The Architecture of Federations: Constitutions, Bargaining, and Moral Hazard *

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Abstract

The paper studies a federal system where (a) a region provides non-contractible inputs into the social benefits from a public policy project with spill-overs to other regions, and (b) where political bargaining between different levels of government may ensure efficient decision making ex post. Allowing intergovernmental grants to be designed optimally, we ask whether project authority should rest with the region or with the central government. Centralization is shown to dominate when governments are benevolent. With regionally biased governments, both centralization and decentralization yield inefficiencies and the second-best institution depends on parameter values if political bargaining is prohibited. When bargaining is feasible, however, the first best can often be achieved under decentralization, but not under centralization. At the root of this dichotomy is the alignment of decision making over essential inputs and project size under decentralized governance, and their misalignment under centralization.

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1 Introduction

The choice between centralized or decentralized political governance is arguably the most critical design element in federal systems. It is not surprising, therefore, that this issue has received considerable attention in the economic literature, starting with the pioneering work of Oates (1972). The main goal of the present paper is to study several empirically relevant – but previously disregarded – additions to the existing paradigm. In doing so, we are able to shed new light on why decentralization will often be beneficial. As in previous work, our starting point is a generic scenario in which a policy project that involves spillovers across the federation can be pursued in one of its regions. A federal constitution assigns authority over project choice either to the regional government or the central government, which may or may not be benevolent.

Models based on this standard setting usually posit that autonomous regional governments choose policies non-cooperatively. The failure to internalize spillovers on other regions then causes a suboptimal outcome under decentralization.[1] Policy choice under centralization is hampered by other imperfections. A benevolent central authority, for example, is often subject to exogenous restrictions such as policy uniformity requirements. Self-interested governments which are composed of regionally biased federal politicians, in contrast, will use their agenda setting power to distort project choice away from the welfare maximizing level. Under this traditional approach, second best optimal governance then selects the regime that causes smaller distortions.

The present paper offers a different perspective of the tradeoffs at work. Our model uses the following building blocks. First, in a critical departure from most of the existing literature,[2] we explicitly account for ex post improvement in the policy outcome through negotiations between jurisdictions. Bargaining over political projects across different layers of government is often observed in practice, regardless of whether decision power rests with the local or the central level of government.[3] Furthermore, although

[1] This is not necessarily true if individuals or production factors are mobile and the resulting equilibria may be efficient. For a recent interesting work with this outcome in a setting with mobile capital, see Ogawa and Wildasin (2009). For a model with both mobile capital and mobile individuals (labor), see Kessler et al. (2002).

[2] To our knowledge, the only exception is Harstad (2007) which is discussed below.

[3] A good example of efficient inter-regional bargaining in a decentralized setting is Chernobyl. The remaining blocks of the Chernobyl nuclear power plant were finally shut down in December 2000 after intense negotiations between Ukraine and the EU. Under the terms of the accord, the EU provided almost one billion US dollars in compensation, and agreed to help build two modern replacement nuclear

transaction costs may often prevent efficient bargaining, a frictionless world provides a benchmark against which alternative views of political negotiations can be judged. This is true *a fortiori* as there is a lack of compelling arguments why these frictions should be more severe under decentralization than under centralization. In the end, it may not matter much whether regional delegates come together in a federal assembly to bargain for a 'centralized' political outcome, or whether they meet as representatives of decentralized regions to negotiate political issues of mutual concern.

Second, in order to successfully reach a mutually beneficial agreement in reality, horizontal or vertical transfers are often called for. This leads us to illuminate the role of grant systems in the determination of optimal governance, and to endogenize the corresponding constitutional provisions.[4] While Oates' original work emphasizes the role of Pigouvian grants and subsidies to resolve spillover problems, the more recent literature usually considers funding provisions as exogenously given at the constitutional stage, rather than being optimally set. In contrast, the present paper investigates optimally designed cost matching grants in both institutional regimes.

Finally, pursuing and implementing political projects usually involves resource consuming preparations on part of the project region. The process involves several stages, and a whole range of measures are paramount for ensuring the final success. Many of these efforts are subject to moral hazard considerations: they are intangible in nature and therefore, cannot be made part of cost sharing arrangements among the member states in a federation. We argue that one important goal of efficient governance is to design authority and funding systems in a way as to resolve or at least alleviate moral hazard concerns.

As an example that illustrates these issues, consider the Canada Line Rapid Transit Project, a rail-based rapid transit line linking the Vancouver Airport to downtown Vancouver, BC. With its more than $ 2.1 billion capital cost, the transit line is one of the largest single public projects in the Vancouver area to date and was completed in Fall 2009. On December 1, 2004 the local agency Greater Vancouver Transportation Authority (TransLink) gave its final approval to the completion of this project. Notably, although Translink alone was put in charge of the Canada line, there had been prolonged

reactors. Another example are national tax policies in the EU. Although the tax authority lies on the national (decentralized) level, member countries in 2006 agreed on exchanging information on capital flows in an attempt to crack down on tax evasion.

[4]Wildasin (2010) provides a systematic overview about intergovernmental transfers and grants in the US.

negotiations involving agreements securing substantial funding contributions from both the federal and the provincial governments prior to the time of final approval.[5] Moreover, even before approval, Translink had already spent an estimated sum of at least $ 30 million on the project, primarily on the administration of the procurement process, property acquisition, community liaison, and public consultations.[6]

The example exhibits the central features – mixed funding, political bargaining, and a costly planning process likely subject to moral hazard – that are often integral elements of public policy formation. All affected levels of government participate in the process through talks and negotiations. The final decision involves financial contributions through cost-sharing (matching) grants or other inter-governmental transfer mechanisms.[7] The way in which this cost-sharing arises is partly codified in the federal constitution, and it is logically distinct from the question of who has authority to implement a certain project. Finally, the support of the local authority is essential for a successful implementation: there are local citizens to convince, local laws to modify, local red tape to overcome; and local infrastructure to make compatible with the project size and design. The efficiency issue is to choose the system of governance and the project output and cost grants so that the local region will have the incentive to make these intangible investments into the success of the project optimally.

The theoretical framework we develop to study the above features is simple. There is a federation consisting of two regions. In the 'project' region a local public project of variable size becomes available. If implemented, this policy project causes spill-overs to

[5]To oversee procurement, design, construction, and implementation of the entire project from start to finish, TransLink created Canada Line Rapid Transit Inc. (CLCO, formerly RAVCO) as a special-purpose subsidiary. Apart from Translink itself, there are three other public funding sources: the federal government of Canada ($ 421 million), the provincial government of British Columbia ($ 387 million), and the Vancouver International Airport Authority ($ 251 million). In 2006, the Provincial government agreed to pay additional $65 million in exchange for design changes. Data Source: RAVCO Annual Report 2004 and Quarterly Report # 1, January – March 2005.

[6]While the amount of these costs appears small relative to the overall project budget, notice that the *benefits* of these investments in terms of improving the project value will likely have been much more significant.

[7]Since almost half of the population in British Columbia lives in and around Vancouver, the benefits to the provincial government are obvious. The federal government's interest in the Canada Line could possibly be attributed to the fact that it was part of the city's preparations for hosting the 2010 Olympics. That the local authority would approve the project was not certain until the final vote in the Translink Board of Directors, a body composed of mayors and officials of all cities that are part of the Greater Vancouver Area. Indeed, there had been several rounds of voting, each of which was followed by a federal or provincial pledge for new funding. For a complete history of the project, see http://www.richmond.ca/discover/services/rav.htm.

a second 'composite' region that comprises a majority of the federation's inhabitants. Representatives from both regions initially sign a 'constitution' that allocates authority rights, and details cost matching and output grant provisions.[8] In a decentralized regime, the project region has the authority to determine the project size. In a centralized regime, authority rests with the federal government which does not pursue the overall public welfare, but is composed of regionally biased delegates who take decisions by majority rule. Hence, the composite region decides on project size. We account for the essential role of regional involvement by assuming that after signing the constitution, the project region can make preparatory investments into the project, which are non-contractible and thus subject to moral hazard. The return accrues in the form of increased project quality, positively depends on implemented project size, and is identical across governance structures. Before the final decision on project size is made, regions may negotiate over this decision to ensure a Pareto improvement, taking into account the regime-dependent default outcome.[9]

We first show that a centralized system works efficiently in a benchmark scenario where the central government is benevolent.The remainder of our analysis then adopts the more realistic view that central decisions are politically motivated rather than benevolent. Importantly, it also allows for inter-governmental negotiations at the project implementation stage to avoid inefficient policy choices. The corresponding bargaining surplus is assumed to be shared according to a simple Nash bargaining solution. Ex post bargaining ensures that projects are chosen efficiently in either governance structure, irrespective of the grant system in place. This outcome does not imply efficient investments, however. Investments affect the project region's payoff through two channels: first, there is a direct effect because investments change the project region's payoff for given project size. Second, a region's payoff from investments is indirectly affected because larger investments boost the project quality and therefore, increase the default project size that would be realized if negotiations fail. Since the sign and size of these effects is controlled by constitutional grants, one may think that a proper grant design

[8]Depending on the context, the notion of a constitution should be interpreted broadly as an initial treaty that governs the subsequent financial relationship among the regions involved.

[9]In the absence of moral hazard, political bargaining would always ensure an efficient outcome, regardless of the authority structure. But even without political bargaining, a constitutional Pigouvian grant easily resolves the externality problem, again rendering the choice of governance structure inconsequential. Hence, the choice between decentralization and centralization can be meaningfully addressed only if either subsidies are suboptimal and bargaining is inefficient, or if a moral hazard problem exists.

renders the choice of authority structure meaningless. In fact, this result is borne out with Pigouvian grants which lead decision-makers to implement efficient policies (so that in equilibrium, political bargaining does not arise). However, these grants are not optimal. Indeed, a central result of the paper demonstrates that with optimal grant design, decentralization will generally dominate centralized governance.

To understand this main finding intuitively, note that the project region will invest heavily if it believes that the project will be large (direct effect), and if it wants to induce a large project (influence effect). When the project region chooses both the investments and the project size they expect and want a large project if the grants are large, which aligns these two investment motives. When the project region chooses investments but not the project size (centralization), a small grant leads the project region to expect a large project but to want a small one. Thus under centralization, unlike decentralization, grants can not generally be chosen to induce the project region to make its intangible investments optimally. Authority matters and decentralization dominates because in contrast to centralization, efficient grant design brings the investing region 'on side' for the success of the local project.

Interestingly, the welfare dominance of decentralization over centralization requires intra-regional negotiations. In their absence, we show that an efficient outcome can never be achieved under both centralized and decentralized governance. The intuition is simple: without negotiations ex post, grants must serve the dual role of implementing optimal investments and optimal project decisions, which in equilibrium leads to inefficiently low investment levels in either regime.

2 Related Literature

The classical theory of federalism (Musgrave, 1959; Oates, 1972) argues that regional governments cater better to the needs of their constituency than a central government due to the latter's tendency towards a uniform provision of public services across the federation. Conversely, the advantage of centralization lies in the internalization of all federation–wide spillover effects of local public decisions.[10] This traditional view is

[10]This reasoning is silent on distributional aspects which might impede on the formation of a centralized federal state. In other words, inter-regional side payments are assumed feasible, and the optimal governance structure maximizes the total available surplus. While we adopt the same assumption, one should emphasize that another important strand of the literature on federalism disregards the feasibility

based on the strong assumptions that the central government acts as a benevolent entity who pursues the common good and, second, that its policies must be uniform across all jurisdictions.

These issues are addressed in the more recent 'new' literature on federalism, which adopts a political-economy view of central government and questions uniformity of provision as a defining feature (and a disadvantage) of centralized public goods supply.[11] In Besley and Coate (2003), the level of impure public goods under centralization is determined either by a minimum-winning coalition of regions, or by cooperative bargaining among the delegates from all regions. In the former scenario, public goods supply is inefficient because the ruling coalition ignores the well-being of minority districts. The latter scenario leads to problems of strategic delegation in that local citizens have an incentive to elect local representatives with above median preferences for their local public good. In either case, centralization can be suboptimal even when polities are relatively homogeneous and the elected policy makers achieve a Pareto-optimal outcome ex post. In Lockwood (2002), regions can propose policy projects in a federal assembly. The projects to be realized are then selected in a sequential voting process. The equilibrium outcome depends on the degree (and the sign) of spill-overs which a regional project has on the majority of other regions. At the same time, the final allocation will be completely independent of the benefits to the home region in which it can be carried out.[12]

This previous literature treats cost sharing rules as exogenous.[13] Moreover, decentralization is characterized by the total lack of cooperation with other regions in the federation,

of side payments. Among others, Casella (1992), Seabright (1996), and Alesina and Spolaore (1997) focus on the tradeoff between scale effects within federations, and the preference heterogeneity among regions.

[11]See the discussion in Oates (2005), who provides an excellent survey of the recent literature on federalism. For an early contribution which abolishes a benevolent planner, see Ellingsen (1998). In his model, a pure public good is provided either in a decentralized fashion, or by a majority region that pursues its own interests under exogenous cost sharing rules.

[12]Several papers in the recent literature analyze federal systems with a hybrid organizational structure. The central government composed of individual regions directs public policies via majority vote. In addition, regions are allowed to top up these provisions (which can be interpreted as federal mandates) by individual choice. See Cremer and Palfrey (2000), Fernandez and Rogerson (2003), Alesina et al. (2005), and Hafer and Landa (2007). A general finding emerging from these papers is that a majority of regions prefers such a dual system over a pure centralized or a pure decentralized regime. See also Rubinchik-Pessach (2005) for a similar approach.

[13]In most settings, a switch from decentralized to centralized governance changes the financing rules of public projects, with cost sharing assumed to be feasible only under centralization.

i.e., any political negotiations among regions in a decentralized system are ruled out. To our knowledge, the only other contribution that explicitly studies political bargaining in decentralized settings is Harstad (2007) and different in focus. The author considers a model where regions do not provide public inputs (investments) but have private information on their valuation of the project. The main result is that a mutual commitment to policy harmonization (uniform policies) may be advantageous in inter-regional negotiations because is reduces delay in bargaining.

In its emphasis on the role of specific investments prior to project realization, and in stressing the relevance of (re-)negotiations, our paper is also closely related to the literature on property rights and incomplete contracting (Grossman and Hart, 1986; Hart and Moore, 1990). There are two main differences. First, we allow not only for an assignment of authority rights but also for monetary grant provisions at a contractual pre-stage.[14] By adding monetary elements which are prevalent in reality, initial contracting opportunities are less incomplete than usually assumed in the literature. Second, the property-rights model often posits that the default payoffs of agents without property rights (authority in our framework) are independent of investments. In contrast, such investment externalities arise naturally in our federalism setting even when negotiations are unsuccessful and when, as a consequence, the region with authority rights chooses a project design that it finds privately optimal. This public-goods character of the project is in line with the approach in Besley and Ghatak (2001) who show that because of this additional externality and in contrast to the central tenet from property-rights theory, the agent who benefits most from the project should be assigned authority rights.[15]

The remainder of the paper proceeds as follows. Section 3 introduces the model, and Section 4 analyzes a benchmark scenario with benevolent central government. Section 5 compares the outcomes under centralization and decentralization both with and without political bargaining. Section 6 discusses some extensions. A final Section 7 concludes. All proofs are relegated to the Appendix.

[14] In its consideration of monetary mechanisms, the paper also contributes to the literature on optimal contractual mechanisms in incomplete contracting environments. See Tirole (1999) for an excellent survey and the discussion in Section 5 for details.

[15] Setting and results of both papers differ significantly. Besley and Ghatak do not consider monetary (grant) schemes. They also confine attention to a binary project choice and assume that both agents always prefer project realization. Hence, the authority structure does not affect the default project size which in our setting, would make centralization and decentralization indistinguishable.

3 The Model

We consider a federal system comprised of two jurisdictions, $j = A, B$. Region A can pursue a public policy. We denote by $x \in [0, \bar{x}]$ the size, or scope, of the policy measure. To fix ideas, we will often think of the policy as an infrastructure project and refer to x as project size (e.g., the capacity of an airport), but other interpretations, such as the quantity or quality of a publicly provided health care or education, or the rigidity of environmental standards are possible as well. The project causes an externality on the other, composite, region B. The realized gross federation–wide benefit $V(x, a, \theta)$ from a project of size x depends on a random shock θ reflecting an uncertain environment, and on investments $a \in R_0^+$ that region A can make at cost $\phi(a)$. These investment or planning costs represent any type of investment outlays by region A that positively affect the implementation of the project and enhance its social value. For instance, if the policy measure is the construction of a new airport, its benefits to both regions increase if A spends additional funds investing into the surrounding infrastructure (streets, public transportation), into airport safety, or improving the planning process. Similarly, if x is the scope of an educational program, a may represent effort A spends designing and implementing the program to ensure that it meets its stated goals. The realization of a project of size x causes implementation costs of $C(x, \theta)$, independent of a. We assume that θ is distributed according to a continuous cumulative distribution function $F(\theta)$ with full support $[\underline{\theta}, \bar{\theta}]$. Benefits and implementation costs of the 'status quo' policy $x = 0$ are normalized to zero. Throughout the paper, we also impose

Assumption 1. *The functions $V(\cdot), C(\cdot)$, and $\phi(\cdot)$ are continuously differentiable, non-negative, and increasing in their arguments. Moreover, these functions satisfy (subscripts denote derivatives)*

a) $\lim_{x \to \bar{x}} V(x, a, \theta) - C(x, \theta) < 0$ *and* $V(x, a, \theta) - C(x, \theta) > 0$ *for all* $a \geq 0$*, some* $\theta < \bar{\theta}$ *and some* $x > 0$*. Also,* $V_{xx} \leq 0$*,* $C_{xx} \geq 0$*, and* $V_{xx} - C_{xx} < 0$ *for any* $x < \bar{x}$*.*

b) $V_{ax} > 0$ *and* $\lim_{x \to \bar{x}} V_a(x, a, \theta) \to \infty$*.*

c) $V_{aa}(\cdot) \leq 0$*,* $\phi_{aa}(\cdot) > 0$*,* $\phi(0) = \lim_{a \to 0} \phi_a(a) = 0$ *and* $\lim_{a \to \infty} \phi_a(a) = \infty$*.*

Part a) states that total surplus $S(x, a, \theta) \equiv V(x, a, \theta) - C(x, \theta)$ (gross of investment costs) is negative at the maximal project size $\bar{x}$, but positive for some θ and x irrespective of a, implying that the socially efficient project size, which maximizes $S(x, a, \theta)$, is

positive and less than $\bar{x}$. Moreover, second derivatives are such that that the socially efficient project size is unique. Part b) states that the return on investments increases without bounds in the project size. The convexity and Inada conditions in c) ensure that some positive but finite investment level is desirable.

Regions are governed by local governments, who by assumption act in the best interest of their respective constituencies.[16] Two distinct behavioral assumptions regarding the central government will be explored. We first assume a benevolent planner who maximizes global welfare as a benchmark. Subsequently, and more realistically, the central government is viewed as a federal assembly that is composed of delegates from both jurisdictions, who pursue the interests of their home regions.

For convenience, we parameterize the regional shares of total benefits from the project. Region A reaps a gross return of $V^A = \beta V(\cdot)$ while the return of the composite region B is $V^B = (1-\beta)V(\cdot)$. Thus, the parameter $\beta \in [0,1)$ measures the relative spillovers of the policy pursued in the project region A on region B.[17]

In cases where subnational layers of governments provide certain goods or services for which the beneficiaries are concentrated locally but which spill over to the rest of the federation, there is often a trade-off between granting local versus federal authority over the policy measure [Oates' (1972)]. At the heart of the present model are two policy-related activities of region A with spill-overs: project size x and investments a. The focus of the analysis will be on how the interplay between the governance structure and federal grants shapes outcomes in terms of x and a. The model has four stages: in a constitutional prestage (stage 0), the regions select an institutional structure (centralization, decentralization) with regard to policy x, and in addition agree on a grant system that is detailed below. In a next stage (stage 1), region A undertakes a public investment which increases the expected benefit of the subsequent policy measure.

[16] This simplifying assumption is natural if individuals in a region have identical preferences. With heterogenous voters, regional representatives may be elected in an intraregional voting process. Voters will elect a politician who represents, e.g., the preferences of the regional median voter. Analyzing intraregional heterogenity would be straightforward but add little insight in the present context, and is therefore omitted.

[17] 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 of negative externalities, $(1-\beta) < 0$ can (with appropriate adjustments) be analyzed analogously and is disregarded. The degenerate case without externalities corresponds to $\beta = 1$ and is equally omitted. As is easily seen, in the absence of spillovers, decentralization always ensures a first-best outcome.

After investments are made, uncertainty about project value and project costs is resolved in stage 2. At this time, regions can enter (binding) negotiations to improve upon any inefficient policy that would be be chosen. The nature of these negotiations is laid out in detail in Section 5. Finally, the project size is implemented in stage 3 by the government which has been assigned constitutional authority: the project region A under decentralization, or the federal government in a centralization regime.

In practice, the extent to which the federal government exercises control over local spending of federal grants varies considerably. In the U.S., for example, the federal government can achieve different degrees of control over public programs at the state or local government level by making them either mandatory (Health, in particular Medicaid) or discretionary (Education, Transportation). It can further differentiate between categorical or block grants, which give state and local governments substantial control over how the money is actually spent, and project grants, which involve more federal oversight.[18] Discretionary grants are often characterized by cost matching or 'maintenance of effort' (MOE) provisions that necessitate financial contribution by the recipient government[19]

To capture the possible governance and grant structures in a stylized way, we will distinguish between *decentralization* where region A decides on policy x, and *centralization*, where the federal government comprised of both region A and region B controls x. We will further assume that in addition to federal lump sum grants t_j to region $j = A, B$, grant payments take the form of the above-mentioned *cost matching* grants that reimburse region A a share of its implementation cost $C(x, \theta)$.[20] Instead of modelling those

[18]In the US, funding for project grants is generally small in comparison to funding for categorical formula grants. In 2011, federal budget authority for transportation grants that are allocated by formulas to state and local governments totalled $ 54 billion. In contrast, only $ 511 million was spent for project grants awarded for bridge replacement projects, intermodal transfer facilities, and rail projects over the same period (Congressional Budget Office, 2013).

[19]Cost matching grants require state and local governments to contribute a designated share of the cost of a program from their own resources. Many federally funded highway grants in the US, for example, mandate state or local governments to contribute 20 percent of a project's cost, with the federal government reimbursing the state or local government for the remaining 80 percent. MOE requirements take on a number of different forms, depending on the program. For instance, to receive their full allocation of Title I funds for the education of disadvantaged children each year, a local education agency must have spent on primary and secondary education in the preceding year at least 90 percent of what it spent the year before that from nonfederal sources (Congressional Budget Office, 2013).

[20]Section 6 below introduces output grants which are contingent on x. In our baseline model, output grants would not affect our qualitative results. Notice that the timing of grant promises matters in our

grants as being paid for by the central government (and refinanced by federation-wide taxation) it is more convenient to formalize them as direct transfer of funds, net of financing cost, that effectively flows from region B to region A. Thus, let α denote the fraction of costs $C(\cdot)$ that is borne by region B. If a project of size x is implemented, region A receives a total cost matching grant of size $\alpha C(x, \cdot)$ (paid for by region B) and only bears $(1-\alpha)C(x, \cdot)$ itself. In addition, any lump sum grants satisfy $t_A + t_B = 0$.

The focus on cost-matching grants is motivated both by observed practice, and by the fact that making cash transfers contingent on other variables, such as regional investments a or project benefits $V(x, \dot{)}$ may not be feasible. Investments are often intangible assets which are hard to verify, or they may represent a bundle of measures so complex that it is impossible to describe them contractually. Likewise, the gross benefit of the policy is a benefit which is idiosyncratic to either region, and thus cannot be easily observed or measured. As we will see below, this non-contractibility generates a moral hazard problem which jeopardizes region A's incentives for efficient investments. Note that unconditional grants will have no effect on outcomes, and thus cannot be used to address investment incentives. Throughout the paper, we will assume that governance structure and the cost-sharing parameter (α) are chosen at the initial stage 0 as to maximize total expected surplus. [21]

Regions are risk-neutral and utility is therefore fully transferable. For a project size x, investments a, cost-matching parameter α and additional lump sum monetary transfers, the utility functions of region A and B are

$$S^A(x, a, \theta) = \beta V(x, e, \theta) - (1-\alpha)C(x, \theta) + t_A - \phi(a),$$

and

$$S^B(x, a, \theta) = (1-\beta)V(x, e, \theta) + t_B - \alpha C(x, \theta)$$

respectively.

In summary, agents play the following stage game under perfect information, which we will solve using a subgame perfect Nash equilibrium as our equilibrium concept.

model. Specifically, if regions agreed on grants only after region A exerted its investments, they would choose a Pigouvian grant to implement the socially efficient project size; hence, grants would lose their purpose of directing investment incentives.

[21] This assumption is justified if any distributional concerns can be addressed by initial inter-regional lump-sum transfers. While size and direction of these transfers depend on the governance structure in force prior to the stage 0, and on the ex-ante bargaining strength of either region, we can be agnostic about these issues because they do not affect our analysis.

Stage 0: Political representatives from each region decide on the authority structure (centralization or decentralization) and on a cost matching grant (α). In addition, there may be a non-contingent lump-sum payment made from one region to the other.

Stage 1: Region A can undertake value-enhancing investments a at non-verifiable cost $\phi(a)$ into a subsequent policy measure, x.

Stage 2: Nature draws θ and the uncertainty is resolved. Representatives from A and the composite region B may negotiate the size of policy measure x using Nash bargaining, in exchange for side payments from one region to the other (see Section 5 for details).

Stage 3: Policy x is implemented at costs $C(x, \theta)$, grant payments are made, and the game ends.

For future reference, we compute the socially optimal policy level $x^*(\cdot)$ to be chosen at stage 3. At that date, region A has already expended a and θ has been revealed. Accordingly, the efficient project size maximizes total surplus $S(x; a, \theta) = S^A(x; a\theta) + S^B(x; a, \theta)$ and solves

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

Under Assumption 1, $x^*(a, \theta) > 0$ for a nonempty set of realizations θ, which is then uniquely determined by the first-order condition

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

Using $V_{ax} > 0$ from Assumption 1, and applying the theorem of the maximum, the socially efficient project size is continuously increasing in the investment level a. Define $S^* \equiv S(x^*(a, \theta), a, \theta)$ as the maximum surplus in stage 3 and note that S^* is independent of β and strictly increasing in a if $x^*(\cdot) > 0$. In stage 1, the socially optimal investments a^* to be undertaken by region A maximize the ex-ante expected overall surplus in the economy, i.e.,

$$a^* \in \arg \max_{a \geq 0} \; U^A(x^*, \cdot) + U^B(x^*, \cdot) = E_\theta \left[S(x^*(\cdot), a, \theta) \right] - \phi(a). \tag{FB}$$

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

$$E_\theta \, V_a(x^*(\cdot), a^*, \theta) = \phi_a(a^*). \tag{3}$$

As expected, marginal expected investment returns (evaluated at the conditionally optimal policy level) are equalized to marginal investments costs at the optimum.

In what follows, we will refer to a *first-best outcome* as one where both investments and project size are efficient. Denote the first-best project size in a state θ, given optimal investments, by $x^{FB}(\theta) = x^*(a^*, \theta)$. The subsequent sections will analyze the equilibrium of the stage game for the various institutional regimes under consideration.

4 Benevolent Central Government

To start with an often used benchmark, consider centralization under the assumption that the federal government is benevolent. Recalling that distributional issues play no role in our setting, this government chooses x in stage 3 so as to maximize $S(x, a, \theta) = V(x, a, \theta) - C(x, \theta)$, resulting in the efficient policy $x^*(a, \theta)$ for given investment a and state of the world θ.[22] Next, we determine the investment decision of project region A in stage 1. With a cost grant α in place, the region chooses a to maximize the net surplus of its inhabitants (P stands for Benevolent Planner),

$$U_P^A(\cdot) = E_\theta \{ \beta V(x^*, a, \theta) - (1 - \alpha) C(x^*, \theta) \} - \phi(a),$$

The first-order condition for the region's equilibrium investments

$$E_\theta \left\{ \beta V_a(x^*, a, \theta) + [\beta V_x(x^*, \cdot) - (1 - \alpha) C_x(x^*, \theta)] \frac{dx^*}{da} \right\} = \phi_a(a), \tag{4}$$

equates the regional marginal return, evaluated at the central government's policy choice $x^*(\cdot)$, to the marginal investment costs. The first term on the left-hand side of (4) represents the direct marginal effect of investments on A's payoff. The second term indicates an indirect 'influence' effect: since the central government's choice $x^*(a, \theta)$ depends on A's investment, region A has indirect control over x. Due to $dx^*/da > 0$, this influence effect is positive (enhances investments) when the region prefers a larger project size than the central government, i.e., for $\beta V_x(x^*, \cdot) - (1 - \alpha) C_x(x^*, \theta) > 0$, and negative otherwise. When region A is entitled to large (small) grants, it prefers a larger (smaller) policy than the one P will provide, and higher (lower) investments are an instrument to achieve this goal. More precisely, region A's preferred policy x^A in stage

[22] Note that since the project size is efficient, there is no room for negotiations in stage 2.

3 maximizes its continuation utility

$$S^A(x, a, \theta, \alpha) = \beta V(x, a, \theta) - (1 - \alpha)C(x, \theta)$$

in each state θ, and for given α and given a. Notice that for $x = x^*(a, \theta)$, the expression $S^A(\cdot)$ is identical to the term in square brackets in (4). The corresponding first-order condition for an interior solution $x^A > 0$ reads

$$\beta V_x(x^A, a, \theta) = (1 - \alpha)C_x(x, \theta). \tag{5}$$

By Berge's maximum theorem and the implicit function theorem, an interior policy $x^A(\cdot)$ continuously increases in a, and continuously decreases in the cost grant α. We introduce

Definition (Pigouvian cost grant): A grant of size $\alpha^P = 1 - \beta$ induces $x^A(\cdot) = x^{FB}(\cdot)$.

With a cost matching grant of size α^P, region A prefers a policy at the socially efficient level x^* for any (a, θ), and the influence effect in (4) disappears. Comparing (4) and (2), spillovers $\beta < 1$ imply underinvestment because the project region does not reap the full social return from its effort. When $\alpha < \alpha^P$ so that $x^A < x^*(\cdot)$, the influence effect in (4) is negative, further contributing to inefficiently low investments. In contrast, the influence effect is positive for grant levels $\alpha > \alpha^P$, where region A prefers a larger-than-efficient project. Combining these findings, we can state

Proposition 1. *Consider centralization with a benevolent federal government. Then, for any degree of spillovers $\beta < 1$, there exists a constitutional grant $\alpha^* > \alpha^P$ that implements a first-best outcome. Under the optimal grant, region A would favor a project size larger than the one chosen by the social planner.*

Proposition 1 establishes centralization as an efficient governance structure when the federal decision maker is benevolent. To understand this result, note that when the policy is selected by a benevolent planner, an efficient project choice x^* prevails regardless of the constitutional grant provisions. Since $x^A(\cdot)$ increases in α, an optimally chosen grant provides proper investment incentives and thus resolves the underlying moral hazard problem. In the presence of spillovers, the optimal grant is such that A always prefers a project larger than the one actually implemented by the central government. Intuitively, since the project region shares the project benefits with the other region, it

necessarily underinvests in value increasing measures when the influence effect is negative or zero. Grants in excess of the Pigouvian level render the influence effect positive and therefore, help to boost investment incentives to the desired level.

5 Federalism with Political Bargaining

The remainder of this paper abandons the construct of a benevolent central government. Instead, we will impose the following main assumptions regarding the decision making in the federation.

Politics: Decentralization entitles the project region A to choose the project size in stage 3. Under centralization, federal policies are selected in a simple majority vote process. Specifically, we envision the central government as a federal assembly, composed of representatives from both regions. These delegates pursue their own idiosyncratic interests which, as said before, coincide across all individuals within each region for simplicity. This setup encompasses parliamentary systems in which political decisions are taken by some form of majority vote in a federal assembly (e.g., as in the UK, Germany or Canada), as well as a Presidential systems in which some elected decision maker is assigned for making these decisions (as, e.g., in the US or in France). With decisions taken via majority rule, the region with more delegates in the assembly can enforce its preferred policy. If region A is the majority region, the outcome then coincides with the one under decentralization. To make the subsequent analysis meaningful, we therefore suppose that delegates from the composite region B form the majority.

Intra-Regional Negotiations: To incorporate another important element of real-world politics, we all allow politicians from different regions to (re-)negotiate the final policy outcome after uncertainty on benefits and costs has been resolved.[23] Because the policy project is associated with spillovers, there are benefits from such a policy coordination prior to the final decision on x. Since utility is fully transferable, renegotiations can be expected to produce the efficient outcome in our framework, where all involved parties have complete information (Coase, 1960). Therefore, rational politicians will in stage 2 enter mutually beneficial negotiations and successfully agree on the ex-post efficient policy $x^*(a, \theta)$. Importantly, this is true regardless of the institutional regime

[23]This is done in a way which borrows from Lülfesmann (2002) who, however, studies a less general framework.

in which they operate; in particular, and in contrast to the existing literature, we assume political negotiations to be feasible not only under centralization, but also in the decentralization regime.[24]

For concreteness and in line with the property-rights literature (e.g., Hart, 1995), we assume that the unfolding bargaining process between the regional representatives can be captured with the generalized Nash-bargaining solution. Under this bargaining protocol, each region obtains fixed share of the surplus gain which is realized through negotiations over and above its disagreement payoff, where the latter depends on who has authority over the project if negotiations fail. The shares of the surplus gain that regions obtain are parameterized as $\gamma \in [0, 1]$ for region A and $(1 - \gamma)$ for region B, respectively, and reflect their respective bargaining strenghts.[25]

In what follows, this general setting is first explored for decentralized governance, where the project region A has constitutional authority. The subsequent subsection investigates the alternative of centralization, where decisions about the project require a majority of delegates in the federal assembly. Recall that monetary side payments across regions are feasible and regional utilities are fully transferable in our framework. Hence, regions in stage 0 always have a mutual interest in adopting the institutional structure that maximizes total surplus.

5.1 Decentralized Politics

We analyze the game using backwards induction. Assuming that region A has authority, the project region can in stage 3 implement a project of size x to maximize regional welfare. Since x^A is not socially optimal in general gains from trade exist. Since regional utilities are fully transferable (monetary side payments from A to B are feasible), regions have an interest to renegotiate $x^A(\cdot)$ and agree on the efficient policy $x^*(a, \theta)$ in stage 2 when the state θ has been revealed, after investments have been undertaken in stage 1. To establish disagreement payoffs for the stage-2 bargaining, suppose negotiations fail.

[24] As mentioned before, we disregard transaction costs that may render an efficient outcome infeasible. Imposing transaction costs would not alter our qualitative results unless they differ across regimes, which often seems implausible. After all, there is no compelling reason why the possibility to reach mutually beneficial agreements is linked to the authority structure as set in the constitution.

[25] While one may argue that these bargaining weights are related to the size, political, or economic importance of regions, we remain agnostic with respect to the determinants of bargaining strength, and also abstract from the possibility of 'renegotiation design' that is sometimes discussed in the literature (see, e.g., Aghion et al., 1994).

With grants α in place, region A will then in stage 3 again choose a project of size $x^A(\cdot)$ as described by the first order condition (5). The efficient choose of $x^*(\cdot)$, in contrast, would increase total surplus in the federation by an amount

$$\Delta_{DP} = \left[V(x^*,\cdot) - C(x^*,\cdot) - (V(x^A,\cdot) - C(x^A,\cdot))\right] = S^*(a,e,\theta) - S(x^A,a,\theta)) \geq 0,$$

which represents the bargaining surplus available in the decentralized politics (DP) regime. With rational agents, frictionless negotiations will in equilibrium be successful and region A appropriates a share γ of Δ_{DP} in Nash bargaining.

Anticipating the outcome of negotiations in stage 2, region A chooses its stage 1 investments to maximize

$$U^A_{DP}(\cdot) = E_\theta \left[S^A(x^A,a,\theta,\alpha) + \gamma(S^*(a,\theta) - S(x^A,a,\theta))\right] - \phi(a). \qquad \text{(DP)}$$

Using the envelope theorem, the first-order condition for equilibrium investments is[26]

$$E_\theta \left\{(\beta-\gamma)V_a(x^A,\cdot) + \gamma V_a(x^*,\cdot) - \gamma\left[V_x(x^A,\cdot) - C_x(x^A,\cdot)\right]\frac{dx^A(\cdot)}{da}\right\} = \phi_a(a). \qquad (6)$$

The first order condition exhibits several channels through which investments affect region A's payoff. The first two terms on the left-hand side of (6) represent the direct effect of investments for given $x^A(\cdot)$. Investments improve not only the region's default payoff through $\beta V_a(x^A,\cdot)$ but at the same time, they increase (respectively, decrease) the share of the available bargaining surplus $\gamma(V_a(x^*,\cdot) - V_a(x^A,\cdot))$ for $x^* > x^A$ (respectively, $x^* < x^A$). Note that the combined direct effect is unambiguously positive for $\beta > \gamma$, when the former effect dominates the latter even if the latter is negative. Second, an indirect effect arises which is captured in the last term in square brackets on the left-hand side of (6). Investments affect the default project x^A which, in turn, alters region's A share of the bargaining surplus $\gamma\Delta_{DP}$. Specifically, for grants in excess of the Pigouvian level ($\alpha > \alpha^P$), we have $x^A > x^*$ implying $V_x(x^A) - C_x(x^A) < 0$: a further investment-induced increase in x^A reduces the sum of default payoffs, with the effect of boosting the bargaining surplus. This renders the indirect effect positive and enhances investments. Similarly, the indirect effect is negative for grants $\alpha < \alpha^P$ with $x^A(\cdot) < x^*(\cdot)$, and it disappears altogether for Pigouvian grants where $x^A(\cdot) = x^*(\cdot)$.

Now suppose the regions agreed on a cost grant $\alpha > \alpha^P$ in stage 0, and consider the left-hand side of (6), region A's investment return at the margin. For $\alpha > \alpha^P$, we found the

[26] We require program (DP) (as well as program (CP), see below) to be well behaved. This is the case if the investment cost function $\phi(\cdot)$ is sufficiently convex.

indirect effect to be positive and therefore, it enhances the region's effort. Intuitively, for those large default policies x^A, the bargaining surplus Δ_{DP} increases in x^A because the sum of default payoffs decreases in x^A which already is inefficiently large. At the same time, the direct effect will also be positive for $\beta > \gamma$, i.e., when spillovers are not too pronounced. For those parameter values, investment incentives monotonically increase in x^A because investments have a larger return for larger project sizes.[27] Taken together, there must exist some optimal grant level $\alpha^*(> \alpha^P)$ which leads to efficient investments. This reasoning leads to

Proposition 2. *Under decentralized politics, political bargaining ensures an efficient policy level level $x^*(a, \theta)$. Moreover, the first best can always be attained for any $\beta > \gamma$, and the optimal grant policy α^* exceeds the Pigouvian level.*

The result conveys that decentralization often yields efficiency, provided an optimal grant system is in place. A sufficient condition is that the project region's benefit from the project is sufficiently large, i.e., $\beta > \gamma$, which implies that both direct and indirect investment incentives are positively influenced by higher grants.[28] Moreover, to achieve this outcome, cost grants are to be set at a level where A's preferred policy x^A exceeds the efficient level x^*. For the case where spillovers are dominant ($\beta < \gamma$), in contrast, the direct effect decreases in x^A, so that for any $x^A(\cdot) > x^*$, the direct and the indirect effect in (6) have opposite signs. While this prevents a general efficiency result for settings with very strong externalities, there are situations where decentralization is efficient regardless of the degree of spillovers, i.e., for any arbitrary combination of (β, γ). This is demonstrated in a simple linear quadratic example in the Appendix, where we specify $V(a, x) = ax$, $C(x) = (1/2)x^2$ and assume no uncertainty, e.g., $\theta \equiv \bar{\theta}$.

The above efficiency result relates to findings in the literature on optimal contracting in long-term relationships (see Tirole, 1999, for a survey). This literature often explores a bilateral trade relationship in which one agent (or both) undertakes relationship specific investments, before actual production and trade occur. For example, the seller may make an investment to either reduce her subsequent unit production costs, or to enhance the quality of the trading good. Che and Hausch (1999) show that in such a setting efficient

[27] We invoke part c) of Assumption 1 here. Notice that an optimal grant design must satisfy $x^A > x^*$ and therefore, $\alpha > \alpha^P$: for a default policy x^A smaller than efficient, the indirect effect in (6) would be negative while the direct effect is not large enough to generate proper investment incentives.

[28] For example, suppose a region's bargaining strength is associated with its population size only. For regions of equal size so that $\gamma = 1/2$, the first best is attained when the project generates a larger benefit in A than in B.

investments can be implemented only if the seller's investments are sufficiently 'selfish', that is, primarily reduce her own costs rather than enhancing the seller's quality. Note that the case of primarily 'selfish' investments is reminiscent to the case $\beta > \gamma$ in our paper. However, most of the existing literature does not explore the interaction of monetary contracts and authority, on which we focus. Accounting for authority gives rise to indirect investment effects, which sometimes allow region A to achieve an efficient outcome even when its investments primarily benefit the other region.

To further illuminate the role of intra-regional political negotiations for the efficiency result of Proposition 2, consider a setting in which political bargaining is ruled out or becomes ineffective, for example, because monetary side payments across regions are infeasible. Then, region A's preferred policy choice x^A [see (5)] is implemented in equilibrium, and the region's stage-1 investments under a grant of size α maximize

$$\hat{U}^A_{DP}(\cdot) = E_\theta \{ \beta V(x^A, a, \theta) - (1-\alpha) C(x^A, e, \theta) \} - \phi(a).$$

The associated equilibrium investments are now described by the first-order condition

$$E_\theta \, \beta V_a(x^A, a, \theta) = \phi_a(a). \tag{7}$$

In comparison to (6), any investment effect associated with political negotiations disappears. With a Pigouvian grant α^P in place, region A will choose the efficient project size $x^A = x^*$. While those grants facilitate an efficient decentralized outcome in absence of investment considerations, they are unable to resolve the moral hazard problem. Condition (7) immediately reveals that for any grant-induced policy x^A , investment incentives are smaller than efficient (conditional on x^A) whenever $\beta < 1$. This must obviously be true for Pigouvian grants α^P as well. We can state

Corollary. *In absence of political bargaining, a first-best outcome is infeasible under decentralization. Moreover, the optimal grant $\alpha^* > \alpha^P = 1 - \beta$ induces the region to implement a policy $x^A(\cdot) \geq x^*(\cdot)$, and to underinvest in value enhancement.*

Without bargaining, grants are unable to resolve the inherent underinvestment problem. Moreover, second-best optimal grant design must induce an excessive project size because a bigger project boosts value-increasing investments while the associated welfare loss from an inefficient project choice is negligible at the margin.

Intuitively, when political bargaining is considered infeasible, grants have to ensure efficient investments and an optimal policy choice at the same time. These goals are

generally incompatible. With political bargaining, in contrast, project size is guaranteed to be efficient. Grants can thus be used to target investment incentives. While achieving this restricted goal may appear straightforward at first glance, one should caution that the presence of political bargaining in itself distorts region A's investment return. In particular, it is not necessarily true that larger cost grants translate into more high powered incentives for region A. The general efficiency result for $\beta > \gamma$ prevails because under decentralization, larger grants positively affect the direct *and* indirect investment incentives, provided the cost grant is large enough that $x^A > x^*$. Importantly, this alignment of effects is specific to the decentralization regime, as the following section will show.

5.2 Centralized Politics

Under centralized governance, the policy outcome x is determined in a federal parliament by majority rule. While a majority faction in the assembly is legally entitled to implement its preferred policy, renegotiations with the minority region can improve total surplus and, in our setting where monetary transfers are feasible, can lead to an outcome which reflects mutual interests. Suppose that delegates from the composite region B form the majority, and that political bargaining in stage 2 is successful. In the out-of-equilibrium event that negotiations fail, region B will in stage 3 implement a policy satisfying

$$x^B(a,\theta) = \arg\max_x S^B(x,a,\theta,\alpha) = (1-\beta)V(x,a,\theta) - \alpha C(x,\theta).$$

The corresponding first-order condition for interior solutions reads

$$(1-\beta)V_x(x^B,a,\theta) = \alpha C_x(x^B,\theta). \tag{8}$$

Importantly, and in contrast to the decentralization regime, the default policy x^B is now *increasing* in the size of the externality (decreasing in β), and *decreasing* in the matching grant parameter α.

Anticipating this default policy and the outcome of stage-2 negotiations, region A maximizes in stage 1 (CP stands for centralized politics)

$$U^A_{CP}(\cdot) = E_\theta\left[S^A(x^B,a,\theta) + \gamma(S^*(a,\theta) - S(x^B,a,\theta))\right] - \phi(a), \tag{CP}$$

which, using the envelope theorem, yield the following first-order condition for equilibrium investments

$$E_\theta \left\{ (\beta - \gamma) V_a(x^B, \cdot) + \gamma V_a(x^*, \cdot) + (1 - \gamma)[V_x(x^B, \cdot) - C_x(x^B, \cdot)] \frac{dx^B}{da} \right\} = \phi_a(a). \quad (9)$$

Inspection shows that the direct investment incentives from any given default policy coincide under centralization and decentralization. Hence, the direct investment effect is again increasing in x^B for $\beta > \gamma$. At the same time, though, centralization *reverses* the sign of the indirect 'influence' effect for any given default policy x. To understand why, notice that since B chooses the default policy, region A now has an additional investment motive, namely, to manipulate x^B in order to boost its own default payoff $S^A(x^B, \cdot)$. Since B's default policy x^B is small when grants are large, and large when grants are small, this additional effect induces region A to invest more (less) when grants are large (small) and x^B is small (large). Under centralization, the indirect effect square brackets is therefore negative whenever $x^B > x^*$, which means that the direct and indirect investment effects of a change in grant size work in opposite directions.[29] The non-aligment of the two effects implies that a first-best outcome can generally not be attained under centralization. For the previous linear quadratic example, for instance, the Appendix demonstrates inefficient outcomes for any combination of (β, γ), and any matching grant α. These arguments and a full analysis of (9) yield

Proposition 3. *Consider centralized governance with majority rule, and suppose that delegates from composite region B form the federal government. Then, a first-best outcome is not generally achieved, even if externalities satisfy $\beta > \gamma$.*

The Proposition states that when political bargaining is feasible, decentralization systematically outperforms centralization in our setting. The result implies that even when explicit monetary incentives are available to deal with the underlying moral hazard problem, authority rights over policy projects matter, and tilt the optimal governance structure in favor of decentralization.

Our analysis also suggests an economically robust explanation for this finding. Recall that under decentralization, larger grant payments trigger a larger default project, which

[29] In technical terms, a marginal change in x^B affects $S^A(x^B, \cdot)$ in the same way as it affects total payoff $S(x^B, \cdot)$ (because of the envelope theorem, B's default payoff $S^B(\cdot)$ remains unaffected). Whenever $\gamma < 1$, this default payoff effect always exceeds γ times the change in total default payoff $S(x^B, \cdot)$ (the bargaining surplus effect) when x^B changes. Hence, the indirect effect has reverse signs in each regime.

raises the direct effect and the indirect effect of investing at the same time.[30] In simple terms, region A's incentives to raise its effort in response to a larger (default) quantity are aligned with its incentives to further raise the default project size.

Under centralization, there is no such alignment of interests. For $x^B > x^*$, direct effect and influence *necessarily* operate in opposite directions. When grants are small so that region B chooses a large x^B, the direct effect is again positive for $\beta > \gamma$ but the influence effect is negative: with small grants, region A has an interest to lower B's preferred x^B, which is achieved through smaller investments. This fundamental misalignment of investment motives prevents an efficient outcome even if spillovers are not very pronounced, as shown in the Appendix for the previous simple example and all conceivable combinations $(\beta < 1, \gamma)$.

The situation can also be related to a classical hold-up problem, which arises when part of the return on an agent's relationship-specific investments is ex post expropriable by his trading partner. To see how, suppose $\alpha = 0$ and region B has authority to decide ex post on x. Since B bears none of the costs from 'trade' (the policy decision), it can credibly threaten to implement an inefficiently large project size unless A is willing to enter negotiations to allow for an efficient choice x^* in exchange for share of the corresponding increase in the gains from trade. A's anticipated loss of will distort region A's investment incentives not only because some its investment may be lost at the margin, but also because an increase in a would raise x^B even more, further increasing the share of the renegotiation surplus appropriated by B. Cost-matching grants $\alpha > 0$ will generally not alleviate the problem since a grant that would cause region A's loss from the (re-)negotiations to vanish ($\alpha = 1 - \beta$, inducing $x^B = x^*$) would still result in underinvestment due to the externality problem $\beta < 1$. Increasing α beyond $1-\beta$ will prompt B to set $x^B < x^*$, which improves A's investment incentives through the indirect effect $dx^B/da > 0$ but lowers incentives through the increased share in bargaining surplus appropriated by B. Unless the former effect happens to dominate, cost matching grants cannot achieve the first-best under B authority. Under A authority, in contrast, increasing α beyond $1-\beta$ will prompt A to set $x^A > x^*$, which improves A's investment incentives through *both* indirect effect $dx^A/da > 0$ and direct effect. The latter holds since, due to $V_{ax} > 0$ and $x^A > x^*$, A's marginal investment return from its share in the bargaining surplus $\beta V_a(a^A, \cdot) + \gamma[V_a(x^*, \cdot) - V_a(x^A \cdot)]$ rises in x

[30] As discussed in the previous Section, this is true if $\beta > \gamma$, and for the relevant grant parameters inducing $x^A > x^*$.

(α, respectively) for $\beta > \gamma$. Resting authority with the investing agent can thus solve the hold up problem by allowing for simple cost-matching grants if share of the federal policy benefit going to A, namely β, is large enough relative to the share γ of it's payoff lost in the ex post negotiations.[31] To conclude, decentralization the dominant organizational mode because larger grants unambiguously increase investment incentives, which is not true under centralization where the investment effect of grants is marred by ambiguity.

Before concluding this Section, let us briefly return to a scenario in which political bargaining is not feasible. One interesting aspect here is whether the welfare dominance of decentralization over centralization carries over to this more restricted setting. Again, all terms relating to renegotiation are shut down in the A's optimization problem, and equilibrium investments are now implicitly determined by the first-order condition

$$E_\theta \, \beta V_a(x^B, a, \theta) + [V_x(x^B, a, \theta) - C_x(x^B, e, \theta)] \frac{dx^B}{da} = \phi_a(a). \tag{10}$$

As before, first term of on the left-hand side of (10) is the positive direct effect, which yields underinvestment for any $\beta < 1$. The additional indirect 'influence' effect in square brackets enhances investment incentives only if $V_x(x^B, \cdot) - C_x(x^B, \cdot) > 0$, that is, if grants exceed the Pigouvian level and $x^B < x^*$. Otherwise, for $\alpha > \alpha^P$ and hence $x^B > x^*$, A has an interest to lower x^B which renders the influence effect negative and hampers the region's effort. These features give rise to the following tradeoff at the constitutional stage: a large α induces a small default payoff and a small direct effect, but allows the influence effect to be positive. The opposite holds when α is small. This fundamental tradeoff cannot generally be resolved in favor of large or small grants: the induced policy can either be larger or smaller than efficient, depending on the specific functional forms. Comparing (10) with (7), we find

Corollary. *Without political negotiations, a first best cannot be achieved under centralization. Moreover, the outcomes under decentralization and centralization differ, and a comparison of regimes with respect to total surplus will generally depend on parameter values.*

When political negotiations are ruled out, neither centralization nor decentralization

[31] Again, this can be related to the literature on hold-up by thinking of β as a measure of how 'selfish' A's investments are. As Aghion et al (1994) and Noeldeke and Schmidt (1995) have shown, contracts conditioning on x can solve the hold up problem if investments are purely selfish, i.e., do not benefit the trading partner ($\beta = 1$ in our context). For purely cooperative investments ($\beta = 0$), Che and Hausch (1999) demonstrate that all feasible contracts are worthless.

generate an efficient outcome when political negotiations are ruled out, and each of those governance modes yields different outcomes when second-best grants are in place. While the economic outcomes coincide for Pigouvian grants such that $x^A = x^B = x^*$, a larger-than-Pigouvian cost grant is always second best optimal under decentralization, but not necessarily in a centralized institutional setting.[32] Which of these regimes dominates depends on the specific situation at hand.

6 Some Extensions

6.1 Suboptimal grants

In the spirit of a positive analysis, this subsection briefly discusses two situations where cost grants are not chosen optimally at the constitutional level. We first look at Pigouvian grants, which are prevalent in reality but, as we have shown, are not optimal when moral hazard considerations are take into account. The analysis shows that

Proposition 4. *With Pigouvian grants, the outcomes under centralization (with or without benevolent planner), and decentralization coincide, whether or not political bargaining is allowed for. The outcome is generally inefficient and region A underinvests.*

With Pigouvian grants, institutions do not matter for the simple reason that they induce the political decisionmaker to align his own preferences regarding project choice with those of the federation as a whole. Specifically, they imply $x^A = x^B = x^*$ regardless of investments, and regardless of the state of the world. This eliminates the need for political bargaining over size project x in stage 3, and also makes the indirect influence effect, which affects A's incentives in regimes where region B (or a benevolent planner) chooses policies, disappear. Investment incentives are thus identical in each regime; moreover, and as expected, the equilibrium underinvestment of A becomes more pronounced the larger the spillovers.

A second interesting situation is one in which region A's is not entitled to any con-

[32] Decentralization unambiguously dominates centralization if the optimal x^B is larger than x^* (which means the indirect investment effect under centralization is negative). However, if the indirect effect is sufficiently sizable, it is optimal to have $x^B < x^*$, because the positive indirect effect causes more efficient investments.

stitutional cost grants, that is, $\alpha = 0$.[33] An immediate observation here is that x^A is smaller than efficient, whereas x^B is too big. At least for $\beta > \gamma$, this renders the direct investment incentives larger under centralization, than under decentralization. On the other hand, the indirect investment effect in all centralization regimes under consideration becomes negative, intuitively, because the project region reduces its investments as an instrument to reduce the project size chosen by the central government.[34] These conflicting forces suggest the absence of any systematic advantage of one institutional regime over the other. Moreover, political bargaining may now stifle rather than stimulate investment incentives. In particular, political bargaining adds a negative indirect effect under decentralization, which may distort investment incentives so much as to outweigh the benefits of a mutual agreement over policies.

6.2 Investments in Cost Reduction

The analysis so far has discussed a model in which the region's investments contribute to the benefit from the subsequent project. In many cases, however, the purpose of investments is rather to lower implementation costs. While a full analysis is relegated to our discussion paper Kessler et al. (2012), the present Section reports some interesting results for this alternative scenario.

To fix ideas, suppose that in contrast to our preceding analysis, region A can at date 1 spend cost reducing investments e at convex costs $\psi(e)$ into the project x. Project costs at date 3 are then $C(x, e, \theta)$ with $C_e(\cdot) < 0$ and $C_{xe} < 0$, ie, a larger project size increases the absolute cost reduction effect of investments. At first glance, one may think that grants are no longer needed to achieve efficient investments. In absence of grants, region A pays the entire costs of policies and is therefore the residual claimant for its cost savings, which should generate proper incentives. However, this argument ignores that without grants and since $\beta < 1$, region A will either choose a smaller than efficient policy (under decentralization), or it will adjust its investments downward in order to reduce the federal government's chosen policy.

[33] In a scenario with political bargaining, the absence of cost grants does not rule out monetary transfer payments between regions. For example, under decentralization, the composite region B in equilibrium pays region A for the latter region's agreement to produce x^* rather than x^A.

[34] For $\alpha = 0$, the influence effect under centralization is zero because region B chooses the corner solution $x^B = \bar{x}$ regardless of investments. Note that the indirect effect reappears when maximum project size is an increasing function of a, ie, $\bar{x}(a)$.

We also note that when investments reduce costs, cost matching grants (or more generally, transfer payments that are contingent on project costs) cease to be a good instrument for resolving the underinvestment problem. To illustrate this point, consider the case of decentralization without bargaining. With x^A again being described as in (5) , A's cost reducing investments e maximize $S^A = E_\theta \left[\beta V(x^A, \theta) - (1-\alpha) C(x^A, e, \theta)\right] - \psi(e)$, which gives rise to a first order condition

$$-E_\theta \, (1-\alpha) C_e(x^A, e, \theta) = \psi_e(e).$$

Contrasting the resulting equilibrium investment with the first best e^* described by $-E_\theta \, C_e(x^*, e, \theta) = \psi_e(e)$ reveals that whenever $\beta < 1$, efficient investments e^* are incompatible with an efficient project choice x^*, which requires a Pigouvian grant $\alpha^P > 0$.[35] This is true more generally as well: a comprehensive analysis (see Appendix) yields

Proposition 5. *With spillovers and cost reducing investments, cost grants are insufficient to achieve efficiency. This is true for centralization and decentralization, with and without political bargaining, and even in an environment with a benevolent political planner.*

Intuitively, whenever the project size is larger than A's preferred choice (as would be the case with political bargaining or benevolent central planner), A has an incentive to manipulate e to lower the ex-post implemented x: the indirect 'influence' effect is negative. The direct effect is positive but generates inefficient incentives for any $\alpha > 0$. Increasing α would raise investments through the indirect effect but reduces the direct effect at the same time, making the general direction of incentives inconclusive.

A remedy to this negative outcome is to make constitutional grants conditional on project size x, rather than project costs. For simplicity, consider a linear grant with parameter $t \geq 0$ which entitles region A to payments of tx when policy of size x is implemented. For the purpose of the following discussion, let us assume that no uncertainty θ exists or more generally, that marginal project benefit $V_x(\cdot)$ and marginal costs $C_x(\cdot)$ are independent of θ. With this assumption in place, regime-dependent Pigouvian output grants t^P implement x^* in every state.[36] We have

[35] Put differently, while region A is the full residual claimant for its cost savings for given policy x if $\alpha = 0$, zero grants are incompatible with efficient project choice in the presence of spillovers.

[36] In contrast to the Pigouvian cost grant α^P, a Pigouvian output grant t^P is regime dependent. Under decentralization (and in the benevolent planner regime), the Pigouvian output grant satisfies $\beta V_x(x^*) - C_x(x^*, e^*) + t^P = 0$. Under centralization, it is defined by $(1-\beta) V_x(x^*) - t^P = 0$.

Proposition 6. *For cost reducing investments and in absence of uncertainty, a (regime dependent) Pigouvian output grant t^P implements a first best outcome regardless of the institutional setting, and regardless of whether or not political bargaining is allowed for.*

This result is easily explained. To provide region A with efficient incentives for cost reducing investments, one has to make this region the residual claimant for its cost savings (hence, $\alpha = 0$). At the same time, the political authority in charge of the project should be given incentives to choose the efficient size x^*. In our setting, a Pigouvian output grant achieves both of these goals at the same time.

In contrast to our baseline setup, we find that the institutional regime does not matter when investments serve to reduce the costs of policies, rather than to enhance their social benefits. The intuitive distinction between these two settings is that regardless of the size of grants, the project benefits yield spillovers, whereas the project costs are incurred by the project region alone. Also, there is no benefit in using cost grants along with output grants. As our discussion paper Kessler et al. (2012) shows, these results change in a more general framework in which region A can undertake *both* value enhancing and cost reducing investments at the same time. In general, regions will use the two instruments of cost matching grants, and output grants, to implement a first best or second best outcome. Most importantly, the main result that decentralization with the feasibility of political bargaining dominates centralization, extends to this more general framework.

7 Concluding Remarks

This paper investigates whether the economic performance of a federal system depends on its governance structure, even when inter-governmental grants are designed optimally under centralization as well as decentralization. We show that in our setting, this is indeed the case. The finding contrasts a central tenet of the standard literature on federalism, according to which corrective (Pigouvian) grants would make economic outcomes in each regime indistinguishable. Our results suggest that with a moral hazard component to government activities, institutions matter and shape the economic outcome even when they are augmented by monetary incentives.

A number of more specific results are borne out in our analysis. Under the perhaps unrealistic assumption of a benevolent central government, centralization is preferable

to decentralization and a first best outcome is achieved through optimal cost matching grants, payable to the project region which invests into value increasing activities. Conversely, when centralized policies are chosen in a partisan fashion and political negotiations are ruled out, no grant system and no authority structure reaches the efficiency frontier. In this latter scenario, grants have to ensure efficient investments and an efficient project size, tasks that cannot be accomplished at the same time. Moreover, no authority structure inherently dominates in this setting.

This changes when political negotiations between regional politicians are taken into account. Perhaps the most striking conclusion of our analysis is that constitutional grant policies are then systematically less effective in a centralized system, at least when externalities are not too large. Under decentralization, grant levels and investment incentives are aligned because larger grants raise not only the region's investment incentives for given default policy (the direct effect), but also because they boost the default policy chosen by this region (the influence effect). Unlike decentralization, larger grants under centralization lead to smaller default policies, which triggers a misalignment of direct and indirect investment incentives.

Since political negotiations are an often used tool to realize mutual gain, we found it crucial to incorporate them into an analysis of federal structures. Communication among decision makers occurs on a regular basis in real-world politics, and the outcome of political negotiations is often enforceable to a large degree.[37] While our results suggest that the possibility to bargain improves the relative performance of decentralized over centralized governance, future research into this important issue is certainly warranted.

[37]See Kessler (2014) for a model where communication is explicitly allowed for but locally held information about project benefits prevents an efficient decision even with negotiations.

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Appendix

Proof of Proposition 1

Let $\eta(x^*, a; \alpha) = E_\theta\big[\beta V_x(x^*, a, \theta) - (1-\alpha)C_x(x^*, \theta)\big]$ be the (expected) indirect effect of a change in region A's investments on its net return from the project through the corresponding change in project size, evaluated at the optimally chosen $x^*(\alpha)$. Comparing (3) and (4), we see that for $\eta(x^*, a; \alpha) = E_\theta\,(1-\beta)V_x(x^*, a^*, \theta) > 0$, region A will invest efficiently, i.e., $a^P = a^*$. To show that this is feasible, note that at the Pigouvian cost grant $\alpha^P = 1-\beta$, we have $\eta(x^*, a; \alpha^P) = 0$ by definition of $x^*(a, \theta)$. Furthermore, $\eta(x^*, a; \alpha)$ in increasing in α for any given level of a, and increases without bounds under Assumption 1 since the derivative dx^*/da is positive, invariant with respect to α, and limited away from zero because x^* is continuous in a by the theorem of the maximum. Hence, there must exist a value $\alpha^* > \alpha^P$ that induces $a^P = a^*$ and, hence, $x^* = x^{FB}$. Moreover, $S_x^A(x^{FB}, a^{FB}, \theta; \alpha^*) > 0$ from (5), implying that region A would prefer a project larger than x^{FB}. □

Proof of Proposition 2

We first show that efficient investments require region A to choose a default policy larger than efficient, $x^A > x^*$ when $\beta < 1$. Recall equation (6),

$$E_\theta\left[(\beta-\gamma)V_a(x^A, \cdot) + \gamma V_a(x^*, \cdot) - \gamma[V_x(x^A, \cdot) - C_x(x^A, \cdot)]\frac{dx^A(\cdot)}{da}\right] = \phi_a(a), \qquad (6)$$

and consider a grant $\alpha < \alpha^P$ that yields $x^A < x^*$. In this case, the first two terms of (6), the direct effect of investments on region A's net surplus, are smaller than the social marginal benefit of investing, evaluated at the optimal x^*:

$$E_\theta\Big\{(\beta-\gamma)V_a(x^A, \cdot) + \gamma V_a(x^*, \cdot) - V_a(x^*, \cdot)\Big\} < 0$$

At the same time, the third term in (6), the indirect effect of investments on x^A and it's bargaining surplus, is negative due to $V_x(x^A, \cdot) - C_x(x^A, \cdot) > 0$ and $dx^A/da > 0$:

$$E_\theta\Big\{ -\gamma[V_x(x^A, \cdot) - C_x(x^A, \cdot)]\frac{dx^A(\cdot)}{da}\Big\} < 0.$$

Hence, region A underinvests for any grant level $\alpha < \alpha^P$.

Next, consider a further increase in α, starting at a Pigouvian cost grant $\alpha = \alpha^P$ so that $x^A = x^*$. For $\alpha = \alpha^P$, the left-hand side of (6) becomes (ignoring expectations for

simplicity)

$$(\beta-\gamma)V_a(x^*,\cdot)+\gamma V_a(x^*,\cdot)-\gamma[V_x(x^*,\cdot)-C_x(x^*,\cdot)]\frac{dx^A(\cdot)}{da}=\beta V_a(x^*,\cdot)<V_a(x^*,\cdot),$$

again implying underinvestment for $\beta<1$. Any larger grant increases the direct investment effect $(\beta-\gamma)V_a(x^A,\cdot)+\gamma V_a(x^*,\cdot)<V_a(x^*,\cdot)$ in a continuous fashion whenever $\beta>\gamma$ (recall $V_{xa}>0$ by Assumption 1). At the same time, the indirect effect $-\gamma[V_x(x^A,\cdot)-C_x(x^A,\cdot)]\frac{dx^A(\cdot)}{da}$ becomes positive, enhancing investments even further. Since $V_a(\cdot)$ increases without bounds as $x^A\to\bar{x}$ for $\alpha\to 1$ by Assumption 1, a will strictly exceed a^* for $\alpha\to 1$. By the theorem of the maximum and the intermediate value theorem, this implies the existence of some optimal grant parameter $\alpha^*\in(\alpha^P,1]$ which implements efficient investments a^*. □

Example where decentralization yields efficiency for any value $\beta<1$.

For simplicity, assume no uncertainty, e.g, $\theta\equiv\bar{\theta}$. Let $V(\cdot,\bar{\theta})=ax$ and $C(\cdot,\bar{\theta})=(1/2)x^2$. Suppose all optimization programs are well behaved, which is always guaranteed by a sufficiently convex investment cost function $\phi(a)$. Considering interior solutions, one then obtains $x^*=a$ and $x^A=\beta a/[(1-\alpha)]$.

Under decentralization, the optimality condition (6), evaluated at the level of efficient investments $a=a^*$, using $\phi_a(\cdot)=V_a(x^*,\cdot)$ and $dx^A/da=x^A/a$, reduces to

$$(\beta-\gamma)x^A-\gamma\left(a^*-x^A\right)\frac{x^A}{a^*}=(1-\gamma)x^*.$$

Noting that $1=a^*/x^*$ this condition can be rewritten as

$$x^A\left[(\beta-\gamma)+\gamma\left(\frac{x^A}{x^*}-1\right)\right]=(1-\gamma)x^* \tag{11}$$

Observe that for any $x^A\leq x^*$ and $\beta<1$, (11) cannot hold as the left-hand side is smaller than the right-hand side. Since the left-hand side of (11) is strictly increasing in x^A, which in turn increases without bounds as $\alpha\to 1$, however, there always exists cost grant parameter $\alpha<1$ that supports a default policy level x^A so that (11) is satisfied.□

Proof of the Corollary to Proposition 2.

From (7), and since $\beta<1$, region A chooses $a<a^*$ when $\alpha=\alpha^P=1-\beta$ which is required for $x^A(\cdot)=x^*(\cdot)$. Efficient investments are therefore incompatible with an

ex-post efficient policy choice. In addition, α^P yields a larger total surplus than any $\alpha < \alpha^P$: first, x^A is closer to x^* with the Pigouvian grant; second, the investment is larger because $V_{xa} > 0$ by Assumption 1, alleviating moral hazard. To see that the optimal cost grant α^* must exceed the Pigouvian level, differentiate $S(x^A(a,\theta),a,\theta)$ with respect to α to obtain

$$\frac{dS(\cdot)}{d\alpha} = \left[V_x(x^A,\cdot) - C_x(x^A,\cdot)\right]\left(\frac{dx^A}{d\alpha} + \frac{dx^A}{da}\frac{da}{d\alpha}\right) + V_a\frac{da}{d\alpha}.$$

Noting that

$$\frac{da}{d\alpha} = -\frac{\beta V_{ax}(dx^A/d\alpha)}{V_{aa} - \phi_{aa}} > 0$$

under Assumption 1, the second term of the differential $dS/d\alpha$ is positive. The first term is also positive for any $\alpha < \alpha^P$ because $V_x - C_x > 0$ for $x^A < x^*$, $dx^A/d\alpha > 0$, and $dx^A/da > 0$. At $\alpha = \alpha^P$ the first term is zero, implying $dS/d\alpha > 0$. The optimal grant therefore must satisfy $\alpha > \alpha^P$. At the efficient level $x^A = x^*$, increasing $x^A(\cdot)$ marginally above $x^*(\cdot)$ has only a second-order effect on allocative efficiency while the associated increase in a induces a positive first order effect. It follows that the second-best optimal policy must entail $x^A(\cdot) > x^*(\cdot)$. □

Proof of Proposition 3

To prove Proposition 3, we show that inefficient outcomes cannot be achieved for the example where $V(\cdot) = ax$ and $C(\cdot) = (1/2)x^2$, for any combination of (β,γ). Note that $x^* = a$ and $x^B = (1-\beta)a/\alpha$ in this case. Recall the first-order conditions of A's equilibrium investments under centralized politics with bargaining, (9). Ignoring again the uncertainty θ, we can evaluate (9) at the efficient level of investments $a = a^* = x^*$, which, using $dx^B/da = x^B/a$ reduces to

$$x^B\left[(\beta-\gamma) + (1-\gamma)\left(1 - \frac{x^B}{x^*}\right)\right] = (1-\gamma)x^*. \tag{12}$$

Note that the left-hand side of (12) is smaller than the right-hand side at $x^B = x^*$, implying underinvestment. Taking the derivatives with respect to x^B, the left-hand side of (12) is increasing in x^B if

$$\beta - \gamma - 2(1-\gamma)\frac{x^B}{x^*} \geq 0 \quad \Leftrightarrow \quad x^B \leq \frac{x^*}{2}\left(1 + \frac{\beta-\gamma}{1-\gamma}\right) \equiv \hat{x}^B \quad < x^*$$

If $\hat{x}^B < 0$ the left-hand side of (12) is obviously smaller than the right-hand side for any $x^* > 0$, with the consequence of underinvestments. Conversely, for positive $\hat{x}^B$, the left hand side of (12) can be written as

$$(1-\gamma)\frac{x^*}{4}\left(1+\frac{\beta-\gamma}{1-\gamma}\right)^2,$$

which by inspection is smaller than $(1-\gamma)x^*$ whenever $\beta < 1$, again implying underinvestments. In conclusion, regardless of parameter constellations (β, γ), there exists no constitutional grant policy (and accordingly, no x^B) which implements an efficient outcome in the centralization regime. □

Proof of the Corollary to Proposition 3.

Efficient project choice $x^B = x^*$ requires a Pigouvian grant $\alpha = \alpha^P$. By (4), the indirect effect $[V_x(x^B, a, \theta) - C_x(x^B, e, \theta)]\frac{dx^B}{da}$ then vanishes and investments become $a < a^*$ due to $\beta < 1$. Hence, efficiency cannot be achieved under centralization without bargaining. Next, notice that in contrast to decentralization, the optimal x^B does not necessarily satisfy $x^B > x^*$. Lowering α below α^P (and hereby, raising x^B above x^*) again boosts the direct investment effect in (4), but the influence effect becomes negative and reduces investments. The opposite may happen if α is raised above α^P: the influence effect becomes positive, while the reduced x^B diminishes the direct investment incentive at the same time. □

Proof of Proposition 4

For the Pigouvian cost grant $\alpha^P = 1 - \beta$, the first order conditions for equilibrium investments (6), (7), (9), and (4) coincide and reduce to $E_\theta\, \beta V_a(x^*, \cdot) = \phi_a(\cdot)$, which implies an equilibrium investment below the first best level for any $\beta < 1$. □

Proof of Proposition 5

Much of the analysis for cost reducing investments can be carried out along the lines of the baseline model discussed in the paper. Notice that the determinants of the efficient policy x^*, and the default policies x^A and x^B, respectively, are identical to the case of value increasing investments. First best investments are now described by the first order condition $-E_\theta\, C_e(x^*, e, \theta) = \psi_e(\cdot)$, equating the marginal social benefit in cost reduction with marginal investment costs.

To show that cost matching grants do not implement efficient investments, consider first the benevolent planner regime. The first order condition for region A's equilibrium investments now reads

$$E_\theta \{ -(1-\alpha)C_e(x^*, e, \theta) + [\beta V_x(x^*, \cdot) - (1-\alpha)C_x(x^*, \cdot)]\frac{dx^*}{de}\} = \psi_e(e). \qquad (13)$$

Note that for $\alpha = 0$, the first term in (13), the direct effect of investments on cost reduction, is of efficient size. Yet, a first best remains infeasible for any $\beta < 1$ because the influence effect in square brackets is negative for $\alpha = 0 < \alpha^P$. Moreover, increasing α increases the indirect effect but reduces the direct effect at the same time, making the general direction of incentives inconclusive.

Next, consider the regimes in which political bargaining is disregarded. For the case of decentralization, the main text shows that efficiency cannot be attained whenever $\beta < 1$. For centralization, the relevant first order condition reads

$$- E_\theta \Big[(1-\alpha)C_e(x^B, e, \theta) + [V_x(x^B, \theta) - C_x(x^B, e, \theta)]\frac{dx^B}{de}\Big] = \psi_e(e). \qquad (14)$$

For $\alpha = \alpha^P$ which is necessary for $x^B = x^*$, the indirect effect is zero whereas the direct effect is smaller than efficient. Accordingly, a first best outcome remains elusive.

Finally, consider the regimes in which political bargaining over the project choice is feasible. Under decentralization, the associated first order equilibrium condition for cost reducing investments reads

$$E_\theta \Big[- (1-\alpha-\gamma)C_e(x^A, \cdot) - \gamma C_e(x^*, \cdot) - \gamma[V_x(x^A, \cdot) - C_x(x^A, \cdot)]\frac{dx^A(\cdot)}{de}\Big] = \psi_e(e). \quad (15)$$

Again, notice that by itself, the direct effect represented by the first two terms of (15), would yield efficient investments if $\alpha = 0$ and $x^A = x^*$. For $\beta < 1$, however, $\alpha = 0$ implies $x^A < x^*$. Moreover, the direct effect decreases in α (for given x) whereas the indirect effect in brackets is again, positive (negative) for $\alpha < (>)\alpha^P$. In general, efficient equilibrium investments are therefore unachievable. The same is true for centralization, as can be seen from the associated first-order condition

$$E_\theta \Big[-(1-\alpha-\gamma)C_e(x^B, \cdot) - \gamma C_e(x^*, \cdot) + (1-\gamma)[V_x(x^B, \cdot) - C_x(x^B, \cdot)]\frac{dx^B(\cdot)}{de}\Big] = \phi_e(e). \quad (16)$$

At $\alpha = 0$, the direct effect is larger than efficient (under Assumption 1 and because $x^B > x^*$), while the indirect effect is negative. Hence, the overall size of incentives

relative to the efficient level is unclear. Moreover, an increase in α moves direct and indirect effect in opposite directions. $\square$

Proof of Proposition 6

By definition, a regime dependent Pigouvian output grant t^P (see the main text) induces for $e = e^*$, policies $x^A = x^B = x^*$ in stage 3. Accordingly, the first order conditions in each regime (including the benevolent planner regime) coincide and become $-E_\theta C_e(x^*, e, \theta) = \psi_e(e)$, which is also the first order condition for efficient investments e^*. $\square$