Central Governance or Subsidiarity:
A Property-Rights Approach to Federalism[*]

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Summary

The paper reconsiders the theory of fiscal federalism in a framework inspired by property rights theory. We set up a two-period model where on a first stage a region in a federation can expend value-enhancing investments into a public project. The project can be implemented on a second stage, and causes spillovers on other regions. Under centralized as well as centralized governance, negotiations on the federal level facilitate the realization of the efficient policy. Still, non-contractibility of investments causes the overall outcome to differ across regimes. If the region with access to the public project bears the entire implementation costs of its policies, underinvestment prevails and subsidiarity (centralized governance) is superior when spillovers are weak (strong). Conversely, if linear cost sharing arrangements are feasible, decentralized authority often leads to a socially optimal outcome while centralized authority (with majority or unanimity rule) does not.

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JEL–Classification: D23, H70, H71, H72, H77.

1 Introduction

There is no straightforward answer to the question of whether authority over policy variables should be assigned to a federal or a regional level. According to established federalism theory as developed in Oates (1972), a virtue of decentralized authority is that local governments are 'closer to the people' living in their jurisdiction and therefore perform better in catering the needs of their respective constituency. Conversely, centralized governance has its merits because it allows to internalize externalities involved in public decisions. While these arguments have intuitive appeal, they rest on some critical presumptions. First, policy coordination among local governments does not take place so that there is no way to account for spillovers under subsidiarity. Second, the central government maximizes overall welfare in the economy. Finally, although the center is seen as a benevolent entity, it is assumed to provide policy projects uniformly across all regions even though their preferences may be heterogenous.[1]

The present paper reconsiders this important issue in a setting that is inspired by the theory of property rights [Grossman and Hart (1986), Hart and Moore (1990)]. According to this approach, ownership rights over a physical asset confer authority because the owner has the residual right to decide how to use the asset when contracts are incomplete. Even though efficient usage is ensured via efficient bargaining among the involved parties, property rights have an economic impact because they determine the parties' threat points in negotiations and thus, how the negotiation surplus is shared. This division of future gains, in turn, affects the parties' incentives to expend non-contractible investments into their relationship. Although property rights theory has primarily focused on the optimal allocation of control rights within firms, we believe that it also provides a natural framework to address the question of authority and optimal governance structure in the context of fiscal federalism.[2] Incomplete contracts play a key role in the relationships of jurisdictions. Bilateral and multilateral treaties, or national constitutions, only roughly specify the rights and obligations of political actors. Mostly, these contracts are confined to assigning authority over certain political

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[1]These last two presumptions have evoked some criticism in the recent literature. See Lockwood (1998) and Besley and Coate (1999) which are surveyed below.

[2]Aghion and Tirole (1997) have noted that authority may not only result from ownership over physical assets, but more generally from a contract allocating the right to decide on specified matters to some member or group of an organization. Hence, we can reinterpret the notion of ownership rights over physical assets as the authority to take decisions over policy variables.

decisions, and to distribute the cost burden of policies among regions in the federation. Also, investments into the returns or costs of subsequently pursued policy projects are often so complex that they cannot be part of inter-jurisdictional arrangements. Examples of such public investments are school reforms that raise the likelihood of success of education programs, efforts in designing welfare programs that improve health care or provide aid to the poor, or industry restructuring that makes environmental regulations more beneficial. In these and other situations the subsequent policy projects are associated with inter-regional spillovers so that jurisdictions have a joint interest to negotiate a mutually beneficial agreement [Coase (1960)]. And indeed, political bargaining to align regional interests seems to be the rule rather than the exception both in national assemblies and in supra-national federal systems as the EU.

We study a simple model with two jurisdictions, one of which can pursue an innovative policy project with spillover effects on the other region. Prior to policy choice, this region can invest resources that positively affect the overall return of the subsequently chosen policy. Authority over the implementation of the policy is assigned either to the regional, or to the federal level. While under decentralized governance the region can unilaterally decide on the project size, in case of centralized governance we distinguish between two scenarios. First, any deviation from the status quo (no new policy) may require the unanimous approval by all regional delegates in the federal assembly.[3] Second, decisions on the federal level may be taken under majority rule in which case the region holding a majority in the central legislature can enforce the policy it prefers.

Since local representatives pursue the interest of their respective home region, spillovers may make policy coordination mutually beneficial in either regime, and we allow for such coordination irrespective of the governance structure.[4] Negotiations always ensure that the surplus-maximizing project level is implemented, so that the relative merits of all possible governance structures have to be judged with respect to the investment incentives they provide. Because authority endogenously determines the 'disagreement' policy which is implemented when negotiations fail, these incentives will generally differ across regimes. Finally, we allow for cost-sharing rules that are prescribed before public investments are made: the cost incidence of policies can be determined in an initial agreement (a constitution) which determines what fraction of final policy costs the

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[3]This setting has been coined 'cooperative federalism' [Inman and Rubinfeld (1997)].

[4]See also Klibanoff and Morduch (1995) and Persson and Tabellini (1996). In contrast, previous literature often assumes that coordination occurs only under centralized governance, while federal regions do not coordinate their policy choice under decentralized governance.

region with access to the project has to bear.[5]

Our main results are as follows. First, without cost sharing provisions, decentralized authority dominates centralized governance whenever the external effect of the policy on other regions is sufficiently weak and vice versa. This finding reinforces the standard theory of federalism, although its explanation is quite different: while the traditional view holds that decentralized authority leads to a suboptimal allocation because spillovers are not internalized, this argument does not apply in our framework where the political bargaining process removes these inefficiencies. Rather, any investment of the jurisdiction with access to the policy increases (in presence of spillovers) not only its own disagreement payoff, but also that of the other region. In addition, the other region participates in the negotiation surplus (which is increasing in spillover size) futher amplifying the underinvestment tendencies. Hence, under decentralization, strong externalities trigger small investments. Conversely, under centralized authority with unanimity rule, each region can unilaterally block the implementation of the policy so that the status quo represents the disagreement point when negotiations fail. Accordingly, the investing region now has to share the entire social net surplus with others which, again, generally results in underinvestment. However, when its bargaining power vis-a-vis other federation members is large, or the externality is strong, its investment incentives are higher than under decentralization.[6]

Second, we show that decentralized authority often becomes strictly superior when cost-sharing arrangements are feasible.[7] In particular, an appropriately chosen linear cost

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[5]Notice that the allocation of decision rights over policies is logically distinct from the question of who finances those projects. Also, contrary to most contributions in the literature which assume that costs are shared equally among all federal citizens under centralized governance, and solely among regional inhabitants otherwise, we allow for more general financing rules. This generality is empirically important in light of the various cost-sharing provisions observed in practice [see Inman and Rubinfeld (1997)], and also sheds light on the economic consequences and desirability of various cost-sharing provisions.

[6]This finding seemingly contradicts basic insights from property-rights theory, according to which authority induces maximal investment incentives. However, in contrast to the standard framework, an externality in our model arises even in the (out-of-equilibrium) event that the parties fail to reach an agreement on the final allocation. See the discussion in Section 3 below.

[7]Categorical grants are quite common. The European Union exhibits a wide variety of regional funds often in form of matching grants, most importantly the agricultural and structural funds. In some policy fields, German states are eligible for cost-sharing grants from the federal government. For example, the construction of universities is subsidized at a matching rate of 50 percent. In the US, the federal health care program Medicaid and the program Aid for Families with Dependent Children (AFDC) are currently open-ended matching programs in which the subsidy varies inversely with state income, ranging from 50 percent to 78 percent [Quigley and Rubinfeld (1996)].

matching grant allows for a socially optimal outcome under dezentralized governance as long as spillovers are not too pronounced. Intuitively, the smaller the region's cost share, the larger the project it chooses when negotiations fail. Since prior investments are more valuable for larger projects, cost matching grants stimulate benefit-enhancing investments. In contrast to this positive outcome, a grant provision leaves investment incentives unaffected under centralized authority with unanimity rule because other regions can veto the project, thereby making the initial agreement obsolete. Finally, while under centralized governance with majority rule matching grants affect the disagreement policy, a socially optimal outcome remains unfeasible if other regions form the majority. Intuitively, those regions can 'exploit' the investing minority region, thereby adversely affecting its investment incentives.

The present paper is related to some recent theoretical contributions on fiscal federalism. Ellingsen (1998), Lockwood (1998) and Besley and Coate (1999) also investigate settings where regions within a federation conduct policies which involve externalities.[8] In these models, decentralized authority suffers from the familiar problem that interregional externalities are not internalized. In Ellingsen, regions can contribute to a pure public good, and the policy outcome is determined by majority vote over individual contributions either in the entire economy (under centralized governance), or within each region (under decentralized governance). While free riding behavior necessarily leads to inefficiencies under decentralized governance, centralized authority does not account for inter-regional heterogeneity. Lockwood (1998) and Besley and Coate (1999) derive policy outcomes from explicit legislative rules and find that the case for decentralization arises from political economy considerations. Lockwood shows (rather than assumes) that under centralized authority policies will be uniform across a federation when externalities are large. Even when regions are homogeneous, this uniformity is a cost to centralized decisionmaking because the political process makes the equilibrium outcome independent from project benefits.[9] In Besley and Coate, elected officials from each region become central decision maker with some probability under centralized governance. Whether centralization or decentralization is preferable

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[8]See also Seabright (1996). In his model, centralization yields benefits from policy coordination, but has its costs in terms of a diminished probability that the welfare of a given region affects the reelection probability of the central government.

[9]In a variety of situations, the gains from decentralization are higher when regions are heterogenous or spillovers are small. However, this general finding has to be qualified because the relative efficiency of centralization is not necessarily monotonically increasing in the spillover size, and some restrictive conditions are required to show that increased heterogeneity renders decentralization more preferable.

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depends on the degree of spillovers, the heterogeneity of districts and a parameterized weight that the central decisionmaker attaches to the interest of the other region. It turns out that centralized governance is more efficient when spillovers are small, or when the degree of heterogeneity among regions is large.

Our paper differs from these approaches in that we assume policy coordination (resulting in ex-post efficient policy choices) to be feasible under both centralized and decentralized governance. For any given investment level, regimes therefore do not differ in the final policy chosen (e.g., the provision of a public good), while they may lead to different incentives to invest into new public projects.[10] Furthermore, we do not take the cost incidence of policies as exogenously given, but allow cost-sharing rules to be optimally adjusted in a way as to provide optimal investment incentives.

The remainder of this paper is organized as follows. Section 2 presents the model. Section 3 analyzes the implications of centralized and decentralized governance in absence of inter-regional cost sharing arrangements. Section 4 introduces matching grants and analyzes decentralized governance as well as centralized governance under unanimity and majority rule. Section 5 concludes.

2 A Model

Consider an economy that is divided into two jurisdictions, $j \in \{A, B\}$, which may be countries, states, or regions in a federal system. Region A has access to a public project x which causes some spillover effect on the other region B.[11] The model has two stages: in a first stage, region A can expend public resources that increase the (uncertain) benefit of the policy measure to be pursued subsequently. For example,

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[10]In that respect, our paper is related to contributions by Schmidt (1996) and Caillaud, Jullien and Picard (1996) who, however, consider frameworks with asymmetric information. Caillaud et al. analyze whether the activities of a private firm should be regulated by a regional government that does not internalize interregional spillovers, or by a central government that does not observe the firm's cost structure. A combination of central grants and decentralized authority turns out to be second-best optimal. In a privatization context, Schmidt (1996) demonstrates that a welfare-maximizing government might find it optimal to privatize a public firm. While production under private governance is inefficient because regulation proceeds under asymmetric information, the resulting informational rents induce the private owner to expend a larger cost-reducing effort than under public governance.

[11]As will become clear later, we can regard B as a composite entity that comprises all federal states except A. Also, the assumption that only one region pursues one policy is made for simplicity only. Our findings immediately translate to the more general case where both regions have access to (possibly multiple) policy projects.

the project may be to build a new airport that benefits both regions and whose social value can be enhanced by investing into the surrounding infrastructure. Thereafter, in stage 2, a state of the world is revealed and regions negotiate on the implementation of the new policy in a way that is specified in detail below.

Regions are governed by local governments and the central government is composed of delegates from both jurisdictions. Throughout the analysis, we assume that local governments as well as regional delegates act in the best interest of their constituents.[12]

Let $x \in [0, \bar{x}] \subset \mathbb{R}$ be the realized size of the project, e.g., the size of an airport, the quantity of a public good provided, or the rigidity of environmental standards. The prior investments of the region with access to the project (region A) are denoted by $e \in \mathbb{R}_0^+$ and the corresponding investment outlays by $\psi(e)$. In stage 2, a project of size x provides a total gross benefit measured in monetary terms of $V(x, e, \theta)$ and imposes (implementation or other) costs $C(x)$. The variable θ is a random shock that is realized at the beginning of stage 2 and is distributed according to a continuous cumulative distribution $F(\theta)$ on the support $[\underline{\theta}, \bar{\theta}]$. Benefits and costs of a 'status quo' policy $x = 0$ are normalized to zero.

Assumption 1. The functions $V(\cdot)$, $C(\cdot)$, and $\psi(\cdot)$ are bounded, non-negative, twice continuously differentiable, strictly increasing in their arguments, and satisfy for all e, θ and $x > 0$ (subscripts denote derivatives)

a) $\lim_{x \to \bar{x}} V(x, e, \theta) - C(x) < 0$ and $V(x, e, \theta) - C(x) > 0$ for some $\theta < \bar{\theta}$,

b) $V_{xx} \leq 0$, $C_{xx} > 0$, $V_{ex}(\cdot) > 0$,

c) $\psi_{ee}(\cdot) > 0$, $\psi(0) = \lim_{e \to 0} \psi_e(e) = 0$ and $\lim_{e \to \infty} \psi_e(e) = \infty$.

Parts a) and b) ensure that the socially efficient project size is strictly positive in some states θ and always less than the maximal size $\bar{x}$, irrespective of investments. The last assumption in b) states that public investments are socially more valuable, the larger the project. Part c) then implies that some positive but finite investment level is optimal ex ante.

Region A reaps a gross return of $V^A = \beta V(\cdot)$ while the return of the other region B is $V^B = (1 - \beta)V(\cdot)$. Thus, the parameter $\beta \in [0, 1]$ measures the relative spillovers of

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the policy pursued in A on region B.[13]

For subsequent reference, we first compute the socially optimal policy level $x^*(\cdot)$ that is to be chosen in stage 2. At that date, region A has already expended e and θ has been revealed. Assuming that utility is perfectly transferable across regions (disregarding wealth effects), the efficient project size solves

$$x^*(e, \theta) = \arg \max_{x \in [0, \bar{x}]} S(x, e, \theta) \equiv V(x, e, \theta) - C(x), \tag{1}$$

Under our previous assumptions, $x^*(e, \theta) > 0$ for a nonempty set of realizations θ, which is then uniquely determined by the first-order condition

$$V_x(x^*; e, \theta) = C_x(x^*). \tag{2}$$

Define $S^* \equiv S(x^*(e, \theta), e, \theta)$ as the maximum surplus in stage 2 and note that S^* is independent of β and strictly increasing in e if $x^*(\cdot) > 0$. In stage 1, the socially optimal investment outlays e^* to be expended by region A maximize the ex-ante expected overall surplus in the economy, i.e.,

$$e^* \in \arg \max_{e \geq 0} E_\theta \left[S(x^*(\cdot), e, \theta) \right] - \psi(e). \tag{FB}$$

Again, Assumption 1 ensures that e^* satisfies the corresponding first-order condition which, using the envelope theorem, reads

$$E_\theta V_e(x^*(\cdot), e^*, \theta) = \psi_e(e^*). \tag{3}$$

Hence, we arrive at the familiar condition that the marginal expected returns from investments (evaluated at the conditionally optimal policy level) equate their marginal costs.

Because the project is associated with spillovers, there are gains from policy coordination before the final decision on x is taken. Hence, we assume that regions will enter negotiations and implement the ex-post efficient policy level $x^*(e, \theta)$ in stage 2, irrespective of whether authority over x initially lies exclusively with region A (under DG)

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[13]For example, suppose x is a pure public good and all individuals in the economy have identical valuations. Then, $V(\cdot)$ is the sum of individual utilities in the overall economy, and β represents the fraction of individuals living in A while $(1 - \beta)$ indicates the fraction of individuals who live in B. The case where there are no externalities corresponds to $\beta = 1$. The case of negative externalities, $(1 - \beta) < 0$ can (with appropriate adjustments) be analyzed analogously and is therefore disregarded in our formal analysis. Finally, one can show that all qualitative results carry over to more general formulations of the surplus function $V(\cdot)$.

or with the central government (under CG).[14] Specifically, we follow the property-rights literature [see, e.g., Hart (1995)] in assuming that the unfolding bargaining process between the representatives from each country results in the generalized Nash-bargaining solution.[15] Thus, each region obtains its regime-dependent disagreement payoff plus a fixed share of the efficiency gains that arise from the implementation of $x^*(\cdot)$ rather than the respective disagreement policy. The shares reflect a region's relative bargaining strength and are parameterized as $\gamma \in [0, 1]$ for region A and $1 - \gamma$ for region B, respectively.

In the remainder, we investigate whether first-best investments e^* can be implemented under any of the two possible regimes DG and CG, and thus explore the relative merits of centralized governance and subsidiarity for different parameters of our model. In doing so, we first consider in Section 3 an institutional structure where the policy costs $C(\cdot)$ are exclusively borne by citizens from region A. Alternatively, region A may be eligible for (federal) cost-sharing grants financed by both regions, which are analyzed in Section 4 below.

3   Federal System without Cost-sharing

Decentralized Governance

In a federal state with decentralized authority, region A can unilaterally decide on the project size x that is provided in stage 2. Let us assume that the regions either signed no agreement prior to stage 1, or that the federal constitution does not comprise any cost-sharing provisions. In both cases, the costs of policies are solely borne by region A. Recall that A's gross surplus a policy x is $\beta V(x, e, \theta)$. Hence, unless negotiations with region B are successful, A chooses a project size so as to maximize $S^A \equiv \beta V(x, e, \theta) - C(x)$. If the corresponding non-cooperative level $x^A(\cdot)$ is positive,

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[14]Thus, we disregard transaction costs (e.g., informational asymmetries) that may prevent the realization of an efficient outcome in the political arena. While this assumption may often be unrealistic, it is made for analytical convenience only and does not qualitatively affect our results provided that transaction costs in negotiations do not differ across regimes. As stated in the Introduction, this approach differs from most of the existing literature where no inter-regional policy coordination takes place under decentralized governance, while inherent transaction costs in the political process prohibit an efficient outcome under centralization.

[15]The assumption that bargaining follows the axiomatic Nash solution is unlikely to be innocuous. In the standard property rights framework, this has been shown by de Meza and Lockwood (1998) who consider outside option bargaining instead.

it is implicitly determined by

$$\beta V_x(x^A, e, \theta) = C_x(x^A), \tag{4}$$

and increasing in e. Comparing (2) and (4) reveals that $\beta < 1$ and $x^* > 0$ imply $x^A < x^*$: since region A does not take the positive external effect on region B into account, it chooses x suboptimally low. The disagreement payoff for region A when negotiations fail is thus given by $\hat{S}^A = S^A(x^A(\cdot), e, \theta)$. Similarly, let $\hat{S} = S(x^A, e, \theta)$ be the joint surplus realized in disagreement with $\hat{S} - \hat{S}^A = \hat{S}^B$ as the default payoff to region B. Since $\hat{S}$ is strictly smaller than the maximal surplus S^* for $x^* > 0$ and $\beta < 1$, renegotiations arise and the regional governments agree upon the ex-post efficient policy $x^*(\cdot)$. Under the Nash-bargaining solution, negotiations lead both regions to split the surplus from negotiations,

$$\Delta_{DG} = S(x^*, e, \theta) - S(x^A, e, \theta) > 0,$$

according to their relative bargaining powers. Anticipating the outcome of negotiations in stage 2, A in stage 1 chooses

$$e_{DG} \in \arg\max_e U^A_{DG}(e) = E_\theta \left[\hat{S}^A + \gamma \Delta_{DG} \right] - \psi(e) \tag{DG}$$
$$= E_\theta \left[S^A(x^A, e, \theta) + \gamma S(x^*, e, \theta) - \gamma S(x^A, e, \theta) \right] - \psi(e).$$

Substituting for the expressions of $S^A(\cdot)$ and $S(\cdot)$ and taking derivatives with respect to e, we obtain

$$E_\theta \left[(\beta - \gamma) V_e(x^A, \cdot) + \gamma V_e(x^*, \cdot) - \gamma (V_x(x^A, \cdot) - C_x(x^A)) \frac{\partial x^A}{\partial e} \right] = \psi_e(e_{DG}), \tag{5}$$

which characterizes an interior solution for the equilibrium investment level e_{DG}. The first term on the left hand side of (5) represents the direct effect of e on those terms in region A's objective function that stem from the disagreement point and has two components: a small increase in e raises its own disagreement payoff by $\partial \hat{S}^A / \partial e = \beta V_e$. Second, holding the default policy x^A fixed, the joint default payoff increases by $\partial \hat{S} / \partial e = V_e$ which causes a one-to-one reduction in the negotiation surplus from which A reaps a fraction γ. The joint effect is positive if and only if $\beta V_e - \gamma V_e > 0$ or $\beta > \gamma$. The second term in (5) captures the effect of investments on maximum surplus, weighted by region A's bargaining power γ. Finally, the last term represents the indirect effect of e on the joint disagreement surplus $\hat{S}$ through a change in the

default project size x^A, again weighted by A's bargaining power.[16] This effect is positive due to $x^A < x^*$ and $\partial x^A / \partial e \geq 0$. As the disagreement payoff rises (the negotiation surplus falls), however, the marginal return from investment is reduced. Analyzing condition (5) yields

Proposition 1. *Suppose there is no interregional cost-sharing. Then, public investments e_{DG} under decentralized governance (DG) are strictly lower than the socially optimal investments e^* if there are spillovers, i.e., $\beta < 1$. Only for $\beta = 1$, region A invests efficiently. If, in addition, $\partial x^A / \partial e$ is non-increasing in β, then e_{DG} is strictly increasing in β for any $\beta \in [\gamma, 1]$.*

Proof. See the appendix.

The explanation for this result is quite different from the traditional argument for inefficiencies under decentralized authority. According to standard theory, a suboptimal outcome emerges because the region that decides on x fails to take into account the external effect on other members of the federation, while negotiations among regional governments always ensure an ex-post efficient policy $x^*(\cdot)$ in our framework. Still, the fact that A does not internalize B's utility also plays a role in our model because if affects A's incentives to provide valuable investments prior to policy implementation, a problem which is often disregarded in the literature. In particular, the size of the externality affects the region's equilibrium utility and, hence, its return from the public investment. If spillovers are absent ($\beta = 1$), for example, we have $x^A = x^*$ so that $\hat{S}^A = \hat{S} = S^*$. Then, programm (DG) coincides with (FB) and the region's public expenditures are socially optimal. For *any* spillovers ($\beta < 1$), however, the region underinvests for two reasons: first, due to $x^A < x^*$, the marginal return of investments on its own disagreement payoff falls short of the social return, and second, because larger investments trigger an increase in the default quantity and therefore a decrease in the negotiation surplus from which A reaps a fraction γ.

Centralized Governance

If decision rights are centralized, the central government C has the authority to direct the implementation of policies at stage 2. When evaluating CG, we must take into account that C is composed of representatives from the individual regions who maximize the payoffs of their respective home regions. Throughout the present subsection, we suppose that decisions in the federal assembly require unanimity, which

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[16]Also, notice that the indirect effect on $\hat{S}^A$ is zero by the envelope theorem, i.e., $\partial \hat{S}^A / \partial x^A = 0$.

means that no policy can be implemented unless the delegates from all regions in the federation agree.[17] An important example for this scenario is the European Union, where each country in a variety of policy fields has veto power on the implementation of new projects. In the EU, policy areas that are subject to unanimity include taxation, industry, culture, as well as the provision of regional and social funds [see, e.g., European Commisission (2000)].

Again, delegates will agree upon an ex-post efficient policy. However, if decisions in the federal assembly have to be taken unanimously, either region can unilaterally veto the realization of the project. Thus, the disagreement payoffs are determined by the status quo $x = 0$ where no policy project is implemented and are equal to zero.[18] The additional surplus which can be realized in the bargaining process under CG is then simply given by

$$\Delta_{CG} = S(x^*, e, \theta) > 0 \quad \text{for} \ \ x^*(e, \theta) > 0.$$

In stage 1, Region A now maximizes $U_{CG}^A(e) = E_\theta \gamma S(x^*, e, \theta) - \psi(e)$ and the corresponding equilibrium investment e_{CG} is determined by the first-order condition

$$\gamma E_\theta V_e(x^*, e_{CG}, \theta) = \psi_e(e_{CG}). \tag{6}$$

Hence,

Proposition 2. *Suppose there is no cost-sharing provision. Then, centralized governance attains efficiency if only if $\gamma = 1$, i.e., if and only if the bargaining power in the federal assemby rests entirely with the delegates from the investing region A. Otherwise, region A will underinvest. The equilibrium expenditures e_{CG} are independent of β and monotonically increasing in γ with $e_{CG} = 0$ for $\gamma = 0$.*

The claim follows immediately by comparing (6) with (3) and a proof is therefore omitted. Intuitively, central governance under unanimity rule results in suboptimal investments because negotiations in the assembly lead to surplus-sharing among the members of the federation. Unless the region that executes a policy has full bargaining power, underinvestments arise because surplus sharing diminishes the marginal return from investments from its individual perspective.

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[17]Centralized governance with majority voting is extensively explored in Section 4 below.

[18]The unanimity rule is the equivalent to the notion of 'joint asset ownership' in the relation between private parties. If renegotiations break down, no party has the right to use an asset independently since asset usage requires the unanimuous consent by both agents [see, e.g., Hart (1995)].

Comparison of Regimes

We now compare the outcomes under centralized and decentralized governance. Recall that in negotations, region A accrues a fraction γ of the maximal surplus S^* in both regimes, and the main difference between DG and CG lies in the disagreement policy. Formally, we can compare the marginal returns (MR) from investment under the two governance structures, which are given by the left-hand side of equations (5) and (6), respectively:

$$ MR_{DG} - MR_{CG} = E_\theta \left[(\beta - \gamma) V_e(x^A, \cdot) - \gamma (V_x(x^A, \cdot) - C_x(x^A, \cdot)) \frac{\partial x^A}{\partial e} \right]. $$

Consider first $\beta \leq \gamma$ and note that $x^A < x^*$ implies $V_x(x^A, \cdot) - C_x(x^A) > 0$. Then, this difference is negative, and marginal investment incentives are *lower* under decentralized governance. As indicated above, in this case the investing region is more concerned with the direct (negative) effect of its investments on the negotiation gain (due to the increase in the disagreement surplus) than it is with their direct (positive) effect on its own disagreement payoff. Moreover, the indirect marginal return from e through the change in x^A, thereby decreasing Δ_{DG}, is negative as well. Both effects are absent under centralization where region A is unable to affect the default policy/diagreement points by its investments. However, if spillovers are absent ($\beta = 1$) the disagreement point coincides with the social optimum and region A invests efficiently under decentralized governance. Formally, this corresponds to $x^A = x^*$ (the second term vanishes) and $MR_{DG} - MR_{CG} > 0$ unless $\gamma = 1$. We have

Proposition 3. *Consider a federal system without cost sharing. Then, centralized authority is the socially optimal governance structure if $\beta \leq \gamma$. Conversely, there exists some $\tilde{\beta} \in (\gamma, 1]$ such that decentralized authority is the socially preferred governance structure if $\beta \geq \tilde{\beta}$.*

Proof. See the Appendix.

The propositon asserts that subsidiarity leads to better results than centralized authority if the degree of spillovers of policy projects on other regions is not too strong, and vice versa. Also, the choice between both authority structures is a second-best choice, because (unless in non-generic circumstances) no regime reaches the pareto-frontier.[19]

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[19]Our findings are thus well in line with Oates' (1972) celebrated 'decentralization theorem'. Yet, the underlying reasons for these qualitatively similar results differ. As emphazised above, the policy

The possibility that centralized authority can give rise to larger investment incentives is seemingly at odds with some fundamental insights from the property rights literature, which suggests a positive correlation between authority and investment incentives. In the standard property-rights framework, though, the involved parties are private agents so that *no externality occurs* if they do not agree on 'working together'. Accordingly, an investment of the party with decision rights (the owner of a physical asset) does not positively affect the other party's disagreement surplus, which triggers strong marginal incentives to invest [Hart and Moore (1990), Hart (1995)]. In our framework, this result corresponds to the case $\beta = 1$ where a first-best outcome is attained under decentralized governance. Unless β is large so that spillovers are relatively unimportant, however, subsidiarity may be dominated. Consider for example $\gamma = 1$ so that the full negotiation surplus accrues to region A. In such a situation, the outcomes under centralized and decentralized governance do *not* coincide because under DG, there is still an external effect (of investments) on region B for $\beta < 1$. Under CG, in contrast, region A cannot realize x unilaterally but recovers the full marginal return from its investments if it has full bargaining power, which leads to efficient investments and renders this regime preferable.

4   Constitutional Grant Systems

We now relax the assumption that regions cannot sign (contingent) agreements prior to the first stage. While we suppose that the nature of public investments e and the state of the world θ is sufficiently complex so that those variables cannot be contracted upon, grant payments may be contingent on the project size x and on the cost $C(x)$ of a given policy. In what follows, we will concentrate on (linear) cost matching grants which are not only frequently observed within nations, but also commonly found in international federations like the EU.[20] Let α be a cost-share parameter that determines the part of production costs that are borne by citizens of country A, while residents from B contribute the fraction $(1 - \alpha)$ of $C(\cdot)$. We start with a simple yet important observa-

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uniformity which harms centralized governance according to Oates plays no role in our model since we allow for efficient negotiations on the federal level. Rather, governance structures differ in the incentives they provide to regions to invest into policies with spillover effects.

[20]Since production costs are an increasing function of x, confining attention to cost-sharing grants is without loss of generality. Also note that purely redistributive transfers (which are not tied to the implementation of the policy) have no impact on subsequent outcomes in absence of income effects.

tion. Under centralized governance and unanimity rule, a constitutional agreement on matching grants has no impact on efficiency: even if an initial grant system requires region B to bear a share $1-\alpha$ of final project cost $C(\cdot)$, the fact that it can unilaterally block the realization of the project later implies that regional disagreement payoffs are independent of α. Hence, the grant system is inconsequential for the outcome of negotiations, and the following conclusion is immediate:

Proposition 4. *Under centralized authority with unanimity rule, matching grants do not affect the outcome. Equilibrium investments e_{CG} are given by (6), independent of $\alpha \in [0, 1]$. Again, a socially optimal outcome is unfeasible unless $\gamma = 1$.*

Thus, even conditional grants have no allocative consequences provided the subsequent decision on project realization has to be taken unanimously. Clearly, this conclusion does not carry over to decentralized governance.

Dezentralized Governance

If region A is eligible for a matching grant with share parameter α, it will in stage 2 unilaterally realize a project of size

$$x^A(\alpha, e, \cdot) = \arg \max_{x \in [0, \bar{x}]} S^A = \beta V(x; e, \theta) - \alpha C(x) \qquad (7)$$

when negotiations with B fail. Two observations are notable: first, $x^A(\alpha, \cdot)$ increases as region A's cost share falls and always coincides with the socially optimal size $x^*(\cdot)$ for $\alpha = \beta$, where the cost subsidy $(1-\alpha)$ equals the size of the external effect $(1-\beta)$. Second, $\lim_{a \to 0} x^A(\cdot) = \bar{x}$, i.e., if region A bears *no* cost at all, its most preferred policy is the largest possible project size $\bar{x}$. Denoting A's disagreement payoff again by $\hat{S}^A = S^A(x^A, e, \theta)$ and the joint default payoff by $\hat{S} = S(x^A, e, \theta)$, and taking the surplus $\Delta_{DG} = S^* - \hat{S}$ to be divided in negotiations into account, region A chooses in stage 1

$$e_{DG} \in \arg \max_e U_{DG}^A = E_\theta \left[S^A(x^A, e, \theta) + \gamma(S^*(e, \theta) - S(x^A, e, \theta)) \right] - \psi(e). \quad \text{(DG')}$$

Accordingly, A's marginal return from investments MR_{DG} reads [see also (5)]

$$E_\theta \left[(\beta - \gamma)V_e(x^A, e, \theta) + \gamma V_e(x^*, e, \theta) - \gamma(V_x(x^A, e, \theta) - C_x(x^A, e, \theta))\frac{\partial x^A}{\partial e} \right]. \qquad (8)$$

Suppose first $\alpha = 1$. Then, (DG') coincides with (DG) and region A underinvests whenever some spillovers are present ($\beta < 1$). Next, consider the 'Pigouvian' cost

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share $\alpha = \beta$. In this case, $x^A(\cdot) \equiv x^*(e, \theta)$ and $\hat{S} \equiv S^*$, i.e., A would unilaterally choose a socially optimal project size. Yet, underinvestment still occurs because for $x^A = x^*$, (8) reduces to $E_\theta[\partial \hat{S}^A / \partial e] = \beta E_\theta V_e(x^*, e, \theta) < E_\theta V_e(x^*, e, \theta) = E_\theta[\partial S^* / \partial e]$ for any $\beta < 1$. Hence, although region A internalizes the external effect of its policy choice for $\alpha = \beta$, investments will be suboptimally low. Note, however, that if

$$\beta > \gamma, \tag{C1}$$

the region's marginal investment incentives for $\alpha = \beta$ still strictly exceeds the marginal return from investments under centralized governance with unanimity rule, given by $E_\theta[\partial \gamma S^* / \partial e] = \gamma E_\theta V_e(x^*, e, \theta)$. Under (C1), therefore, DG weakly dominates CG with unanimity rule. The condition requires either region A's bargaining power or the size of the externality to be small. To see why these values are important, notice that for $\alpha = \beta$ we have $\hat{S} = S^*$ and no negotiations arise at stage 2. Thus, the region's investment incentives are represented by the direct effect on its default payoff $\beta V(x^*(\cdot), \cdot)$, which exceeds incentives under centralized governance with unanimity rule if $\beta > \gamma$. Finally, let us examine $\alpha = 0$ so that $x^A(\cdot) = \bar{x} > x^*(e, \theta)$ and $\partial x^A / \partial e = 0$. From (8),

$$MR_{DG} = E_\theta \left[(\beta - \gamma) V_e(\bar{x}, e, \theta) + \gamma V_e(x^*, e, \theta) \right], \tag{9}$$

which exceeds the social marginal return $E_\theta[\partial S^*(\cdot) / \partial e] = E_\theta V_e(x^*, e, \theta)$ if (C1) holds and

$$\lim_{x \to \bar{x}} E_\theta V_e(x, e, \theta) > \frac{1 - \gamma}{\beta - \gamma} E_\theta V_e(x^*, e, \theta). \tag{C2}$$

Recall that returns to investment increase in project size, that is, $V_{ex} > 0$. Hence, the inequality in condition (C2) essentially requires the maximal project size $\bar{x}$ to be sufficiently large. In particular, (C2) will be satisfied for all reasonable functional forms of $V(\cdot)$ and finite investment levels e as long as x can in principle be chosen arbitrarily high. If (C1) holds in addition, region A's marginal return from investment strictly increases in its default policy x^A and, since the latter exceeds the socially optimal policy x^*, for sufficiently small α, may be well above the social return.

Summarizing the preceding discussion, we have seen that $e_{DG} < e^*$ for $\alpha = \beta$ and, provided (C1) and (C2) are satisfied, $e_{DG} > e^*$ for $\alpha \to 0$. Applying the Theorem of the maximum and a simple intermediate value argument, the following proposition is immediate.

Proposition 5. *Consider cost-matching grants and suppose that condition (C1) holds. Then, decentralized governance accompanied by a linear grant scheme $\alpha = \beta$ is socially preferred to centralized governance with unanimity rule. If, in addition, (C2) is satisfied, there exists a linear cost-sharing parameter $\alpha^* \in (0, \beta)$ that induces A to invest efficiently under decentralized governance.*

Thus, if spillovers are not too strong or region A's bargaining power is small, cost sharing generally implements the socially optimal outcome under decentralized governance.[21] Moreover, under the optimal grant scheme, the region obtains a subsidy that is strictly larger than the Pigouvian level: the distribution of costs must be biased to the advantage of the region that conducts a policy to account for the external effect of its investments.

It is important to note that (C1) and (C2) are only sufficient conditions for socially optimal investments to be implementable with linear matching grants under DG. For $\alpha < \beta$ so that $x^A > x^*$, the last term in (8) which measures the indirect effect of e on joint default surplus $\hat{S}$ through the induced policy change is strictly positive. Intuitively, when A bears only a small portion of implementation costs, it can increase the negotiation gain by decreasing the joint default surplus which becomes operational because a larger investment increases x^A and thus decreases $S(x^A, \cdot)$ when $x^A > x^*$.[22] The appendix presents a natural example with specific functional forms $V(.) = xe\theta$, $C(.) = x^2/2$ and $\psi(e) = e^3/3$ where this effect is sufficiently pronounced to always ensure socially optimal investments for all levels of γ, and all $\beta > 0$.

Centralized Governance under Majority Rule

We now examine centralized governance under majority rule where a majority group in the federal assembly can succeed with its preferred policy against the will of the minority. In reality, most legislatures apply simple majority rules to determine policy outcomes.[23] In our stylized framework with homogenous delegates from only two re-

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[21]If bargaining power is associated with a region's relative economic wealth, Proposition 5 suggests that matching grants are more likely to render an efficient outcome feasible the less affluent the region to which this grant is assigned.

[22]Technically, for $\alpha < \beta$ so that $x^A > x^*$ we have $V_x(x^A, e, \theta) - C_x(x^A, e, \theta) < 0$ by definition of x^*. Since $\partial x^A(\cdot)/\partial e > 0$ in some states and the joint default surplus falls (the negotiation surplus rises) as x^A grows, this indirect effect provides additional investment incentives.

[23]Examples are Congress and Senate in the US whose members are elected in their home states, or the Council of the European Union which is responsible for most policy decisions in the EU. This body is composed of ministers from each country who are responsible to their national parliaments and

gions, a policy x that is preferred by a majority (a Condorcet winner) always exists for any predetermined cost-sharing rule α.[24] In particular, the region with a greater number of delegates in the federal assembly can always enforce its preferred choice.[25] Our subsequent analysis presumes that delegates from region A represent the minority while delegates from region B form the majority in the central parliament (otherwise, the outcomes under centralized and decentralized governance coincide and there is no loss in assigning authority to A). This scenario would naturally arise in our context if one interprets B as a composite region which encompasses delegates from all federal states except A. If negotiations fail, region B can then force A to implement its preferred policy x^B in stage 2, which is defined as

$$x^B(\alpha, e, \cdot) = \arg \max_{x \in [0, \bar{x}]} (1 - \beta)V(x, e, \theta) - (1 - \alpha)C(x). \tag{10}$$

For obvious reasons and in contrast to DG, B's disagreement policy is strictly increasing in α, the cost burden of A. For $\alpha \neq \beta$, $x^B(\cdot)$ again differs from the efficient project size so that negotiations that lead to $x^*(\cdot)$ yield an efficiency gain $\Delta_{CG} = S^* - \hat{S}$ where $\hat{S}(\cdot)$ is as before the joint disagreement surplus, now evaluated at x^B. Accordingly, A's optimization program at stage 1 can be written as

$$U_{CG}^A = E_\theta \left[S^A(x^B, e, \theta) + \gamma(S(x^*, e, \theta) - S(x^B, e, \theta)) \right] - \psi(e). \tag{CG'}$$

With the appropriate substitutions, region A's marginal return from investment thus yields

$$E_\theta \left[(\beta - \gamma)V_e(x^B, \cdot) + \gamma V_e(x^*, \cdot) + (1 - \gamma)(V_x(x^B, \cdot) - C_x(x^B, \cdot)) \frac{\partial x^B}{\partial e} \right]. \tag{11}$$

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public opinions. Decisions in the Council are taken by qualified majority voting in some policy fields, and by unanimity in others. In some countries, the central government is split into two chambers, one of which is comprised of representatives from the state governments within the federation. In Germany, for example, the *Bundesrat* acts as Upper House of Parliament and takes decisions by majority vote.

[24]Thus, we do not have to impose additional assumptions to determine a default policy outcome that prevails when inter-regional negotiations fail. In a framework with more than two jurisdictions and heterogeneous preferences across these regions, specific legislative rules have to be imposed to find out the voting outcome. See Lockwood (1998) who applies the agenda-setting process put forward by Ferejohn, Fiorina and McKelvey (1987).

[25]In the European Union or the Bundesrat, representatives from more populous countries (or states) carry a greater weighting in the legislative process. In the EU, Council decisions that are subject to qualified majority voting pass by a number of 62 out of 87 votes (roughly a two-thirds majority). Specifically, the largest countries France, Germany, Italy and the UK each have 10 votes. Conversely, the smallest countries Ireland, Denmark and Finland carry 3 votes and Luxembourg 2 votes.

Notice that (11) differs from the corresponding condition (8) in two important respects. First, marginal default payoffs are evaluated at x^B rather than x^A. Second, for identical default quantities in either regime, the indirect effects [the third term] have opposite signs. The combination of both features may render it impossible to induce efficient investments by appropriate choice of α even if spillovers are not too strong. To see this, suppose $\beta > \gamma$ so that, as under decentralized governance, the first term in (11) strictly increases in the default quantity. In contrast to regime DG, however, a large x^B now requires a *small* grant. Consider $\alpha > \beta$ which implies $x^B > x^*$ and leads the first term to be large. Then, however, the third term is unambiguously negative which reduces investment incentives. Hence, the investment effect of an increase in α is unclear because the negative indirect effect may outweigh the positive direct effect.

These opposing effects make it difficult to derive a clearcut conclusion. Whether the first best is attainable for some α, now depends on the size of $V_e(.)$ on the one hand, and $(V_x(\cdot) - C_x(\cdot))\partial x^B/\partial e$ on the other. For the natural example we used to show that DG can be generically efficient, no subsidy scheme attains the first best under CG for any combination of β and γ, and the underinvestment problem cannot be overcome under centralized authority with majority vote. Thus, we can state

Proposition 6. *Consider centralized authority with majority rule and suppose region A is in the minority. In general, there does not exist a cost-matching grant α which induces A to invest efficiently and underinvestment prevails.*

This result may run counter immediate intuition. As under decentralized governance, an appropriately chosen grant scheme generates any desired default policy $x^B(\cdot)$ which then affects the investment incentives of region A. Hence, one may be tempted to believe that, at least if $\beta > \gamma$, the first best can be attained. This argument, however, ignores one crucial distinction between DG and CG with majority rule: under decentralized governance, a large matching grant (a small α) leads not only to a large default policy level x^A and therefore to high marginal returns on investments, but makes it also desirable for A to exert investments in order to raise the subsequently chosen default project size [the third term in (8) is positive]. In contrast, a large default policy $x^B(\cdot)$ chosen by region B under CG requires that A pays a large portion α of implementation costs. Now, A has an interest to reduce $x^B(\cdot)$ by lowering its investments [the third term in (11) is negative]. A change in α therefore triggers two opposing effects, and the first best remains in general unfeasible even if the matching grant can be optimally

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chosen.

Our findings have a nice economic interpretation. Subsidiarity leaves not only the investment choice, but also the implementation decision in the hands of the region which invests into a new public project. Hence, a large cost subsidy aligns the region's incentives to expand the project size, and to sink considerable investments. Conversely, centralized governance with majority rule adds an element of exploitation of the minority by the majority, and therefore leads minority regions to pursue a suboptimal investment policy.[26]

5   Conclusion

The present paper has argued that the relative merits of centralized and decentralized governance depend on how authority over allocative decisions interacts with constitutional provisions concerning the cost incidence of policies. Most of the literature assumes that the costs of a public policy are equally shared among all individuals in a federation in a centralized regime, while have to be borne by the citizens in the region conducting a policy under decentralization [see, for example, Caillaud, Jullien and Picard (1995), Ellingsen (1998) and Lockwood (1998)].[27] In view of the various vertical or horizontal transfer schemes observed in reality, we found it important to take a broader perspective and to examine the primitives that lead to cost-sharing arrangements. An important element of our model was to allow the jurisdictions in the federation to negotiate the final policy decision, irrespective of governance structure. While we do not doubt that political decision processes are subject to possibly large transaction costs which may prevent successful negotiations to the efficiency frontier, there seems to by no compelling reason why the size of transaction costs is affected by the mode of governance. Naturally, if jurisdictions are members of a federal system, the federal assembly provides a forum for negotiations prior to policy impementation regardless of whether the final policy decision rests *a priori* with a jurisdiction or with the federal

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[26]We can also compare the two modes of centralized governance. Since $\alpha = \beta$ implements the same investments under DG and CG with majority rule, Proposition 5 implies that the majority rule performs strictly better than unanimity if $\beta > \gamma$. Hence, if matching grants are feasible, the majority rule strictly dominates the unanimity rule as long as spillovers are sufficiently weak. Otherwise, if $\beta < \gamma$, the efficiency ranking is ambiguous.

[27]For an exception, see Besley and Coate (1999) who assume that all individuals in the economy pay identical head taxes.

government. But even if jurisdictions are autonomous countries, international treaties can be negotiated to ensure a mutually beneficial policy choice.

Starting from this presumption, our main results were as follows. If an initial agreement (or the constitution) does not prescribe a cost-sharing arrangement, either governance structure fails to implement an efficient outcome. Centralized authority is socially preferable when externalities are large, while regional authority leads to higher investment in reverse situations. This picture changes when we consider optimally adjusted cost-sharing and grant systems. We found that whenever a country's bargaining power is relatively small or spillovers are not too pronounced, it is possible to design a linear matching grant scheme that induces a region to invest efficiently under decentralized governance. In contrast, centralized governance does not resolve the underinvestment problem in general. Therefore, our findings suggest that subsidiarity may be the dominant governance mode if countries in a federation can design cost-sharing arrangements at a constitutional prestage.

Appendix

Proof of Proposition 1:

Recall that e^* solves (FB) and e_{DG} solves (DG). If $\beta = 1$, $x^A \equiv x^*$ so that program (DG) coincides with (FB) by inspection. Hence, $e_{DG} = e^*$. Next, we argue that $\beta < 1$ implies $e_{DG} < e^*$. By Assumption 1, $e^* > 0$ so that the claim follows trivially if $e_{DG} = 0$. If $e_{DG} > 0$, both are interior optima and therefore satisfy the first order conditions (3) and (5), respectively, which equate the marginal return of investments (MR) with their marginal costs $\psi_e(e)$. Since the latter are independent of β, it suffices to show that $\beta < 1 \Rightarrow MR_{FB} > MR_{DG}$ for all levels of e: e_{DG} must then be different from e^* and cannot exceed e^* because marginal costs are increasing in e. Hence, we must have $e_{DG} < e^*$. Subtracting MR_{DG} [the left hand side of (5)] from MR_{FB} [the left hand side of (3)] yields

$$MR_{FB} - MR_{DG} =$$
$$E_\theta \left[(1-\gamma)V_e(x^*, e, \theta) - (\beta - \gamma)V_e(x^A, \cdot) + \gamma(V_x(x^A, \cdot) - C_x(x^A))\frac{\partial x^A}{\partial e} \right].$$

Since $\beta < 1$, $x^A(\cdot) \le x^*(\cdot)$ with strict inequality whenever $x^* > 0$. $V_{ex} > 0$ thus implies $E_\theta V_e(x^A, \cdot) < E_\theta V_e(x^*, \cdot)$ for all e so that the sum of the first two terms is strictly

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positive. Likewise, $V_x(x^A, \cdot) - C_x(x^A) \geq 0$ as $x^A(\cdot) \leq x^*(\cdot)$ by definition of x^*. Due to $\partial x^A/\partial e \geq 0$, the third term is non-negative. Thus, $\beta < 1 \Rightarrow MR_{FB} - MR_{DG} > 0$ for all e which together with $\psi_e > 0$ implies $e_{DG} < e^*$.

Finally, suppose $\partial x^A/\partial e$ is non-increasing in β. Under this assumption, we proceed to show $\beta' > \beta \Rightarrow MR_{DG}(\beta') \geq MR_{DG}(\beta)$ for all $\beta, \beta' \geq \gamma$ with strict inequality if $e_{DG}(\beta) > 0$. By the same argument as above, this proves $e_{DG}(\beta') \geq e_{DG}(\beta)$ with strict inequality for $e_{DG}(\beta) > 0$. If this is the case, we can use (5) to compute

$$MR_{DG}(\beta') - MR_{DG}(\beta) = E_\theta \Big[(\beta' - \gamma) V_e(x^A(\beta'), \cdot) - (\beta - \gamma) V_e(x^A(\beta), \cdot)$$

$$- \gamma [V_x(x^A(\beta'), \cdot) - C_x(x^A(\beta'))] \frac{\partial x^A(\beta')}{\partial e} + \gamma [V_x(x^A(\beta), \cdot) - C_x(x^A(\beta))] \frac{\partial x^A(\beta)}{\partial e} \Big].$$

For $\beta' > \beta \geq \gamma$, $x^A(\beta') \geq x^A(\beta)$ so that the first difference is strictly positive due to $V_{ex} > 0$. Similarly, $x^* \geq x^A(\beta') \geq x^A(\beta)$ implies $V_x(x^A(\beta'), \cdot) - C_x(x^A(\beta') \leq V_x(x^A(\beta), \cdot) - C_x(x^A(\beta))$ because $S(x, e, \theta)$ is strictly concave in x by Assumption 1. Hence, the second difference is non-negative if $\partial x^A(\beta')/\partial e \leq \partial x^A(\beta)/\partial e$ which completes the proof. □

Proof of Proposition 3:

The line of reasoning in the text shows that $MR_{DG} - MR_{CG} < 0$ if $\beta \leq \gamma$. By the same argument as in the proof of Proposition 1, this implies $e_{CG} \geq e_{DG}$ with strict inequality if $\gamma > 0$ which proves the first part of the proposition (recall that $e_{CG} > 0$ for all $\gamma > 0$ because $E_\theta V_e(x^*, e, \theta) > 0$). Next, we know from Proposition 1 that $e_{DG} = e^*$ for $\beta = 1$, irrespective of γ so that for all $\gamma < 1$, $e_{DG}(\beta = 1) > e_{CG}$ by Proposition 2. Now let $e_{DG}(\beta)$ be a continuous selection from the correspondence $\varepsilon(\beta) \equiv \arg\max_e U_{DG}^A(e, \beta)$ (the Theorem of the Maximum ensures that such a correspondence exits). Since $e_{DG}(0) < e_{CG}$ and $e_{DG}(1) \geq e_{CG}$ with strict inequaliy if $\gamma < 1$, there must exist a $\tilde{\beta} \in (\gamma, 1]$ such that $\beta \geq \tilde{\beta}$ implies $e_{DG}(\beta) > e_{CG}$ which proves the second part of the proposition. If one additionally assumes that $\partial x^A/\partial e$ is non-increasing in β, $e_{DG}(\beta)$ will be strictly increasing in β (see Proposition 1) and $\tilde{\beta}$ will be unique. Decentralized governance is then socially preferable if and only if $\beta \geq \tilde{\beta}$. □

Example: First Best (Un)Feasible under Decentralized (Centralized) Authority

Suppose that

$$V(x, e, \theta) = xe\theta, \quad C(x) = \frac{1}{2}x^2 \quad \text{and} \quad \psi(e) = \frac{1}{3}e^3.$$

Under these assumptions, $S(e, x, \theta)$ is strictly concave in both arguments. For simplicity, we take $\bar{x} \to \infty$ so that we can ignore corner solutions for x. Then, $x^* = e\theta$ and $e^* = E_\theta(\theta^2)$. We first show that for all values of γ and $\beta > 0$, we can find a cost-sharing parameter α such that $MR_{DG}(e^*) \equiv MR_{FB}(e^*)$, and, hence, $e_{DG} \equiv e^*$. From the Proof of Proposition 1, this condition is satisfied if and only if

$$E_\theta \left[(1-\gamma)V_e(x^*, e^*, \theta) - (\beta - \gamma)V_e(x^A, e^*, \theta) + \gamma(V_x(x^A, e^*, \theta) - C_x(x^A))\frac{\partial x^A}{\partial e} \right] = 0,$$

For the specific functional forms above, $x^A(e, \cdot) = \beta e\theta/\alpha$ and this condition reads

$$E_\theta \left\{ (1-\gamma)(e^*\theta^2) - \left[(\beta - \gamma)\frac{\beta}{\alpha} + \gamma\frac{(\beta - \alpha)\beta}{\alpha^2} \right] (e^*\theta^2) \right\} = 0,$$

which requires for $e^* > 0$,

$$\frac{\beta}{\alpha^2}[\alpha(\beta - \gamma) + \gamma(\beta - \alpha)] = 1 - \gamma. \tag{12}$$

For any $\beta > 0$, the left-hand side of (12) becomes positive and converges to infinity if $\alpha \to 0$. Note that the second term in brackets (the indirect effect) weakly dominates the first term (the direct effect) as $\alpha \to 0$ so the marginal return from investments increases in α even if $\beta \le \gamma$. Conversely, as $\alpha \to 1$, the LHS converges to a value smaller than (equal to) the right-hand side for any $\beta < 1$ (for $\beta = 1$). Accordingly, continuity of the LHS in α guarantees the existence of some $\alpha^* \in (0, 1]$ so that condition (12) holds and the socially optimal investments can be implemented under decentralized governance for any $\beta > 0$.

Next, consider centralization with majority rule (and region A in the minority). We proceed to show that $MR_{CG}(e^*) < MR_{FB}(e^*) \Rightarrow e_{CG} < e^*$ for all values of α, β and γ. Using (11), this condition is equivalent to

$$E_\theta \left[(1-\gamma)V_e(x^*, e^*, \theta) - (\beta - \gamma)V_e(x^B, e^*, \theta) - (1-\gamma)[V_x(x^B, e^*, \theta) - C_x(x^B)]\frac{\partial x^B}{\partial e} \right] > 0,$$

which translates for the specific functional forms of the example and $x^B = (1-\beta)e\theta/(1-\alpha)$ into

$$1 - \gamma > \frac{(\beta - \gamma)(1 - \beta)}{1 - \alpha} - (1 - \gamma)\frac{(\alpha - \beta)(1 - \beta)}{(1 - \alpha)^2}. \tag{13}$$

Manipulating (13), our claim holds if and only if

$$1 > \frac{1 - \beta}{1 - \alpha} \left[\frac{\beta - \gamma}{1 - \gamma} + \frac{\beta - \alpha}{1 - \alpha} \right]. \tag{14}$$

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Note first that for $\beta = 1$, the the right-hand side of (14) is zero. Thus, suppose $\beta < 1$ and notice that RHS strictly decreases in γ. Inserting $\gamma = 0$ and taking the derivative of the right-hand side of (14) with respect to α, we find

$$sign\left\{\frac{dRHS}{d\alpha}\right\} > (<)\,0 \quad \Leftrightarrow \quad \alpha < (>)\frac{3\beta - 1}{1 + \beta} \equiv \hat{\alpha}.$$

Hence, we only need to consider the grant schemes $\alpha = 0, \alpha = \hat{\alpha}$ and $\alpha = 1$, respectively. For $\alpha = 0$, (14) reads $1 > 2\beta(1 - \beta)$ which holds for any β. For $\alpha = \hat{\alpha}$, condition (14) becomes $1 > (1 - \beta)^2/4$ and is always satisfied. Finally, for $\alpha \to 1$, the term in brackets on the RHS of (14) is strictly negative for $\beta < 1$, so that $RHS \to -\infty$. Consequently, underinvestment prevails under centralized governance with majority rule for any (α, β, γ).

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