_i^j}{\partial (a_j^i)^2} > 0, \quad \frac{\partial \pi_i^j}{\partial \theta} > 0. \quad (2)$$

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<sup>7</sup>This specification refers to a situation where defensive activities against one region do not improve defense against other regions. An alternative formulation would be to assume that investments  $d_i$  improve defense against all other regions (increasing returns to defense). Both types of defensive technologies coexist in reality. The qualitative nature of the results would not change with this alternative specification.

<sup>8</sup>See Hirshleifer (2001).



The first two conditions make sure that an increase in defensive and free-riding activities is productive from the point of view of every region. The third and fourth conditions guarantee the existence of an interior maximum. The fifth condition is a normalization of the effect of  $\theta$  on defense.

The representative agents in regions  $i = 1, \dots, n$  derive utility from the consumption of the private good,  $x_i$ , as well as from the consumption of the public goods,  $c_1, \dots, c_n$ . The utility functions of the representative agents are strictly quasi-concave and given by  $u_i(x_i, c_1, \dots, c_n)$ . We analyze a two-stage game where we look for subgame-perfect Nash equilibria:

**Stage 1:** At stage 1 all regions decide how much private ( $y_i$ ) and public goods ( $c_i$ )<sup>9</sup> they produce and how much they invest in defense and free riding. The outcome of this stage defines a primary allocation  $X_i = \{y_i, c_i, E_i^j\}$ ,  $E_i^j = (1 - \pi_j^i(a_i^j, d_j^i, \theta))c_j$ ,  $i = 1, \dots, n$ ,  $j \neq i$ , where  $E_i^j$  denotes the amount of the public good produced by region  $j$  on which region  $i$  succeeds in free riding.

**Stage 2:** At stage 2 every region  $i = 1, \dots, n$  can levy user charges  $p_i^j$  as prices for the use of public goods by regions  $j \neq i$ . These charges are measured in units of the private good which we assume can be freely traded among regions. The price of the private good is therefore equal in all regions and is normalized to be equal to 1. If, for example, region  $i$  levies a user charge for the use of roads on drivers from other regions and a car driver from region  $j$  decides to free-ride in 20% of the cases he will pay the user charge  $p_i^j$  in 80% of the cases he drives through region  $i$ . We denote by  $p = \{p_1^2, \dots, p_n^{n-1}\}$  the vector of user prices.

## 2.2 Centralization

An alternative institutional structure is to centralize the supply of the public goods. By *centralization* we define a situation where the public goods are still produced

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<sup>9</sup>We have to distinguish between the quantity produced,  $y_i$ , and the quantity consumed,  $x_i$ , for the private good and not for the public good because the former is rival in consumption whereas the latter is not, and a region will never decide to exclude itself from the consumption of public goods produced by itself.

within the regions, but where the regions decide to introduce a single authority (the *center*) with the power to tax the regions and to buy public goods from the tax revenues. The center does not rely on the exclusion mechanism to finance the public goods but on its coercive power to tax the regions. Hence, the center does not exclude any of the regions from the use of the public goods. The difference between the mechanisms that can be used for the financing of public goods between centralized and decentralized agencies – exclusion mechanism on the one hand and taxation on the other – and the associated transaction costs define the basic tradeoff that will be analyzed in this paper.

The use of tax mechanisms creates different types of costs. In this paper we use a reduced form of costs of centralization. We explicitly distinguish between exogenous resource costs  $C$  and endogenous resource costs due to commitment problems. The interpretation of the exogenous resource costs  $C$  is as follows. Centralization itself requires the creation of an agency. Part of the exogenous resource costs are the costs of creating such an agency. A measure of these costs is for example the number of working hours of the individuals of the economy that is spent in this agency. In addition, the principal-agent problem resulting from the creation of a center may not be perfectly solved by the use of incentive mechanisms. These necessary agency costs can be converted into resource equivalents and define another part of  $C$ . Third, the taxes levied to finance the public supply of public goods may create distortions. In this case, part of  $C$  has also be thought of as the resource equivalent of these marginal costs of public funds. Because the direction of additional distortions are obvious and well-studied in the literature,<sup>10</sup> we restrict attention to the reduced-form representation of the costs of centralization.

We distinguish these costs from the endogenous costs of insufficient commitment in order to make the decentralized and the centralized model comparable. As we have argued before, the costs of decentralization depend on the ability of the regions to find an ex-ante commitment for the user charges. This commitment problem is unaffected by the degree of centralization. If the regions face a commitment problem with a decentralized supply they most likely face the same type of commitment

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<sup>10</sup>For excellent surveys see for example Cornes and Sandler (1996) and Wildasin (1987).

problem with a centralized supply and vice versa.

### 3 Analysis of the equilibria

#### 3.1 Decentralization

We solve the game by backward induction. The outcome of stage 1 is a tuple  $X = \{X_1, \dots, X_n\}$ . Denote by  $c_i^{jD}$  the demand of public good  $c_j$  by region  $i$  and by  $c_i^{jS}$  the supply of public good  $c_i$  to region  $j$ . Every region  $i$  maximizes its utility  $u_i(x_1, c_1, \dots, c_n)$  under the following constraints:

$$c_i + \sum_{j \neq i} p_j^j c_i^{jD} = y_i + \sum_{j \neq i} p_j^i c_i^{jS}, \quad c_j = E_i^j + c_i^{jD}, \quad i = 1, \dots, n, j \neq i. \quad (3)$$

The first term on the left-hand side measures expenditures for the consumption of the private good by region  $i$ , whereas the second term on the left-hand side measures expenditures for the consumption of public goods produced by regions  $j \neq i$  consumed by region  $i$ . The first term on the right-hand side measures the total potential income from the private good produced by region  $i$ , whereas the second term on the right-hand side measures the total income generated by the supply of the public good produced in region  $i$ .

The first-order conditions of the associated Lagrangean ( $\lambda_i$  is the Lagrange parameter) are:

$$c_i^{jD} : \quad \frac{\partial u_i}{\partial c_j} = \lambda_i p_j^j, \quad i = 1, \dots, n, j \neq i, \quad (4)$$

$$c_i^{jS} : \quad \lambda_i p_j^i > 0 \quad i = 1, \dots, n, j \neq i, \quad (5)$$

$$x_i : \quad \frac{\partial u_i}{\partial x_i} = \lambda_i \quad i = 1, \dots, n, j \neq i. \quad (6)$$

(4) and (6) imply that the marginal rate of substitution between the public good produced by region  $j$  and the private good has to be equal to the user price charged by region  $j$ . (5) implies that for every given user price charged to region  $j$ , region  $i$  wants to allow access to the full amount of public good available. This is an immediate consequence of the non-rival nature of the public good: excluding individuals

from other regions from the consumption of the public good would destroy some of the potential value the good has for the region. This finding stresses that exclusion is used as a mechanism to achieve an optimal allocation, not as a means to actually exclude.<sup>11</sup> As a consequence, it must be that  $c_i^{jS} = \pi_i^j c_i$   $i = 1, \dots, n, j \neq i$ .

A solution of the above problem gives rise to Marshallian demand and supply functions  $c_i^{jD}(p, X)$ ,  $x_i(p, X)$ ,  $c_i^{jS}(p, X)$ . An equilibrium at stage 2 is a vector of user prices  $p^*$  such that the demand and supply for all public and for the private goods coincide:

$$c_i^{jD}(p^*, X) = \pi_j^i(a_i^j, d_i^j)c_j(p^*, X) \quad i = 1, \dots, n, j = 1, \dots, n, j \neq i, \quad (7)$$

$$\sum_{i=1}^n x_i(p^*, X) = \sum_{i=1}^n y_i. \quad (8)$$

Inserting the equilibrium prices into the Marshallian demand functions and the Marshallian demand functions into the utility functions gives rise to indirect utility functions  $v_i(X)$ ,  $i = 1, \dots, n$ .

At stage 1 every region  $i$  maximizes its indirect utility function  $v_i$  by the choice of  $X_i$  under the restriction that  $x_i + c_i + \sum_{j \neq i} a_i^j + \sum_{j \neq i} d_i^j = 1$ . Denoting by  $\mu_i$  the Lagrange parameter of the associated maximization problem we can derive the following first-order conditions by the use of the Envelope Theorem:

$$y_i : \quad \lambda_i + \lambda_i \Delta_{y_i} = \mu_i \quad i = 1, \dots, n, \quad (9)$$

$$a_i^j : \quad -\frac{\partial u_i}{\partial c_j} \frac{\partial \pi_j^i}{\partial a_i^j} c_j + \lambda_i \Delta_{a_i^j} = \mu_i \quad i = 1, \dots, n, j = 1, \dots, n, j \neq i, \quad (10)$$

$$d_i^j : \quad \lambda_i p_j^i \frac{\partial \pi_i^j}{\partial d_i^j} c_i + \lambda_i \Delta_{d_i^j} = \mu_i \quad i = 1, \dots, n, j = 1, \dots, n, j \neq i, \quad (11)$$

$$c_i : \quad \frac{\partial u_i}{\partial c_i} + \lambda_i \sum_{j \neq i} p_j^i \pi_i^j + \lambda_i \Delta_{c_i} = \mu_i \quad i = 1, \dots, n, j \neq i, \quad (12)$$

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<sup>11</sup>This result differs from Fraser (1996) and Janeba and Swope (2001) who analyze user charges in different applications. Both papers get positive exclusion in equilibrium. The reason for their result is that in their models the supplier of the public good is not allowed to discriminate prices between different users and is therefore restricted to Cournot-price setting, whereas in our model every region can perfectly discriminate prices. This shows that the implementation of Lindahl prices by a decentralized market mechanism requires a monopoly that is allowed to discriminate prices among users.

where

$$\Delta_{\sigma_i} = \left( \sum_{j \neq i} \frac{dp_i^P}{d\sigma_i} \pi_i c_i - \sum_{j \neq i} \frac{dp_j^P}{d\sigma_i} (1 - \pi_j) c_j \right) \quad \sigma_i \in \{y_i, c_i, a_i, d_i\}, i = 1, 2, j \neq i \quad (13)$$

measures the net effect of a change in equilibrium prices. It can be interpreted as the change in the net-income position of region  $i$  due to the change in equilibrium prices. This effect can be interpreted as a net-income effect of price changes. It is a consequence of the sequential structure of the game: markets for public goods are thin in the sense that every public good is produced by only one region and access prices are determined for every other region separately. Hence, different to the case of private goods where it is standard to assume that the individual supplier does not have to take into account the effects of his supply decision on the equilibrium prices, the supply decision for a public good may very well change equilibrium prices. The terms  $\Delta_{\sigma_i}$  take these changes into consideration. These effects cancel if either the regions are short-sighted or able to write and enforce long-term contracts specifying the user charges of the public goods before they are produced.<sup>12</sup>

Using (4), (6), and (9) we can manipulate (12) to get

$$\frac{\partial u_i}{\partial c_i} / \frac{\partial u_i}{\partial l_i} + \sum_{j \neq i} \left( \frac{\partial u_j}{\partial c_i} / \frac{\partial u_j}{\partial l_j} \pi_i^j \right) = 1 + (\Delta_{y_i} - \Delta_{c_i}), \quad i = 1, \dots, n. \quad (14)$$

(14) is a modified Samuelson condition for the decentralized provision of public goods. The Samuelson condition states that the sum of marginal rates of substitution between the public good and the private good for all regions has to be equal to the marginal rate of transformation between the public and the private good, which is equal to 1 because of linear production. (14) shows two deviations from this rule:

- Assume  $\pi_i = 1$ . Every region has an incentive to use the supply of public goods to change the equilibrium prices in their favor. Assume all goods are normal

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<sup>12</sup>It is worthwhile to point out a formal similarity between our model and the theory of the firm developed by Grossman and Hart (1986). In their model the lack of long-term price contracts makes the production decision of a single agent a strategic variable because it influences its ex-post bargaining position. Bargaining, in their model, is without cost. The terms  $\Delta_{\sigma_i}$  result from the same lack of commitment. Bargaining and contest models, however, differ with respect to the underlying assumption about wasted resources.

goods. In this case an increase in the supply of public good  $i$  will decrease its relative price with respect to the other goods, which implies that  $\Delta_{c_i} < 0$ . In addition, an increase in the consumption of the private good  $i$  will increase the relative price of the public good in  $i$ ,  $\Delta_{y_i} > 0$ . In summary,  $\Delta_{y_i} - \Delta_{c_i} > 0$ , the ability of the regions to manipulate equilibrium prices tends to reduce the supply of public goods compared to the Pareto-efficient solution. This is the first inefficiency inherent to decentralization: even if exclusion of free riding is without costs, regions may have an incentive to strategically use the supply of public goods to change prices in their favor.

- Assume  $\Delta_{\sigma_i} = 0$ . Every region deviates from the first-best Samuelson condition because of the costs of private enforcement: the marginal rates of substitution for all other regions have to be multiplied by the fraction of the public good that is successfully defended against free riding. This deviation defines another aspect of the transaction costs of using the exclusion mechanism for the allocation of public goods. Let us focus on two special cases:
  - If the public good is a regional public good,  $\partial u_j / \partial c_i = 0$  for all  $j \neq i$ . This implies that the marginal rate of substitution has to be equal to the marginal rate of transformation in each region. The decentralized equilibrium is *ceteris paribus* efficient.
  - If exclusion does not generate any costs,  $\theta = 0$ , we get  $\pi_i^j = 1$  for all  $i = 1, \dots, n$ ,  $j = 1, \dots, n$ ,  $j \neq i$ . This implies that the decentralized provision of public goods is first-best efficient. This demonstrates Coase's (1960) insight that in the absence of transaction costs a decentralized solution is efficient as long as property rights are perfectly enforced.

We will next analyze the optimal relationship between defensive and free-riding investments. Assuming an interior solution for  $a_i^j$  and  $d_i^j$  we get from (10) and (11)

$$p_i^j \frac{\partial \pi_i^j}{\partial d_i^j} c_i = -p_j^i \frac{\partial \pi_j^i}{\partial a_i^j} c_j + (\Delta_{a_i} - \Delta_{d_i}). \quad (15)$$

Defensive and free-riding activities are chosen such that the marginal returns from both activities are equal. The marginal returns are equal to the weighted marginal

change in free riding/defending times the quantity of the public good under consideration plus the net effect of price changes. This factor is weighted by the relative price of both public goods. We call the solution of the decentralized problem  $\mathcal{D}$  in the following.

The characterization of optimal defensive and appropriative activities allows it to identify a third element of the costs of decentralization. In addition to the deviation from the marginal conditions characterizing a first-best optimum, the direct resource costs of the free-rider contest contribute to the total transaction costs. Even without strategic supply decisions and perfect exclusion but with positive investments in equilibrium, the resulting Samuelson condition characterizes the optimum for a smaller total amount of private and public goods.

### 3.2 Centralization

As we have said before, centralization captures a situation where the regions agree to establish a center providing the public goods by the means of taxation. The ability to tax regions enables the center not to use the exclusion mechanism. The center maximizes the sum of utilities of the regions by the choice of public-goods supply. The structure of the centralized solution depends on the center's ability to enforce long-term prices for the public goods. If it can enforce them the strategic use of public-goods supply by the regions vanishes. If not, one is confronted with strategic quantity decisions by the regions in the same way as with a decentralized supply. We will analyze both situations in the following.

**1. Long-term price contracts possible.** We start the analysis with the assumption that the center can levy region-specific taxes  $t_i$ . The maximization problem of the center is therefore

$$\begin{aligned} \max_{c_1, \dots, c_n, t_1, \dots, t_n} \sum_{i=1}^n u_i(x_i, c_1, \dots, c_n) \quad s.t. \quad & 1 - t_i - x_i \geq 0, i = 1, \dots, n \quad (16) \\ \wedge \quad & \sum_{i=1}^n t_i = \sum_{i=1}^n c_i + C. \end{aligned}$$

The first set of restrictions guarantees that each region's time budget is balanced.

The second restriction is the center's budget constraint taking into consideration the total resource costs of centralization,  $C$ . Let  $\gamma_i^1$ ,  $i = 1, \dots, n$  and  $\gamma^2$  be the Lagrange parameters for the constraints. The first order conditions for the center are

$$x_i : \quad \frac{\partial u_i}{\partial x_i} = \gamma_i^1, \quad i = 1, \dots, n, \quad (17)$$

$$c_i : \quad \sum_{j=1}^n \frac{\partial u_j}{\partial c_i} = \gamma^2, \quad i = 1, \dots, n, \quad (18)$$

$$t_i : \quad \gamma_i^1 = \gamma^2. \quad (19)$$

These conditions can easily be manipulated to yield the Samuelson condition:

$$\sum_{j=1}^n \frac{\partial u_j}{\partial c_i} / \frac{\partial u_j}{\partial x_j} = 1. \quad (20)$$

This implies that the center has the right incentives to supply the public goods. However, in doing so he maximizes welfare for a smaller size of the cake because part of the resources of the economy have to be spent in order to create the center. We will call this solution  $\bar{C}$  in the following.

**2.** Long-term price contracts are not possible. If the center suffers from the same problems in writing long-term contracts as the regions, it is confronted with strategic quantity-setting by the regions. We analyze a situation where the center cannot make any price commitments at all, which boils down to the assumption that it uses a simple cost-reimbursement rule for every amount of the public goods produced by the regions.<sup>13</sup>

**Stage 1:** The regions (non-cooperatively) choose quantities of the public goods  $c_1, \dots, c_n$ .

**Stage 2:** The center reimburses the costs of the regions by levying region-specific taxes  $t_1, \dots, t_n$ . The total amount of taxes has to cover both, the centralization costs

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<sup>13</sup>The financial crisis of New York City in 1995 is a good example for the commitment problems of a center, in this case the federal government of the United States under President Gerald Ford. After a time of large investments in public infrastructure of the city of New York the city was almost bankrupt. In the negotiations to follow, President Ford was strongly in favor not to bail out the city. However, he finally failed and federal bonds were issued to bail it out. See Burns and Sanders (1999) for details.



and the costs for the public goods,  $\sum_{i=1}^n t_i = \sum_{i=1}^n c_i + C$ . We assume the following cost-sharing rule:  $t_i = c_i + C/n$ .

Stage 2 is trivial because of the cost-reimbursement rule by the government. At stage 1 each region maximizes his utility  $u_i(x_i, c_1, \dots, c_n)$  anticipating the cost-reimbursement rule  $t_i = c_i + C/n$  and the time constraint  $c_i + t_i = 1$ . Inserting the constraint into the utility function yields

$$u_i(1 - c_i - C/n, c_1, \dots, c_n). \quad (21)$$

Maximization with respect to  $c_i$  yields the following first-order condition:

$$\frac{\partial u_i}{\partial c_i} / \frac{\partial u_i}{\partial x_i} = 1. \quad (22)$$

If the center uses a cost-reimbursement rule, every region supplies public goods until their marginal rate of substitution is equal to the marginal rate of transformation: they treat public goods as if they were private goods, the resulting allocation is inefficient. This inefficiency adds to the extra costs of centralization.

Both solutions of the centralized solution define opposite extremes for incentives induced by centralization. These extremes will prove to be useful to get a deeper understanding of the economic effects of centralization and decentralization when we turn to the analysis of a functional specification. We will call the solution of this problem  $\underline{C}$  in the following.

It is easy to establish that in a world with long-term price contracts and without transaction costs,  $\theta = 0$  (exclusion of free riding incurs no cost) and  $C = 0$  (creation of a center incurs no cost), centralization and decentralization are equally efficient. This demonstrates the validity of the Coase theorem for the case of public goods. We will show in the next section how this comparison can be extended to more general situations using a functional specification of the model.

With region-specific taxes the regions face the following trade-off when making the decision to centralize the supply of public goods: if the supply remains decentralized every region has an incentive to invest in free-riding, which in turn implies that they have an incentive to invest in defense against free riding. In addition, every region has an incentive to strategically use public-goods supply. Both incentives

are eliminated if the provision of public goods is centralized, however, centralization itself requires the use of resources. Centralization is optimal if its resource costs are lower than the resource costs of the exclusion mechanism.

The above model 1. maximizes the tendency towards centralization because it abstracts from costs associated with centralization different from  $C$ . Apparently obvious costs of centralization result from asymmetric information. This line of argument has been extensively stressed in the literature on fiscal federalism during the last couple of years. However, most of the literature does not discuss the optimal allocation of political responsibilities but starts from a situation of centralization and analyzes how asymmetric information influences the optimal allocation. It is a straightforward application of the result by Crampton, Gibbons, and Klemperer (1987) that public property might *reduce* the incentive problems due to asymmetric information because of a change in the participation constraints (compared to a situation of private property). This result can directly be applied to the case of public goods in a two-agent economy. However, as Rob (1982) has shown, the allocation problem for private and public goods differ for economies with more than two agents. Hence, the evidence is mixed.

## 4 Functional specification

In the last section we have characterized the basic trade-off between decentralization and centralization. Because both institutional settings create deviations from the first best, a normative evaluation is impossible by a comparison of the first-order conditions alone. In order to gain further insights we will use the following functional specification of the utility and contest functions.

We assume that the agents of each region have identical, homothetic utility functions where public goods provided by other regions spend less utility than the public good provided by the own region,

$$u_i(x_i, c_1, \dots, c_n) = \ln(x_i) + \ln(c_i) + \sum_{j \neq i} \frac{1}{n-1} \ln(c_j). \quad (23)$$

This specification approximates the road example where we assume that residents of region  $i$  use roads in region  $i$  more frequently than roads in region  $j$ .

We use a generalized Tullock function to model the free-rider contest,

$$\pi_i^j(a_j^i, d_i^j) = \frac{d_i^j}{d_i^j + \theta a_j^i}. \quad (24)$$

$\theta$  is a parameter that measures the total as well as the marginal impact of defensive and free-riding investments (Grossman 2001). If  $\theta = 0$ ,  $\pi_i^j = 1$ , hence exclusion has no cost.

### Decentralization:

The symmetry of the problem allows it to solve the problem as if it were a two-agent economy. In order to see this we simplify the maximization problem in the following way.

$$\max_{x_i, c_i^{-iD}} \ln(x_1) + \ln(c_i) + \ln(c_{-i}) \quad s.t. \quad x_i + (n-1)c_i^{-iD} = y_i + (n-1)\pi_i^{-i}c_i, \quad (25)$$

where  $-i$  denotes all agents except of agent  $i$ . For simplicity we will therefore talk about agent 1 and 2 in the following. Utility maximization at stage 2 gives rise to the following Marshallian demand functions for the public goods:

$$c_1^{2D} = \frac{c_1 p_1^2 \pi_1^2 - c_2 p_2^1 (1 - \pi_2^1) + y_1}{2p_2^1}, \quad c_2^{1D} = \frac{c_2 p_2^1 \pi_2^1 - c_1 p_1^2 (1 - \pi_1^2) + y_2}{2p_1^2}. \quad (26)$$

The Marshallian demand functions for the private good follow directly from the budget constraints. The numerator measures the effective income of an agent, which is equal to his endowment  $y_i$  plus the net income from selling and buying access to the public goods. The denominator divides this by the relative price of the good.

Market clearing gives rise to access prices in equilibrium that are equal to

$$p_1^2 = \frac{y_2 + \pi_2^1(y_1 + y_2)}{c_1(n-1)(1 + \pi_1^2 + \pi_2^1)}, \quad (27)$$

$$p_2^1 = \frac{y_1 + \pi_1^2(y_1 + y_2)}{c_2(n-1)(1 + \pi_1^2 + \pi_2^1)}. \quad (28)$$

Inserting the Marshallian demand functions and the equilibrium prices into the utility functions gives rise to indirect utility functions (using the time constraint to

eliminate  $y_i$ ):

$$v_1 = \ln(x_1) + \ln(c_1) + \ln(c_2), \quad (29)$$

$$v_2 = \ln(x_2) + \ln(c_2) + \ln(c_1), \quad (30)$$

where

$$\begin{aligned} x_i = & \frac{-\theta(d_j + \theta a_i)(a_n(-1 + c_i + a_i(n-1) + d_i(n-1))) + d_i(2a_i + a_j + 2d_i + d_j)n}{3d_i d_j + 2a_i d_i \theta + 2a_j d_j \theta + a_i a_j \theta^2} \\ & + \frac{-\theta(d_j + \theta a_i)(-d_i(3 + 2a_i + a_j - 2c_i - c_j + 2d_i + d_j))}{3d_i d_j + 2a_i d_i \theta + 2a_j d_j \theta + a_i a_j \theta^2}. \end{aligned} \quad (31)$$

Maximization of  $v_1, v_2$  with respect to  $c_1, d_1, a_1$  and  $c_2, d_2, a_2$  respectively gives rise to

$$c_1 = c_2 = \frac{3 + 4\theta + \theta^2}{5 + 9\theta + 2\theta^2}, \quad (32)$$

$$a_1 = d_1 = a_2 = d_2 = \frac{\theta}{5(n-1) + (n-1)9\theta + (n-1)2\theta^2}, \quad (33)$$

and indirect utility functions  $W_i(\theta)$ :

$$W_1(\theta) = W_2(\theta) = \ln \left( \frac{(1+\theta)(2+\theta)}{5+\theta(9+2\theta)} \right) + 2 \ln \left( \frac{(1+\theta)(3+\theta)}{5+\theta(9+2\theta)} \right). \quad (34)$$

### Centralization:

*Problem 1. (commitment possible):* The center solves the following optimization problem (we can restrict attention to uniform taxes  $t_i = t_j = t$  because of the symmetry of the problem, and we use  $c_i = c_j = c$ ):

$$\max_{c,t} n (\ln(1-t) + n \ln(c)) \quad s.t. \quad t \cdot n = C + n \cdot c. \quad (35)$$

The solution is

$$c = \frac{n-C}{n+1}, \quad t = \frac{C}{n(n+1)} + \frac{n}{n+1}, \quad (36)$$

with indirect utility function

$$v(n, C) = \ln \left( 1 - \frac{C}{n(n+1)} + \frac{n}{n+1} \right) + n \cdot \ln \left( \frac{n-C}{n+1} \right). \quad (37)$$

*Problem 2. (commitment not possible):* With a cost-reimbursement rule every region solves

$$\max_{c_i} \ln(1 - c_i - C/n) + \ln(c_i) + \ln(c_j), \quad i = 1, \dots, n, j \neq i. \quad (38)$$

The solution to this problem gives rise to the following provisions of public goods:

$$c_i = \frac{n - C}{2n} \quad i = 1, \dots, n, \quad (39)$$

yielding an indirect utility function

$$v_i = \ln(1 - C/n + (C - n)/2n) + 2 \ln((n - C)/2n), \quad i = 1, \dots, n. \quad (40)$$

We are now in a position to compare the centralized and the decentralized solution. The crucial parameters for this comparison are  $\theta$ ,  $n$ , and  $C$ . Figure 1 shows the indirect utility functions for  $\mathcal{D}$ ,  $\bar{\mathcal{C}}$ , and  $\underline{\mathcal{C}}$  at  $C = 0$  and  $n = 2$ . The upper straight

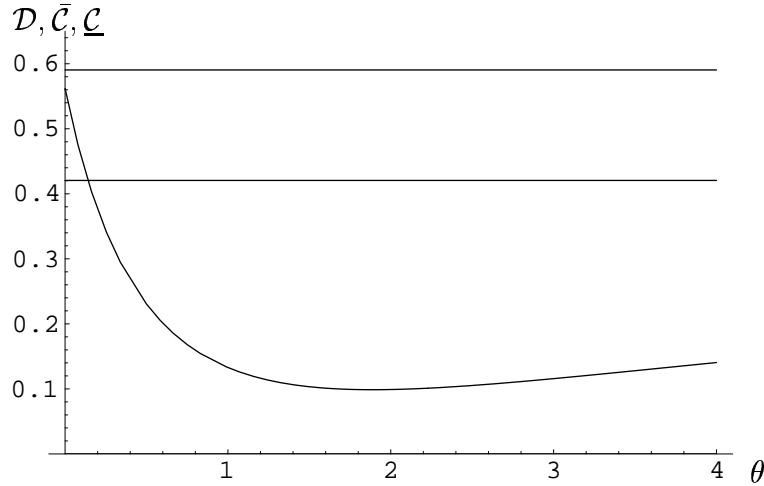


Figure 1: Welfare levels with  $C = 0$  and  $n = 2$ .

line corresponds to  $\bar{\mathcal{C}}$ , whereas the lower straight line corresponds to  $\underline{\mathcal{C}}$ . The third line corresponds to  $\mathcal{D}$ . Comparing  $\bar{\mathcal{C}}$  with  $\mathcal{D}$  shows that irrespective of  $\theta$  centralization is better than decentralization if the center can commit to prices. The vertical distance between both graphs at  $\theta = 0$  is a measure for the welfare loss resulting from the

strategic setting of quantities by the regions. If enforcement becomes more difficult (rise in  $\theta$ ), the welfare of the decentralized solution decreases because part of the resources are devoted to free riding and defense. However, if  $\theta$  is becoming sufficiently large, this effect is reversed, utility starts rising again. This apparently surprising effect is related to the *paradox of power* (Hirshleifer 1991): if it is becoming very easy to free ride for the other regions they will reduce their investments in free riding, which, as a consequence, induces the providing region to reduce in investments. Hence, time resources become available for productive use.

A comparison of  $\underline{\mathcal{C}}$  and  $\mathcal{D}$  shows that even without any direct costs of centralization the incentive mechanisms available for the center are crucial for the comparison of decentralization and centralization. If the center cannot commit to prices ex ante but can be expected to bail-out the regions ex-post, decentralization is advantageous for small values of  $\theta$ , the strategic price effect does not over-compensate the adverse effects of the cost-reimbursement rule. What happens if  $\theta$  is getting very large? It can be shown that

$$\begin{aligned} \lim_{\theta \rightarrow \infty} v_i(\mathcal{D}) &= \lim_{\theta \rightarrow \infty} \left[ \ln \left( \frac{(1+\theta)(2+\theta)}{5+\theta(9+2\theta)} \right) + 2 \ln \left( \frac{(1+\theta)(3+\theta)}{5+\theta(9+2\theta)} \right) \right] \\ &= \ln(1/2) + 2 \ln(1/2) \\ &= v_i(\underline{\mathcal{C}}), \end{aligned}$$

which implies that for very large values of  $\theta$  decentralization and centralization with cost-reimbursement are equivalent. This result is intuitive: the paradox of power results from the fact that the regions reduce their investment in the free-rider contest, it does not imply that the providing region is more successful in excluding the free riders. On the contrary, if  $\theta$  is getting very large, exclusion is impossible. Hence, the other regions free-ride for free. As a consequence,  $\pi_i = 0$ , every region equalizes the marginal rate of substitution to the marginal rate of transformation, as in the case of a cost-reimbursement rule.

Figure 2 shows the same situation as in Figure 1, with the exception that the introduction of a center incurs costs  $C = 0.1$ , which implies that the introduction of a federation costs 10% of the regions' time resources. The figure shows that in this case  $\mathcal{D}$  dominates  $\bar{\mathcal{C}}$  for small values of  $\theta$ : the administrative costs of central-

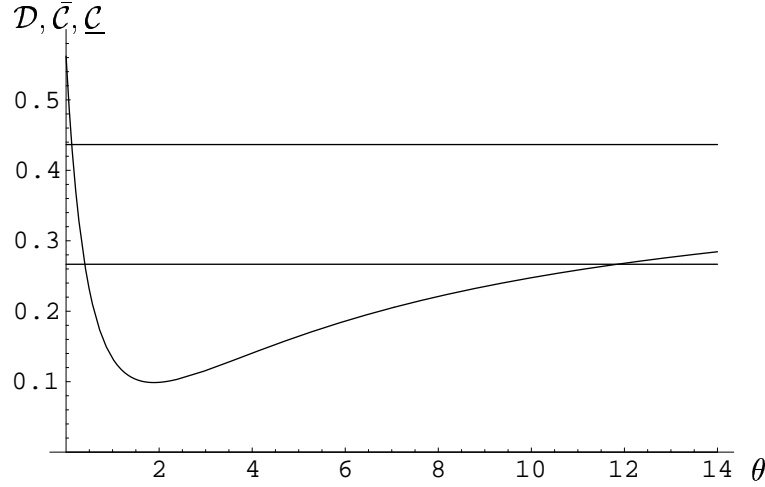


Figure 2: Welfare levels with  $C = 0.1$  and  $n = 2$ .

ization over-compensate the adverse effects of strategic quantity setting if exclusion is relatively easy. Perhaps most interestingly, if the center cannot commit to prices, decentralization is the worse alternative compared to cost-reimbursement only for ‘intermediate’ values of  $\theta$ . This time, the paradox of power bites if exclusion is very difficult. The total resources spent for the free-rider contest become smaller than the administrative costs of centralization. Decentralization dominates centralization with cost reimbursement if exclusion is very easy *and* very difficult. It is straightforward to show that the same effect can occur for a comparison of decentralization and centralization with commitment if  $C$  is large enough.

Figure 3 shows the utility values for different numbers of regions and administrative costs for  $C = 0.1$ . We plot  $\mathcal{D}$  for three different specifications of  $\theta$ ,  $\theta \in \{0, 1, 100\}$ . The uppermost straight line corresponds to  $\theta = 0$  where enforcement is without cost, and the lowermost straight line corresponds to  $\theta = 1$ . The straight line in the middle corresponds to  $\theta = 100$ . It dominates  $\theta = 1$  because of the paradox of power. The uppermost curved graph corresponds to  $\bar{\mathcal{C}}$ , whereas the lowermost curved graph corresponds to  $\underline{\mathcal{C}}$ . Both graphs are increasing in  $n$  because the fixed costs of the center can be distributed among more regions, which implies that as long as  $C < 1$ ,  $\bar{\mathcal{C}}$  will

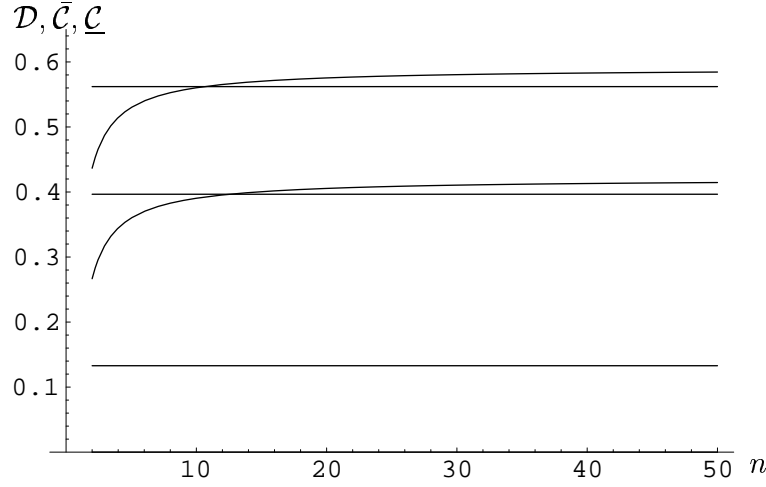


Figure 3: Welfare levels with  $C = 0.1$  and different values of  $\theta$ .

eventually dominate  $\mathcal{D}$ . The number of regions also helps  $\underline{\mathcal{C}}$  compared to  $\mathcal{D}$ .

## 5 Summary

The basic hypothesis of this paper has been that decentralization requires the use of an exclusion mechanism whereas centralization relies on a tax mechanism. If this is the case the costs of using this mechanism relative to the costs of centralization can explain the decision to centralize the provision of public goods.

If the provision of public goods is decentralized, three types of distortions occur. First, if regions cannot commit to access prices ex-ante, the regions have an incentive to use the quantity of the public good provided to influence the equilibrium prices. This problem occurs because optimal access prices require individualized prices, which, in turn, imply thin markets where the price taking assumption is not obvious. Second, the regions have to use the exclusion mechanism in order to finance the supply of public goods. If exclusion is costly this creates a free-riding contest between the regions. This free-rider contest in general distorts the first-order



conditions compared to the first best and creates resource costs.

If the provision of public goods is centralized, no free-rider contest is created because the center relies on taxes in order to finance the public goods. Hence, the distortions present with decentralization have to be compared to the costs of centralization. Immediate costs of centralized are the costs of creating a center itself. Second, the center can be limited in the mechanisms it can use when buying the public goods an additional distortion is created. We have analyzed the two polar cases where the center faces no incentive problems and where the center is restricted to use cost-reimbursement rules, for example due to a lack in credible commitment not to bail out the regions.

As a consequence, the optimal allocation of responsibilities for the supply of public goods depend on a comparison of both costs. If the center is an efficient mechanism for the provision of public goods there is an a-priori argument in favor of centralization because it avoids the strategic setting of quantities as well as the waste of resources in the contest. However, if the costs of establishing a federation are large this advantage can be over-compensated by the costs, especially if exclusion is relatively easy. Surprisingly, decentralization may also be advantageous if there exist substantial costs of centralization and exclusion is *very difficult*.

It is ambitious to assume that the center can use perfect procurement mechanisms in reality. If restricted to cost-reimbursement rules or with high costs of establishing a center an interesting additional effect can occur. Decentralization does not only dominate centralization when exclusion is easy, but also when it is very difficult. This surprising fact is a consequence of the paradox of power, which states that the investments in the free-rider contest will finally be reduced if exclusion is becoming more difficult because of the low marginal effectiveness of defensive investments. As a consequence, it may be optimal to decentralize the provision of public goods even if exclusion is almost impossible. Hence, it is in general not true that centralization is better than decentralization if exclusion is very costly and decentralization is better than centralization if exclusion is without cost, it depends on the comparison of costs.

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